**3GPP TSG RAN WG1 Meeting #103-e R1-2009678**

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

**Source: Moderator (CATT)**

**Title: FL Summary #9 for Potential Positioning Enhancements**

**Agenda item: 8.5.3**

**Document for: Discussion and Decision**

# Introduction

This document provides a summary of the following email discussion:

[103-e-NR-ePos-03] Email discussion/approval on potential positioning enhancements until 11/02; address any remaining aspects by 11/10 – Ren Da (CATT)

Potential Positioning Enhancements were discussed in RAN1#102-e [1]. The document further investigates the following aspects related to potential positioning enhancements based on proposals from [2-24]:

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| 1. Enhancements of DL positioning reference signals    1. DL PRS processing with aggregated DL PRS resources    2. DL PRS transmission patterns and additional DL PRS configuration    3. Simultaneous transmission and reception DL PRS with other signals/channels    4. DL PRS muting enhancements    5. New DL reference signals for positioning 2. Enhancements of UL positioning reference signals    1. UL SRS transmission patterns    2. UL SRS transmission with aggregated SRS resources    3. Simultaneous transmission of UL SRS for positioning with other signals/channels    4. Enhancement of SRS cyclic shift patterns    5. Power control for SRS for positioning    6. Mitigation of UL interference    7. Frequency hopping of UL SRS for positioning    8. New UL reference signals for positioning    9. Multi-port transmission of UL SRS for positioning 3. Enhancements of UE/gNB measurements    1. Multipath mitigation    2. Additional enhancements of UE/gNB measurements    3. Other issues related to the UE/gNB measurements 4. Enhancements of positioning methods and measurement procedure    1. UE positioning in idle/inactive states    2. On-demand DL PRS, A-PRS, SP-PRS   On-Demand DL PRS, A-PRS (closed)   * 1. Enhancements of UL AoA and DL-AoD   2. Methods for reducing positioning latency   3. Methods for reducing timing measurement errors   UE/gNB Rx/Tx transmission delays (closed)  Network synchronization error   * 1. Enhancements on E-CID positioning   2. Enhancements related to Measurement gap   3. UE-based positioning   4. SRS transmission time   5. UE positioning in DRX state   6. Beam-management of positioning   7. Additional proposals related to signalling enhancements   8. On-demand UL SRS for positioning   9. Additional positioning methods  1. Other proposals |

**Notes:**

* The following highlights will be used in this summary:
  + “Pink highlights” are used for proposals for discussion with high priority
  + “Yellow highlights” are used for proposals for discussion with medium priority
  + “Dark Yellow highlights” are used for proposals for discussion with low priority
  + “Turquoise highlights” are used for offline consensus/conclusion based on offline discussion or comments
  + “Grey highlights” are used for proposals that have been resolved in this meeting.
  + The above priority highlights are used mainly as a suggestion of the priority for online discussion. The priority indications may be changed based on the received comments.
    - During the email discussion, it is assumed that interested companies will provide comments to the proposals regardless of the priority indications, since this is the last meeting of the SI.
* To facilitate the preparation of the TR, the following terms are used in the proposals to be discussed in this summary:
  + **"[X] is** **recommended for normative work**" (instead of "[X] should be supported in Rel-17 WI) for a proposed enhancement to be supported in Rel-17 WI;
  + **"[X] is (are) left for further discussion in normative work"** (instead of "[X] will be further discussed/investigated in Rel-17 WI phase) for the potential issue(s) that need to be addressed in Rel-17 WI for a proposed enhancement.
* When providing the comments, it would be helpful to indicate explicitly whether to“support”, or “not support”, or provide a suggestion of modification. A comment of “high/medium/low priority” is only interpreted as a suggestion for the priority for online discussion. For a proposal with multiple options, it would be helpful to indicate which of the option(s) are “supported” and/or “preferred”.
* For a proposed enhancement, if we cannot reach a consensus on whether to support/consider it in Rel-17, we may conclude that “a consensus cannot be reached for the proposed enhancement”, which does not necessarily mean the proposed conclusion is included/not included in the TR. Whether and how to include a proposed enhancement without consensus in the TR is subject to the TR discussion.

# Enhancements of DL positioning reference signals

## DL PRS processing with aggregated DL PRS resources

Background

In RAN1#102-e, we have reached following agreements to investigate the aggregation of multiple DL positioning frequency layers [1].

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| Agreement:   * Aggregating multiple DL positioning frequency layers of the same or different bands for improving positioning performance for both intra-band and inter-band scenarios will be investigated in Rel-17, which may take into account at least the following * The scenarios and performance benefits of aggregating multiple DL positioning frequency layers * The impact of channel spacing, timing offset, phase offset, frequency error, and power imbalance among CCs to the positioning performance for intra-band contiguous/ non-contiguous and inter-band scenarios * UE complexity considerations * Note: What is captured in the TR will be discussed separately. |

Submitted Proposals

* (Huawei R1-2007577) Proposal 3:
  + Rel-17 should support at least intra-band contiguous and non-contiguous frequency aggregation with phase continuity.
* (CATT R1-2007755) Proposal 5:
  + No support of aggregating multiple intra-band non-contiguous and/or inter-band DL/UL frequency layers for positioning in Rel-17 due to the large TAE errors between the carriers.
* (CATT R1-2007755) Proposal 6:
  + Whether to support aggregating multiple intra-band contiguous DL/UL frequency layers for positioning in Rel-17 depends on whether it is feasible to reduce the TAE between the carriers within 1-2 ns. RAN4 may need to be consulted on the feasibility of reducing the TAE within 1-2 ns.
* (Intel R1-2007946) Proposal 8:
  + Support for aggregation of multiple DL positioning layers of the same or different bands with definition of a limit on the maximum component carriers spacing in the frequency domain
* (OPPO R1-2008226) Proposal 6:
  + Do not to support the aggregation of multiple positioning frequency layers for positioning enhancement in Rel-17.
* (Sony R1-2008365) Proposal 3:
  + Support aggregating multiple DL positioning frequency layers of the same or different bands for positioning accuracy enhancements
* (Qualcomm R1-2008619) Proposal 2:
  + Support enhancements to enable **DL/**UL PRS bundling in frequency domain in both intra-band and inter-band scenarios within the same FR, including at least the following aspects:
    - Signaling enhancements related to Timing, Phase, Power offsets, and QCL relations, amongst the PRS resources of different PFLs from the same TRP.
    - Enhancements related to Measurement period, accuracy requirements, and UE capabilities for scenarios of coherent and concurrent processing of multiple PFLs from the same TRP.
* (Ericsson R1-2008765) Proposal 28:
  + RAN1 shall not study coherent multicarrier DL PRS in Rel. 17. If this should be studied at all it should be done in a separate study item and feasibility should be studied in RAN4 before any RAN1 resources are spent on this issue;

FL’s Comments

Seven companies provide their proposals related to the aggregation of multiple DL positioning frequency layers. Among them,

* 4 companies support aggregating multiple DL positioning frequency layers of the same or different bands;
* 1 company support aggregating multiple DL positioning frequency layers of the same band;
* 1 company may support aggregating multiple DL positioning frequency layers of the intra-band contiguous frequency aggregation;
* 2 companies do not support aggregating multiple DL positioning frequency layers

The main concern on the support of the aggregation of multiple DL positioning frequency layers is the impact of timing offset, channel spacing, phase offset, frequency error, and power imbalance among CCs on the positioning performance. The impact may be different for different carrier aggregation scenarios, especially related to whether the transmitter and the receiver use one or multiple Rx/Tx RF chains. For example, multiple Tx/Rx chains may be required for supporting inter-band carrier aggregation, while one single Tx/Rx chains may be used for supporting intra-band contiguous carrier aggregation, depending on UE’s capability. Thus, suggest discussing the different carrier aggregation scenarios separately.

Proposal 2-1

* Select one of the following options:
  + Option 1: Aggregating multiple DL positioning frequency layers in both intra-band and inter-band scenarios within the same FR is recommended for normative work;
    - the corresponding signaling, measurement, accuracy requirements, UE capabilities, etc. are left for further discussion in normative work
  + Option 2: Aggregating multiple DL positioning frequency layers in intra-band contiguous/non-contiguous scenarios are recommended for normative work;
    - the corresponding signaling, measurement, accuracy requirements, UE capabilities, etc. are left for further discussion in normative work
  + Option 3: Aggregating multiple DL positioning frequency layers in intra-band contiguous scenarios are recommended for normative work;
    - the corresponding signaling, measurement, accuracy requirements, UE capabilities, etc. are left for further discussion in normative work
  + Option 4: Not support aggregating multiple DL positioning frequency layers in Rel-17.

Comments

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| **Company** | **Comments** |
| Qualcomm | Support Option 1 |
| MTK | The phase continuity (due to time offset between carriers or other reasons) could be a crucial factor. If we agree on supporting CA for positioning, at least the requirement at the transmission should be defined. The intra-band contiguous CA could be the case to maintain better phase continuity than intra-band non-contiguous CA.  From UE receiver side, the general structure for receiving intra band contiguous CA is by 1 LNA, 1 mixer and 1 PGA (baseband gain amplifier). For receiving intra-band non-contiguous CA, it is by 1 LNA, 2 mixers and 2 PGAs. So we think intra-band non-contiguous CA would be more challenging to maintain phase continuity at both the transmission and receiving side.  Therefore, we prefer to consider intra-band contiguous CA case only🡪 option 3 |
| CATT | We support Option 3. In our point of view, no support of aggregating multiple intra-band non-contiguous and/or inter-band DL/UL frequency layers for positioning in Rel-17 due to the large TAE errors between the carriers. And Whether to support aggregating multiple intra-band contiguous DL/UL frequency layers for positioning in Rel-17 depends on whether it is feasible to reduce the TAE between the carriers within 1-2 ns. RAN4 may need to be consulted on the feasibility of reducing the TAE within 1-2 ns. |
| CMCC | From our perspective, introducing multiple PFLs aggregation (including both intra- and inter-band CA) can theoretically improve the measurement quality and positioning accuracy, which is a good thing, especially when we consider the case that more than one carriers would be deployed in IIoT scenarios. However, we also understand that it may be difficult to keep phase continuity in reality, and it may impose great complexity on the UE side. We prefer Option 1, and would like to hear views from more companies. |
| OPPO | Support Option 4 since the benefit of aggregation can only be achieved with ideal assumption, and cannot be achieved for practical gNB/UE.  1. From the perspective of gNB  According to the requirement of TS 38.104, the TAE requirement for intra-band contiguous CA cannot support the high accuracy of positioning   |  | | --- | | 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. |   2. From the perspective of UE  Even for intra-band CA, because of the limited IF spectrum coverage with baseband circuits, for example amplifier, filter etc, we still need multiple different receive signal paths to support both contiguous and non-contiguous intra-band CA. The current implementation of 5G chipset is that each IF chain corresponds to one carrier. |
| vivo | Support option 4.  Firstly, the performance of PRS aggregation is greatly impacted by factors such as timing offset, phase offset and channel spacing, only when these values are very small, the accuracy gain can be obtained. However, it is unclear whether these values can be guaranteed to be small enough. Therefore, whether PRS aggregation can be applied in actual scenarios is still unknown.  Besides, these factors also make it difficult to define RAN4 requirements. For example, when the network configures PRS aggregation of 50MHz+50MHz, what accuracy should the network expected from the UE, 50MHz, or 100MHz, or between 50MHz and 100MHz? Furthermore, whether the accuracy expected by the network is different if the channel spacing of two FLs is different?  Also, too much normative work will be introduced; however our standardization time is limited. For example, complex requirements and UE capability should be defined, new measurement gap to process aggregated positioning frequency layers should be introduced.  Finally, from the perspective of the SID ‘Enhancements to Rel-16 positioning techniques, if they meet the requirements, will be prioritized, and new techniques will not be considered in this case’, judging from the baseline evaluation results of most companies, the accuracy requirements can be met without PRS aggregation, so we think PRS aggregation as a ‘new technology’ cannot be prioritized in Rel-17. |
| ZTE | 1st preference for option 1 , we can live with option 2 and option 3, at least RS aggregation should be studied and supported . |
| Huawei/HiSilicon | We prefer Option 2. We suppose that the “intra-band contiguous” means that channel is contiguous, instead of PRS transmission.  In reply to OPPO   * RAN4 requirements only specify the worst case as it may impact UE Rx. As Rel-16 positioning cannot work under such large synchronization specified by TAE. The sync requirement is not specified by RAN4. * In case from UE side, each IF corresponds to one carrier, it is still possible to compensate the path delays between different IF chains. |
| Lenovo, Motorola Mobility | Support Option 3 from the spec effort point of view, FFS may be needed to further understand UE complexity implications of interband scenarios in Option 1 and intraband non-contiguous scenarios in option 2. The impact of the impairments mentioned (e.g. timing offset, channel spacing, phase offset, frequency error) can be further investigated in terms of UEs with advanced capabilities but the potential benefits of aggregating multiple FLs for accuracy enhancement are promising for timing-based positioning methods. |
| Intel | Option 2.  FFS: Option 1.  Our understanding, that simultaneous DL PRS transmission by gNB is possible starting from Rel.16, at least from RAN1 perspective.  We assume that the discussion is about UE reception of aggregated CCs. |
| Ericsson | Option 4. The current evaluations does not point to meaningful gains once realistic impairements are considered. |
| Futurewei | Option 4.  The TAE issues need to be resolved and we don’t believe it is in the scope of this SI/WI to do this since it has always been part of RAN4 requirement discussions. We are open to consider Option 3. |
| Qualcomm2 | We can accept Option 2 also |

FL comments

It seems the companies have diverged views on whether and which CA scenarios should be supported. Among the responses from 10 companies, 3 companies are supportive to Option 1, 2 companies are supportive to Option 2, 3 companies are supportive to Option 3, and 2 companies are supportive to Option 4. Based on the feedbacks, it might be better to separate the discussions for each of the CA scenarios. Also, to align the wording between the proposals of the DL CA and UL CA, in the revised version, the wording of “simultaneous transmission and reception across multiple carriers” is used instead of “aggregating multiple positioning frequency layers” for both DL and UL.

Proposal 2-1a

* Simultaneous transmission by the gNB and reception by the UE of the DL PRS across multiple intra-band contiguous carriers is recommended for normative work.

Comments

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| **Company** | **Comments** |
| Qualcomm | Support. |
| vivo | We’d like to get clarification regarding the term “continuous”. Our understanding of RAN4 definition/requirements on carriers is that there may still be small gap between two adjacent carriers even if they are inside one band. If that’s the case, continuous carriers do not automatically guarantee timing/phase continuity which are assumed in performance evaluation showing the gain. We think this should be reflected as well. Not just a statement saying something is recommended without mentioning any underlying conditions. |
| CATT | Need further study. Whether to support aggregating multiple intra-band contiguous DL/UL frequency layers for positioning in Rel-17 depends on whether it is feasible to reduce the TAE between the carriers within 1-2 ns. RAN4 may need to be consulted on the feasibility of reducing the TAE within 1-2 ns. |
| MTK | We support intra-band contiguous case. For this case, the minimal channel spacing smaller than the nominal channel spacing is feasible. |
| OPPO | Not support. More study is needed. |
| Huawei/HiSilicon | Support.  To vivo, for contiguous, we share similar understanding as vivo for the gap between CCs, which is already taken into account by RAN4 TS 38.101-1 for example.   |  | | --- | | The channel spacing for intra-band contiguous carrier aggregation can be adjusted to any multiple of least common multiple of channel raster and sub-carrier spacing less than the nominal channel spacing to optimize performance in a particular deployment scenario.  For intra-band non-contiguous carrier aggregation, the channel spacing between two NR component carriers in different sub-blocks shall be larger than the nominal channel spacing defined in this clause. |   Whether different CCs have additional delay offset or phase offset depends on IF/RF architecture, and at least based on our understanding, intra-band contiguous CA can be implemented using single RF, which allows phase continuity and delay consistency between CCs. |
| Intel | Support. |
| ZTE | Support. |
| Lenovo, Motorola Mobility | Support the intra-band contiguous CA case. |
| Ericsson | We agree with the comments from CATT. According to TS 38.104, the TAE requirement for intra-band continuous carriers is 260ns. As mentioned by CATT, whether it is feasible to reduce the TAE to within 1-2ns needs a RAN4 discussion. |
| Sony | Support |
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Proposal 2-1b

* Simultaneous transmission by the gNB and reception by the UE of the DL PRS across multiple intra-band non-contiguous positioning frequency layers can be considered for normative work.

Comments

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| **Company** | **Comments** |
| Qualcomm | Support |
| vivo | Do not support. As we commented toward original proposal 2-1, based on our evaluation, we have concern on obtaining the performance gain of aggregation of multiple non-contiguous positioning frequency layers. |
| CATT | We prefer not to support it. In our point of view, no support of aggregating multiple intra-band non-contiguous and/or inter-band DL/UL frequency layers for positioning in Rel-17 due to the large TAE errors between the carriers. |
| Apple | Do not support, similar view as vivo |
| MTK | We consider NOT to support the intra band non-contiguous case |
| OPPO | Not support |
| Huawei/HiSilicon | Support as “can be considered for normative work”. As long as the UE capability supports the bandwidth combination set, we do not see much of a problem. |
| Intel | Support. |
| ZTE | Support. |
| Ericsson | Do not support. We agree with the comments from VIVO and CATT. |
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Proposal 2-1c

* Simultaneous transmission by the gNB and reception by the UE of the DL PRS across multiple inter-band DL positioning frequency layers in the same FR can be considered for normative work.

Comments

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| **Company** | **Comments** |
| Qualcomm | Support |
| vivo | Do not support. Aggregation of multiple positioning frequency layers across inter-band would be even more difficult to obtain the gain than intra-band case. |
| CATT | We prefer not to support it. In our point of view, no support of aggregating multiple intra-band non-contiguous and/or inter-band DL/UL frequency layers for positioning in Rel-17 due to the large TAE errors between the carriers. |
| MTK | We consider NOT to support. Because inter-band case may not help for better resolution (accuracy). It could be used for path detection but the performance is still not clear to us |
| OPPO | Not support |
| Huawei/HiSilicon | We think inter-band CA should be lowest priority. |
| Intel | Do not support. The feasibility of implementation and performance gain need to be justified. |
| Ericsson | Do not support. We agree with the comments from VIVO and CATT. |
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FL’s Comments

It seems there are still diverged views on whether to support of the aggregation of multiple DL positioning frequency layers for NR positioning.

Proposal 2-1 (Revision 1)

The following sources (Huawei, vivo, CATT, Intel, OPPO, Sony, Qualcomm, Ericsson) have provided the evaluation and/or analysis of the aggregating multiple DL positioning frequency layers for both intra-band and inter-band scenarios.

* The following sources ( Sony, Qualcomm) consider it is beneficial to support aggregating multiple DL positioning frequency layers for inter-band scenarios for increasing positioning accuracy;
* The following sources (Huawei, Intel, Sony, Qualcomm) consider it is beneficial to support aggregating multiple DL positioning frequency layers for intra-band non-contiguous scenarios for increasing positioning accuracy;
* The following sources (Huawei, Intel, Sony, Qualcomm) consider it is beneficial to support aggregating multiple DL positioning frequency layers for intra-band contiguous scenarios for increasing positioning accuracy;
* The following sources (vivo, CATT, OPPO, Ericsson) do not consider it is beneficial and feasible to support coherently aggregating multiple DL positioning frequency layers due to the impact of various factors, especially the time offset errors between carriers.

Comments

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| **Company** | **Comments** |
| MTK | We think it should be careful to list the proposals from Tdocs. Devil in the details. Let me give an example,  In R1-2007946 by Intel, in section 2.3.4, it is very impressive to see the analysis of channel spacing impact to the observed channel impulse response. Fig. 9 shows the improved performance with aggregated BW under the condition “The impairments considered above were not modeled, therefore, it represents a potential performance bound that could be achieved“.  This also means, the transmission side takes a certain responsibility on how to mitigate the impairment.Otherwise, the performance gain due to the aggregated BW would be compromised.  We think that, the transmission side ability to mitigate the impairment could be RAN4 issue. We have the following proposal:   * RAN1 to continue on intra-band contiguous DL CA discussion in WI phase. Send LS to RAN4 to check the impairment handling immediately after this e-meeting. RAN1 to determine whether to go for normative work after RAN4 assessment     Note: we are also open if other companies also want to consider intra-band non-contiguous DL CA case |
| CATT | Support.  We want to repeat our views on the DL/UL carrier aggregating for positioning:   * No support of aggregating multiple **intra-band non-contiguous and/or inter-band** DL/UL frequency layers for positioning in Rel-17 due to the large TAE errors between the carriers. * Whether to support aggregating multiple **intra-band contiguous** DL/UL frequency layers for positioning in Rel-17 depends on whether it is feasible to reduce the TAE between the carriers within 1-2 ns.   Therefore, we share the same view with MTK that RAN1 should send an LS to RAN4 to ask the feasibility of reducing the TAE within 1-2 ns. |
| vivo | Thanks for the hard work of FL, we also want to emphasize the evaluation results for the RAN1 102e agreement  1）No companies provide the evaluation results of inter-band;  2) Performance will be worse due to the impact of channel spacing, timing offset, phase offset among CCs for intra-band contiguous/ non-contiguous from [3] sources (Ericsson, vivo, Qualcomm) out of [3] sources  Agreement:   * Aggregating multiple DL positioning frequency layers of the same or different bands for improving positioning performance for both intra-band and inter-band scenarios will be investigated in Rel-17, which may take into account at least the following * The scenarios and performance benefits of aggregating multiple DL positioning frequency layers * The impact of channel spacing, timing offset, phase offset, frequency error, and power imbalance among CCs to the positioning performance for intra-band contiguous/ non-contiguous and inter-band scenarios * UE complexity considerations * Note: What is captured in the TR will be discussed separately. |
| OPPO | The [4] sources show benefits based on the ideal assumption (no timing alignment error, no group delay at Rx, …), which is not feasible for practical UE/gNB. Whether or not performance gains can be achieved by aggregation of positioning frequency layers should be evaluated based on feasible assumption. Thus, we suggest to send LS to RAN4 as the feasible values for practical products on the following issues   * Timing alignment error between different carriers * Group delay at different carriers * … |
| Huawei/HiSilicon | We think the wording “of the same or different bands for both intra-band and inter-band scenarios” seems a little bit redundant, but it is OK.  From our view, we think intra-band case should be priorizited over inter-band case for this release, so Huawei can be removed from the first bullet.  In addition, based on the contribution, we can hardly see vivo and CATT “do not consider it beneficial and feasible” at least the intra-band contiguous case, which needs further clarification from the source companies.  The categorization is also bit confusing. Why the opposing companies are listing without mentioning intra-band C/intra-band NC/inter-band? We are not sure that all the 4 companies do not consider intra-band contiguous “benficial and feasible”. |
| LG | We respect the evaluation results provided by each company, but we are not sure what the outcome will be for us if we agree on this proposal. We are Okay to capture this as an observation and also fine with sending an LS to RAN4 for the feasibility check as proposed by MTK. |
| ZTE | Although we don’t provide proposal in this meeting, we consider this feature would be helpful to timing estimation. At least for intra-CA scenario, it’s possible that different CCs share the same RF chain, which will lead to delay consistency. And the model for impairments (channel spacing, timing offset, phase offset among CCs) may be needed under RAN4’s direction.  In addition, we don’t understand what will be the conclusion based on those observations? |
| Intel | We support intra-band contiguous and non-contiguous cases. The feasibility of inter-band implementation needs to be carefully investigated, especially the impact of the channel spacing on the accuracy of performance and other impairments.  In the provided summary (above), please remove Intel from the supporters of inter-band CC aggregation. |

FL’s Comments

For the suggestion that RAN4 should be consulted, yes, I would agree that RAN4 may need to be consulted if we decide to work on the enhancement in the WI phases.

For Huawei and Intel’s comments, the FL proposal was prepared based on the proposals from the contributions. I will remove Huawei and Intel from the sources supporting from inter-band cases based on the comments.

For LG’s proposal, if we cannot reach the consensus to support the proposed enhancement, it would be better to capture the discussion and proposed enhancement, similar with the section “Additional Enhancement Identified for NR Positioning” in TR 38.855.

As commented by multiple companies, the impact of channel spacing, timing offset, phase offset, frequency error, and power imbalance among CCs to the positioning performance for intra-band contiguous/ non-contiguous and inter-band scenarios depend heavily on the transmitter and receiver’s RF architecture and the possibility to use a single Tx/Rx RF chains to support the aggregation. Thus, it is worthy to discuss separately on different CA scenarios. The proposals are revised to addressed the concerns on the comments.

### (Closed) Proposal 2-1a (Revision 2)

* Simultaneous transmission by the gNB and reception by the UE of the DL PRS across multiple intra-band contiguous carriers is recommended for normative work
  + From both gNB and UE perspective, the applicability and feasibility of this enhancement for different scenarios, configurations, bands and RF architectures, is expected to be further analysed in the work item phase in RAN1 and RAN4.

Comments

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| **Company** | **Comments** |
| Huawei/HiSilicon | Support.  Based on our understanding, PRS frequency layer aggregation and SRS carrier aggregation are among the highest priorities that can improve the positioning accuracy compared Rel-16 solutions with less controversy. If companies wish to increase positioning accuracy for Rel-17, this one should be one deserving recommendation. |
| ZTE | Support for improving accuracy. |
| vivo | Not support  To Huawei, it is obvious that most companies can achieve the target in SH, so CA isn’t the highest priority issue. |
| Lenovo, Motorola Mobility | Supportive in the context of Rel-17 accuracy enhancements. |
| Intel | Support. |
| CATT | We support further study this issue in the work item in RAN1 and RAN4. Whether to support aggregating multiple **intra-band contiguous** DL frequency layers for positioning in Rel-17 depends on whether it is feasible to reduce the TAE between the carriers within 1-2 ns. |
| Qualcomm | Support |
| Nokia/NSB | We can be okay with this. |
| CMCC | Support. |
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Proposal 2-1b (Revision 2) (Closed)

* Simultaneous transmission by the gNB and reception by the UE of the DL PRS across multiple intra-band **non-contiguous** carriers is recommended for normative work
  + From both gNB and UE perspective, the applicability and feasibility of this enhancement for different scenarios, configurations, bands and RF architectures, is expected to be further analyzed in the work item phase in RAN1 and RAN4.

Comments

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| **Company** | **Comments** |
| Huawei/HiSilicon | Support.  If companies have concerns, we can accept it being lower priority than Proposal 2-1a. |
| ZTE | Support for improving accuracy. |
| vivo | Not support |
| Intel | Support. |
| CATT | We prefer not to support aggregating multiple **intra-band non-contiguous and/or inter-band** DL frequency layers for positioning in Rel-17 due to the large TAE errors between the carriers. |
| Qualcomm | Support |
| Nokia/NSB | We are not really in favour of this proposal and at best we think the wording should be a bit softer as the issues seems to be worse for non-contiguous case. |
| Apple2 | To be given a lower priority than 2-1a. We prefer, if simultaneous DL-PRS across bands is agreed to be further analyzed, it is limited to intra-band contiguous CA |

In case we cannot reach a consensus to support aggregating multiple DL positioning frequency layers, it is suggested to capture the TP into the TR as the conclusion of the investigation of aggregating multiple DL positioning frequency layers.

**To all companies:** please feel free to add/remove your companies’ names to the supporting/not supporting sources when you review the proposal.

Proposal 2-1 (Revision 2 Alternative) (Closed)

Capture the following TP as conclusion in TR:

[8] sources (Huawei/HiSilicon, vivo, CATT, Intel, OPPO, Sony, Qualcomm, Ericsson) have provided the evaluation and/or analysis of the aggregating multiple DL positioning frequency layers for both intra-band and inter-band scenarios.

* For aggregating multiple DL positioning frequency layers for inter-band scenarios for increasing positioning accuracy, it is considered to be beneficial and feasible to support it from [2] sources (Sony, Qualcomm). However, it is not considered to be beneficial and feasible to support it from [4] sources (vivo, CATT, OPPO, Ericsson).
* For aggregating multiple DL positioning frequency layers for intra-band non-contiguous scenarios for increasing positioning accuracy, it is considered to be beneficial and feasible to support it from [4] sources (Huawei/HiSilicon, Intel, Sony, Qualcomm). However, it is not considered to be beneficial and feasible to support it from [4] sources (vivo, CATT, OPPO, Ericsson).
* For aggregating multiple DL positioning frequency layers for intra-band contiguous scenarios for increasing positioning accuracy, it is considered to be beneficial and feasible to support it from [5] sources (Huawei/HiSilicon, Intel, Sony, Qualcomm, Lenovo). However, it is not considered to be beneficial and feasible to support it from [3] sources (vivo, OPPO, Ericsson).
* Multiple sources (e.g., MTK, CATT, LGE, ZTE) consider that RAN4 needs to be consulted for the feasibility and benefits of the support of aggregating multiple DL positioning frequency layers for increasing positioning accuracy due to the potential impact of the impairments (channel spacing, timing offset, phase offset among CCs).
* Positioning accuracy is degraded under the impact of channel spacing, timing offset, phase offset among CCs for intra-band contiguous/ non-contiguous from [3] sources (Ericsson, vivo, Qualcomm)

Comments

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| --- | --- |
| **Company** | **Comments** |
| Huawei/HiSilicon | Till now, only two items (IDLE/INACTIVE state positioning and on-demand PRS) are agreed to be recommended for normative specification work, and they have nothing to do with improving positioning accuracy. Based on our understanding, PRS frequency layer aggregation and SRS carrier aggregation are among the highest priorities that can improve the positioning accuracy compared Rel-16 solutions with less controversy. If companies wish to increase positioning accuracy for Rel-17, this one should be one deserving recommendation. |
| vivo | Support in principle and we suggest capturing the impact of channel spacing, timing offset, phase offset among CCs for intra-band contiguous/ non-contiguous, for example   * Performance will be worse due to the impact of channel spacing, timing offset, phase offset among CCs for intra-band contiguous/ non-contiguous from [3] sources (Ericsson, vivo, Qualcomm) out of [3] sources |
| Lenovo, Motorola Mobility | Added our support to third bullet, even without an explicit proposal in our contribution. |
| CATT | Support to capture the TP into the TR as the conclusion, if we cannot reach a consensus to support aggregating multiple DL positioning frequency layers. |
| Qualcomm | We think that at least the intraband contiguous deserves a stronger treatment than what is described above. The “multiple sources that want to consult for RAN4”, do they think that this is really needed for intraband contiguous CA? |
| Nokia/NSB | We are opposed to inter-band but are okay to capture some generic wording in the TR. |
| CMCC | Support to capture the TP in the TR as the conclusion, and add our name to support intra-band contiguous CA. |
| MTK | 1, We agree with HW that our progress is getting so slow. In the mean time, we also think the worst case of TAE (260ns) need to be further restricted, otherwise there would be no gain. We also believe that some implementation can reduce TAE, and some don’t. So we should not stop the CA development for positioning  2, As tie break, we have the following suggestions:   * To recommend intra-band contiguous CA for normative work in RAN1 * RAN1 or RAN4 to suggest the tolerable range of TAE * The deployment without meeting the tolerable range of TAE can’t enable intra-band contiguous CA for positioning |
| OPPO | Support FL’s proposal |
| LG | We are supportive of capturing the proposal 2-1 (revision 2 alternative) |
| Sony | Support the TP to be included into TR. |
| FL | For vivo’s comment to include the impact of channel spacing, timing offset, phase offset among CCs for intra-band contiguous/ non-contiguous, we assume the similar observation can be include in the evaluation section. |

FL Comments

The following agreement was made online for intra-band contiguous scenarios.

|  |
| --- |
| Agreement:  Capture the following in the TR:  Simultaneous transmission by the gNB and reception by the UE of intra-band one or more contiguous carriers in one or more contiguous PFLs can be studied further and if needed, specified during normative work   * From both gNB and UE perspective, the applicability and feasibility of this enhancement for different scenarios, configurations, bands and RF architectures, can be further studied |

With above agreement, and with the consideration of the online/offline comments, it seems unlikely for us to reach the consensus for include intra-band non-contiguous and inter-band scenarios into Rel-17. Thus, it is suggested to close the discussion of the support of intra-band non-contiguous and inter-band scenarios.

Also, since the evaluation and observations for CA scenarios are discussed in AI 8.3.2. It seems there is no need to further discuss Proposal 2-1 (Revision 2 Alternative) in AI 8.5.3. Thus, also suggest no further discussion of Proposal 2-1 (Revision 2 Alternative).

FL Suggestion

Close the discussion of 2.1 DL PRS processing with aggregated DL PRS resources in AI 8.5.3.

Additional Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Huawei/HiSilicon | Fine with the suggestion. |
| CATT | Support to close the discussion. |
| vivo | OK |
| ZTE | OK for lack of time. |
| OPPO | Support |
| Fraunhofer | Support |
| Qualcomm | Fine (assuming that observations in the 8.5.2 will still be discussed) |

## DL PRS transmission patterns and additional DL PRS configuration

Background

In Rel-16, full staggering patterns are used for DL PRS transmission, with at least 2 OFDM symbols per DL PRS resource. The minimum DL PRS transmission bandwidth is 24 PRBs. For reducing the positioning latency, minimizing the interference, and optimizing the resource usage, many companies are interested in supporting partial staggering and non-staggering DL PRS transmission pattern, e.g., 1-symbol PRS transmission, in Rel-17, as shown in the following proposals.

Submitted Proposals

* (Huawei R1-2007577) Proposal 1:
  + Rel-17 should support 1-symbol PRS at least for comb 12 and comb 4.
* (ZTE R1-2007755) Proposal 3
  + New method (e.g. new relative RE offsets) should be studied to reduce/mitigate the collision problem caused by different starting symbol configuration of PRS resources. The method should at least be applicable to full-staggering RE mapping, UL PRS and **DL PRS**.
* (CATT R1-2007755) Proposal 10:
  + In Rel-17 support DL PRS bandwidth smaller than 24 PRBs at least for one of the DL PRS resource sets in a TRP in a positioning frequency layer.
* (Intel R1-2007946) Proposal 1
  + Support Comb-4 and Comb-6 for two symbols DL PRS resource configuration
* (Intel R1-2007946) Proposal 2
  + Support new DL PRS transmission schedules aiming to randomize a set of TRPs/gNBs transmitting in the same set of resources
* (Samsung R1-2008168) Proposal 1:
  + New PRS pattern should be studied to avoid collision between multiple TRPs and two PRS patterns can be configured simultaneously and separated in time, frequency or space domain.
* (OPPO R1-2008226) Proposal 1:
  + Study to enhance the RE mapping of DL PRS resource to resolve the interference issue and increase the capacity of DL PRS resource.
* (OPPO R1-2008226) Proposal 2:
  + Support partial staggering and non-staggering PRS RE mapping with different combinations of comb-factors and symbol lengths.
* (Sony R1-2008365) Proposal 4:
  + Support PRS configuration with 1 symbol PRS transmission.
* (Sony R1-2008365) Proposal 10:
  + Support coordinated PRS transmission to mitigate interference of PRS transmission.
* (LG R1-2008417) Proposal 11:
  + Support 1-symbol PRS resource for Rel-17 NR positioning.
* (Qualcomm R1-2008619) Proposal 13:
  + Support partially-staggered or non-staggered DL-PRS transmissions
    - Signalling enhancements for addressing potential time-domain aliasing due to the partial/non-staggering PRS should be introduced
* (Ericsson R1-2008765) Proposal 18:
  + Allow configuration of DL-PRS with any combination of comb-factor and symbol length, including symbol length 1.

Feature lead’s view

The enhancements related to DL PRS transmission patterns were intensively discussed in RAN1#102e. However, consensus was not reached on the enhancements. One of the main issues that prevent the group from reaching the consensus was whether to explicitly mention the 1-symbol PRS transmission. In addition, there were some companies that considered the enhancements are of low priority in Rel-17.

### Proposal 2-2

* Partial staggering and non-staggering PRS RE mapping with different combinations of comb-factors and symbol lengths TRP is recommended for normative work.
* More details of the enhancements, which may include, but not limited to the following aspects, are left for further discussion in normative work:
  + Additional PRS RE mapping patterns
  + 1-symbol DL PRS pattern
  + Methods/signalling for addressing potential time-domain aliasing due to the partial/non-staggering PRS.

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Qualcomm | We are supportive of this enhancement to be recommended for normative work assuming that “Methods/signalling for addressing potential time-domain aliasing due to the partial/non-staggering PRS” is also recommended in the first bullet. |
| CATT | Support proposal 2-2. |
| OPPO | Support the proposal |
| Xiaomi | Support the proposal |
| vivo | Support. |
| ZTE | Revise the third sub-bullet as follow,   * + Methods/signalling for addressing potential time-domain aliasing/interference due to the full/partial/non-staggering PRS. |
| Huawei/HiSilicon | Support. |
| Intel | We support additional PRS RE mapping and methods/signalling (i.e. bullets 1 and 3) and do not support bullet 2.  We think that 1-symbol DL PRS (i.e. bullet 2) does not provide sufficient performance gain in terms of latency reduction and resource utilization. |
| MTK | 1, We think we need to define the scope of “additional PRS RE mapping patterns”. Whether it includes 2 symbols, 3 symbols? Or just to have a different staggered structure, such as supporting staircase-like  2, We feel that, one main latency issue for downlink is to use the repetition of PRS (for averaging to improve SNR). Beam sweeping could be a needed consumption. Beam repetition may not. We have analysed in Rel-16 that symbol number of a resource determine SNR improvement, and comb structure is less related to how SNR can be improved at the receiver side. In real scenario, we really wonder SNR improvement capability of using 1 symbol PRS. Furthermore, if we try to repeat 1 symbol PRS, then why not consider 2-symbol or 3-symbol without repetition?  3, so from receiver SNR improvement point of view, we prefer 2 symbols. The simulation may not really reflect what will encounter in the field. So the “protection” is needed.  4, So, we support bullet 1 and 3, and for bullet 1, we consider 2 symbols partial staggering, similar to what we have in Rel-16 SRS (2 symbol comb-4) |
| CMCC | Support |
| ZTE2 | As proposed by OPPO/Samsung/ZTE, the RE mapping of PRS resource to resolve/mitigate the interference/collision problem among different PRS resources (e.g. caused by different starting symbol configuration of PRS resources) should be reflected in proposal. Suggest to have another main bullet or a separate proposal,   * Enhance the RE mapping of PRS resource to resolve/mitigate the interference/collision problem among different PRS resources (e.g. caused by different starting symbol configuration of PRS resources)   + The enhancement may be applied to both DL PRS and UL PRS |
| Sony | Support the proposal |
| Nokia/NSB | We only support 1-symbol PRS. The other proposals have unclear gains and the DL PRS is already very flexible in Rel-16. |
| MTK2 | For 1-symbol PRS, the intention is for lower latency, if I understand correctly. If the repetition\_factor is further configured for 1-symbol PRS, then it may lose the benefit.  If repetition\_factor is configured under 1-symbol PRS for the reason of RX beam training, actually, multipl-symbol pattern can be configured and UE can train the RX beam.  We can consider to accept 1-symbol PRS with a constraint: repetition is not applied |
| CEWiT | Support |

FL comments

Based on the email discussion, the main difference is still whether to support 1-symbol PRS transmission. Some companies consider the 1-symbol PRS as low priority or should not be supported, while some companies consider the only 1-symbol PRS should be supported.

A consensus cannot be reached for the proposed enhancement after online discussion.

## Simultaneous transmission and reception of DL PRS with other signals/channels

Background

For Rel-16, UE is not expected to process DL PRS in the same OFDM symbol where other DL signals and channels (e.g., SS/PBCH) are transmitted to the UE. In Rel-17 we need to support very-low positioning latency in some scenarios, e.g., time-critical positioning service, while not to cause any significant performance degradation on data communication services in most scenarios. For reducing the positioning latency and improving the network and UE efficiency, the following proposals are submitted to support simultaneous reception DL PRS and other signals/channels and to define the priority rules for the reception of the DL PRS and other DL signals/channels for supporting different positioning scenarios.

Submitted Proposals

* (Huawei R1-2007577) Proposal 2:
  + Rel-17 should support RB-level multiplexing of PRS and SSB
* (vivo R1-2007666) Proposal 3:
  + Regarding PRS simultaneous reception with other signals and channels, we should support enhancements as follows:
    - PRS FDM with other DL signals and channels at RB level outside of PRS time-frequency grid.
    - Introduce the priority indications of PRS for low latency positioning in Rel-17.
  + Note: PRS simultaneous reception with other DL signals and channels is applied when measurement gap is not configured.
* (Intel R1-2007946) Proposal 14:
  + Study mechanisms for prioritization of transmissions carrying reference signals and channels with control signaling for positioning vs other NR reference signals and channels
* (CMCC R1-2008015) Proposal 1:
  + DL PRS FDMed multiplexing with other DL signals/channels in a PRB level should be supported in Rel-17.
* (CMCC R1-2008015) Proposal 2:
  + The priority of DL PRS, at least that of the on-demand DL PRS, should be defined in Rel-17.
* (Xiaomi R1-2008083) Proposal 6:
  + The priority of PRS should be differentiated for different latency requirement.
* (Sony R1-2008365) Proposal 1:
  + Support FDM transmission of DL PRS with other signals/channels and TDM transmission of DL PRS with other signals/channels within a measurement gap.
* (Sony R1-2008365) Proposal 2:
  + Proposal 2: Support the operation of **DL PRS** and UL SRS with ignallingion (high/low) to support low latency positioning and high accuracy positioning.
* (InterDigital R1-2008491) Proposal 4 :
  + Prioritization of **PRS** or SRS for positioning with respect to other signals and channels should be studied for reducing latency

Feature lead’s view

The issue was discussed intensively in RAN1#102e without reaching a consensus. While many companies support the enhancements, some companies think the enhancement is of low-priority, and some other companies think the enhancement can be handled directly in WI phase.

### Proposal 2-3

* FDM transmission of DL PRS and other signals/channels in PRB-level in the same OFDM symbol(s) from the same TRP is recommended for normative work;
* More details of the enhancements, which may include, but not limited to the following aspects, are left for further discussion in normative work:
  + Simultaneous processing/reception of DL PRS and other signals/channels
  + Priority rules for the processing/reception of DL PRS and other signals/channels

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| InterDigital | Support |
| CATT | Suppport Proposal 2-3. |
| OPPO | It is related to Proposal 5-7. This feature can be supported only when PRS reception without measurement gap is supported. Thus, we prefer to merge Proposal 2-3 and 5-7. |
| Xiaomi | Support the proposal |
| Vivo | Support |
| Huawei/HiSilicon | Support |
| Qualcomm | Do not support |
| Apple | Do not support |
| MTK | We can support PRS FDMed with SSB with some constraints, for example, the ratio of PRS BW over SSB BW should be larger than a certain threshold to reduce the impact of CIR observation |
| CMCC | Support |
| ZTE | Not sure the proposal is only for the simultaneous reception of PRS and SSB. Otherwise, the PRS is received within MG, simultaneous receptions of PRS and other channels may not exist. |
| Sony | Support |
| Huawei/HiSilicon | The Rel-16 behaviour of not allowing PRS and SSB to be transmitted on the same symbol is too restrictive, and may reduce the PRS transmission opportunity. In our evaluation results shows that if only 20 RBs of PRS is not transmitted due to collision with SSB, there is little impact. So we consider the first bullet important, and the relative normative work can be further defined in RAN1 and RAN4. |
| ZTE2 | It’s not clear what “from the same TRP” means. Because other signals/channels, such as PDSCH and CSI-RS, aren’t associated with TRP ID. Prefer to only consider the case that SSB and PRS are from the same TRP. |

FL comments

Based on the email discussion, it seems we need further discussion before reaching the consensus to support the proposed enhancements.

## DL PRS muting enhancements

Background

DL PRS muting is an effective approach to reduce DL PRS interference. Flexible DL PRS muting pattern in time-domain is supported with the granularity of DL RS resource set. One company proposes to study the enhance the DL PRS muting with the granularity of DL RS resource, and one company proposes to study the enhance the DL PRS muting in the frequency domain.

Submitted Proposals

* (Samsung R1-2008168) Proposal 6:
  + Frequency domain muting should be studied
* (OPPO R1-2008226) Proposal 5:
  + Study to support DL PRS resource-specific muting.

Feature lead’s view

DL PRS muting with the granularity of DL RS resource and/or the frequency domain may further reduce the DL PRS interference. The proposed enhancements were discussed in RAN1#102e without reaching a consensus.

### Proposal 2-4

* The enhancements of DL PRS muting (e.g., DL PRS resource-specific muting and Frequency domain muting) can be considered for normative work.

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| InterDigital | Support |
| CATT | Support Proposal 2-4. |
| OPPO | Support |
| Vivo | Support. |
| LG | Support. In our understanding, the frequency domain muting would mean that a part of PRBs of a PRS resource is configured as zero-power. It seems like a partial muting of PRS resource(s), so we would like to add partial muting of PRS resource(s) as an example, as follows.   * The enhancements of DL PRS muting (e.g., DL PRS resource-specific muting, partial muting of PRS resource(s), and Frequency domain muting) can be considered for normative work. |
| Qualcomm | Unclear the gains, do not support |
| Apple | Do not support, proposal is too broad (e.g. the procedure, gain over Rel-16 muting patterns, etc) |
| MTK | We don’t support freq domain muting. And for resource-specific muting, it is not clear to us. Rel-16 already support instance level muting and beam (resource) level muting |
| ZTE | Don’t support. |
| Sony | Support. In our understanding, DL PRS muting can also be beneficial to improve network efficiency / interference mitigation. |
| Nokia/NSB | Agree with QC. |

FL comments

Based on the email discussion, it seems we may not reach the consensus to support above proposed enhancements. It is suggested to capture the following TP into the TR.

## New DL reference signals for positioning

Background

The design of the DL positioning reference signals is of the key importance for all positioning methods that use the DL PRS measurements. Significant efforts were spent in Rel-16 for the development DL PRS reference signals. For improving the positioning performance (e.g., reducing the interference), several companies propose introducing new DL positioning reference in Rel-17.

Submitted Proposals

* (ZTE R1-2007755) Proposal 2:
  + To increase PRS capacity, orthogonal cover code (OCC) for positioning reference signals can be introduced especially for PRS patterns with time domain repetition.
* (LG R1-2008417) Proposal 10:
  + NR should consider cyclic shift based SFN transmission of PRS.
    - Need to study on benefit of the simultaneous transmission of a common PRS sequence with different intentional cyclic time-domain delays.
* (Ericsson R1-2008765) Proposal 25:
  + TRS is a candidate for positioning in release 17.

Feature lead’s view

The above-proposed enhancements were discussed in RAN1#102e without reaching a consensus.

### Proposal 2-5

* Whether to introduce new DL positioning reference signals (e.g., orthogonal cover code (OCC) for positioning reference signals, cyclic shift based SFN transmission of PRS, TRS) for positioning enhancements can be considered for normative work.

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CATT | Support Proposal 2-5. |
| LG | Support. In our understanding, introducing TRS is reuse of the existing RSs, so we would like to add SSB. |
| ZTE | Support OCC to increase PRS capacity. |
| Nokia/NSB | Do not support. |
|  |  |

FL comments

Based on the email discussion, it seems we need further discussion before reaching the consensus to support the proposed enhancements.

# Enhancements of UL positioning reference signals

## UL SRS transmission patterns

Background

In RAN1#102e, we made the following agreements for the investigation of Partial staggering and non-staggering RE mapping of SRS for positioning:

|  |
| --- |
| Agreement:  Partial staggering and non-staggering RE mapping of SRS for positioning with different combinations of comb-factors and symbol lengths will be investigated in Rel-17.   * The methods/signalling for addressing potential time-domain aliasing due to the partial/non-staggering RE mapping will be included in the study |

Submitted Proposals

* (Huawei R1-2007577) Proposal 4:
  + Rel-17 should support all combinations of comb size and number of symbols for SRS for positioning.
* (ZTE R1-2007755) Proposal 3
  + New method (e.g. new relative RE offsets) should be studied to reduce/mitigate the collision problem caused by different starting symbol configuration of PRS resources. The method should at least be applicable to full-staggering RE mapping, **UL PRS** and DL PRS.
* (Intel R1-2007946) Proposal 4:
  + Support Comb-4 for one symbol SRS resource configuration for positioning.
* (OPPO R1-2008226) Proposal 8:
  + Study to support larger Comb size(s) in SRS resource for positioning to support larger transmission bandwidth.
* (OPPO R1-2008226) Proposal 10:
  + Study the enhancement of RE mapping of SRS resource for positioning to resolve the interference issue and increase the capacity of SRS resource for positioning.

Feature lead’s view

Based on the agreement made in RAN1#102e, different combinations of comb-factors and symbol lengths for UL SRS will be investigated. However, only 4 companies submitted the proposals related to the enhancements with different proposals of the enhancements. Thus, it may be difficult to decide which combinations of comb-factors and symbol lengths should be supported in this meeting. One possible resolution is to leave the investigation of the details to the WI phase.

Proposal 3-1

* Partial staggering and non-staggering RE mapping of SRS for positioning with different combinations of comb-factors and symbol lengths is recommended for normative work.
* The details of the enhancements (e.g., which of the combinations of comb size and the number of symbols to be supported and the methods and ignalling for addressing potential time-domain aliasing due to the partial/non-staggering RE mapping) are left for further discussion in normative work.

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Nokia/NSB | We do not support this proposal. The SRS for positioning configuration is already quite flexible in Rel-16 and we are unclear what gains (and even what metrics those gains apply to) would be achieved by this enhancement. |
| MTK | We don’t think that non-staggered pattern is needed. The reason is, the SNR gain at the receiver side is the same for non-staggered and staggered patterns. The non-staggered pattern has the SNR gain through averaging (simple linear interpolation) since the RS at different symbols occupy same subcarriers. The staggered pattern has the SNR gain though larger IDFT size to suppress noise.  Also, feMIMO is doing SRS enhancement. Basically they are still based on non-staggered pattern with certain enhancement, such as td-occ for improving multiplexing. So we don’t think there is no need for positioning to enhancing SRS under non-staggered structure.  We feel that the whole spec direction can go for two ways:  1, positioning SRS to follow mimo SRS,  2, positioning SRS to build up a more comprehensive staggered structure. This existing staggered structure (zig-zag like, not ladder like) is more feasible to support partial stagger. We can utilize this nice property.  Actually, mimo SRS can also consider staggered structure, since the staggered structure support both larger UE multiplexing and larger observation range. The non-staggered structure can only support larger UE multiplexing through for example td-occ. But this is not what we can do to influence mimo people.  Rel-16 SRS for positioning has supported for partial staggering. Our preference is to further extend for more cases: comb-4 1 symbol, comb-8 1 symbol and comb-8 2 symbols |
| CATT | Support Proposal 3-1. |
| CMCC | Support |
| OPPO | Support |
| Xiaomi | Support the proposal |
| Vivo | Don’t support. Partial staggering and non-staggering SRS patterns for positioning such as {comb-2, 1 symbol},{comb-4, 2 symbols} and {comb-8, 4 symbols} have already been supported in Rel-16. Additional enhancement is not needed. |
| LG | Similar view with Nokia |
| ZTE | Revise the second bullet as follow,   * The details of the enhancements (e.g., which of the combinations of comb size and the number of symbols to be supported and the methods and ignalling for addressing potential time-domain aliasing/interference due to the full/partial/non-staggering RE mapping) are left for further discussion in normative work. |
| Huawei/HiSilicon | Support |
| Fraunhofer | Support.  Based on the InF evaluations at least one symbol comb-4/comb-8 for SRS for positioning should be supported. |
| Intel | We do not support current wording, since it opens the door for the long unnecessary debates. Prefer to define specific configurations constraints, for example, at least 1-symbol SRS with additional comb sizes. |
| Ericsson | Support the proposal. In our view, the potential enhancements should include the support of rel15 SRS as it is an already available non-staggered RS which is supported by some positioning methods. |
| Qualcomm | There are already single-symbol pattern, and a few partially-staggered patterns. Can the scope be reduced further? For example, what is missing is: 1-symbol with more comb-size, or multi-symbol with unstaggered pattern (like MIMO). Maybe we can focus on the additional missing parts, together with the potential gains that can exist, and try to see if there is a consensus. |

FL’s comments

It seems there are concerns on the scope, potential benefits, etc. of the proposal. To avoid opening unnecessary discussion for RE mapping of SRS for positioning, it might be better to clarify the scope of the enhancements.

Proposal 3-1 (Revision 1)

* Additional resource configuration of SRS for positioning with the combinations of (comb-factors, symbol lengths) = {(4, 1), (8, 1), (8, 2)} is recommended for normative work.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Nokia/NSB | We can accept this proposal as a compromise, but the benefits of these additional configurations are not so clear to us. |
| CATT | Support. |
| MTK | Support |
| LG | Support |
| CMCC | Support |
| OPPO | Support |
| Huawei/HiSilicon | Support |
| Intel | We support (4, 1) configuration for the comb factor and symbol length.  We have concerns with (8,1) and (8,2) configurations, since 8 is not aligned with the PRB size of 12. It means that the configuration will be dependent on the total number of PRBs allocated per band. This will complicate signalling. |
| ZTE | Support |
| Vivo | Do no support. What is the benefits of these configurations on top of Rel-16? Does it satisfy Rel-17 requirement by having these SRS configuration? |
| Fraunhofer | Support |
| vivo 2 | We want to emphasize no company provides the evaluation results of partial staggering SRS and the impact of aliasing, especially for (8, 1), (8, 2).  Agreement:  Partial staggering and non-staggering RE mapping of SRS for positioning with different combinations of comb-factors and symbol lengths will be investigated in Rel-17.   * The methods/ignaling for addressing potential time-domain aliasing due to the partial/non-staggering RE mapping will be included in the study |
| Ericsson | We support FL’s proposal. |
| Qualcomm | We could accept to introduce an additional single-symbol option with comb>2, but jumping into concluding that we need both (4,1) and (8,1) without any additional evaluation or analysis on the effect of aliasing, is going a bit too far.  Can we consider to recommend at least one (N,1) with N>2 for normative work, and continue the rest in the WI? |

FL’s comments

Based on the feedback, the main concerns for the Proposal 3-1 (Revision 1) is that it lack of the evaluation results to support the suggested enhancement of the additional resource configurations. One possible solution may be, as suggested by Qualcomm is not the define the specific mapping pattern, but as (N,1), and then leave the N to be decided in WI phase.

Proposal 3-1 (Revision 2)

* Additional resource configurations of SRS for positioning with the combinations of (comb-factors, symbol lengths) = (N, 1) [without repetition in a lost] is recommended for normative work, where the N > 2 is to be determined during normative work.

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Huawei/HiSilicon | Support. |
| ZTE | Support. |
| Vivo | We can agree for progress |
| Intel | Support. |
| Qualcomm | OK assuming also the DL-PRS partial/unstaggered pattern is agreed also. We think both deserve to be specified in the same release. We are confused into why some companies are OK for single-symbol SRS but not single-symbol DL-PRS. |
| MTK | To QC: our view is to support 1 symbol and 2 symbols for both uplink and downlink. Our main concern is, 1 symbol may have limited SNR improvement at the receiver side. We don’t think the simulation can really cover all possible scenarios in the field. So from spec point of view, it is necessary to provide a comprehensive solution.  Are we going to repeat 1-symbol pattern (repeat the resource) ? To do so, it means there is intention to enhance received SNR. Then from low latency point of view, supporting more symbols for a resource is more proper than repeating 1-symbol resource.    Also we don’t have comb-8 for DL PRS. In rel-16, we already propose the symmetric design between uplink and downlink, and we see very strong objection.  Similar to what we mention in DL PRS, the repetition is not considered for 1-symbol SRS |
| Apple2 | Support. |
| CATT | Support. |
| OPPO | Support |
| FL | For MTK’s comment, I don’t see any company proposes repetition. So, I added “w/o repetition” to address the concern. For Qualcomm’s comment, the suggestion is to separate the discussion between the DL and UL as in previous meeting. Otherwise, it would make the discussion much more difficult. Any further comments? Can we declare offline consensus for Proposal 3-1 (Revision 2)? |
| vivo2 | We are fine with previous Proposal 3-1.  Regarding the description of ‘without repetition in a slot’, does it mean that inter-slot repetition is not excluded? Once inter-slot repetition of SRS-posResource is configured, does it affect low latency requirement of 1-symbol SRS? This makes confused. We think the previous writing is clear enough. In addition, whether to support SRS-posResource repetition for different SRS patterns is another issue which we may discuss in WI phase.  We are okay for offline consensus |
| Fraunhofer | We are fine with the proposal. We agree with vivo2 that *repetition in a slot* is not clear; can’t this details be left for the WI? |
| Nokia/NSB | We can live with this but want to check, is the common understanding that no new comb sizes will be introduced? If so we should be explicit about that. |
| Ericsson | Agree with QC, we should support single symbol both in UL and DL. Note there is a type in the proposal (“repetition in a lost” should be “repetition in a slot”). |
| FL | From the comments from MTK, vivo and Fraunhofer, it seems there are different views on whether to support the repetition of -symbol SRS. For Nokia’s comment of “no new comb sizes will be introduced”, I assume the intention of the proposal is to introduce new comb size N for 1-symbol SRS. |

If we cannot reach the consensus to support of the additional resource configurations of SRS for positioning, the following alternative proposal may be considered as the conclusion for the issue.

Proposal 3-1 (Revision 2 Alternative)

* Partial staggering and non-staggering RE mapping of SRS for positioning with different combinations of comb-factors and symbol lengths were proposed and investigated by the following resources (Huawei/HiSilicon(R1-2007577), ZTE (R1-2007755), Intel(R1-2007946), OPPO(R1-2008226)) for the enhancements of the UL positioning performance. However, the agreement for supporting the enhancement could not be reached mainly due to the concerns of lacking simulation evaluation to show the benefits of the enhancements (FL summary, R1-2009396).

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Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CATT | Support this alternative, if we cannot reach the consensus on this issue. |
| OPPO | Hope we can get some consensus on partial/unstaggered pattern of PRS/SRS |
| ZTE | The same view as OPPO. |
| Ericsson | Same view as oppo. This proposal is a backup to the previous one. |
|  |  |

FL Comments

Based on the comments received so far, it seems the majority companies are supportive to add combinations of (comb-factors, symbol lengths) = (N, 1) (N>2). However, there are different views on whether to support the repetition of the 1-symbole DL PRS and whether to include new comb-factor. The proposal is revised as follows.

Proposal 3-1 (Revision 3)

Capture the following in TR

* Additional resource configurations of SRS for positioning with the combinations of (comb-factor, symbol length) = (N, 1) is recommended for normative work, where the N > 2 is to be determined during normative work.

*If we cannot reach the consensus on above proposal, suggest capturing the following in TR as an alternative:*

* Partial staggering and non-staggering RE mapping of SRS for positioning with different combinations of comb-factors and symbol lengths were investigated. [x] sources (Huawei/HiSilicon, ZTE, vivo, Intel, Qualcomm, MTK, Apple, CATT, OPPO, Fraunhofer, Ericsson) consider it is beneficial to support the combinations of (comb-factor, symbol length) = (N, 1), where the N > 2). However, a consensus is not reached due to different views on whether to explicitly excluding the support of the repetition of the 1-symbole DL PRS within a slot.

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CATT | Support. |
| Huawei/HiSilicon | We suggest to agree for both DL-PRS and SRS. One way to do it is to change SRS to RS and remove “DL” from the last sentence. |
| vivo | Support |
| ZTE | Support |
| Intel | Support. |
| OPPO | Support |
| FL | For Huawei’s comment, we may bring the comment for removing “DL” to the GTW session to see if we can have the consensus on it. |
| Nokia/NSB | To further clarify our comments during GTW: we can be okay with 1 symbols SRS/PRS for the comb. Sizes which are already supported in Rel-16. However, we are not okay to open the discussion beyond that point as this topic has been debated for a long time already. Can any company that wants to propose N which is not in Rel-16 explain the potential gains? |
| FL | For Nokia’s comments, my understanding is that there are different views on the N:   1. want to have further investigation/evaluation for any N to be introduced, even when the N (e.g., 4 or 8) are already supported for 2/4 symbols as shown in the comments to Proposal 3-1 (Revision 1) 2. want to introduce N that are currently not supported for other length of symbols for further improving positioning performance. |

FL Comments

Based on the considerations:

1. we have already spent significant effort on this enhancement;
2. it seems we may still not able to converge due to the lack of the simulation evaluation to back up the claimed benefits of additional combinations
3. the enhancement seems small incremental improve on the existing SRS pattern.

The suggestion is to take a final look to see if we could agree to support (comb-factor, symbol length) = (4, 1), which might be beneficial for the highly dense environments as suggested by Intel(R1-2007946). If we still could not make the agreement, suggest take an alternative to take each companies’ views as observations.

### Proposal 3-1 (Revision 4)

* Additional resource configurations of SRS for positioning with the combinations of (comb-factor, symbol length) = (4, 1) is recommended for normative work.

*If we cannot reach the consensus on above proposal, suggest capturing the following in TR as an alternative:*

* Partial staggering and non-staggering RE mapping of SRS for positioning with different combinations of comb-factors and symbol lengths were investigated, including
  + [1] source (Huawei R1-2007577) proposed to support all combinations of comb size and number of symbols for SRS for positioning;
  + [1] source (ZTE R1-2007755) proposed to new relative RE offsets to reduce/mitigate the collision problem caused by different starting symbol configuration of PRS resources.
  + [1] source (Intel R1-2007946) proposed to support Comb-4 for one symbol SRS resource configuration for positioning
  + [1] source (OPPO R1-2008226) proposed to support larger Comb size(s) in SRS resource for positioning to support larger transmission bandwidth
* No consensus is reached to support new resource configurations of SRS for positioning due to the lack of the evaluation results that show the potential benefits.

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CATT | Support.  In our point of view, such additional resource configurations of SRS for positioning with the combinations of (comb-factor, symbol length) = (4, 1) is reasonable for some scenarios. The operators can decide whether to adopt such additional resource configurations of SRS for positioning in the real network deployment. |
| LG | We prefer to the proposal captured in the Chairman’s note, and we do not understand why the DL PRS is excluded for this enhancement. |
| CMCC | Support. We are okay for the N values that have already supported in Rl6 SRS pos, e.g., 4, 8.  Regarding whether to include DL PRS or not, we have no objections to support 1 symbol DL PRS; however, since companies share different view, to help make progress, we think the enhancements on transmission pattern of DL PRS and UL SRS pos can be discussed and agreed separately. |
| ZTE | We can support this proposal. We have some additional comments.  In previous meeting, we have following agreement. The agreement clearly says that time-domain aliasing problem will be studied, however, the current proposal only discusses new combinations of comb-factors and symbol lengths . As we know, even for legacy RE mapping (i.e. full staggering RE mapping), the time-domain aliasing or interference will largely degrade performances. We suggest FL to have a separate proposal to discuss time-domain aliasing or interference problem.  Agreement:  Partial staggering and non-staggering RE mapping of SRS for positioning with different combinations of comb-factors and symbol lengths will be investigated in Rel-17.   * The methods/signalling for addressing potential time-domain aliasing due to the partial/non-staggering RE mapping will be included in the study |
|  |  |
|  |  |

FL comments

A consensus cannot be reached for the proposed enhancement after online discussion.

## UL SRS transmission with aggregated SRS resources

Background

In RAN1#102-e, we have the following agreements on the investigation of aggregation of UL SRS resources in time and frequency domain [1]

|  |
| --- |
| Agreement:  Simultaneous transmission by the UE and reception by the gNB of the SRS for positioning across multiple CCs and multiple slots can be investigated in Rel-17, which may consider   * The scenarios and performance benefits of the enhancement * The impact of channel spacing, TA and timing offset, phase offset, frequency error, and power imbalance across slots or CCs to the positioning performance for intra-band contiguous/ non-contiguous and inter-band scenarios |

Submitted Proposals

* (Huawei R1-2007577) Proposal 3:
  + Rel-17 should support at least intra-band contiguous and non-contiguous frequency aggregation with phase continuity
* (CATT R1-2007755) Proposal 5:
  + No support of aggregating multiple intra-band non-contiguous and/or inter-band DL/UL frequency layers for positioning in Rel-17 due to the large TAE errors between the carriers.
* (CATT R1-2007755) Proposal 6:
  + Whether to support aggregating multiple intra-band contiguous DL/UL frequency layers for positioning in Rel-17 depends on whether it is feasible to reduce the TAE between the carriers within 1-2 ns. RAN4 may need to be consulted on the feasibility of reducing the TAE within 1-2 ns.
* (Intel R1-2007946) Proposal 9:
  + Support reception by the gNB of the SRS for positioning across multiple CCs and multiple slots
* (OPPO R1-2008226) Proposal 6:
  + Do not to support the aggregation of multiple positioning frequency layers for positioning enhancement in Rel-17.
* (Qualcomm R1-2008619) Proposal 2:
  + Support enhancements to enable DL/**UL** PRS bundling in frequency domain in both intra-band and inter-band scenarios within the same FR, including at least the following aspects:
    - Signaling enhancements related to Timing, Phase, Power offsets, and QCL relations, amongst the PRS resources of different PFLs from the same TRP.
    - Enhancements related to Measurement period, accuracy requirements, and UE capabilities for scenarios of coherent and concurrent processing of multiple PFLs from the same TRP.

Feature lead’s view

Similar to the aggregation of multiple DL positioning frequency layers, the aggregation of multiple UL positioning frequency layers needs also to consider the impact of timing offset, channel spacing, phase offset, frequency error, and power imbalance among CCs on the positioning performance. The impact may be different for different carrier aggregation scenarios, especially related to whether the transmitter and/or the receiver use one or multiple Rx/Tx RF chains. For example, multiple Tx/Rx chains may be required for supporting inter-band carrier aggregation, while one single Tx/Rx chains may be used for supporting intra-band contiguous carrier aggregation, depending on UE’s capability. Thus, we need to discuss different carrier aggregation scenarios separately.

Proposal 3-2

* Select one of the following options:
  + Option 1: Simultaneous transmission by the UE and reception by the gNB of the SRS for positioning across multiple intra-band and inter-band CCs within the same FR is recommended for normative work;
    - the corresponding signaling, measurement, accuracy requirements, UE capabilities, etc. are left for further discussion in normative work.
  + Option 2: Simultaneous transmission by the UE and reception by the gNB of the SRS for positioning across multiple intra-band CCs is recommended for normative work;
    - the corresponding signaling, measurement, accuracy requirements, UE capabilities, etc. are left for further discussion in normative work.
  + Option 3: Simultaneous transmission by the UE and reception by the gNB of the SRS for positioning across multiple intra-band contiguous CCs is recommended for normative work;
    - the corresponding signaling, measurement, accuracy requirements, UE capabilities, etc. are left for further discussion in normative work.
  + Option 4: No support of simultaneous transmission by the UE and reception by the gNB of the SRS for positioning across multiple CCs in Rel-17.

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Qualcomm | Support of Option 1 |
| MTK | If DL PRS transmission under CA is not agreed, then there is no need to agree on SRS transmission under UL CA.  There are multiple PA structure for UL CA. we think single PA case maybe suitable for phase continuity.  We prefer to consider intra-band contiguous UL CA case, which is option 3 |
| CATT | We support Option 3. In our point of view, no support of aggregating multiple intra-band non-contiguous and/or inter-band DL/UL frequency layers for positioning in Rel-17 due to the large TAE errors between the carriers. And Whether to support aggregating multiple intra-band contiguous DL/UL frequency layers for positioning in Rel-17 depends on whether it is feasible to reduce the TAE between the carriers within 1-2 ns. RAN4 may need to be consulted on the feasibility of reducing the TAE within 1-2 ns. |
| CMCC | Option 1. See comments on proposal 2.1 |
| OPPO | Support Option 4. The same reason as 2-1. |
| Vivo | Support Option 4. For uplink transmission, we keep similar views as proposal 2-1. |
| ZTE | 1st preference for option 1 , we can live with option 2 and option 3, at least RS aggregation should be studied and supported . |
| Huawei/HiSilicon | Option 2. See comments on proposal 2-1 |
| Intel | Our understanding, that in Rel.16 the simultaneous transmission of up to 2 CCs is already supported within a band and per band combination.  It is not clear what is discussed here: reception by the gNB or combination of multiple CCs, i.e. more than 2 (?).  Clarification is needed. |
| Ericsson | Option 4. The issues for SRS are the same as for DL PRS. The current evaluations does not point to meaningful gains once realistic impairements are considered. |
|  |  |

Feature lead’s view

Similar to the discussion of DL cases, the aggregation of multiple UL positioning frequency layers needs also to consider the impact of timing offset, channel spacing, phase offset, frequency error, and power imbalance among CCs on the positioning performance. The impact may be different for different carrier aggregation scenarios, especially related to whether the transmitter and/or the receiver use one or multiple Rx/Tx RF chains. For example, multiple Tx/Rx chains may be required for supporting inter-band carrier aggregation, while one single Tx/Rx chains may be used for supporting intra-band contiguous carrier aggregation, depending on UE’s capability. Thus, we need to discuss different carrier aggregation scenarios separately.

Proposal 3-2a

* Simultaneous transmission by the UE and reception by the gNB of the SRS for positioning across intra-band contiguous carriers is recommended for normative work.

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Qualcomm | support |
|  | Need further study. Whether to support aggregating multiple intra-band contiguous DL/UL frequency layers for positioning in Rel-17 depends on whether it is feasible to reduce the TAE between the carriers within 1-2 ns. RAN4 may need to be consulted on the feasibility of reducing the TAE within 1-2 ns. |
| MTK | Support |
| OPPO | Not support |
| Huawei/HiSilicon | Support. Refer to 2-1a. |
| ZTE | Support |
| Ericsson | Needs further study. We agree with the comments from CATT. Whether it is feasible to reduce the TAE to within 1-2ns needs a RAN4 discussion. |
| Sony | Support |

Proposal 3-2b

* Simultaneous transmission by the UE and reception by the gNB of the SRS for positioning across intra-band non-contiguous carriers can be considered for normative work.

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Qualcomm | support |
| CATT | We prefer not to support it. In our point of view, no support of aggregating multiple intra-band non-contiguous and/or inter-band DL/UL frequency layers for positioning in Rel-17 due to the large TAE errors between the carriers. |
| MTK | We consider NOT to support |
| OPPO | Not support |
| Huawei/HiSilicon | Support “can be considered for normative work”. Refer to 2-1b. |
| ZTE | Support |
| Ericsson | Agree with CATT. |
|  |  |

Proposal 3-2c

* Simultaneous transmission by the UE and reception by the gNB of the SRS for positioning across inter-band carriers within the same FR can be considered for normative work.

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Qualcomm | support |
| CATT | We prefer not to support it. In our point of view, no support of aggregating multiple intra-band non-contiguous and/or inter-band DL/UL frequency layers for positioning in Rel-17 due to the large TAE errors between the carriers. |
| MTK | We consider NOT to support  Note: I change Proposal 3-3c (in above) to 3-2c |
| OPPO | Not support |
| Huawei/HiSilicon | Lowest priority, Refer to 2-1c. |
| Ericsson | Agree with CATT |
|  |  |

FL’s Comments

It seems there are still diverged views on whether to support of the aggregation of multiple UL positioning frequency layers for NR positioning.

Proposal 3-2 (Revision 1 Alternative)

[5] sources (Huawei, CATT, Intel, OPPO, Qualcomm) have provided the evaluation and/or analysis of the simultaneous transmission by the UE and reception by the gNB of the SRS for positioning across multiple CCs. Among them,

* [3] sources (Huawei, Intel, Qualcomm) consider it is beneficial to support simultaneous transmission by the UE and reception by the gNB of the SRS for positioning across multiple CCs for increasing positioning accuracy;
* [2] sources (CATT, OPPO) do not consider it is beneficial and feasible to support coherently aggregating multiple frequency layers due to the impact of various factors, especially the time offset errors between carriers.

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| MTK | Similar to what we have mentioned in proposal 2-1, we have the following proposal   * RAN1 to continue on intra-band contiguous UL CA discussion in WI phase. Send LS to RAN4 to check the impairment handling immediately after this e-meeting. RAN1 to determine whether to go for normative work after RAN4 assessment     Note: we are also open if other companies also want to consider intra-band non-contiguous UL CA case |
| CATT | Support.  We want to repeat our views on the DL/UL carrier aggregating for positioning:   * No support of aggregating multiple **intra-band non-contiguous and/or inter-band** DL/UL frequency layers for positioning in Rel-17 due to the large TAE errors between the carriers. * Whether to support aggregating multiple **intra-band contiguous** DL/UL frequency layers for positioning in Rel-17 depends on whether it is feasible to reduce the TAE between the carriers within 1-2 ns.   Therefore, we share the same view with MTK that RAN1 should send an LS to RAN4 to ask the feasibility of reducing the TAE within 1-2 ns. |
| OPPO | Similar comment as Proposal 2-1 (Revision 1) |
| LG | We have similar comment what we mentioned in proposal 2-1. We respect the evaluation results provided by each company, but we are not sure what the outcome will be for us if we agree on this proposal. We are Okay to capture this statement as one of the observations. |
| ZTE | Similar view as proposal 2-1. |
| Intel | Our understanding, that in Rel.16 the simultaneous transmission of up to 2 CCs is already supported within a band and per band combination.  It is not clear what is discussed here: reception by the gNB or combination of multiple CCs, i.e. more than 2 (?).  Clarification is needed. |
| Huawei/HiSilicon | Similar comment to Proposal 2-1a (Revision 2), 2-1b (Revision 2), and 2-1 (Revision 2 Alternative). |
| Vivo | Similar view as proposal 2-1a. |
| Nokia/NSB | Same view as on Proposal 2-1a (revision 2’s) |
| CMCC | See comments on Proposal 2-1a (Revision 2) and Proposal 2-1 (Revision 2 Alternative) |
| MTK | To Intel: we think what we already agree in Rel-16 doesn’t guarantee the receiver performance. So further condition for UE transmission is needed, such as one PA usage |

FL’s Comments

Proposal 3-2 (Revision 1) is revised to the following based on the agreement made for aggregating the DL PRS across intra-band contiguous.

### (Closed) Proposal 3-2 (Revision 2)

Capture the following in the TR:

Simultaneous transmission by the UE and reception by the gNB of the SRS for positioning in intra-band one or more contiguous carriers can be studied further and if needed, specified during normative work

* From both gNB and UE perspective, the applicability and feasibility of this enhancement for different scenarios, configurations, bands and RF architectures, can be further studied

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Huawei/HiSilicon | Support. |
| CATT | Support. |
| Vivo | Okay. |
| LG | Support |
| ZTE | Support |
| OPPO | Support |
| Fraunhofer | Support |
| Nokia/NSB | Okay. |
| CMCC | Support |

## Transmission of UL SRS for positioning with other signals/channels

Background

The collision rule of PUSCH and periodic and semi-periodic SRS for positioning is already defined in Rel-16. The collision rule of PUSCH and a-periodic SRS for positioning is under discussion in Rel-16. To reduce the positioning latency for some scenarios, additional priority rules may need to be introduced in Rel-17 for a-periodic SRS/on-demand SRS.

Submitted Proposals

* (vivo R1-2007666) Proposal 15:
  + Introduce the priority indications of SRS-PosResource for low latency positioning in Rel-17
* (Intel R1-2007946) Proposal 14:
  + Study mechanisms for prioritization of transmissions carrying reference signals and channels with control signaling for positioning vs other NR reference signals and channels
* (Sony R1-2008365) Proposal 2:
  + Support the operation of DL PRS and **UL SRS** with prioritisation (high/low) to support low latency positioning and high accuracy positioning.
* (InterDigital R1-2008491) Proposal 4 :
  + Prioritization of PRS or **SRS** for positioning with respect to other signals and channels should be studied for reducing latency
* (InterDigital R1-2008491) Proposal 5:
  + Co-existence of SRS for positioning with prioritized PUSCH and PUCCH should be studied to achieve latency reduction.

Feature lead’s view

In Rel-17 we need to support very-low positioning latency in some scenarios, e.g., time-critical positioning service, while not to cause any significant performance degradation on data communication services. There is a need to define the priority rules, allowing the network to use different configurations to support different scenarios. The enhancement was discussed intensively in RAN1#102e, most companies consider the issue can be handled during the WI without the need to spend time in SI for the investigation.

### Proposal 3-3

* Priority rules of handling the possible collision of the transmission of SRS for positioning with other UL signals/channels in the same OFDM symbol(s) in the same UL carrier can be considered for normative work.

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| InterDigital | Support |
| CATT | Support Proposal 3-3. In our point of view, aperiodic SRS-Pos should have a higher transmission priority than PUSCH, and PUSCH should be dropped in the overlapped symbols when colliding with aperiodic SRS-Pos. We can further discuss the details of priority rules of SRS-Pos with PUSCH during the WI phase. |
| OPPO | Aperiodic SRS for positioning has been supported. It offers flexibility for gNB. Most of the cases (if not all) can be addressed by gNB scheduling. Thus, the potential benefits are not clear so far. |
| vivo | Support. Priority of SRS for positioning was discussed in Rel-16 CR stage. However, no agreement/conclusion was reached due to limited time. Companies believed that this issue should be discussed in the Rel-17 stage. We believe this issue should be discussed in Rel-17 WI. |
| ZTE | The flexibility in Rel-16 is enough. |
| Intel | Support. |
| Apple | Do not support. PUSCH must be anyway considered as higher priority. |
| CMCC | Support. It has concluded in the R16 maintenance phase that this issue will be enhanced in R17. From our perspective, at least the priority rule of AP SRS pos should be considered, when it collides with low priority PUSCH. |
| Xiaomi | Support the proposal |
| Sony | Support |
| Nokia/NSB | Support. |

FL Comments

It seems there are different views on whether there is a need to define the priority rules of the transmission of SRS for positioning with other UL signals/channels for supporting very-low latency positioning

## Enhancement of SRS cyclic shift patterns

Background

Rel-16 SR for positioning reuses the formula of the legacy SRS cyclic shifts. The potential issues were identified in Rel-16 WI due to the staggered patterns are used in SRS for positioning. The solutions for these issues were discussed during Rel-16 WI and also in RAN1#102e without reaching a consensus.

Submitted Proposals

* (Huawei R1-2007577) Proposal 5:
  + Rel-17 should support the enhancement to reduce the issue caused by cyclic shifts for Rel-16 SRS for positioning
* (CATT R1-2007755) Proposal 12:
  + Symbol-specific cyclic shifts for SRS-Pos should be supported in order to keep phase continuities when a staggered SRS-Pos pattern is de-staggered for the SRS-Pos detection at the receiver
* (MTK R1-2008519) Proposal 2-1:
  + The phase rotation pattern for Rel-16 staggered SRS structure should be defined in work item phase
* (MTK R1-2008519) Proposal 2-2:
  + For cyclic shift operation enhancement, consider that a general formulation for cyclic shift operation on all the symbols for a SRS resource can be written as

,

where the subscript i has the range of 0 <= *i* < , as the enhancement for the existing cyclic shift operation as shown below,

* (MTK R1-2008519) Proposal 2-3:
  + The maximum cyclic shift number can be scaled up under the staggered SRS structure, since the observation range is increasing due to staggering
* (Fraunhofer R1-2008841) Proposal 9:
  + For Rel-17 update SRS sequence generation by modifying the equations:

configured via and

is configurable (range for *cyclicshift* is extended)

Note: the maximum value of cyclic shift is not changed

* (Fraunhofer R1-2008841) Proposal 10:
  + For Rel-17 SRS enhancement support:
    - phase correction for the staggered SRS
    - maintaining the cyclic shift step size of Rel-15.
    - extending the range of the cyclic shift.
* (Ericsson R1-2008765) Proposal 21:
  + The cyclic shift of the UL SRS with staggered pattern can be configured to be 1) the same in each symbol, according to REL-15 behavior or 2) per SRS resource, across all symbols in the SRS resource, according to equation 1 above
* (Ericsson R1-2008765) Proposal 22:
  + The maximum number of available cyclic shifts for the SRS for positioning is configurable by the gNodeB as part of the RRC configuration.

Feature lead’s view

The issues of the cyclic shifts of SRS for positioning were identified and the potential solutions were also intensively discussed in Rel-16 and also in RAN1#102e without the consensus. Suggest resolving this issue in Rel-17 WI phase.

### Proposal 3-4

* The enhancements to address the issues from the existing cyclic shift patterns for SRS for positioning can be considered for normative work.

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CATT | Support Proposal 3-4. We believe it is a critical issue which need to discussed during the WI phase in order to improve the detection performance of SRS-Pos in the gNB. |
| OPPO | Support. It is an issue identified in Rel-16 and we should address it. |
| Fraunhofer | Support |
| Qualcomm | Do not support. There is no issue. The staggered patterns are specified assuming the network does not know where the UE is, so the network cannot orthgonalize UEs by cyclic shifting. We can add unstaggered patterns if there is a need to increase the multiplexing of UEs. |
| Apple | Do not support, similar view as QC |
| MTK | 1, We DO support. The staggered pattern is used to increase observation range. Under some scenarios such as indoors, the propagation distance is not long and thus the observation range doesn't need to be large. So the cyclic shift (shortening the observation range) can be applied to multiplex some UEs under staggered pattern. For outdoors, if propagation distance is a concern, we may choose not to multiplex UEs, or give a larger range between adjacent cyclic shift location  2, we also suggest the wording change as “recommended for normative work” |
| CMCC | Support |
| ZTE | Do not support, similar view as QC |
| Fraunhofer\_2 | Based on the comment from QC the following is common understanding: When applying staggered patterns on Rel-16 SRS for positioning, the network cannot separate the UEs by different cyclic shifts.  This is clearly an open issue from Release 16 to be resolved. Unstaggered patterns means that ambiguities and aliases that SRS-for-positioning was designed to resolve are discarded. |

FL Comments

It seems there are different views on whether there is a need to address the issues of the existing cyclic shift patterns for SRS for positioning.

## Power control for SRS for positioning

Background

In Rel-16, open-loop power control is supported for SRS for positioning, i.e., the Tx power of SRS for positioning is based on the path loss estimation, but not subject to TPC command from the gNB. This could potentially result in interference with other UL signals/channels. Several companies propose to support the enhancements of the power control for SRS for positioning in Rel-17.

Submitted Proposals

* (Huawei R1-2007577) Proposal 6:
  + Rel-17 should support closed loop power control, and support the following procedures
    - Neighbouring TRP sending SRS power adjustment to the LMF
    - LMF sending the SRS power adjustment to the serving gNB
    - Power headroom report for SRS for positioning.
* (vivo R1-2007666) Proposal 16:
  + PHR based on SRS-PosResource should be introduced in Rel-17
* (vivo R1-2007666) Proposal 17:
  + Introduce the priority indications of SRS-PosResource for transmission power reductions in Rel-17
* (TCL R1-2007886) Proposal 3:
  + Support Closed-loop power control for the transmission of SRS for positioning.
* (OPPO R1-2008226) Proposal 9:
  + Study the enhancement of uplink power control of SRS for positioning
    - Support closed-loop power control on SRS for positioning.
    - Support per SRS resource configuration of power control parameters
* (Nokia R1-2008301) Proposal 6:
  + At least open-loop power control enhancements of SRS for positioning will be investigated in Rel-17:
    - FFS: whether the TPC towards the serving gNB/TRP only, or also towards the neighbor gNBs/TRPs
* (Fraunhofer R1-2008841) Proposal 7:
  + For positioning purposes, power control needs to be considered in Rel-17, when a spatial relation is not configured.

Feature lead’s view

The enhancements of the power control for SRS for positioning were discussed intensively in RAN1#102e without the consensus. In this meeting, several companies have investigated the potential benefits of the enhancements of power control of SRS for positioning for the improvement of the positioning accuracy, latency, network, and UE efficiency. However, there are diverged views on the potential solutions for the enhancements, and thus it may be difficult to reach a consensus on which of the solutions are adopted for Rel-17 during this meeting. Suggest agreeing on the need for the support of the enhancements and leave the discussion of the solutions for the enhancement to the WI phase.

Proposal 3-5

* The enhancements of power control of SRS for positioning’s can be considered for normative work.
* The details of the enhancements are left for further discussion in normative work, which may include, but not limited to the following aspects:
  + Closed-loop power control with potential coordination between gNB/TRPs/LMF, e.g., SRS power adjustment messages between gNBs, and between gNBs and LMF;
  + Power headroom reporting for SRS for positioning
  + Priority indications of SRS-PosResource for transmission power reductions
  + Enhancements on open-loop power control for SRS for positioning
  + per SRS resource configuration of power control parameters

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CATT | Support Proposal 3-5. |
| OPPO | Support |
| Xiaomi | Support the proposal |
| vivo | Support. |
| LG | From our side, we would like to suggest the enhancement of open-loop power control associated with transmission beam configuration, since the path-loss reference is configured for each SRS resource set, while the transmission beam is configured for each SRS resource.  So, we would like to suggest a modification of the fourth bullet:   * Enhancements on open-loop power control for SRS for positioning including the consideration of TX beam for SRS transmission. |
| Huawei/HiSilicon | We suggest to revise the wording to “recommended for normative work”.  The reasons is that for positioning SRS, even the serving gNB has no access of controlling SRS transmission power dynamically, which may result in additional intra-cell interference. |
| Fraunhofer | Support |
| Qualcomm | Do not support. Unclear the gains. How many companies provided results of the gains of Closed loop precoding? |
| CMCC | In our view, additional signalling among neighbouring TRP, serving TRP, and LMF is needed to support the close loop power control enhancements. The performance gain is not clear, while the higher layer exchanging signalling and latency would be increased. |
| ZTE | Not sure closed-loop power control can be instantaneous enough to update the power information of SRS intended to be received by neighbor cells. |
| Nokia/NSB | Support in principle. It seems many companies have issues with closed loop power control which we can understand. We think that it is a critical issue still to address enhancing TPC from Rel-16 for positioning. We suggest to remove closed loop and consider open loop first to see if we can make progress. Suggest removing the first subbullet under the second bullet completely. |
| Huawei/HiSilicon2 | There are two issues that we suggest to clarify:   * Allow TPC command of SRS does not necessarily mean that there would be signaling exchange with other TRPs. * SRS Tx power not controlled by the serving gNB via L1-signaling is not a good idea for intra-cell interference management based on our understanding.   Can opponents understand dilemma from gNB that every time the gNB needs update the transmission power of SRS for positioning, an RRC reconfiguration needs to be provided to the UE?  It is really really weird that mimo-SRS/PUSCH/PUCCH can be controlled by L1 TPC command, but pos-SRS cannot. |

FL comments

It seems there are different views on what kinds of the enhancements should be considered for the power control and what the benefits are for the enhancements.

For LG’s comment, it may be already covered in the last sub-bullet “per SRS resource configuration of power control parameter”. Maybe we can combine the last two sub bullets together

For Huawei/HiSilicon comments, it would be better to use “recommended for normative work” once we have the consensus to support the enhancements.

For Qualcomm, CMCC, ZTE, and Nokia’s comments on closed-loop power control, maybe we can remove “closed-loop” to see if we can address the concern.

### Proposal 3-5 (Revision 1)

* The enhancements of power control of SRS for positioning’s can be considered for normative work.
* The details of the enhancements are left for further discussion in normative work, which may include, but not limited to the following aspects:
  + Enhancements of power control with potential coordination between gNB/TRPs/LMF, e.g., SRS power adjustment messages between gNBs, and between gNBs and LMF;
  + Power headroom reporting for SRS for positioning
  + Priority indications of SRS-PosResource for transmission power reductions
  + per SRS resource (per Tx beam) power control for SRS for positioning

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Nokia/NSB | We support this proposal and think that it could have a strong impact on the accuracy performance of UL and DL+UL techniques. |
| LG | We prefer to keep the previous “open loop” power control for SRS for positioning. Per resource power control is unclear to us. Does it mean the closed-loop or open-loop ? If it means that the path-loss RS can be configured per each resource, we do not see the necessity, which results in the increase of signalling overhead and big spec change. In case of open-loop power control enhancement, we can consider more general features. For example, we can simply allow the number of the path-loss reference RSs per SRS resource set, which might be a way to address multiple beam directions and their corresponding power consumption. So, we propose again the following sub-bullet  Enhancements on open-loop power control for SRS for positioning including the consideration of TX beam for SRS transmission. |
| CATT | Support.  In our point of view, the enhancements to power control of SRS-Pos has potential benefits to reduce UL interference among SRS-Pos from different gNBs, and it is important for the network to improve the accuracy of positioning measurements. |
| vivo | Support |
| ZTE | The first sub-bullet should be revised to reduce the scope.   * + Enhancements of open-loop power control with potential coordination between gNB/TRPs/LMF, e.g., SRS power adjustment messages between gNBs, and between gNBs and LMF; |
| Huawei/HiSilicon | From us, we think the closed-loop power control is also beneficial to reduce INTRA-CELL interference between pos-SRS and mimo-SRS, and even between pos-SRS and pos-SRS from different UEs.  Allowing gNB to have dynamic control of UL transmission power of any kind is essential and fundamental for wireless communication.  The necessity on power control feedback from other TRPs can be further studied.  Therefore, we have the following suggestion.   * The enhancements of power control of SRS for positioning’s can be considered for normative work. * The details of the enhancements are left for further discussion in normative work, which may include, but not limited to the following aspects:   + Enhancements of power control with potential coordination between gNB/TRPs/LMF, e.g., SRS power adjustment messages between gNBs, and between gNBs and LMF;   + Support of closed-loop power control mechanism as in Rel-15 (i.e. by DCI from the serving gNB)   + Power headroom reporting for SRS for positioning   + Priority indications of SRS-PosResource for transmission power reductions   + per SRS resource (per Tx beam) power control for SRS for positioning |

FL comments

The proposal is revised as follows with the consideration of LG, Huawei, and ZTE’s comments.

### Proposal 3-5 (Revision 2)

* The enhancements of power control of SRS for positioning’s *can be studied further and if needed, specified* during normative work.
* The details of the enhancements are left for further discussion in normative work, which may include, but not limited to the following aspects:
  + Enhancements of open-loop power control with potential coordination between gNB/TRPs/LMF, e.g., SRS power adjustment messages between gNBs, and between gNBs and LMF;
  + Support of closed-loop power control mechanism as in Rel-15 (i.e. by DCI from the serving gNB)
  + Power headroom reporting for SRS for positioning
  + Priority indications of SRS-PosResource for transmission power reductions
  + Enhancements on open-loop power control for SRS for positioning including the consideration of TX beam for SRS transmission.
  + per SRS resource configuration of power control parameters

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| vivo | Support |
| LG | Support |
| Huawei/HiSilicon | Support. |

## Mitigation of UL interference

Background

In Rel-16, each serving gNB decides the configuration of the transmission of SRS for positioning, and there is no support of the coordination among adjacent gNB/TRPs and LMF, which may result in the potential collision of the UL transmission of the UEs in adjacent gNB/TRPs, and avoidance of the potential collision of the UL transmission of the UEs are difficult to be implemented without the communication between gNBs and between gNBs and the LMF. Thus, several companies propose to support the coordination schemes for the configurations of the SRS for positioning among adjacent gNB/TRPs and LMF to avoid a potential collision.

Submitted Proposals

* (CATT R1-2007755) Proposal 11:
  + Support SRS-Pos resource coordination to achieve orthogonal SRS-Pos resource assignment and SRS-Pos interference cancellation to eliminate inter-cell SRS-Pos interference in Rel-17.
* (CMCC R1-2008015) Proposal 6:
  + The SRS for POS coordination should be studied
* (Fraunhofer R1-2008841) Proposal 8:
  + Consider UL interference coordination for Rel-17 NR positioning including interference from positioning RSs or other interference sources.

Feature lead’s view

The enhancement was discussed in RAN1#102e without consensus, where some companies think the issue can be handled by the implementation.

### Proposal 3-6

* Mechanisms coordinating the configuration of SRS for positioning to achieve orthogonal SRS-Pos resource assignment and avoid potential collision of the SRS for positioning from UEs can be considered for normative work.

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CATT | Support Proposal 3-6. |
| OPPO | Support |
| ZTE | Don’t support. It’s network implementation. |
| Fraunhofer | Support |
| Qualcomm | Do not support; network implementation |
| Apple | Don’t support |
| CMCC | Support |
| Huawei/HiSilicon | Can supporting companies be more specific what we are going to do?  Is it about enhancement on LMF recommending SRS configuration to the serving gNB in e.g. NRPPa POSITIONING INFORMATION REQUEST, a.k.a. LMF-initiated on-demand SRS? |
| Fraunhofer\_2 | From our view, the interference from data to positioning SRS can occur and cannot be resolved by network implementation. |

## Frequency hopping of UL SRS for positioning

Background

In Rel-16, UL SRS for positioning does not support frequency hopping. For minimizing the interference, it is proposed to support the frequency hopping in the transmission of UL SRS for positioning in Rel-17.

Submitted Proposals

* (Huawei R1-2007577) Proposal 7:
  + Rel-17 should support SRS frequency hopping
* (CATT R1-2007755) Proposal 13:
  + Frequency hopping of SRS-Pos for positioning is recommended for normative work in order to obtain better positioning accuracy.
* (OPPO R1-2008226) Proposal 7:
  + Study to support frequency-hopping in SRS resource for positioning to support larger transmission bandwidth.

Feature lead’s view

The proposal was discussed in RAN1#102e without the conclusion. The discussion was deprioritized in RAN1#102e, partially due to the fact that the enhancement that was proposed by a single company at that time.

### Proposal 3-7

* Frequency hopping of SRS for positioning can be considered for normative work.

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CATT | Support Proposal 3-7. |
| OPPO | Support |
| Huawei/HiSilicon | Suggest to change the word “recommended for normative work”.  We think that SRS frequency hopping is important for coverage enhancement. |
| CMCC | Support |
| ZTE | Support. |
| Nokia/NSB | During Rel-17 we remember some discussion on frequency hopping, and it seemed common understanding that UE may have trouble to keep phase coherency. Do we plan to address this in Rel-17? If not, then what would be the benefit for frequency hopping for SRS-Pos? |
| Huawei/HiSilicon | To Nokia, we understand that the phase offset (if exist) can be in one implementation handled by gNB Rx algorithm, similar to what we are facing in SRS CA. |
| vivo | Don’t support.  We have the same concern as Nokia. Whether phase continuity can be ensured across frequency hops is not clear, and even for CA, some companies also worry about its feasibility. In addition, compared with frequency hopping, we think a larger comb size (such as 3-1) are better solutions.   * From both gNB and UE perspective, the applicability and feasibility of this enhancement for different scenarios, configurations, bands and RF architectures, can be further studied |
| Huawei/HiSilicon | To vivo:  How about adding the following Note   * Note: the case when UE is not required to maintain phase continuity is prioritized. |

## UL reference signals for positioning

Background

For improving the positioning efficiency, there is a proposal to reuse SRS for MIMO for the purpose of Positioning measurements.

Submitted Proposals

* (Qualcomm R1-2008619) Proposal 16:
  + For the purpose of enhanced efficiency, support reusing SRS for MIMO for the purpose of Positioning measurements.

Feature lead’s view

Reusing “SRS for MIMO” for the purpose of positioning may enhance the network efficiency especially for the case for the serving gNB. For the neighboring gNBs, we may need to introduce the signaling support for the neighboring gNBs to receive the SRS for MIMO.

### Proposal 3-8

* Reusing SRS for MIMO for positioning measurements for efficiency enhancement can be considered for normative work.
* The details of the signaling support for reusing SRS for MIMO for positioning is left for further discussion in normative work.

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CATT | Support Proposal 3-8. |
| OPPO | This issue is related to 3-1 in some sense. SRS for MIMO can be regarded as some new patterns. Thus, it is better to discuss 3-1 and 3-8 together. |
| Huawei/HiSilicon | Support. |
| Fraunhofer | Support |
| Apple | Do not support, UE should be indicated if SRS transmission is only used for Positioning purpose or more, for example some transmission techniques could be quite different for MIMO SRS and Pos-SRS |
| CMCC | The motivation is clear, not sure if it can be merged to the discussion of 3-1. |
| ZTE | Support. |
| Nokia/NSB | Could the proponents be a bit clearer on the potential gains? For non-serving gNB would SRS for MIMO be the best RS? |

## Multi-port transmission of UL SRS for positioning

Background

In Rel-16, SRS for positioning is transmitted on a single antenna port. For Rel-17, there is a proposal to support the transmission of UL SRS for positioning from more than 1-port with the potential to improve the measurement accuracy (e.g., multipath mitigation)

Submitted Proposals

* (Fraunhofer R1-2008841) Proposal 2:
  + Study multi-port SRS transmission for positioning in Rel. 17.

Feature lead’s view

The enhancement was discussed in RAN1#102e. With the understanding that one of the main motivations for proposing multi-port positioning RS transmission again is related to the support of the multipath mitigation, it was suggested to include the investigation of the multiport transmission of UL SRS for positioning as a part of the investigation of the multipath mitigation.

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CATT | Agree to FL’s view. |
| ZTE | Agree with FL. |
| Fraunhofer | We don’t share the FL’s view here; the main motivation is not the support for multipath mitigation.  Our simulation results in 8.5.2 show that multi-port SRS enables similar performance for -20dBm using 4-ports SRS compared with a single port +23dBm SRS. In this sense MIMO-SRS outperforms SRS for positioning!  Achieving the accuracy targets while configuring SRS resource sets with low power transmissions motivates our proposal. In the presence of interference this effect becomes even more relevant. |
| Fraunhofer\_2 | At least for FR2 the antennas may have a high directivity and different orientations. Rel-16 allows a single port transmission of SRS-for-positioning hence inefficient sequential transmission compared multi port SRS transmission of multi-port. To increase the efficiency and achieving the accuracy targets; Rel 17 shall consider multi-port transmission for SRS: Proposal 3-9  * Multi-port transmission of UL SRS for positioning can be considered for normative work. |

FL’s comments

Based on the comments from Fraunhofer, the following proposal is added for further discussion

### Proposal 3-9

* One source (Fraunhofer R1-2008841) considers it is beneficial to support multi-port transmission of UL SRS for positioning for increasing the positioning efficiency and achieving the positioning accuracy.

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Fraunhofer | Multi-port SRS should be supported for the following reasons:   * Improvement in terms of NW efficiency especially in FR2 scenarios * Improvement in terms of accuracy when considering non-ideal antennas * Improvement in terms of accuracy and coverage for low power transmission * No new feature is added (are using MIMO SRS features for positioning) |
|  |  |

# Enhancements of UE/gNB measurements

## Multipath mitigation

Background

Positioning accuracy can be significantly degraded due to the impact of the multipath caused by NLOS signals, which is especially true for IIoT scenarios. Rel-16 has introduced limited support of multipath mitigation by allows reporting multiple measurements from the same (pair of) TRPs. The following agreements were made for further investigation of multipath mitigation approaches:

|  |
| --- |
| Agreement:   * Multipath mitigation techniques will be investigated in this SI for improving positioning accuracy, which may include, but not limited to the following:   + The applicable scenarios and performance benefits of multipath mitigation techniques   + The methods/measurement/signaling for the LOS/NLOS detection and identification   + The measurements for supporting the multipath mitigation/utilization   + The procedure and signaling for supporting the multipath mitigation/utilization   + Implementation-based solutions (e.g., outlier rejection) without the need of any additional specified method/measurements/procedures/signaling. * Note: The above study applies to DL only, UL only, DL+UL positioning solutions for UE-based and UE-assisted positioning. |

Submitted Proposals

* (Futurewei R1-2007552) Proposal 3:
  + Multipath mitigation methods support the feedback and mechanisms of a LOS/NLOS indicator, reuse of existing Rel-16 defined reference signals (DL PRS, UL SRS) and its configurability.
* (Futurewei R1-2007552) Proposal 4:
  + Additional measurements definition of the DL PRS including relative power to the first detected path should be supported to improve the positioning accuracy, specifically for DL-AoD positioning methods.
* (Huawei R1-2007577) Proposal 8:
  + Rel-17 should support angle information report associated with multi-paths.
* (Huawei R1-2007577) Proposal 9:
  + Rel-17 should support LOS/NLOS identification to improve the positioning accuracy.
* (vivo R1-2007666) Proposal 1:
  + The enhancements to improve positioning accuracy are needed for the NLOS scenario
* (vivo R1-2007666) Proposal 18:
  + LOS/NLOS detection/identification should not be considered in Rel-17.
* (vivo R1-2007666) Proposal 32:
  + The differential positioning technique and machine learning technique can be studied as the method for improving the accuracy in the presence of NLOS error
* (ZTE R1-2007755) Proposal 1:
  + Study mechanisms to assist determination of LOS & NLOS communication links. For example, coherence bandwidth can be attached in positioning measurement report.
* (Intel R1-2007946) Proposal 5:
  + Support signaling indicating the LOS/NLOS link propagation type for NR positioning
  + Support signaling of reliability metric (with probability meaning) for NLOS detection (variable u in the range from 0 to 1, with absolute value showing reliability of decision)
* (Intel R1-2007946) Proposal 6:
  + Support for additional first arrival path measurements, including:
    - Power of the first arrival path
  + Continue study of Doppler effect, velocity measurement, K-factor etc.
* (Intel R1-2007946) Proposal 7:
  + Study potential benefits of the multi-path measurements, clarify how these measurements can be potentially used in the positioning equations
* (Lenovo R1-2007998) Proposal 9:
  + A Measurement and signalling framework for LOS/NLOS identification can be deemed beneficial for the LMF/UE. Aspects of FFS include:
    - Triggering and reporting the TRP/link status in terms LOS/NLOS.
    - Associated procedures in the event of insufficient availability of suitable LOS TRPs/links.
    - Measurement period for LOS/NLOS TRP/link classification.
* (Xiaomi R1-2008083) Proposal 7:
  + To indicate the first arrival path by reporting the arrival time of each beam in beam measurement report.
* (Samsung R1-2008168) Proposal 4:
  + Angle based LOS/NLOS differentiation with joint measurement should be studied.
* (Samsung R1-2008168) Proposal 5:
  + In addition to the measurement reporting of RSRP, RSTD, RX-TX time difference, UE reports indication of LOS/NLOS.
* (OPPO R1-2008226) Proposal 13:
  + For multipath mitigation, only focus on the implementation-based solutions in Rel-17.
* (Nokia R1-2008301) Proposal 7
  + RAN1 to study NLOS identification and reporting from the UE to the LMF during at least UE-A DL positioning.
* (Nokia R1-2008301) Proposal 8:
  + RAN1 to study NLOS identification and reporting from the LMF to the UE during at least UE-B DL positioning.
* (Nokia R1-2008301) Proposal 9:
  + RAN1 to study both LOS/NLOS identification methods computed in PHY layer processing and LMF localization processing.
* (Sony R1-2008365) Proposal 5:
  + Support LOS & NLOS detection and measurement report mechanism, particularly to mitigate multipath issue in IIoT use-cases.
* (LG R1-2008417) Proposal 3:
  + For the improvement of positioning accuracy, a method and signalling should be considered to identify the NLoS using the polarization characteristics.
* (LG R1-2008417) Proposal 4:
  + For NLOS identification, RAN1 needs to consider signalling and benefits of the method introducing the propagation time difference threshold/window between a reference and a target TRP.
* (InterDigital R1-2008491) Proposal 13:
  + Study LOS and NLOS identification methods
* (InterDigital R1-2008491) Proposal 14:
  + Consider path identification mechanism
* (InterDigital R1-2008491) Proposal 15:
  + Study dynamic update of spatial information for SRS for positioning for multi-RTT positioning methods
* (Qualcomm R1-2008619) Proposal 5:
  + Support reporting from UE and the gNB to the LMF additional time-domain paths (beyond 2 paths which is already specified) and their corresponding relative powers.
* (Fraunhofer R1-2008841) Proposal 1:
  + Support enhanced CIR reporting for NR-Positioning in Rel-17.
* (Fraunhofer R1-2008841) Proposal 3:
  + The following candidates should be considered for LOS/NLOS detection and identification:
    - First-arriving-path tracking over multiple time instants
    - Phase tracking over multiple time instants
* (CEWiT R1-2008718) Proposal 1:
  + LOS confidence, power level and angle information of LOS path should be reported along with timing measurements in Release-17.
* (Ericsson R1-2008765) Proposal 1:
  + RAN1 should study what characteristics (such as e.g. power, angle of arrival, doppler frequency) of the detected paths that are useful to report for positioning purposes, and also how many paths that are useful to report.
* (Ericsson R1-2008765) Proposal 2:
  + The network should configure values P and Q for the measurements to be performed and reported by the UE, where P is the number of paths and Q is the number of beams.
* (Ericsson R1-2008765) Proposal 3:
  + Magnitude, SNR, Doppler frequency, angle of arrival of every path should be reported.
* (Ericsson R1-2008765) Proposal 4:
  + It shall be unambiguously defined what additional paths a UE shall report.
* (Ericsson R1-2008765) Proposal 5:
  + The UE shall always report both the first path and the strongest path
* (Ericsson R1-2008765) Proposal 6:
  + RAN1 should study how the UE should decide unambiguously what additional paths to report beyond the first path and the strongest path.
* (Ericsson R1-2008765) Proposal 7:
  + RAN1 should specify reporting of the strongest peak in rel. 17
* (Ericsson R1-2008765) Proposal 8:
  + We propose that RAN1 should study LOS detection techniques and reporting of LOS indicators for potential specification in Rel. 17.
* (Ericsson R1-2008765) Proposal 9:
  + Following measurements should be specified in Rel-17. These measurements can be part of rich reporting.
    - Location and magnitude of the first peak.
    - Location and magnitude of the highest peak.
    - Components of PDP/CIR around first/highest peak.

Feature lead’s view

Many companies have investigated the multipath mitigation techniques and provided their views on this issue according to the agreements made in RAN1#102e.

For multipath mitigation techniques, it seems the majority companies are supportive to the LOS/NLOS detection and identification method. However, there are some companies that are not convinced of the benefits of the method. Other methods are also proposed, e.g., differential positioning technique, machine learning technique, and implementation-based solutions, although these methds attract much less interests.

For the measurements for supporting the multipath mitigation/utilization, as discussed in previous meeting, there are significant interests for multipath mitigation based on the enhancements of the measurement reporting, e.g., angle, power, PDP, CIR, Doppler, SINR associated with multi-paths. In addition, there are proposal to mitigate the impact of multipaths through difference threshold/windows, Spatial information, etc.

In addition, there are proposals related to the signalling support and related positioning solutions.

Proposal 4-1

* Multipath mitigation techniques are recommended for normative work for improving positioning accuracy;
* The details for supporting the multipath mitigation techniques are left for further discussion in normative work, which may include, but not limited to the following:
  + The methods/measurement/signaling for the LOS/NLOS detection and identification
  + The enhancement of measurement reporting (signal angle, power, and channel information etc.) for supporting the multipath mitigation/utilization
  + The procedure and signaling for supporting the multipath mitigation/utilization
  + Implementation-based solutions (e.g., outlier rejection) without the need of any additional specified method/measurements/procedures/signaling.

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Nokia/NSB | Support. |
| InterDigital | We are supportive of the proposal. However, for clarity, the note from the agreement should be kept in the proposal so that it is clear that the enhancements can be applied to all positioning methods, i.e., DL, UL and DL&UL positioning methods.   * Multipath mitigation techniques are recommended for normative work for improving positioning accuracy; * The details for supporting the multipath mitigation techniques are left for further discussion in normative work, which may include, but not limited to the following:   + The methods/measurement/signaling for the LOS/NLOS detection and identification   + The enhancement of measurement reporting (signal angle, power, and channel information etc.) for supporting the multipath mitigation/utilization   + The procedure and signaling for supporting the multipath mitigation/utilization   + Implementation-based solutions (e.g., outlier rejection) without the need of any additional specified method/measurements/procedures/signaling. * Note: The above study applies to DL only, UL only, DL+UL positioning solutions for UE-based and UE-assisted positioning. |
| Qualcomm | We have several aspects to point out regarding this proposal.   * First, we believe that the proposal above is too broad and general, and does not really reduce/constraint the scope of the normative work. We need to be able to conclude what type of enhancement we would do for the purpose of multipath mitigation/utilization. As an example, do we plan to specify “LOS/NLOS detection”, i.e. by specifying enhancements in DL PRS waveform that enable a UE to do LOS/NLOS detection, or do we plan to specify some generic “LOS/NLOS indication”, i.e., just a feedback from UE/gNB on whether a link is LOS/NLOS, in other words, a second, different “quality metric” on top of the quality metric that is already supported. * Also, if “implementation-based” solutions are still in scope, then how can we recommend them for normative work? * Furthermore, it is not clear what we mean by LOS/NLOS path. Is it the strict meaning of physical sense, or also a reflection that has TOA very close to the TOA of the true LOS is considered as an “almost-LOS”? In the latter case, it looks related to the already-supported, (but never evaluated), feature of “additional-path reporting”. If the UE is unsure whether a TOA is really LOS, because there are a few close-by paths which could be good candidates, a UE/gNB can already report up to 2 additional paths. Such a feature seems to have more useful information than a generic LOS/NLOS feedback reporting. Companies that support adding a “LOS/NLOS feedback bit” or a “soft quality metric of LOS/NLOS”, have they considered enhancing the feature of “additional path reporting” further, and let the LMF make the decision whether something is LOS or NLOS? Either way, adding a LOS/NLOS indicator will not be a formal “measurement”, no algorithm will be specified on how to compute it, and its definition, at best, will be another abstract quality metric.   Finally, I think there is a need for companies to digest at the simulation results, and discuss more on these, before recommending a specific normative work on this topic, (e.g., see whether indeed LOS/NLOS is really helpful, on top of an outlier rejection algorithm.) |
| MTK | We agree in general, and we prefer implementation based solutions. UE can actually reject to report the measurements which may not be suitable (outlier rejection) |
| CATT | Support Proposal 4-1. |
| CMCC | Support |
| OPPO | We prefer the implementation-based solutions without the need of any additional RAN1 specification. We are ok with the current proposal from FL. |
| NTT DOCOMO | Support |
| Xiaomi | Support the proposal |
| vivo | For recommending techniques for normative work, we share the similar understanding with QC. We believe that we can recommend multipath mitigation techniques which can be captured in WID after reaching the correct observation in the discussion of ‘achievable accuracy and latency’. For example, for LOS/NLOS identification, some companies think that LOS/NLOS identification is not needed since the outlier rejection method (implementation-based solutions) is enough, while other companies don’t think so. Without reached observation, it is too early to recommend multipath mitigation techniques in this email discussion. |
| LG | Support. |
| ZTE | Support. We think the last sub-bullet will not have spec efforts, may be we can remove it. |
| Huawei/HiSilicon | Support. |
| Lenovo, Motorola Mobility | Open to support FL’s proposal and further down scoping of solutions may be needed in ongoing discussions for solutions that have an actual impact for normative work. It is unclear how implementation-based solutions can be considered for further study. |
| Fraunhofer | Support. |
| Intel | Support. Our results have shown benefits of LOS/NLOS classification. |
| Ericsson | We support the proposal in principle, but would like some clarifications.   * We think the list of methods to be supported in the future normative work should be listed clearly in the first bullet. We agree with the second bullet that there is no need for details on exactly how the solutions will be supported by the specifications, but the first bullet should at least list the supported methods. * The last sub bullet states that implementation based solution will be supported. However, this are supposed to be without the need of any additional specification impact. Therefore we wonder if this bullet should be here at all.   We propose the following rewording:   * Multipath mitigation techniques are recommended for normative work for improving positioning accuracy, including:   + LOS/NLOS detection and identification   + enhancement of measurement reporting * The details for supporting the multipath mitigation techniques are left for further discussion in normative work, which may include, but not limited to the following:   + The methods/measurement/signaling enhancements. for the LOS/NLOS detection and identification   + Which of the enhancement of measurement reporting (signal angle, power, and channel information etc.) for supporting the multipath mitigation/utilization   + The procedure and signaling for supporting the multipath mitigation/utilization   + ~~Implementation-based solutions (e.g., outlier rejection) without the need of any additional specified method/measurements/procedures/signaling.~~ |
| Futurewei | Support but with further clarifications on top of what’s proposed by Ericsson. The reason is that we haven’t really discussed what and how to enhance the reporting. Perhaps then to keep it general.   * Multipath mitigation techniques are recommended for normative work for improving positioning accuracy, including:   + LOS/NLOS detection and identification   + Possible enhancement of measurement reporting and/or configurations. * The details for supporting the multipath mitigation techniques are left for further discussion in normative work, which may include, but not limited to the following:   + The methods/measurement/signaling enhancements. for the LOS/NLOS detection and identification   + Which of the enhancement of measurement reporting (signal angle, power, and channel information etc.) for supporting the multipath mitigation/utilization   + The procedure and signaling for supporting the multipath mitigation/utilization   + ~~Implementation-based solutions (e.g., outlier rejection) without the need of any additional specified method/measurements/procedures/signaling.~~ |

FL comments

Based on the feedback, most of the comments suggest the clarification of the scope of the enhancements. There are also comments that it is too early to recommend multipath mitigation techniques in this email discussion. The following is a revised version of the proposal for comments. However, we may delay the online discussion of the revised proposal with the consideration of the discussion of the evaluation results for the multipath mitigation techniques in AI 8.3.2.

Proposal 4-1 (Revision 1)

* Multipath mitigation techniques are recommended for normative work for improving positioning accuracy, including:
  + LOS/NLOS detection and identification
  + Possible enhancements of measurement reporting and/or configurations.
* Note: The details for supporting the multipath mitigation techniques are left for further discussion in normative work, which may include, but not limited to the following:
  + The methods/measurement/signaling enhancements for the LOS/NLOS detection and identification
  + Which of the enhancement of measurement reporting (signal angle, power, and channel information etc.) for supporting the multipath mitigation/utilization

Comments

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| **Company** | **Comments** |
| Qualcomm | We pointed out several issues with the concept of “LOS/NLOS detection and identification”. Companies do not have same understanding on what will be specified, and we cannot leave this up to normative work. The scope of it is another study item. Some companies are talking about “new measurements” or “new PRS/methods”, others just “additional reporting”. The scope need to be reduced to understand what is going to be specified. Can companies be more specific on what they envision? For example, from our side, the only enhancement that we saw some gain in one scenario is: Power Delay Profile reporting from gNB/UE and multiple angle reporting. In most of the scenarios, just outlier rejection was working. No gain is observed by “LOS/NLOS flag”, or “LOS/NLOS detection”. |
| vivo | Do not support.  As we showed in our evaluation results, the gain of LOS/NLOS detection and identification is not justified to recommend such work into WI. Even if we assume 100% LOS identification rate, the performance is still worse than an implementation based outlier rejection method. |
| Nokia/NSB | Support. |
| CATT | Support. |
| Apple | Do not support. Not clear what can be specified here |
| MTK | We think the report of LOS/NLOS may not be needed. UE can already report additional paths. UE can choose not to report the measurement if the first path can’t be detected easily.  We are not convinced that LOS/NLOS report can further improve RAIM (receiver autonomous integrity monitoring ) significantly. (RAIM has been applied in GNSS by using more measurements to check satellite links which may have problem) |
| InterDigital | Support |
| LG | In our view, it is too early to exclude the implementation based solution(s). We prefer to include implementation based solution to address the LoS/NLoS issue. |
| CMCC | Support |
| OPPO | Not support. Implementation-based solution seems sufficient. The benefit of additional specification is not clear |
| Huawei/HiSilicon | Support.  We think LOS/NLOS identification is beneficial, especially for the case where LOS links are limited. Our understanding of LOS/NLOS identification means that the measurement entity (UE/NG-RAN) reports the LOS/NLOS status (could be soft or hard) based on DL/UL measurement. LMF may further use this information for the positioning fix, and the performance gain have been verified by various sources. It does not mean that LMF will discard the measurement labelled as NLOS; it can be still useful in the following cases   * The LOS links are not sufficient for a positioning fix and NLOS links are used. * The warning of location error/location uncertainty when NLOS links are used.   We also would like to ask the opponents of LOS/NLOS identification for the evaluation assumption, whether the additional NLOS delay is processed with delay quantization. From the following evaluation of NLOS additional delay, it is very hard for us to be convinced that NLOS links can be used in RAIM/RANSAC to achieve 0.5 meter accuracy, let alone 0.2 meter accuracy.    If companies have concern on the scope, we have the following suggestion on refinement of the wording.   * Multipath mitigation techniques are recommended for normative work for improving positioning accuracy, including:   + LOS/NLOS status reporting   + Possible enhancements of measurement reporting and/or configurations. * Note: The details for supporting the multipath mitigation techniques are left for further discussion in normative work, which may include, but not limited to the following:   + The methods/measurement/signaling enhancements for the LOS/NLOS detection and identification   + Which of the enhancement of measurement reporting (signal angle, power, and channel information etc.) for supporting the multipath mitigation/utilization |
| Intel | Support.  To QC/Apple:  As a minimum functionality we envision report of link type (LOS/NLOS) and associated reliability (or probability) of correct decision.  The specific method how this metric is derived can be left up to UE/gNB implementation.  To MTK:  Intel has shown benefits of LOS/NLOS classification for different methods.  The performance benefits of the LOS/NLOS classification over the reference Rel.16 performance were clearly demonstrated in R1-2005878.  The performance benefits over RAIM/RANSAC outlier rejection algorithms are clearly demonstrated in tdoc R1-2007945. We also believe such techniques are good methods to simplify/improve RAIM/RANSAC implementation and can be used in combination providing better performance. |
| Lenovo, Motorola Mobility | Support Proposal 4-1 (Revision 1). |
| Xiaomi | Support |
| Sony | Support. The details are left for the discussion in normative work. Furthermore, up to now, everything seems to be “possible”. Hence, we propose to update the second bullet point: o ~~Possible~~ enhancements of measurement reporting and/or configurations. |
| Fraunhofer | Support, we are also fine with the proposal from HW. |

FL comments

Based on the feedback, it seems we will need further discussion on the whether to support the method based on the LOS/NLOS detection and identification for multipath medication, and whether to consider the enhancements of measurement reporting and/or configurations for multipath medication in Rel-17.

Proposal 4-1 (Revision 2)

[15] sources have (Futurewei, Huawei, vivo, CATT, TCL, Lenovo, CMCC, Xiaomi, OPPO, Nokia, Sony, InterDigital, LGE, Qualcomm, CEWiT) have investigated and/or evaluated the multipath mitigation techniques for improving positioning accuracy. Among them:

* [12] sources (Futurewei, Huawei, Intel, Lenovo, Samsung, Nokia, Sony, LGE, InterDigital, Fraunhofer, Ericsson,CEWiT) consider it is beneficial to support the LOS/NLOS detection and identification
* Some sources consider it is beneficial to support additional measurements for multipath mitigation, e.g., power and/or relative power (Futurewei, Intel, Ericsson), angle information report associated with multi-paths (Huawei), coherence bandwidth (ZTE R1-2007755), reliability metric for NLOS detection (Intel, CEWiT), Doppler effect (Intel, Ericsson), K-factor (Intel R1-2007946), the arrival time of each beam (Xiaomi R1-2008083), angular information (Samsung, CEWiT, Ericsson), additional paths and their corresponding relative powers (Qualcomm, Ericsson), PDP/CIR reporting (Fraunhofer, Ericsson), SNR (Ericsson R1-2008765) etc.
* [3] sources (vivo, OPPO, Qualcomm) consider it is not beneficial to support LOS/NLOS detection/identification method
* [1] source (vivo R1-2007666)considers it is beneficial to support differential positioning technique and machine learning technique for improving the accuracy in the presence of NLOS errors

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| MTK | We request to clarify one thing.    When we talk about “LOS/NLOS detection and identification”, we think this is receiver implementation, unless we have additional design at the transmission to facilitate the detection and identification at the receiver. For example, two-port transmission (current DL-PRS only single port)  If there is no change for the transmission, then only the reporting deserves the normative work. Or we treat the detection and identification as the normative work at RAN4 for defining the requirement? |
| CATT | Support.  For MTK’s comments, in our point of view, if we agree to support “LOS/NLOS detection and identification” in Rel-17 enhancements, the normative work related to “LOS/NLOS detection and identification” should at least include ignalling additional measurements and reporting to assist “LOS/NLOS detection and identification”, and two-port DL-PRS transmission. |
| Huawei/HiSilicon | We are fine with the observation.  For the clarification request from MTK, our understanding is that whether changes from transmission side can be further discussed. Currently, we are suggesting to enhance the reporting signalling from UE to LMF and from gNB to LMF. Whether there will be the requirement in RAN4 will be discussed in RAN4. |
| LG | We have similar comment what we mentioned in proposal 2-1. We respect the evaluation results provided by each company, but we are not sure what the outcome will be for us if we agree on this proposal. We are Okay to capture this as one of the observations. |
| ZTE | Support.  Majority of companies show the necessity to enhance LOS/NLOS detection and identification under low LOS probability scenario.  Regarding detailed technique, it can be discussed in WI phase. |
| Lenovo, Motorola Mobility | Thanks to the FL for capturing the observation, maintain support for Proposal 4-1 (Revision 1). |
| Intel | Support.  We think that support of “LOS/NLOS detection and identification” is very beneficial to improve positioning accuracy and achieve requirements. The performance benefits of the LOS/NLOS classification over the reference Rel.16 performance were clearly demonstrated in R1-2005878.  The performance benefits over RAIM/RANSAC outlier rejection algorithms are clearly demonstrated in tdoc R1-2007945. We also believe such techniques are good methods to simplify/improve RAIM/RANSAC implementation and can be used in combination providing better performance.  To MTK:  As a minimum functionality we envision report of link type (LOS/NLOS) and associated reliability (or probability) of correct decision. |
| Ericsson | Support |
| Qualcomm | Some questions on the new formulation:   * Is additional paths and their corresponding relative powers and PDP/CIR reporting really different? I think they can be lumped together? * Also, what do we mean by “power and/or relative power”? If it is about the relative power of the additional paths, then what is the difference from the “additional paths and their relative powers”? * What is the “angular information”? The observation need to be more specific to understand what it corresponds to. Is it different than the “angle information report associated with multipath”? * What do companies mean by “LOS detection”? If they mean LOS/NLOS indicator report, we prefer the [12] companies to be more specific about what they find beneficial:   + If they have a different understanding, we suggest them to be clarified further. E.g., “Enhancement in reporting “is much different than “enhancement of the DL/UL PRS”, or “Enhancement in the UE/gNB measurement but without enhancement in the report” * “reliability metric for NLOS detection” is within the scope of the first bullet. * Suggest to add first the proposals that have more support. * With regards to the additional “measurements for multipath mitigation”, we think it should be about “reporting” from the UE and the gNB:   Some sources consider it is beneficial to support additional reporting from UE and gNB for multipath mitigation, e.g.,   * + power and/or relative power (Futurewei, Intel, Ericsson), additional paths and their corresponding relative powers (Qualcomm, Ericsson, Fraunhofer), angular information (Samsung, CEWiT, Ericsson), angle information report associated with multi-paths (Huawei), coherence bandwidth (ZTE R1-2007755), Doppler effect (Intel, Ericsson), K-factor (Intel R1-2007946), the arrival time of each beam (Xiaomi R1-2008083), , , SNR (Ericsson R1-2008765) etc. |
| Xiaomi | Support proposal 4-1 (revision 2) |

**To all companies:** please feel free to add/remove your companies’ names to the supporting/not supporting sources when you review the proposal.

FL comments

Based on the feedbacks, it seems the majority companies are supporting to the enhancements of the measurement reporting for supporting multipath mitigation, although there are differences are on what kind of the information should be reported, e.g., the information related to LOS/NLOS identification, the information related to the measurement power, etc. So, Proposal 4-1 is revised to see if we can reach some consensus for the enhancements.

Proposal 4-1 (Revision 3)

* Enhancements of reporting from UE and gNB for supporting multipath mitigation are recommended for normative work for improving positioning accuracy.
* Note: The details of the enhancements of measurement reporting are left for further discussion in normative work, which may include, but not limited to the following information associated with multi-paths, e.g., LOS/NLOS identification, time of arrival of the multi-paths, signal power and/or relative power, power delay profile, angle information, Doppler, channel information etc.

Comments

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| **Company** | **Comments** |
| Huawei/HiSilicon | Support. |
| ZTE | Suggest to revise the note,   * Note: The details of the enhancements of measurement reporting are left for further discussion in normative work, which may include, but not limited to the following information for LOS/NLOS detection and identification, e.g., LOS/NLOS status, channel information etc. |
| vivo | Not support |
| Lenovo, Motorola Mobility | Support |
| Intel | Support, with modification (in red):   * Enhancements of measurement reporting for supporting NLOS multipath mitigation to reduce an impact of excess time offset in propagation delay are recommended for normative work for improving positioning accuracy. * Note: The details of the enhancements of measurement reporting are left for further discussion in normative work, which may include, but not limited to the following information associated with multi-paths, e.g., LOS/NLOS detection and identification, signal power and/or relative power, angle information, Doppler, channel information etc. |
| Qualcomm | 1. We do not agree adding “NLOS” in the main bullet. We do not agree also on: “to reduce an impact of excess time offset in propagation delay”. 2. Is it correct understanding that we are talking about enhancements of the reporting from both UE and gNB? If yes, we think it needs to be added. 3. For us, measurements are written in 38.215: RSTD, RSRP, Rx-Tx, RTOA, etc. “Quality metric” is not strictly a measurement in RAN1; “additional path reporting” is not strictly a measurement in RAN1. A LOS/NLOS flag in the report, is it considered a measurement, or just enhancement in the report? For us, It is just an enhancement in the measurement report.    * Having said the above, the proposal is about the “enhancements in the report” and not in the “measurements” in the strict Ran1 sense, nor in the “reference signals”. 4. A few companies, as I pointed out in my previous reply are talking about “Power delay profile”, which seems to be missing in the note.    * Note: The details of the enhancements of measurement reporting are left for further discussion in normative work, which may include, but not limited to the following information associated with multi-paths, e.g., LOS/NLOS identification, time of arrival of the multi-paths, signal power and/or relative power, angle information, Doppler, channel information etc. |
| Futurewei | Support. On Qualcomm’s comments: agree with point #1 and agree that measurements aspects need to clear in the wording with point#2. For point #3, to us it is still open and can be resolved towards the end of the WI what are the specs impact. |
| Nokia/NSB | Support and generally agree with the comments from QC/Futurewei. |
| CMCC | Support the main bullet. |
| FL | For ZTE comments, the point of the main bullet is about the enhancement of the reporting (e.g., NLOS indication) from UE and gNB, but the methods of the detection of NLOS, since how to do the NLOS detection will be up to the implementation. Also, it would be better to keep other information for reporting that are proposed by other companies for now;  For Intel’s comments, again, the intention of the main bullet is about the enhancement of the reporting. The proposed adding “NLOS”, “to reduce an impact of excess time offset in propagation delay”, and “detection and” may not be needed;  For Qualcomm/Futurewei/Nokia’s comments, it seems fine to me to make the changes as Qualcomm suggested. |
| Huawei/HiSilicon | To QC  2> In our understanding, this is all about “reporting”.  3> We think LOS/NLOS flag, path power, path Doppler, etc. are all about reporting. We do not expect RAN1 to define the measurement in 215 or RAN4 to develop performance requirements for those aspects from both UE and gNB. |
| Xiaomi | Support proposal 4-1 (revision 3) |
| CATT | Support the current updated proposal 4-1. In our point of view, whether the above information associated with multi-paths can benefit for improving positioning accuracy, and which information should be specified are worth to be studied in Rel-17 WI phase. |
| Sony | Support this proposal 4-1 (rev 3) |
| Nokia/NSB | Support the revised proposal. Could any proponents explain why Doppler is included in the list? We think we could remove it. Unclear how that would relate to NLoS mitigation. |
| InterDigital | Support |
| ZTE2 | We can accept the current version. But to be fair, can you also include “coherence bandwidth” in the list. |

In case we cannot reach a consensus for the enhancements of measurement reporting for supporting multipath mitigation, it is suggested to capture the following TP in Proposal 4-1 (Revision 3 Alternative) into the TR as the conclusion of the investigation of multipath mitigation techniques.

**To all companies:** please feel free to add/remove your companies’ names to the supporting/not supporting sources when you review the proposal.

Proposal 4-1 (Revision 3 Alternative)

[15] sources (Futurewei, Huawei, vivo, CATT, TCL, Lenovo, CMCC, Xiaomi, OPPO, Nokia, Sony, InterDigital, LGE, Qualcomm, CEWiT) have investigated and/or evaluated the multipath mitigation techniques for improving positioning accuracy. Among them:

* [12] sources (Futurewei, Huawei, Intel, Lenovo, Samsung, Nokia, Sony, LGE, InterDigital, Fraunhofer, Ericsson,CEWiT, CATT) consider it is beneficial to support the LOS/NLOS detection and identification method.
* Some sources consider it is beneficial to support additional reporting from UE and gNB for multipath mitigation, e.g., power and/or relative power (Futurewei, Intel, Ericsson), additional paths and their corresponding relative powers (Qualcomm, Ericsson, Fraunhofer), angular information (Samsung, CEWiT, Ericsson), angle information report associated with multi-paths (Huawei), coherence bandwidth (ZTE R1-2007755), Doppler effect (Intel, Ericsson), K-factor (Intel R1-2007946), the arrival time of each beam (Xiaomi R1-2008083), SNR (Ericsson R1-2008765) etc.
* [3] sources (vivo, OPPO, Qualcomm) consider it is not beneficial to support LOS/NLOS detection/identification method.
* [1] source (vivo R1-2007666)considers it is beneficial to support differential positioning technique and machine learning technique for improving the accuracy in the presence of NLOS errors.
* [1] source (vivo R1-2007666)consider the positioning performance of LOS/NLOS detection method degrades as the LOS/NLOS detection incorrectly rate increases.

Comments

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| **Company** | **Comments** |
| Huawei/HiSilicon | If proposal 4-1 (Revision 3) cannot have consensus, we think that it is because companies have different preference on particular enhancement, and we do not see possibility of settle them in this meeting. At least from our side, we can still have time to address the note in the second bullet during the WI phase, and thus the first bullet proposal 4-1 is the common ground among companies’ interests, and should be a compromise for companies to be agreed as recommended for normative work. |
| ZTE | Majority of companies support the enhancement, so we can approve proposal 4-1 (Revision 3) first.Then detailed techniques can be discussed in WI phase. |
| vivo | We are okay with this formulation. But please add the following sub-bullet to capture vivo’s view:   * [1] source (vivo) consider the positioning performance of LOS/NLOS detection method degrades as the LOS/NLOS detection incorrectly rate increases. |
| Lenovo, Motorola Mobility | Support |
| Qualcomm | From the 12 companies that seem to be supporting the LOS/NLOS topic, how many companies find beneficial to support:   * Enhancements in Reference Signals ? * Enhancements in Measurements ? * Enhancements in Reporting ?   Without understanding what the impact, or what the companies find beneficial, it is difficult to argue that we have concluded successfully this scope of the study item. At least in the 2nd bullet, some proposals are more clear; not all of them, still unclear how these are different:   * angular information (Samsung, CEWiT, Ericsson), angle information report associated with multi-paths (Huawei) |
| Futurewei | This should not be a standalone proposal. Rather, in our view, the question for this proposal is whether it should be added to the Proposal 4-1 (Revision 3) or not as additional information. |
| CMCC | We believe companies shared the same view that multipath is one of the main factors that degrades the positioning accuracy, and should be enhanced in R17 WI to attain the target sub-meter accuracy. Therefore, we think that a common statement that enhancements on multipath mitigation/utilization are recommended for normative work (e.g. main bullet of Proposal 4-1 Revision 3) needs to be agreed. For the detailed scope, if companies cannot reach a consensus, we are ok to capture the above TP in the TR. |
| FL | For Huawei’s, ZTE’s and CMCC’s comment, yes, we will try to see if we can make the agreement of the first bullet in the meeting without the second bullet.  For vivo’s comment, the proposed sub-bullet is added.  For Qualcomm’s comment to further list the companies that supporting different enhancements of RS, measurement, and reporting, my assumption is that most companies are supportive for the reporting the NLOS identification after the detection of the NLOS.  For Futurewei’s comment, the intention of the Proposal 4-1 (Revision 3 Alternative) is to be used when we could not reach the consensus to support Proposal 4-1 (Revision 3). |
| MTK | We kind of agree with QC’s view in above.  We support 2nd bullet, which is additional reporting |
| Huawei/HiSilicon | To QC  In our understanding, this is all about “reporting”. The angle information reporting from our side means that gNB will provide additional UL AoA with respect to each path. It is shown in our paper R1-2008321 to be beneficial for path-VA association if we want to use reflecting path for positioning. |
| Xiaomi | Proposal 4-1 (Revision 3 Alternative) is also acceptable for us. |
| CATT | Support it as the alternative, if we cannot reach the consensus.  We add our name in the first bullet to support the LOS/NLOS detection and identification method. |
| OPPO | Support Proposal 4-1 (Revision 3 Alternative) as it reflects the current status. As some companies are claiming additional reporting is beneficial, there are too many proposed alternatives (8 or more?) for potential enhancement. If even some alternative can get some performance gain in some cases, we don’t think our group can have enough time to do sufficient simulations to identify it from so many alternatives. We are afraid the situation will be similar as NOMA session if we go further. |
| CEWiT | We support this proposal in principle. Reporting the angle (AoA) measurements for all the (LOS and NLOS) paths helps improve the accuracy of position estimates. Our proposal is on similar lines to multipath reporting. The UE should report the path angles (AoA), path power, and confidence of each path being LOS along with RSTD. Further, the BS should also report path-AoD to LMF. The enhanced reporting not only helps in the LOS/NLOS classification and mitigation but is also useful in improving the positioning accuracy using DL-TDoA+DL-AoD+DL-AoA based hybrid positioning methods at LMF. |
| LG | We are OK to capture the FL’s proposal 4-1(Revision 3 Alternative) in TR, and we have minor suggestion to correct typo as follows:  [15] sources ~~have~~ (Futurewei, Huawei, vivo, CATT, TCL, Lenovo, CMCC, Xiaomi, OPPO, Nokia, Sony, InterDigital, LGE, Qualcomm, CEWiT) have investigated and/or evaluated the multipath mitigation techniques for improving positioning accuracy. Among them: |
| Sony | Support the first two main bullets. |

FL comments

Based on today’s online discussion, it was suggested to include some observations and/or evaluation results before making recommendation of an enhancement. Proposal 4-1 is revised as follows for further comments.

Proposal 4-1 (Revision 4)

Capture the following in TR:

[18] sources (Futurewei, Huawei, vivo, CATT, TCL, Lenovo, CMCC, Xiaomi, OPPO, Nokia, Sony, InterDigital, LGE, Qualcomm, CEWiT, Fraunhofer, Ericsson, ZTE) have investigated and/or evaluated the multipath mitigation techniques for improving positioning accuracy. The evaluation results with different he multipath mitigation techniques are presented in Section 8 in the TR. Additionally,

* [13] sources (Futurewei, Huawei, Intel, Lenovo, Samsung, Nokia, Sony, LGE, InterDigital, Fraunhofer, Ericsson,CEWiT, CATT) consider it is beneficial to support the LOS/NLOS detection, identification and reporting of the information related to LOS/NLOS detection and identification (e.g., the confidence metric).
* Multiple sources consider it is beneficial to support enhancements of additional reporting from UE and gNB for multipath mitigation, e.g., power and/or relative power (Futurewei, Intel, Ericsson), additional paths and their corresponding relative powers (Qualcomm, Ericsson, Fraunhofer, Sony),, angle information report associated with multi-paths (Samsung, CEWiT, Ericsson, Sony Huawei), coherence bandwidth (ZTE), Doppler effect (Intel, Ericsson), K-factor (Intel), coherence bandwidth (ZTE), the arrival time of each beam (Xiaomi), SNR (Ericsson) etc.
* [3] sources (vivo, OPPO, Qualcomm) consider it is not beneficial to support LOS/NLOS detection/identification method.
* [1] source (vivo) considers it is beneficial to support differential positioning technique and machine learning technique for improving the accuracy in the presence of NLOS errors.
* [1] source (vivo) considers the positioning performance of LOS/NLOS detection method degrades as the LOS/NLOS detection incorrectly rate increases.

Based on the investigation, enhancements of information reporting from UE and gNB for supporting multipath mitigation can be studied further, and if needed, specified during normative work for improving positioning accuracy.

* Note: The details of the enhancements of reporting are left for further discussion in normative work, which may include, but not limited to the following information associated with multi-paths, e.g., LOS/NLOS identification, time of arrival of the multi-paths, signal power and/or relative power, power delay profile, angle, and/or polarization information, channel information etc.

Comments

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| **Company** | **Comments** |
| Huawei/HiSilicon | Support. |
| CATT | Support. |
| vivo | We can compromise with “can be considered for normative work” considering the benefit is unclear at least for us |
| LG | Support |
| OPPO | Regarding the recommendation, we suggest to use the similar wording as Proposal 2.1, e.g., can be studied further and if needed, specified during normative work |
| Fraunhofer | It is better to clarify the second bullet:  From our view reporting can be the channel state (LOS/NLOS). The UE (or TRP in UL case) can use any measurement to estimate the channel state.  Another option is that additional measurements (listed in proposal) are reported to the LMF which estimates the channel state.  Proposed modification on the second bullet can be:   * Multiple sources (Fraunhofer,…) consider it is beneficial to support enhancements of reporting a LOS/NLOS channel state information from UE and gNB for multipath mitigation, * Multiple sources consider it is beneficial to use or report the following measurements from UE and gNB for multipath mitigation, e.g., power and/or relative power (Futurewei, Intel, Ericsson), additional paths and their corresponding relative powers (Qualcomm, Ericsson, Fraunhofer), angular information (Samsung, CEWiT, Ericsson), angle information report associated with multi-paths (Huawei), coherence bandwidth (ZTE), Doppler effect (Intel, Ericsson), K-factor (Intel), the arrival time of each beam (Xiaomi), SNR (Ericsson) etc. |
| FL | For vivo and OPPO’s comments, it might be good to compromise use “can be studied further and if needed, specified during normative work” as compromise instead of “recommended for normative work”.  For Fraunhofer’s comment, my suggestion is not to add “a LOS/NLOS channel state information”, since the enhancements of reporting is not limited to the “LOS/NLOS channel state information”. Also, it seems to me that add “ to use or report the following measurements” may not be needed, since the information for reporting may not necessarily be limited to the “measurements” |
| Futurewei | Support. Propose to add polarization information into the Note:   * Note: The details of the enhancements of reporting are left for further discussion in normative work, which may include, but not limited to the following information associated with multi-paths, e.g., LOS/NLOS identification, time of arrival of the multi-paths, signal power and/or relative power, power delay profile, angle and/or polarization information, channel information etc. |
| Nokia/NSB | Support the revision and are also okay to use “can be studied further…” as suggested by vivo. |
| Qualcomm | In light of OPPO, vivo and FL suggestion, and in the spirit of not spending too much online, we also support FL’s suggestion to change it to “**can be studied further and if needed specified during normative work**” so that we break this deadlock before going online. Clearly there is no consensus on what needs to be specified, but there is a lot of support on doing some enhancement on the reporting aspect, but since we haven’t been able to nail down exactly what that should be, a way to proceed is to continue during the WI phase. Hopefully during the WI we may be able to have a consensus on what is really useful to be reported.  From our side, and in the spirit of further technical discussion, we really want to ask companies to look into the following aspects during the phase of “additional study” that they plan to do:   * Wouldn’t a LOS/NLOS flag be computed mainly based on a quantized PDP and angle information? Why not enhance the reporting of these “fundamental quantities” rather than trying to agree on “by-products”; each company would have its favorite byproduct (k-factor, coherence BW, kyrtosis, and many many others that one can found in the academic literature)? Similarly, if K-factor or coherence BW is the proposal by some companies, isn’t this something that the server can compute using a quantized PDP feedback? * Why “a LOS/NLOS flag”, which would not be specified how is computed (i.e. it will be left up to UE implementation), would be better than a higher-information feedback like a quantized PDP? * Why do companies think that the “quality metric” already specified does not include LOS/NLOS information? Why isn’t a reasonable UE/gNB implementation to decrease the quality of a link if it considers that a link is NLOS? Either way, how the “quality metric” is implemented is up to each UE implementation, and likely already can use it for the purpose that the companies suggest. It would be great if the companies explain why the already specified “quality metric” cannot be used an indicator that a measurement is “bad”, where the level of how bad is, may already depend on whether the UE thinks it is LOS or NLOS? * Companies that show results with “LOS/NLOS flag” over results without such flag, should also include comparison with optimized outlier rejection algorithms and try to make sure that indeed this additional reporting is useful. |
| Futurewei | We can also support QC’s proposal of using “**can be studied further and if needed specified during normative work**” in order to have consistent wording on on any items/enhancements that cant be agreed directly as part of normative work, but also considered a ‘second’ level agreement over over other enhancements that is not being part of the study in the normative phase. This understanding is important to clarify the meaning of all these agreements that we are making. |
| vivo 2 | For the sake of progress, we can compromise to the following statement:  Based on the investigation, enhancements of information reporting from UE and gNB for supporting multipath mitigation can be studied further and if needed, specified during normative work.  We have a clarification question on the 1st and 2nd bullet of observations on each source’s investigation. Is the “LOS/NLOS detection and identification method” the same as or a subset of “enhancements of information reporting from UE and gNB”? If it is, then we suggest not duplicating observations of the same thing and only need to keep one bullet. If companies think they are different, then we’d like to understand what exactly is the proposal for further study? |
| FL | Thanks for the discussions. It seems we may have the compromised resolution with the words “can be studied further and if needed, specified during normative work”. The proposal is updated for further comments.  For vivo’s comment, my understanding 1st and 2nd bullets are different. My understanding is that for 2nd bullet, UE/gNB reports the information without indicating whether measurements are from the LOS/NLOS, the receiving side will make the decision of LOS/NLOS, while the 1st bullet is that UE/gNB reports the measurement with the indication of the LOS/NLOS. |
| vivo 3 | Thanks for FL’s explanation. So you are saying that [13] sources’ investigations showed that they see the benefits of improving accuracy with LOS/NLOS identification (e.g., a flag) only without any other enhancements of information reporting? We’re not sure that’s the case.  If so, we’d like to get confirmation from all [13] sources that they see the benefits of improving accuracy with LOS/NLOS identification (e.g., a flag) only without any other enhancements of information reporting.  Our understanding of many sources’ investigation is that the potential benefits actually stem from the extra information reporting not just a simple flag which is why we are willing to compromise for further study.  We propose to clearly and correctly capture the observations into the TR. |
| Huawei/HiSilicon | We are OK with the compromised solutions.  In response to QC’s question, we assume that we are potentially discussing different algorithms at LMF, which is a server in the core network. To us, leaving the judgement to RAN/UE on LOS/NLOS identification may reduce the LMF load, and fully utilize the RAN/UE expertise, and since RAN/UE is anyway processing signals, the effort of extracting such information (LOS/NLOS status) is marginal. |
| Xiaomi | Support |
| LG | We are fine with the modified proposal. |
| ZTE | 1. The evaluation result in our contribution assumes that additional assistance information is reported rather than a flag. So we suggest to remove our company name from first sub-bullet. If some companies evaluated the LOS/NLOS identification (e.g., a flag) , please conform that the first sub-bullet should be kept . Otherwise, it can be put in proposal as further enhancement instead of observation. 2. To QC, we agree that K-factor or coherence BW can be computed using a quantized PDP feedback. But we should consider quantized PDP feedback may lead to the large report overhead , it’s better that UE estimates channel information( e.g. K-factor or coherence BW) to compress overhead. Anyway, those can be discussed in WI phase.   3.We are generally fine with the proposal. But to be fair, can you also include “coherence bandwidth” in the list. |
| CATT | Support the updated proposal. With such wording, it means we can firstly study the benefits and feasibility of multipath mitigation techniques in Rel-17 WI, then decide whether and how to specify it in Rel-17. |
| CMCC | Support the FL updated proposal.  Regarding the first 2 observation bullets of Proposal 4-1 (Revision 4), here is my understanding:  By reading companies' contributions and following the discussion, to my understanding, the first bullet is related to UE/gNB report the LOS/NLOS status (hard or soft) to the LMF, the NLOS links would be discarded or mitigated when calculating the position. For the second bullet, richer information of multi-paths are reported, with which the LMF may adopt more advanced algorithms to further improve the detection/identification performance of LOS/NLOS. On the other hand, the LMF can also utilize these information to further improve the accuracy (e.g., to use the angle of the reflecting path for accuracy performance enhancement) |
| Ericsson | Support. Note: It seems Ericsson is missing from the first list of [15] sources, which should include all sources listed in the bullets below if our understanding is correct. |
| OPPO | Support the updated proposal |
| Lenovo, Motorola Mobility | Support the updated compromised proposal. Minor typo in the main proposal “normative work” repeated. |
| Nokia/NSB2 | Support the latest Revision 4. Question for my understanding, we will agree to both the bottom part and the observation/summary of company views? If so, will they go in different parts of the TR (or is that a separate discussion)? |
| CEWiT | Our understanding with 1st bullet is that we are identifying the need for the LOS/NLOS indication from UE and gNB. On the other hand, 2nd bullet mentions the actual methods/quantities to be reported from UE and gNB for NLOS/LOS detection and indication.  We would like to add the LOS confidence level reporting in the second bullet which will be used to weigh the reported quantities per path at the LMF for LOS/NLOS indication and help reduce computational complexity of method at the LMF.  Modification could be,   * Multiple sources consider it is beneficial to support enhancements of reporting from UE and gNB for multipath mitigation, e.g., power and/or relative power (Futurewei, Intel, Ericsson, CEWiT), additional paths and their corresponding relative powers (Qualcomm, Ericsson, Fraunhofer), angular information (Samsung, , Ericsson), angle information report associated with multi-paths (Huawei, CEWiT), coherence bandwidth (ZTE), Doppler effect (Intel, Ericsson), K-factor (Intel), the arrival time of each beam (Xiaomi), SNR (Ericsson), ), LOS confidence metric (CEWiT) etc.   Another modification from our side is that we added CEWiT support to “angle information report associated with multi-paths” instead of “angular information” that is what we expected in our contribution. |
| FL | For the discussion around vivo’s comment on the discussion of the difference of the 1st and 2nd sub-bullet, I added “reporting from UE and/or gNB” in 1st sub-bullet and “additional” reporting in the 2nd sub-bullet to distinguish these two sub bullets.  Also, make the changes with the consideration of ZTE, Ericsson and Lenovo’s comments.  For Nokia’s comment, the intention is to discuss both parts to see if we can agree both or only one of them. How to capture in the TR can be further discussed in TR preparation.  For CEWiT, the reporting of the information related to LOS/NLOS identification (e.g., confidence metric) should be the 1st subbullet. I assume a number of companies (e.g., Intel) have made the similar proposal. |
| Sony | We would like to add our company position for the second bullet:   * Multiple sources consider it is beneficial to support enhancements of additional reporting from UE and gNB for multipath mitigation, e.g., power and/or relative power (Futurewei, Intel, Ericsson), additional paths and their corresponding relative powers (Qualcomm, Ericsson, Fraunhofer, Sony), angular information (Samsung, CEWiT, Ericsson, Sony), angle information report associated with multi-paths (Huawei), coherence bandwidth (ZTE), Doppler effect (Intel, Ericsson), K-factor (Intel), coherence bandwidth (ZTE), the arrival time of each beam (Xiaomi), SNR (Ericsson) etc. |
| Intel | Support with modification as below:  [18] sources (Futurewei, Huawei, vivo, CATT, TCL, Lenovo, CMCC, Xiaomi, OPPO, Nokia, Sony, InterDigital, LGE, Qualcomm, CEWiT, Fraunhofer, Ericsson, ZTE) have investigated and/or evaluated the ~~multipath~~ NLOS excess delay mitigation techniques for improving positioning accuracy. The evaluation results with different he ~~multipath~~ NLOS excess delay mitigation techniques are presented in Section 8 in the TR. Additionally,  We think that “multipath mitigation” is a confusing term, therefore propose to replace it with “NLOS excess delay mitigation” to clarify the proposal. |
| CEWiT 2 | Regarding 2nd bullet again one clarification question what is the difference between “power and/or relative power (Futurewei, Intel, Ericsson)” and “additional paths and their corresponding relative powers (Qualcomm, Ericsson, Fraunhofer, Sony)”?  Similarly, what is the meaning of additional path? is it the additional measurements above Rel16 measurement? But in that case, we don’t have power reporting in Rel16.  We support reporting the power(relative power) per path. So, we would like to be in either of the options but not now sure the details about the two. |
| FL | Add ‘Sony’ after angle information based on Sony’s comment.  For Intel’s comment, my understanding is that “multipath mitigation” is a term that is commonly used and understood in positioning and navigation fields. But, “NLOS excess delay mitigation” is not a popular term to my knowledge. Thus, suggest keeping “multipath mitigation”.  For CEWiT’s comment on the power and/or relative power, and “additional paths and their corresponding relative powers”, my understanding is that the Rel-16 has already supported the measurements related to 3 paths. The former is about the power information related to the up to 3 paths, e.g., the first arrival path, as indicated in their proposals. The latter is about to support reporting more than 3 paths and their power information. |

FL Comments

We have gone through very intensive discussion on Proposal 4-1 (Revision 4). It seems the proposal is near stable. Suggest further discuss whether we can reach the consensus to consider the enhancements of information reporting from UE and gNB for supporting multipath mitigation. If we cannot reach the consensus, suggest capturing the TP that summarise the discussion into the TR as an alternative.

### (Closed) Proposal 4-1 (Revision 5)

Enhancements of information reporting from UE and gNB for supporting multipath/NLOS mitigation can be studied further, and if needed, specified during normative work for improving positioning accuracy.

* Note: The details of the enhancements of reporting are left for further discussion in normative work, which may include, but not limited to the following information associated with multi-paths, e.g., LOS/NLOS identification, time of arrival of the multi-paths, signal power and/or relative power, power delay profile, angle, and/or polarization information, coherence bandwidth, channel information etc.

*If we cannot reach the consensus on above proposal, suggest capturing the following in TR as an alternative:*

[18] sources (Futurewei, Huawei, vivo, CATT, TCL, Lenovo, CMCC, Xiaomi, OPPO, Nokia, Sony, InterDigital, LGE, Qualcomm, CEWiT, Fraunhofer, Ericsson, ZTE) have investigated and/or evaluated the multipath mitigation techniques for improving positioning accuracy. The evaluation results with different he multipath mitigation techniques are presented in Section 8 in the TR. Additionally,

* [13] sources (Futurewei, Huawei, Intel, Lenovo, Samsung, Nokia, Sony, LGE, InterDigital, Fraunhofer, Ericsson,CEWiT, CATT) consider it is beneficial to support the LOS/NLOS detection, identification and reporting of the information related to LOS/NLOS detection and identification (e.g., the confidence metric).
* Multiple sources consider it is beneficial to support enhancements of additional reporting from UE and gNB for multipath mitigation, e.g., power and/or relative power (Futurewei, Intel, Ericsson), additional paths and their corresponding relative powers (Qualcomm, Ericsson, Fraunhofer, Sony),, angle information report associated with multi-paths (Samsung, CEWiT, Ericsson, Sony Huawei), coherence bandwidth (ZTE), Doppler effect (Intel, Ericsson), K-factor (Intel), the arrival time of each beam (Xiaomi), SNR (Ericsson) etc.
* [3] sources (vivo, OPPO, Qualcomm) consider it is not beneficial to support LOS/NLOS detection/identification method.
* [1] source (vivo) considers it is beneficial to support differential positioning technique and machine learning technique for improving the accuracy in the presence of NLOS errors.
* [1] source (vivo) considers the positioning performance of LOS/NLOS detection method degrades as the LOS/NLOS detection incorrectly rate increases.

Comments

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| --- | --- |
| **Company** | **Comments** |
| CATT | Support. |
| LG | Support this proposal (revision 5) |
| Huawei/HiSilicon | Support. |
| vivo | Support alternative proposal with modification as below to avoid duplication:   * Multiple sources consider it is beneficial to support enhancements of additional reporting from UE and gNB for multipath mitigation, e.g., power and/or relative power (Futurewei, Intel, Ericsson), additional paths and their corresponding relative powers (Qualcomm, Ericsson, Fraunhofer, Sony),~~,~~ angle information report associated with multi-paths (Samsung, CEWiT, Ericsson, Sony Huawei), coherence bandwidth (ZTE), Doppler effect (Intel, Ericsson), K-factor (Intel), ~~coherence bandwidth (ZTE)~~, the arrival time of each beam (Xiaomi), SNR (Ericsson) etc. |
| ZTE | We support Proposal 4-1 (Revision 5). There are two comments from our side,   1. We would like to include “coherence bandwidth “ in the note of Proposal 4-1 (Revision 5). 2. Agree with vivo’s modification. |
| Intel | Support. Suggest replacing “multipath mitigation” to “NLOS mitigation”. |
| Xiaomi | Support |
| Lenovo, Motorola Mobility | Support |
| OPPO | Support |
| FL | Changes are made based on the comments from vivo and ZTE, i.e., add “coherence bandwidth” into the note of the Proposal 4-1 (Revision 5), and remove the redundant “coherence bandwidth (ZTE)”  For Intel’s comment, yes, both “multipath mitigation” and “NLOS mitigation” are used in the literatures, but they may refer to same scenarios in some literatures, while refer to different scenarios in others. The list of proposed enhancements cover both. Thus, suggest change “multipath mitigation” to “NLOS/multipath mitigation”.    Reference: Mark Petovello, “Multipath vs. NLOS signals”, InsideGNSS, Nov/Dec 2013. |
| CMCC | Support |

## Additional UE/gNB measurements

Background

In addition to the measurements proposed for multipath mitigation discussed in the previous section, new types of the measurements are proposed, mainly for the enhancements of the DL/UL positioning accuracy and reliability.

Submitted Proposals

* (CATT R1-2007755) Proposal 17:
  + Support NR carrier phase measurements for DL positioning in Rel-17. The reference signals for DL carrier phase measurements are NR DL reference signals (e.g., DL PRS)
* (CATT R1-2007755) Proposal 18:
  + Support NR carrier phase measurements for UL positioning in Rel-17. The reference signals for UL carrier phase measurements are NR UL reference signals (e.g., UL SRS for positioning)
* (CATT R1-2007755) Proposal 19:
  + Consider supporting the carrier phases measurements from two or more carrier frequencies for fast resolution of the integer ambiguity.
* (Fraunhofer R1-2008841) Proposal 4:
  + Consider carrier phase measurements for positioning in both UL and DL timing-based methods at least in FR1.
* (Ericsson R1-2008765) Proposal 10:
  + Consider absolute time reporting in release 17 measurement reports

Feature lead’s view

The above proposals were discussed in RAN1#102e without the consensus. We may check again the companies’ views on whether to support above new positioning measurements.

### Proposal 4-2

* The new UE/gNB measurements for the enhancements of the positioning performance can be considered for normative work, which may include:
  + Carrier phase measurements
  + Absolute time reporting

Comments

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| **Company** | **Comments** |
| CATT | Support Proposal 4-2. In our point view, carrier phase measurement can be further studied during the WI phase. |
| Fraunhofer | Support. |
| MTK | We can consider carrier phase measurement in Rel-18 at least starting from a SID. |
| CMCC | We are okay with this proposal.  To our understanding, the carrier phase measurement can theoretically improve the accuracy performance, and the performance gain under InF-HH scenario is shown in CATT’s contribution. However, we still wonder the benefits under other scenarios, especially those with rich NLOS paths. |
| Sony | We are fine with absolute time reporting. We are not sure with the carrier phase measurements. |
| Nokia/NSB | Same view as MTK. |
| ZTE | Same view as MTK. |
|  |  |

## Other issues related to the UE/gNB measurements and reporting

Background

In this section, we discuss the proposed enhancements related to the UE/gNB measurements for increasing positioning accuracy, reducing the latency and improving the efficiency that are not covered in previous sections.

Submitted Proposals

* (vivo R1-2007666) Proposal 33:
  + Introduce 10 ms level granularity for the response time and reporting intervals in *CommonIEsRequestLocationInformation*.
* (vivo R1-2007666) Proposal 36:
  + For UE power saving perspective, support to introduce positioning measurement window in Rel-17.
* (vivo R1-2007666) Proposal 37:
  + For UE power saving perspective, the following approaches are benefit and should be considered in Rel-17.
    - Extending PRS period
    - Reducing the number of TRPs to be measured
    - Reducing the number of positioning frequency layers to be measured
* (LG R1-2008417) Proposal 1:
  + For the improved positioning accuracy, RAN1 needs a method/signalling to enable the UE and gNB to use the same measurement averaging rule for Rx-Tx time difference for periodic PRS resource(s) and SRS resource(s).
* (Qualcomm R1-2008619) Proposal 6:
  + Support the reporting of additional motion state / kinematics constraints information for both UE-based and UE-assisted including, but not limited to, signaling of side information/constraints on potential trajectory, path, velocity, direction of the target device.
* (Qualcomm R1-2008619) Proposal 11:
  + Support enhancements in the reporting of the positioning measurements (from the UE and the gNB) to enable reporting measurements of each Measurement Occasion (MO):
    - Introduce additional reporting periodicities,
    - Enable multiple measurement reporting from different timestamps derived on the same TRP/PRS resources
* (Qualcomm R1-2008619) Proposal 12:
  + Support Enhanced PRS processing capabilities:
    - Increased number of PRS resources processing per unit of time.
* (Qualcomm R1-2008619) Proposal 16:
  + For the purpose of enhanced efficiency, support reusing SRS for MIMO for the purpose of Positioning measurements.
* (Ericsson R1-2008765) Proposal 11:
  + RAN1 should with help from RAN4 study the possibility to define define two (or multiple) sets of requirements (based on UE-capabilities) for RSTD accuracy, UE RX-TX time difference accuracy and UE TX timing accuracy in order to accommodate for both general purpose eMBB Ues and for Ues requiring high (sub-meter) accuracy positioning in e.g. I-IoT scenarios.
* (Ericsson R1-2008765) Proposal 12
  + Send LS to RAN4, requesting RAN4 to investigate the possibility to define two (or multiple) sets of requirements (based on UE-capabilities) for RSTD accuracy, UE RX-TX time difference accuracy and UE TX timing accuracy in order to accommodate for both general purpose eMBB Ues and for Ues requiring high (sub-meter) accuracy positioning in e.g. I-IoT scenarios.
* (Ericsson R1-2008765) Proposal 17
  + In order to maintain accuracy, the target latency must factor the need for tracking measurement, i.e. UE mobility
* (Ericsson R1-2008765) Proposal 19:
  + Introduce signaling of a threshold relative to the strongest peak for the UE search of the first peak and define the DL RSTD and UE RX-TX time difference measurements based on the first identified peak which is stronger than the strength of the strongest peak multiplied with the signaled relative threshold factor.
* (Ericsson R1-2008765) Proposal 20:
  + RAN1 to study network control of thresholds for the UE search for the first peak including threshold relative to the estimated noise level (aimed at avoiding noise peaks), threshold relative to the strongest peak (aimed at avoiding channel peaks with delay longer than the measurement range) and delay dependent thresholds (aimed at avoiding side peaks).

Feature lead’s view

For vivo’s proposal to introduce 10 ms level granularity for the response time and reporting intervals in *CommonIEsRequestLocationInformation*, suggest delaying the discussion to WI phase since the issue is related a particular value of the parameter, which is normally decided in WI phase.

For vivo’s proposal to extend PRS period, reducing the number of TRPs to be measured, and the number of positioning frequency layers to be measured, suggest delaying the discussion to WI phase since these numbers are related to UE’s capability and normally determined during the WI phase.

For Qualcomm’s proposal to support enhanced PRS processing capabilities by increasing the number of PRS resources processing per unit of time, suggest delaying the discussion to WI phase since these numbers are related to UE processing capability are normally discussed during WI phase.

For Ericsson’s proposal to study the define of two (or multiple) sets of measurement accuracy requirements, suggest delaying the discussion to WI phase since the accuracy requirements will be related to the enhancements to be developed in R17, and it is too early for RAN4 to consider measurement accuracy requirements.

For Ericsson’s proposal to factor the need for tracking measurement for the target latency, the issue can be discussed in AI 8.3.1, where the target latency is discussed.

For other proposals, suggest discussing them separately in this meeting.

### Proposal 4-3a

* + The introduction of the positioning measurement window can be considered for normative work.

Comments

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| --- | --- |
| **Company** | **Comments** |
| CATT | Support Proposal 4-3a. |
| Huawei/HiSilicon | Support. |
| vivo | Support. |
| ZTE | We think the enhancement is related to latency reduction, it can be discussed in proposal 5-4. |
| Qualcomm | Support |
|  |  |

### Proposal 4-3b

* + The enhancement of the method/signalling to enable the UE and gNB to use the same measurement averaging rule for Rx-Tx time difference for periodic PRS resource(s) and SRS resource(s) can be considered for normative work.

Comments

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| **Company** | **Comments** |
| CATT | Support Proposal 4-3b. |
| LG | Support this proposal.  For the high accuracy of the positioning measurement, periodic and/or semi-persistent reporting for the periodic PRS resource(s) and the periodic positioning SRS resource(s) is important since both of the UE and gNB are able to obtain the “UE Rx-Tx time difference measurement” and “gNB Rx-Tx time difference measurement” multiple shots/times so that  the noise effect can be reduced. In general, the UE and the gNB perform averaging across multiple Rx-Tx time difference measurements for the measurement reporting.  In general, the UE/gNB ignallin for measurement averaging would be left up to implementations. However, if it is left up to implementations, it could lead to degrade the positioning accuracy perforamcne. As we described this issue in our contribution (R1-2008417), the UE and the gNB have different ignallin for the measurement averaging for the periodic PRS resource(s) and the SRS resource(s) up to their implementations. For sub-meter level accuracy, we think that the aligned averaging rule is required for both of the UE and the gNB. |
| Huawei/HiSilicon | We are not sure whether the average rule will be specified. At least for Rel-16, there is no layer-3 filtering for positioning measurement except for the DL E-CID. The solution can be via what is proposed in Proposal 4-3c. |
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### Proposal 4-3c

* + The enhancements in the reporting of the positioning measurements (from the UE and the gNB) to enable reporting measurements of each Measurement Occasion (MO) can be considered for normative work, which include
    - Introduce additional reporting periodicities,
    - Enable multiple measurement reporting from different timestamps derived on the same TRP/PRS resources

Comments

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| **Company** | **Comments** |
| InterDigital | The proposal can be generalized as follows. We agree that enhancements for reporting are needed, but more general scope is desired since other enhancements may have an impact on the reporting procedure.  The enhancements in the reporting of the positioning measurements (from the UE and the gNB) ~~to enable reporting measurements of each Measurement Occasion (MO)~~ can be considered for normative work, which include but not limited to the following   * + - Introduce additional reporting periodicities,     - Enable multiple measurement reporting from different timestamps derived on the same TRP/PRS resources |
| CATT | Support Proposal 4-3c. |
| Huawei/HiSilicon | Support. |
| Qualcomm | Support |
| LG | Support |
| ZTE | The proposal is not clear to us. From our understanding, we don’t have the definition of MO in Rel-16. |

### Proposal 4-3d

* Introduce signaling of a threshold for the UE search of the first peak for DL RSTD and UE RX-TX time difference measurements can be considered for normative work. The candidate thresholds may include:
  + the threshold relative to the estimated noise level (aimed at avoiding noise peaks),
  + the threshold relative to the strongest peak (aimed at avoiding channel peaks with a delay longer than the measurement range)
  + delay dependent thresholds (aimed at avoiding side peaks).

Comments

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| **Company** | **Comments** |
| InterDigital | Threshold relative to RSRP is also a candidate. |
| CATT | Support Proposal 4-3d. |
| Huawei/HiSilicon | Based on the description, it can be left up to UE implementation. |
| Sony | Support |
| Fraunhofer | The proposal is related to UE implementation |
| Qualcomm | Up to UE implementation |
| MTK | Seems not needed. UE can also report additional paths with relative power |
| ZTE | It seems to be UE implementation. |

### Proposal 4-3 (Revision 1)

Capture the following in TR:

The following enhancements were proposed related to the UE/gNB measurement reporting for increasing positioning accuracy, reducing the latency and improving the efficiency:

* [1] source (vivo) proposed the following enhancements for UE power saving perspective:
  + Introducing positioning measurement window
  + Extending PRS period
  + Reducing the number of TRPs to be measured
  + Reducing the number of positioning frequency layers to be measured
* [1] source (LG R1-2008417) proposed the enhancement of the method/signalling to enable the UE and gNB to use the same measurement averaging rule for Rx-Tx time difference for periodic PRS resource(s) and SRS resource(s) for the improved positioning accuracy;
* [1] source (Qualcomm R1-2008619) proposed the enhancements in the reporting of the positioning measurements (from the UE and the gNB), including
  + additional motion state / kinematics constraints information for both UE-based and UE-assisted including, but not limited to, signaling of side information/constraints on potential trajectory, path, velocity, direction of the target device
  + additional reporting periodicities
  + multiple measurement reporting from different timestamps derived on the same TRP/PRS resources
* [1] source (Ericsson R1-2008765) proposed to introduce signaling of a threshold relative to the strongest peak for the UE search of the first peak and define the DL RSTD and UE RX-TX time difference measurements based on the first identified peak which is stronger than the strength of the strongest peak multiplied with the signaled relative threshold factor.
* [1] source (Ericsson R1-2008765) proposed to study network control of thresholds for the UE search for the first peak including threshold relative to the estimated noise level (aimed at avoiding noise peaks), threshold relative to the strongest peak (aimed at avoiding channel peaks with delay longer than the measurement range) and delay dependent thresholds (aimed at avoiding side peaks).

Comments

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| **Company** | **Comments** |
| CATT | Support. |
| LG | Support  We have the same comment. For the high accuracy of the positioning measurement, periodic and/or semi-persistent reporting for the periodic PRS resource(s) and the periodic positioning SRS resource(s) is important since both of the UE and gNB are able to obtain the “UE Rx-Tx time difference measurement” and “gNB Rx-Tx time difference measurement” multiple shots/times so that  the noise effect can be reduced. In general, the UE and the gNB perform averaging across multiple Rx-Tx time difference measurements for the measurement reporting.  In general, the measurement averaging would be left up to implementations. However, if it is left up to implementations, it could lead to degrade the positioning accuracy perforamcne. As we described this issue in our contribution (R1-2008417), the UE and the gNB have different ignallin for the measurement averaging for the periodic PRS resource(s) and the SRS resource(s) up to their implementations. For sub-meter level accuracy, we think that the aligned averaging rule is required for both of the UE and the gNB. |

# Enhancements of positioning methods and measurement procedure

## UE positioning in idle/inactive states

Background

UE positioning in idle/inactive states was discussed in Rel-16, but not supported. In RAN1#102-e, the following agreement was made

|  |
| --- |
| Agreement:   * NR positioning for Ues in RRC\_IDLE state and Ues in RRC\_INACTIVE state will be investigated in Rel-17, including the benefits on latency, network/UE efficiency and UE power consumption * FFS: which positioning methods to be supported, e.g., DL positioning, UL positioning, DL+UL positioning and/or Multi-RTT * FFS: the details of how to enable the UE positioning in RRC\_IDLE state and RRC\_INACTIVE state   + Reference signals (e.g., based on DL PRS signals, UL SRS signals, both of them, etc.)   + Signaling and procedures (e.g., based on PRACH procedure, paging triggered UL SRS transmission, etc.) |

Submitted Proposals

* (Futurewei R1-2007552) Proposal 5:
  + Extend the support of Rel-16 positioning methods to Inactive and Idle Ues, at least for the DL positioning by adapting the Rel-16 DL PRS signals.
* (Huawei R1-2007577) Proposal 16:
  + Rel-17 should support
    - DL measurement in IDLE/INACTIVE state,
    - Measurement report for the DL measurement using small data,
    - SRS/PRACH transmission for the purpose of positioning in INACTIVE state.
* (Huawei R1-2007577) Proposal 17:
  + Rel-17 should support paging trigger non-periodic SRS transmission in INACTIVE state.
* (vivo R1-2007666) Proposal 2:
  + The enhancements are needed for positioning latency, network efficiency, and device efficiency
* (vivo R1-2007666) Proposal 20:
  + To enable UL idle/inactive state positioning in NR, a UE needs to keep dedicated UL resource (e.g. SRS) after leaving connected mode. With this enhancement, the UE can transmit dedicated UL signal for UL positioning.
* (vivo R1-2007666) Proposal 21:
  + For idle/inactive positioning, DL positioning method, UL positioning method and DL+UL positioning method should be supported
* (CATT R1-2007755) Proposal 3:
  + Positioning for Ues in RRC\_IDLE/INACTIVE states should be supported in Rel-17 for both UE-assisted and/or UE-based positioning with the enhancements as follows:
    - Using PRACH for UE in RRC\_IDLE/INACTIVE state for positioning purpose
    - Sending SRS-Pos for UE in RRC\_INACTIVE state.
* (CATT R1-2007755) Proposal 4:
  + Ues in RRC\_IDLE/INACTIVE state have three SRS configuration methods:
    - Using RRC connected state SRS-Pos configurations information.
    - Using SRS-Pos configuration information carried in the paging message.
    - Using SRS-Pos configuration information obtained by UE in a new RACH procedure
* (TCL R1-2007886) Proposal 1:
  + Support positioning in RRC\_IDLE/INACTIVE states.
* (Intel R1-2007946) Proposal 12:
  + Support NR positioning techniques for Ues in the RRC\_INACTIVE state
    - FFS: enhancements for RRC\_IDLE state
* (Intel R1-2007946) Proposal 13:
  + Enhance a two-step RACH mechanism to facilitate accurate low-latency NR positioning for Ues in RRC\_INACTIVE state
* (Lenovo R1-2007998) Proposal 7:
  + LMF should configure the appropriate DL-PRS configuration by taking into account the latency and accuracy requirements for RRC\_IDLE/ RRC\_INACTIVE state positioning.
* (Lenovo R1-2007998) Proposal 8:
  + Consider physical layer enhancements for lowering the DL-PRS configuration latency while in RRC\_IDLE/RRC\_INACTIVE state.
* (CMCC R1-2008015) Proposal 6: The following should be supported for UE positioning in idle/inactive state:
  + At least UE-based and UE-assisted DL positioning, and NW-assisted UL positioning should be supported
  + DL PRS and UL SRS should be supported
  + RACH procedure (2-step and 4-step) should be supported
  + Configuration, activation, and triggering of UL SRS transmission in idle/inactive state should be supported
* (Xiaomi R1-2008083) Proposal 8:
  + Measurement report can be sent to gNB by PUSCH in Msg 3 or Msg A during random access procedure for idle/inactive UE.
* (Xiaomi R1-2008083) Proposal 9:
  + Consider to pre-configure the PRS for idle/inactive UE when UE is in connected mode.
* (Xiaomi R1-2008083) Proposal 10:
  + Random access procedure can be reused for UL and DL&UL positioning of Idle/Inactive UE.
* (Xiaomi R1-2008083) Proposal 11:
  + Random access preamble can be reused as UL reference signal for Idle/Inactive UE.
* (Samsung R1-2008168) Proposal 2:
  + For UE positioning in RRC\_idle state and RRC\_inactive state,
    - PRACH preamble, PRS and SRS are starting point as a candidate reference signal
    - How to support large bandwidth to transmit/receive these reference signals for better positioning accuracy is studied
    - How to report the measurement by UE is studied in case PRS is utilized for the positioning
* (Samsung R1-2008168) Proposal 3:
  + When the location server initiates the location transfer procedure to UE in RRC\_idle and RRC\_inactive state, NR paging message can deliver the LPP Request Location information message. Details are up to RAN2.
* (OPPO R1-2008226) Proposal 12:
  + For NR positioning in RRC\_INACTIVE state and RRC\_IDLE state, support DL-based, UL-based and DL-based + UL-based method.
    - Support the UE to obtain positioning assistance data in system information broadcast.
    - Support the UE to request system information of positioning assistance data through a RACH
    - Support a RACH-like uplink PRS transmission in RRC\_INACTIVE and RRC\_IDLE state.
* (Nokia R1-2008301) Proposal 1:
  + Support RRC inactive and idle mode positioning for at least DL and UL RAT-dependent positioning methods.
* (Nokia R1-2008301) Proposal 2:
  + Support of DL RAT-dependent positioning methods for inactive modes should include at least measurement of DL PRS and reporting of measurements without moving to RRC connected state.
* (Nokia R1-2008301) Proposal 3:
  + Support use of small data transmission for DL PRS measurement reports (e.g., RSTD and PRS-RSRP).
* (Nokia R1-2008301) Proposal 4:
  + RAN1 to study how UL RAT-dependent positioning methods can also be supported in RRC inactive and idle modes.
* (Nokia R1-2008301) Proposal 5:
  + RAN1 to consider the impacts of assistance data changing over time in the design of inactive mode positioning support.
* (Sony R1-2008365) Proposal 6:
  + Support both DL-TDOA and UL-TDOA Positioning in RRC idle/inactive.
* (LG R1-2008417) Proposal 13:
  + RAN1 needs to consider positioning support of Ues in the RRC idle and inactive modes at least for RA-dependent positioning techniques from the perspective of latency and device efficiency.
* (InterDigital R1-2008491) Proposal 9:
  + Adopt IDLE/INACTIVE mode positioning
* (InterDigital R1-2008491) Proposal 10:
  + Study mechanisms to support timing alignment during idle/inactive mode positioning
* (InterDigital R1-2008491) Proposal 11:
  + Study measurement reporting mechanism for idle/inactive mode positioning
* (InterDigital R1-2008491) Proposal 12:
  + Study configuration mechanism for PRS or SRS for mobility during positioning in idle/inactive mode
* (MTK R1-2008519) Proposal 6-1:
  + For RRC idle state, the downlink only measurement with UE based mode is considered
* (MTK R1-2008519) Proposal 6-2:
  + For RRC inactive stare, the following cases can be considered,
    - Downlink only measurement with UE assisted mode
    - Downlink and uplink measurement with UE assisted mode
    - Downlink and uplink measurement with UE based mode
* (MTK R1-2008519) Proposal 6-3:
  + For the case of downlink and uplink measurement with UE based mode under RRC inactive state, Msg1/MsgA can be used for UL PRS transmission, and Msg4/MsgB can be used to provide assistance information which may include the UL-RTOA measurement results for the UE to facilitate synchronization error cancellation
* (DCM R1-2008550) Proposal 2:
  + RACH preamble (i.e. TA based positioning) can be considered for NR positioning of Ues in RRC idle/inactive state.
* (Qualcomm R1-2008619) Proposal 15:
  + Support the following enhancements:
    - Location measurement reporting during RRC Inactive state (overlap with the SDT WI in RAN2 should be carefully considered)
    - SRS for positioning transmission during RRC Inactive state.
* (CEWiT R1-2008718) Proposal 8:
  + In inactive mode, broadcast channel should be used for ProvideAssistanceData and RequestLocationInformation message. Whereas availability of positioning SIB should be indicated to UE using RAN based paging.
* (CEWiT R1-2008718) Proposal 9:
  + In inactive mode, UE will report its positioning measurement in MsgA of RACH.
* (CEWiT R1-2008718) Proposal 10:
  + For RRC idle mode, CN paging and positioning SIB should be used for signalling ProvideAssistanceData and RequestLocationInformation message from LMF. For reporting, RACH procedure should be used.
* (CEWiT R1-2008718) Proposal 11:
  + Change in UE tracking area or RAN notification area need to be convey to LMF.

Feature lead’s view

Although there are some similarities for supporting NR positioning for Ues in RRC\_INACTIVE state and for Ues in RRC\_INACTIVE state, different signaling and procedures, may need to be adopted for these two features. For the support of NR positioning for Ues in RRC\_INACTIVE state, it seems all responses are positive. For the support NR positioning for Ues in RRC\_IDLE, most of responses are positive, but a few companies believe a further investigation is needed, especially for UL positioning. Thus, it seems we need to have separate discussions on the support of the UE positioning in RRC\_INACTIVE state and in RRC\_IDLE state.

Proposal 5-1a

* NR positioning for Ues in RRC\_INACTIVE state is recommended for normative work, including
  + DL, UL, DL+UL, and Multi-RTT positioning methods
  + UE-based and UE-assisted positioning solutions
* The details of how to enable the UE positioning in RRC\_ INACTIVE state, are left for further discussion in normative work, while may include, but not limited to the following aspects:
  + DL reference signals (e.g., DL PRS) for DL measurements
  + UL reference signals (e.g., SRS for positioning, PRACH preambles) for UL measurements
  + Signalling and procedures for support the assistance data delivery, DL-PRS configuration, UL SRS for positioning resource configuration, measurement reporting), which may be developed based on the enhancements of existing signalling and procedures (e.g., existing 2-step and/or 4-step PRACH procedures, paging procedure, small data transmission).

Comments

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| **Company** | **Comments** |
| Nokia/NSB | Support in principle. Two minor comments:   * The first sub-bullet says DL+UL and Multi-RTT. I guess we don’t need to say multi-RTT on top of DL+UL. * Under the 2nd bullet, 1st sub-bullet I don’t think any company has suggested a different RS for inactive in DL. We prefer to not mix this discussion with addition RS discussion. Suggest to change the first sub-bullet to “Extending DL positioning measurements to RRC\_inactive state” |
| InterDigital | We support the proposal from the feature lead. |
| Qualcomm | We are supportive but we should try to try to clarify further the scope for the normative work. For example, why cannot we try to conclude which DL/UL RS to be used? |
| MTK | 1, in NRPPa, we don’t see multiple-RTT technique. Multiple-RTT can be realized by configuring UE RX-TX time difference measurement to the UE and configuring gNB RX-TX time different measurement to the gNB. So multiple-RTT techniques can be treated as the combining of DL measurement and UL measurement. Location server can also configure DL-RSTD measurement to the UE and configure UL-RTOA measurement to the gNB, which can be used to refine DL-RSTD measurement results (cancel sync error and in the mean time estimate the sync error. So probably it is okay to just say DL, UL and DL+UL  2, we don’t expect any new DL PRS design for RRC inactive state. So we are okay for nokia’s view of “change the first sub-bullet to Extending DL positioning measurements to RRC\_inactive state” |
| CATT | Support Proposal 5-1a. |
| CMCC | Support. One thing to be clarified for both Proposal 5-1a and 5-1b, where only mentions RS configuration, measurement and reporting, are we excluding obtaining the location information (e.g., for UE-assisted positioning) in idle/inactive state? |
| OPPO | Support |
| NTT DOCOMO | Support |
| Xiaomi | Support the proposal |
| vivo | Support. And we propose to delete the description of ‘Multi-RTT’ in the first bullet, since DL+UL method includes Multi-RTT method. |
| LG | For the Ues in RRC inactive mode, SSB could also be used for DL RS. |
| ZTE | Support |
| Huawei/HiSilicon | Support. We suggest to modify the following subbullet to be more specific.   * + Measurement of DL reference signals (e.g., DL PRS) |
| Lenovo, Motorola Mobility | Support |
| Intel | Support. |
| Ericsson (revised comment) | DL based measurements may be feasible in Inactive. But the motivation to support this should not be power savings as it is not intended for redcap, power limited Ues. If there is latency savings one may consider. Hence some gain should be shown by proponent companies on the latency.  Configuring UL SRS in Inactivate (resource allocation/release), controlling the power/interference and direction for UL SRS may be difficult. Thus, this should be removed or should be second priority.  RAN2 should as well capture observations/conclusions on the impact on their own specifications for this issue.  Further, the change proposed by Nokia for 2nd bullet is not needed at this stage. |
| Futurewei | Support but we need to clarify in the agreement what should be RAN1 scope |
| Xiaomi | Support |

FL comments

The Proposal 5-1a was discussed in online session. See Chaiman’s notes for the agreements.

Proposal 5-1b

* NR positioning for Ues in RRC\_ IDLE state is recommended for normative work, including
  + DL, UL, and Multi-RTT positioning methods
  + UE-based and UE-assisted positioning solutions
* The details of how to enable the UE positioning in RRC\_ IDLE state, are left for further discussion in normative work, while may include, but not limited to the following aspects:
  + DL reference signals (e.g., DL PRS) for DL measurements
  + UL reference signals (e.g., SRS for positioning, PRACH preambles) for UL measurements
  + Signalling and procedures for support the assistance data delivery, DL-PRS configuration, UL SRS for positioning resource configuration, measurement reporting), which may be developed based on the enhancements of existing signalling and procedures (e.g., existing 2-step and/or 4-step PRACH procedures, paging procedure, small data transmission).

Comments

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| **Company** | **Comments** |
| Nokia/NSB | Okay. |
| InterDigital | Support. |
| MTK | For RRC idle state, we only consider DL only UE based, which should have been supported according to existing specification. |
| CATT | Support Proposal 5-1b. |
| CMCC | Support. See comments for Proposal 5-1a. |
| OPPO | Lower priority compared to RRC\_INACTIVE |
| NTT DOCOMO | Support |
| Xiaomi | Support the proposal |
| vivo | Support. And we propose to change the description of ‘Multi-RTT method’ to ‘DL+UL method’ in the first bullet to align with proposal 5-1a. |
| ZTE | Support |
| Huawei/HiSilicon | We think DL measurement in IDLE state should be prioritized over other enhancements.  In addition, we suggest to modify the following subbullets to be more specific.   * + Measurement of DL reference signals (e.g., DL PRS) |
| Lenovo, Motorola Mobility | Support |
| Intel | For L1 perspective we are supportive, but the final decision should be done taken into account RAN2 conclusions/comments.  It cannot be decided by RAN1 only. |
| Ericsson (revised comment) | DL based measurements may be feasible in Idle. But the motivation to support this should not be power savings as it is not intended for redcap, power limited Ues. If there is latency savings one may consider. Hence some gain should be shown by proponent companies on the latency.    Configuring UL SRS in Inactivate (resource allocation/release), controlling the power/interference and direction for UL SRS may be difficult. Thus, this should be removed or should be second priority.  RAN2 should as well capture observations/conclusions on the impact on their own specifications for this issue. |
| Futurewei | Support but we need to clarify in the agreement what should be RAN1 scope |

FL comments

It seems most companies are supportive to the proposal. One company is supportive only for DL only UE based. For Intel’s comment that the final decision needs to take RAN2’s conclusions/comments into account, the understanding here is that the agreement/conclusion made in RAN1’s discussion is from RAN1’s perspective. How to make the conclusion of the SI for the TR of the SI may need further discussion, including taking RAN2’s conclusions/comments into account. The Proposal 5-1b was revised the consideration of the agreement related to NR positioning for Ues in RRC\_ INACTIVE state and the some companies concern of UL positioning.

Proposal 5-1b (Revision 1)

* NR positioning for UEs in RRC\_IDLE state is recommended for normative work, including
  + DL positioning methods
    - FFS: UL and DL+UL positioning methods
  + UE-based and UE-assisted positioning solutions
  + Support of UE positioning measurements for Ues in RRC\_IDLE state
    - Options that can be considered include DL-PRS only, or DL-PRS and SSB
  + FFS: Support of gNB positioning measurements for Ues in RRC\_ IDLE state

Comments

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| **Company** | **Comments** |
| Qualcomm | RAN2 is only working SDT using RRC Inactive in this Release and not in RRC Idle. We don’t see how the UE-assisted and network-based would be enabled in RRC Idle. We also think that there are issues related to High-layer positioning architectures. On the other hand, UE-Based DL-only methods do not require reporting from UE, no transmission from the UE, so we have preference to only focus in RRC Idle Positioning to UE-Based DL-only methods only.  So, we would like to focus on RRC-idle on DL-only UE-based methods. Do the “FFS” mean that are “left for future normative work”, or that it will be decided in the WI phase? We believe that UL methods and UE reporting in RRC idle should be left for a future normative work, not be debated further during an upcoming Rel-17 WI. |
| Vivo | Support.  We also prefer to have UL positioning method in the 1st sub-bullet, along with DL positioning methods instead of FFS. Correspondingly, we support gNB measurements for Ues in RRC\_IDLE state as well, not FFS for the last sub-bullet. |
| CATT | Support. |
| MTK | Pretty much the same view as QC  1, We have RRC inactive state in NR and small data enhancement WID is to focus on transmission in RRC inactive state. We can re-use the defined structure  2, Therefore, we don’t think the need to support UE transmission in RRC idle. We only consider DL only UE based |
| InterDigital | Support |
| LG | Support. In the third sub-bullet, we propose to add “SSB only” in addition to DL-PRS only, or DL-PRS and SSB. |
| CMCC | Agree with vivo. We believe that UL-based positioning can be achieved using RACH procedure or (pre)-configured SRS pos for Ues in idle state, therefore, UL positioning method should be supported in idle state as well |
| OPPO | Share the same view as QC and MTK. RAN2 SDT WI is only for RRC\_INACTIVE state. Thus, UL-based positioning should not be supported. |
| Huawei/HiSilicon | Support. We think DL measurement (excluding reporting) in RRC\_IDLE inactive state (similar to NB-IoT) should be the main focus for IDLE state positioning. The spec impact on top of supporting DL PRS measurement in INACTIVE is marginal. |
| Intel | For L1 perspective it can be feasible, but the final decision should be done by RAN2.  It cannot be decided by RAN1 only. |
| ZTE | Idle state is not supported in Rel-17 SDT, UE-assisted positioning solutions and DL+UL positioning methods may not work. |
| Lenovo, Motorola Mobility | Support at least in the case of DL-based positioning. |
| Xiaomi | Support. We have same view with vivo. |
| Ericsson | Only DL based measurements would be possible in RRC Idle. But what positioning accuracy levels and latencies can we achieve in IDLE? In terms of power saving, isn’t it the case that most of the Ues in an indoor industrial scenario are likely in RRC inactive? So further discussion is needed to justify the benefits of this enhancement over the potential enhancements in RRC Inactive in an IioT setting. |
| Sony | Support and we have the same view as vivo on the inclusion of UL positioning (i.e remove FFS). |
|  |  |

FL comments

The proposal 5-1b- is revised based on the comments, mainly separating the proposals for different scenarios.

Proposal 5-1b-1

* UE-based DL positioning for UEs in RRC\_IDLE state **is recommended** for normative work from physical layer perspective, including
  + Support of UE positioning measurements for UEs in RRC\_IDLE state
    - Options that can be considered include DL-PRS only, or DL-PRS and SSB

Proposal 5-1b-2

* UE-assisted DL positioning for UEs in RRC\_IDLE state **is recommended** for normative work from physical layer perspective, including
  + the support of UE positioning measurements for UEs in RRC\_IDLE state
    - Options that can be considered include DL-PRS only, or DL-PRS and SSB

Proposal 5-1b-3

* UE-assisted and UE-based UL and DL+UL positioning for UEs in RRC\_IDLE state **is recommended** for normative work from RAN1’s perspective, including
  + the support of UE positioning measurements for UEs in RRC\_IDLE state
    - Options that can be considered include DL-PRS only, or DL-PRS and SSB
  + Support of gNB positioning measurements for UEs in RRC\_ IDLE state

Comments

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| --- | --- |
| **Company** | **Comments** |
| Xiaomi | We support Proposal 5-1b-1, Proposal 5-1b-2 and Proposal 5-1b-3. |
| Sony | Support the proposals. However, we would still prefer to have UL-based positioning as well. |
| Intel | Decision on support of RRC\_IDLE UE-assisted positioning should be decided by RAN2.  Decision on support of RRC\_IDLE UE-based positioning with reporting to gNB should be decided by RAN2. |
| CEWiT | We support all proposals |
| Ericsson | We have similar views as Intel. |
| ZTE | Share similar views as Intel. |
| Lenovo, Motorola Mobility | Support all proposals in principle, clarification on Proposal 5-1b-3 on the meaning of “UE-assisted and UE-based UL and DL+UL positioning” may be needed. |
| CATT | Support all the three proposals. |
| vivo | Support the three proposals in principle, and we also have concerns about the description of ‘UE-based UL and DL+UL positioning’, since 'UE-based UL and DL\_UL positioning' is not supported even in connected state. |
| Sony2 | It seems the proposal has been updated (proposal 5-1b-3 was “considered” now, it becomes “recommended”). So, we support all proposals. |
| LG | We have a similar view with Intel. In our view, it would be appropriate to discuss positioning support of UEs in RRC\_IDLE state from RAN1’s perspective after RAN2 discussions and decision regarding the feasibility of positioning information reporting by the UE in RRC\_IDLE state. |
|  |  |

FL Comments

For Sony’s comments, it is unclear what the “UL-based” positioning is. UE-assisted positioning is normally “network-based” positioning, i.e., the position solution is calculated by the network.

For Intel and Ericsson’s comment, consider the potential impact on the physical layer of the proposed enhancements for supporting IDLE UE positioning, e.g., the enhancements of DL/UL, RAN1 may need also be involved in the decision on whether to support RACH IDLE UE positioning.

The enhancements for NR positioning for UEs in RRC\_IDLE state was discussed on GTW session without conclusion. For Proposal 5-1b-1, the comment was that whether there is any additional enhancement is needed for UE-based DL positioning in Rel-17 in addition to Rel-16. For Proposal 5-1b-2 and Proposal 5-1b-3, there are different views on the feasibility and the benefits as well as whether the issue to support NR positioning for UEs in RRC\_IDLE state should be discussed in RAN1 or RAN2.

Proposal 5-1b is revised as follows as suggested conclusion of the discussion.

Proposal 5-1b (Proposed conclusion)

* It is up to RAN2 to decide whether to support the enhancements of NR positioning for RRC\_IDLE UEs.

Comments

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| **Company** | **Comments** |
| CATT | Support.  In our point of view, UE positioning in RRC\_IDLE state has a close relation with RAN2. |
| LG | Support. It would be reasonable to discuss positioning support for UEs in RRC\_IDLE state from the RAN1 perspective depending on RAN2 decision. |
| vivo | We cannot agree with it. Based on previous agreement as below, we investigated the benefits on latency and power consumption for positioning in idle state in out Tdoc, and it can be observed the benefit of NR positioning for UEs in RRC\_IDLE state is clear. From our point of view, at least, the DL measurement in RRC\_IDLE state should be supported and decided in RAN1 scope.  In addition, if we cannot achieve the agreement, suggest capturing observation about the related benefits in TR.  Agreement:   * NR positioning for UEs in RRC\_IDLE state and UEs in RRC\_INACTIVE state will be investigated in Rel-17, including the benefits on latency, network/UE efficiency and UE power consumption |
| ZTE | Support. Main impacts are in RAN2. |
| Intel | Support. |
| Lenovo, Motorola Mobility | The decision on which type/configuration of positioning measurements while in RRC\_IDLE state should be under RAN1 scope, while we are ok that RAN2 may take the lead on deciding on whether to enable this enhancement and thereafter come back to RAN1 with related impacts. RAN2 LS may be needed. |
| OPPO | Support. Main spec impacts are within RAN2 |
| FL | For LG and Lenovo’s comments, I assume RAN1 would provide the necessary support if RAN2 decides to support NR positioning for RRC\_IDLE UEs;  For vivo’s comments, yes, we can have a further discussion on how to capture the observations related to the benefits of NR positioning for RRC\_IDLE UEs in this meeting. |

Proposal 5-1b-1 (Proposed conclusion, suggested to be captured in Chairman’s notes)

* It is up to RAN2 to decide whether to support the enhancements of NR positioning for RRC\_IDLE UEs.
* If RAN2 makes the decision to support the enhancements of NR positioning for RRC\_IDLE UEs, RAN1 should provide the necessary support from physical layer perspective.

(Closed) Proposal 5-1b-1 (Revision 1) (suggested to be captured in Chairman’s notes)

* RAN1 considers that it is feasible for a UE to perform DL positioning measurement in RRC\_IDLE state. It is up to RAN2 to decide whether to support the reporting of DL positioning measurements and/or positioning estimates for RRC\_IDLE UEs.

Comments

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| **Company** | **Comments** |
| CATT | Support. |
| vivo | Support |
| ZTE | Support |
| Huawei/HiSilicon | Support. |
| LG | For Proposal 5-1b-1, we are generally fine, but, as we mentioned, “RAN2 to decide whether to support of positioning measurement or location estimate of RRC\_IDLE UEs” seems more clear, since the meaning of “enhancements of NR positioning for RRC\_IDLE UES” seems too broad. |
| FL | Revised with the consideration of LG’s comments.   * RAN1 considers that it is feasible for a UE to perform DL positioning measurement in RRC\_IDLE state. It is up to RAN2 to decide whether to support the reporting of DL positioning measurements and/or positioning estimates for RRC\_IDLE UEs. |

Proposal 5-1b-2 (Suggested to be captured in TR)

* NR positioning for UEs in RRC\_IDLE state was investigated, including the benefits on latency, network/UE efficiency and UE power consumption. The following enhancements were proposed related to NR positioning for UEs in RRC\_IDLE state:
  + [x] sources (Futurewei R1-2007552, vivo R1-2007666, CATT R1-2007755, Xiaomi R1-2008083, Nokia R1-2008301, OPPO R1-2008226, Sony R1-2008365, LG R1-2008417) proposed to support DL positioning for IDLE UEs
  + [x] sources (vivo R1-2007666, CATT R1-2007755, Xiaomi R1-2008083, Nokia R1-2008301, OPPO R1-2008226, Sony R1-2008365, LG R1-2008417) proposed to support UL positioning for IDLE UEs
  + [x] sources (vivo R1-2007666, CATT R1-2007755, Xiaomi R1-2008083, OPPO R1-2008226, Sony R1-2008365, LG R1-2008417) proposed to support UL+DL positioning for IDLE UEs;
  + [x] sources (Futurewei R1-2007552, CATT R1-2007755, CMCC R1-2008015, Samsung R1-2008168, InterDigital R1-2008491) proposed to use DL PRS signals for NR positioning of IDLE UEs
  + [x] sources (vivo R1-2007666, CATT R1-2007755, CMCC R1-2008015, Xiaomi R1-2008083, Samsung R1-2008168, InterDigital R1-2008491) proposed to use UL SRS signals for NR positioning of IDLE UEs
  + [x] sources (CATT R1-2007755, CMCC R1-2008015, Xiaomi R1-2008083, Samsung R1-2008168, DCM R1-2008550) proposed to use PRACH signals for NR positioning of IDLE UEs
  + [x] sources (Huawei R1-2007577, Nokia R1-2008301) proposed to use small data transmission for DL measurements (e.g., RSTD and PRS-RSRP) reporting
  + [x] sources (CATT R1-2007755, CMCC R1-2008015, CEWiT R1-2008718, Xiaomi R1-2008083, OPPO R1-2008226) proposed to extend PRACH procedure to support for NR positioning of IDLE UEs
  + [1] source (vivo R1-2007666) proposed that UE needs to keep dedicated UL resource (e.g. SRS) after leaving connected mode to support UE transmitting dedicated UL signal for UL positioning.
  + [1] source (CATT R1-2007755) proposed to support three SRS configuration methods by
    - Using RRC connected state SRS-Pos configurations information.
    - Using SRS-Pos configuration information carried in the paging message.
    - Using SRS-Pos configuration information obtained by UE in a new RACH procedure
  + [1] source (Lenovo R1-2007998) proposed to support
    - LMF configures the appropriate DL-PRS configuration by taking into account the latency and accuracy requirements
    - Physical layer enhancements for lowering the DL-PRS configuration latency while UE is in RRC\_IDLE state.
  + [1] source (CMCC R1-2008015) proposed to support
    - at least UE-based and UE-assisted DL positioning, and NW-assisted UL positioning
    - the configuration, activation, and triggering of UL SRS transmission for UE positioning in IDLE state
  + [1] source (Xiaomi R1-2008083) proposed to support
    - measurement report from UE to gNB by PUSCH in Msg 3 or Msg A during random access procedure.
    - pre-configure the PRS for idle UE when UE is in connected mode.
  + [1] source (Samsung R1-2008168) proposed to,
    - use large bandwidth to transmit/receive these reference signals for better positioning accuracy
    - study how to report the measurement by UE is studied in case PRS is utilized for the positioning
    - when the location server initiates the location transfer procedure to UE in RRC\_idle state, NR paging message can deliver the LPP Request Location information message
  + [1] source (OPPO R1-2008226) proposed to support
    - UE to obtain positioning assistance data in system information broadcast.
    - UE to request system information of positioning assistance data through a RACH
    - RACH-like uplink PRS transmission
  + [1] source (InterDigital R1-2008491) proposed to study
    - the mechanisms to support timing alignment
    - the measurement reporting mechanism
    - the configuration mechanism for PRS or SRS for positioning
  + [1] source (MTK R1-2008519) proposed to consider the downlink only measurement with UE based mode
  + [1] source (CEWiT R1-2008718) proposed to
    - support CN paging and positioning SIB for signalling ProvideAssistanceData and RequestLocationInformation message from LMF.
    - convey change in UE tracking area or RAN notification area to LMF.

The bullets are drafted with some modifications/combination from the original proposals, and thus may not necessarily capture precisely the original intention of the proposals. *Proponents for the bullets with single source are encouraged to make the modifications directly on above TPs.* For the bullets with multiple sources, please put your comments in the following table, so I can take the comments into the consideration with revising the proposed TP.

Comments

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| **Company** | **Comments** |
| Nokia/NSB | We can be okay with the proposed conclusion, but we are not sure it is strictly needed in RAN1. Unless RAN2 is explicitly waiting for RAN1 input on this topic RAN2 can discuss what they would like and we think most companies already view this as clearly in RAN2 scope. |
| CATT | Support both proposals. |
| CMCC | Support both. |
| Xiaomi | Support both proposals |
| InterDigital | Thank you very much for creating the detailed proposal. Regarding the first three bullets, could you add InterDigital, as follows.   * + [x] sources (Futurewei R1-2007552, vivo R1-2007666, CATT R1-2007755, Xiaomi R1-2008083, Nokia R1-2008301, OPPO R1-2008226, Sony R1-2008365, LG R1-2008417, InterDigital R1-2008491) proposed to support DL positioning for IDLE UEs   + [x] sources (vivo R1-2007666, CATT R1-2007755, Xiaomi R1-2008083, Nokia R1-2008301, OPPO R1-2008226, Sony R1-2008365, LG R1-2008417, InterDigital R1-2008491) proposed to support UL positioning for IDLE UEs   + [x] sources (vivo R1-2007666, CATT R1-2007755, Xiaomi R1-2008083, OPPO R1-2008226, Sony R1-2008365, LG R1-2008417, InterDigital R1-2008491) proposed to support UL+DL positioning for IDLE UEs;   In addition, the following bullet, regarding the PRACH procedure   * + [x] sources (CATT R1-2007755, CMCC R1-2008015, CEWiT R1-2008718, Xiaomi R1-2008083, OPPO R1-2008226, InterDigital R1-2008491) proposed to extend PRACH procedure to support for NR positioning of IDLE UEs   In addition, regarding the third last bullet, could you modify the last sub-bullet as follows:   * + [1] source (InterDigital R1-2008491) proposed to study     - the mechanisms to support timing alignment     - the measurement reporting mechanism     - the configuration mechanism for PRS or SRS for mobility during positioning |

### Proposal 5-1b-2 (Revision 1) Suggested to be captured in TR)

* NR positioning for UEs in RRC\_IDLE state was investigated.
  + [9] sources (Futurewei, vivo, CATT, Nokia, OPPO, Sony, LG, CMCC, CEWiT) consider it is beneficial to support NR positioning for UEs in RRC\_IDLE state for reducing the positioning latency
  + [9] sources (vivo, Xiaomi, Nokia, OPPO, Sony, LG, Samsung, Lenovo, CEWiT) consider it is beneficial to support NR positioning for UEs in RRC\_IDLE state for reducing UE power consumption
  + [4]sources (vivo, Xiaomi, Nokia, OPPO) consider it is beneficial to support NR positioning for UEs in RRC\_IDLE state for reducing signalling overhead
  + [11] sources (Futurewei, vivo, CATT, OPPO, Sony, LG, CMCC, InterDigital, Lenovo, MTK, CEWiT) consider it is feasible to support DL positioning for UEs in RRC\_IDLE state;
  + [8] sources (vivo, CATT, OPPO, Sony, LG, CMCC, Lenovo, InterDigital) consider it is feasible to support UL positioning for UEs in RRC\_IDLE state;
  + [8] sources (vivo, CATT, OPPO, Sony, LG, CMCC, Lenovo, InterDigital) consider it is feasible to support DL+UL positioning for UEs in RRC\_IDLE state

Comments

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| **Company** | **Comments** |
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## On-demand PRS, A-PRS, and SP-PRS

Background

In RAN1#102-e, the following agreement was made related to A-PRS, SP-PRS and On-demand PRS

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| Agreement:   * Semi-persistent and a-periodic transmission and reception of DL PRS will be investigated in Rel-17.   + FFS: the details on when and how to enable semi-persistent and a-periodic DL PRS   + FFS: to be supported for which positioning methods, e.g.,     - UE-assisted and/or UE-based positioning     - DL positioning and/or Multi-RTT * On-demand transmission and reception of DL PRS will be investigated in Rel-17.   + FFS: the details on when and how to enable on-demand DL PRS   + FFS: to be supported for which positioning methods, e.g.,     - UE-assisted and/or UE-based positioning     - DL positioning and/or Multi-RTT * Notes:   + Semi-persistent means MAC-CE triggered   + Aperiodic would correspond to DCI-triggered   + On-demand corresponds to the UE-initiated or network-initiated request of PRS and/or SRS. So, it is NOT the same as whether PRS is DCI-triggered or MAC-CE triggered. It is about UE or LMF request/suggesting/recommending specific PRS pattern, ON/OFF, periodicity, BW, etc. |

Submitted Proposals

* (Futurewei R1-2007552) Proposal 1:
  + On-demand DL PRS transmissions can be triggered by the UE through UL signaling e.g. uplink control signaling or dedicated pre-allocated UL SRS resources. On-demand PRS configurations should support at least the same configurability as in Rel-16 e.g. transmission period, multiple periods and muting.
* (Futurewei R1-2007552) Proposal 2:
  + On-demand DL PRS transmissions should be supported for both UE-assisted and UE-based positioning, including DL positioning and Multi-RTT
* (Huawei R1-2007577) Proposal 10:
  + Rel-17 should support the following 3 types of PRS requested by LMF
    - Type 1 5GC periodic PRS
    - Type 2 5GC semi-persistent PRS
    - Type 3 5GC aperiodic PRS
* (vivo R1-2007666) Proposal 4:
  + For on-demand PRS positioning, support at least one of the following behavior:
    - Option1:
      * Support the request/suggesting/recommending message from UE or LMF to gNB for suggesting a configuration of on-demand PRS
      * Support configuring a or multiple on-demand PRS for the response the requesting
    - Option 2:
      * Support pre-configuring multiple on-demand PRS for requesting
      * Support the request message or trigger message with an on-demand PRS from UE or LMF to gNB for the transmitting of on-demand PRS.
* (vivo R1-2007666) Proposal 5:
  + Configuring on-demand PRS within a flexible window as a specific PRS pattern can be considered in Rel-17.
* (vivo R1-2007666) Proposal 6:
  + Periodic, aperiodic, and semi-persistent on-demand PRS should be supported.
* (vivo R1-2007666) Proposal 7:
  + On-demand DL PRS supports semi-persistent configuration with MAC CE or DCI activation/deactivation.
  + On-demand DL PRS supports aperiodic configuration with triggered by DCI.
* (vivo R1-2007666) Proposal 8:
  + Choose one architecture of multi-TRP for semi-persistent/ aperiodic on-demand PRS:
    - Option 1: multi-TRP belongs to the serving cells (in this case, the procedure and message of CSI-RS can be used as a reference for semi-persistent/ aperiodic on-demand PRS)
    - Option 2: multi-TRP belongs to serving cells and neighbor cells (in this case, the procedure and message of SRS can be used as a reference for semi-persistent/ aperiodic on-demand PRS)
* (vivo R1-2007666) Proposal 9:
  + Both UE-initiated and network-initiated can be supported for on-demand PRS triggering if multi-TRP belongs to the serving cells.
  + Network-initiated trigger for on-demand PRS is preferred if multi-TRP belongs to serving cells and neighbor cells.
* (vivo R1-2007666) Proposal 10:
  + On-demand PRS should be supported for UE-assisted and UE-based positioning.
  + On-demand PRS should be supported for DL positioning and Multi-RTT positioning.
* (vivo R1-2007666) Proposal 11:
  + Semi-persistent DL PRS supports configuration with MAC CE or DCI activation/deactivation.
  + Aperiodic DL PRS supports aperiodic configuration with triggered by DCI.
* (vivo R1-2007666) Proposal 12:
  + Choose one architecture of multi-TRP for semi-persistent/ aperiodic DL PRS:
    - Option 1: multi-TRP belongs to the serving cells (in this case, the procedure and message of CSI-RS can be used as a reference for semi-persistent/ aperiodic DL PRS)
    - Option 2: multi-TRP belongs to serving cells and neighbor cells(in this case, the procedure and message of SRS can be used as a reference for semi-persistent/ aperiodic DL PRS)
* (vivo R1-2007666) Proposal 13:
  + Semi-persistent/ Aperiodic DL PRS should be supported for UE-assisted and UE-based positioning.
  + Semi-persistent/ Aperiodic DL PRS should be supported for DL positioning and Multi-RTT positioning.
* (vivo R1-2007666) Proposal 14:
  + Triggering a PRS window including all the triggered PRS can be considered in Rel-17.
  + Triggering an MG window and the PRS window together can be considered in Rel-17.
* (vivo R1-2007666) Proposal 34:
  + Aperiodic positioning measurement report can be considered in Rel-17.
* (CATT R1-2007755) Proposal 1:
  + Semi-persistent and a-periodic transmission and reception of DL PRS should be supported in Rel-17 for DL positioning and Multi-RTT methods of both UE-assisted and UE-based positioning.
* (CATT R1-2007755) Proposal 2:
  + On-demand transmission and reception of DL PRS should be supported in Rel-17 for DL positioning and Multi-RTT methods of both UE-assisted and UE-based positioning.
* (TCL R1-2007886) Proposal 2:
  + Study and support aperiodic and on-demand PRS transmission.
* (Intel R1-2007946) Proposal 3:
  + Support both semi-persistent and aperiodic DL PRS allocation for DL-TDOA, DL-AoD, Multi-RTT positioning methods
* (Lenovo R1-2007998) Proposal 1:
  + Support On-demand DL-PRS procedures based on UE-initiated and network-triggered requests.
* (Lenovo R1-2007998) Proposal 2:
  + Support On-demand DL-PRS procedures for DL-based and DL+UL-based positioning methods.
* (CMCC R1-2008015) Proposal 2:
  + The priority of DL PRS, at least that of the on-demand DL PRS, should be defined in Rel-17.
* (Xiaomi R1-2008083) Proposal 1:
  + To introduce positioning request between UE and serving gNB.
    - UE can indicate the positioning request to gNB by PRACH or SR.
    - gNB can indicate the positioning request to UE by paging or MAC CE/DCI.
* (Xiaomi R1-2008083) Proposal 2:
  + Support UE to recommend the PRS configuration parameter set ID by PUSCH during RA procedure or scheduled responding to SR.
* (Xiaomi R1-2008083) Proposal 3:
  + Support gNB to indicate the PRS configuration parameter set ID by MAC CE/DCI.
* (Xiaomi R1-2008083) Proposal 4:
  + The mapping between PRS configuration parameter set ID and related PRS configuration parameter set need to be transmitted to UE by LMF or serving gNB in advance.
* (OPPO R1-2008226) Proposal 3:
  + The framework of SP and AP CSI-RS can be used as the starting point for SP and AP DL PRS. Support a multi-instance transmission of AP DL PRS
* (OPPO R1-2008226) Proposal 4:
  + For on-demand DL PRS:
    - Support it for UE-based positioning, UE-assisted DL-based method, UE-assisted multi-RTT method
    - Support UE-specific configuration of the following parameters: QCL configuration, number of PRS resource repetition, BW, number of symbols, comb size, periodicity, number of transmission instances.
* (Nokia R1-2008301) Proposal 12:
  + On-demand and dynamic PRS should be supported for both UE-assisted and UE-based positioning.
* (Sony R1-2008365) Proposal 7:
  + On-demand PRS can be transmitted in relation with the legacy / periodic PRS transmission. Both on-demand and periodic PRS can be multiplexed in FDM and TDM.
* (Sony R1-2008365) Proposal 8:
  + Support semi-persistent and a-periodic transmission and reception of DL PRS that can be used for DL-TDOA and Multi-RTT.
* (InterDigital R1-2008491) Proposal 6:
  + Adopt on-demand PRS for flexibility in configuration of PRS, latency reduction and positioning with high accuracy
* (InterDigital R1-2008491) Proposal 7:
  + Timing of sending on-demand PRS in the multi-RTT positioning method should be studied
* (LG R1-2008417) Proposal 14:
  + In Rel-17, RAN1 needs to consider the RS overhead reduction by introducing the SSB for timing measurement and the on-demand type PRS.
* (Qualcomm R1-2008619) Proposal 14:
  + Support on-demand DL PRS, including, but not limited to, the following aspects:
    - Required signaling & procedures to enable a target device or the network to request/recommend specific PRS configurations (e.g., ON/OFF, bandwidth, PRS resources/sets), and/or Positioning methods.
* (CEWiT R1-2008718) Proposal 12:
  + UE will dynamically indicate the DL or UL PRS resources to be configured based on favourable beam configuration from the set of configured resources by LMF.

Feature lead’s view

Based on the submitted proposals, it seems most companies are supportive of on-demand PRS, A-PRS, SP-PRS for both UE-assisted and UE-based positioning, including DL positioning and Multi-RTT positioning solutions.

Proposal 5-2a

* Semi-persistent and a-periodic transmission and reception of DL PRS are recommended for normative work, including
  + DL and Multi-RTT positioning methods
  + UE-based and UE-assisted positioning solutions
* The signalling and procedures for enabling semi-persistent and a-periodic transmission and reception of DL PRS, including the configuration, transmission, reception and measurement reporting etc. are left for further discussion in normative work.

Proposal 5-2b

* On-demand transmission and reception of DL PRS, including periodic, semi-persistent and a-periodic PRS, are recommended for normative work, including
  + DL and Multi-RTT positioning methods
  + UE-based and UE-assisted positioning solutions
  + UE-initiated and LMF(network)-initiated on-demand DL PRS
* The signalling and procedures for enabling on-demand DL PRS, including the configuration, transmission, reception and measurement reporting etc. are left for further discussion in normative work.

Comments

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| **Company** | **Comments** |
| Nokia/NSB | Support in principle. If we agree to 5-2b is there a need to have 5-2a? Even if on-demand and AP/SP PRS have differences both seem to be covered by 5-2b. |
| InterDigital | Supportive of the proposal. We have a suggestion to change wording in Proposal 5-2b. The difference between Porposal 5-2a and 5-2b is what initiates PRS transmission. The modified proposal 5-2b is shown below.   * On-demand transmission and reception of DL PRS, ~~including periodic, semi-persistent and a-periodic PRS~~, are recommended for normative work, including   + DL and Multi-RTT positioning methods   + UE-based and UE-assisted positioning solutions   + UE-initiated and LMF(network)-initiated on-demand DL PRS including periodic, semi-persistent and a-periodic PRS * The signalling and procedures for enabling on-demand DL PRS, including the configuration, transmission, reception and measurement reporting etc. are left for further discussion in normative work. |
| Qualcomm | Support. It seems 5-2b has included SP/AP PRS, and it is also repeated in 5-2a. We are supportive of both features. |
| MTK | For both proposal 5-2a and proposal 5-2b, we suggest to change as DL and DL+UL positioning methods (we already mention the reason in above) |
| CATT | Support Proposal 5-2b. |
| CMCC | Support Proposal 5-2a/b |
| OPPO | Support Proposal 5-2b that is including 5-2a |
| Xiaomi | Support Proposal 5-2b |
| vivo | Support both 5-2a and 5-2b. |
| LG | Support |
| ZTE | Support Proposal 5-2b. |
| Huawei/HiSilicon | Proposal 5-2a   * For SP-PRS, we do not see the gain on latency aspects regarding MAC CE triggered SP PRS, as the PRS configuration by LMF is more like LMF triggered “SP-PRS”. In addition, we assume LMF would any request location measurement from the UE. In summary, we do not see the need of SP-PRS. * For AP-PRS, we think that PRS configuration should anyway be provided in advance, and given that the latency reduction is still in question. In addition, to allow PRS transmission/reception triggered by DCI, additional DCI codepoints overhead should be considered. Therefore, instead of recommending, we suggest to further study it in the WI. * In addition, for AP-PRS, we think a more feasible way is allow higher layer to configure the single-shot reception to the UE, rather than using DCI. * We suggest to change the description as * A-periodic transmission and reception of DL PRS can be considered for normative work, including   + DL and Multi-RTT positioning methods   + UE-based and UE-assisted positioning solutions * The signalling and procedures for enabling a-periodic transmission and reception of DL PRS, including the configuration, transmission, reception and measurement reporting etc. are left for further discussion in normative work.   Proposal 5-2b   * Support. |
| Lenovo, Motorola Mobility | Supportive of both 5-2a and 5-2b |
| Fraunhofer | Support both proposals |
| Intel | Support both. |
| Ericsson | For 5-2a: we do not support aperiodic / SP DL PRS. We think the signalling involved to support AP/SP PRS is too demanding. With the amount of required signalling overhead, the impact on latency make the potential gain questionable. If the solution was restricted to a single cell, the signalling would be reduced. But in this case, we would prefer supporting aperiodic/SP positioning using exisiting signals such as CSI RS, which are already available in the specifications. A multi-TRP type of configuration of CSI-RS would be suitable for an indoor factory environment such as the one discussed in rel17.  For 5-2b, we do not support the UE-initiated on-demand DL PRS, and do not want to include the SP/AP DL PRS. |
| Futurewei | Support both proposals |
| CATT | Support both Proposal 5-2a and Proposal 5-2b. |
| Sony | Support proposal 5-2a, 5-2b |

FL Comments

There are indeed some overlapping between the two proposals. If Proposal 5-2b is agreeable, one may argue that Proposal 5-2a may not be needed. Based on the feedbacks, it seems most companies are supportive to SP-PRS, A-PRS, and on-demand PRS with periodical, SP, and A-P transmission. However, one company does not consider the support of SP-PRS is needed for non-on-demand case, and one company has the concern on the support of SP-PRS and A-PRS. The concerns may need to be resolved in online session. The proposals are revised to separate the cases, which may make the online discussion easier.

Proposal 5-2a (Revision 1)

* A-periodic transmission and reception of DL PRS can be considered for normative work for not on-demand DL PRS;
* Semi-persistent transmission and reception of DL PRS can be considered for normative work for not on-demand DL PRS;
* Above enhancements are considered for both DL and Multi-RTT positioning methods and both UE-based and UE-assisted positioning solutions.

Proposal 5-2b (Revision 1)

* On-demand transmission and reception of DL PRS is recommended for normative work, including
  + UE-initiated on-demand DL PRS
  + LMF(network)-initiated on-demand DL PRS
  + Periodic on-demand DL PRS
  + Semi-persistent on-demand DL PRS
  + A-periodic on-demand DL PRS
* Above enhancements are recommended for both DL and Multi-RTT positioning methods and both UE-based and UE-assisted positioning solutions.

Comments

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| **Company** | **Comments** |
| vivo | Support |
| vivo2 | Revision to our comments due to my negligence. I didn’t notice the wording difference of those two revised proposals.  We support proposal 5-2b (revision 1) and want to support semi-persistent and a-periodic transmission and reception of DL PRS Rel-17 normative work as well. However, the wording of proposal 5-2a (revision 1) is changed into “can be considered”.  Respond to comment from Huawei and Ericsson, we’re not sure about why and what study is needed further. The latency benefit is shown in our evaluation Tdoc for A-PRS. If a-periodic on-demand PRS is specified, we feel it’s straight forward to support A-PRS in general as well. About signalling overhead, it should be well understood that this to achieve latency requirement. Signalling reduction details are in the scope of WI work. |
| Nokia/NSB | We support proposal 5-2b (revision 1). We can be okay with proposal 5-2a (revision 1) but we are not sure that the wording of “not for on-demand PRS” is appropriate. If we specify AP/SP PRS then it is up to the network implementation how to use those signals. |
| CATT | Support both proposals. |
| Apple | * We support both 5-2a(Rev1) and 5-2b(Rev1), with the note from original proposals that “The signalling and procedures for enabling xxx, including the configuration, transmission, reception and measurement reporting etc. are left for further discussion in normative work.” |
| MTK | We support both  We also suggest to change “multiple-RTT” as “DL+UL”, because UE RX-TX time difference measurement + gNB RX-TX time difference measurement for RTT, and DL-RSTD measurement + UL-RTOA measurement for RSTD refinement are feasible and both under the category of DL+UL |
| InterDigital | Support in principle, but “not on demand” may be confusing. One suggestion is to combine both proposals as follows.   * On-demand transmission and reception of DL PRS is recommended for normative work, including   + UE-initiated on-demand DL PRS   + LMF(network)-initiated on-demand DL PRS   + ~~Periodic~~ On-demand periodic DL PRS * A-periodic transmission and reception of DL PRS, including UE initiated on-demand a-periodic PRS, can be considered for normative work * Semi-persistent transmission and reception of DL PRS, including UE initiated on-demand semi-persistent PRS, can be considered for normative work * Above enhancements are considered for both DL and Multi-RTT positioning methods and both UE-based and UE-assisted positioning solutions. |
| LG | We think AP PRS would be beneficial in terms of latency performance, and we were OK with the previous proposal 5-2a. In the revised version, we propose to remove “for not on-demand DL PRS” of Proposal 5-2a(Revision 1) which is not necessary. In our view, if we need to support AP PRS regardless of on-demand. There is no clear reason to support A-periodic PRS only for on-demand, where the A-PRS is triggered by DCI. |
| CMCC | Support both |
| OPPO | Support |
| Huawei/HiSilicon | We cannot agree to either 5-2a or 5-2b.  For 5-2a, comments are   * What does “not on-demand PRS” mean? * We do not see any the necessity of SP DL-PRS, as we do not see any benefit of SP DL-PRS in L1 latency.   For 5-2b, a comment is   * It is unclear what periodic/semi-persistent/aperiodic on-demand PRS means in the context. In our contribution, we propose the three types using 5GC PR/SP/AP PRS to denote a different mechanism of triggering by LMF to NG-RAN, but proposal seems not to be aligned with our understanding, and thus we suggest to remove the last three subbullets.   To vivo, we do not think that the latency evaluation for AP-PRS is sound, due to the following reasons   * To support serving gNB sending DCI to the UE to trigger UE to receive AP-PRS, coordination with neighbouring TRPs needs to be taken into account, which requires additional signaling exchange between LMF and neighbouring TRP using 5GC on-demand PRS mechanism, and further forward the information to the serving gNB with the PRS transmission timing to determine a proper trigger, which is not reflected in the analysis * In the evaluation, UE requests measurement gap and receives measurement gap configuration prior to DCI activation, how would UE know when PRS will be received in the information to request MG to the serving gNB; it is anti-causal. * Since L1 latency analysis starts with gNB transmitting the LPP request location information, it would have latency reduction if LMF could provide the specific PRS Rx timing in the respective LPP request location information message or even LPP assistance data, we do not even need gNB L1 signaling to the UE at all. * Remember in Rel-16, we have AP-SRS used for UL positioning measurement; although it is claimed that some latency reduction can be achieved, the RAN3 signaling somehow compromised the benefit. For example, LMF needs to send activation request to the serving gNB, receive the activation response containing the activation slot, and then forward the timing of the SRS to the TRPs. Due to the lack of latency information for NRPPa transport via gNB 🡪 AMF 🡪LMF 🡪AMF🡪 TRP, the serving gNB needs to be very conservative when it comes to deciding the AP-SRS triggering. For example, serving gNB receives the activation request in slot X, and considering the activation response to LMF, and further measurement request from LMF to the TRP may take at least 26ms, serving gNB would consider it safe to activate UE to transmit AP SRS in slot X+52. Is there any latency gain for AP-SRS? |
| Intel | We support proposal 5.2b.  We support proposal 5.2a with change of the wording from “can be considered” to “is recommended” like in proposal 5.2b. |
| ZTE | InterDigital’s revision may be better to avoid confusion. |
| Lenovo, Motorola Mobility | Supportive of the proposal 5-2b (revision 1). The intention of proposal 5-2a (revision 1) is unclear with respect to the use of “not on-demand” in first two bullets. Suggest rewording for better clarity. |
| Xiaomi | We support proposal 5.2b. |
| Sony | Support 5.2b. Same view as Nokia on proposal 5-2a. “Not on-demand” seems to be out-of-scope as we are discussing On-demand here. |
|  |  |

FL’s Comments

Based on the online GTW discussion, it was suggested to first summarize the benefits of the proposed enhancements based on the investigation. Then, based on that to decide if we can make a recommendation to the WI phase for the proposed enhancements that might have the consensus to support.

The Proposal 5-2b is modified based on the suggestion. In the following revised proposal, I have listed the supporting companies for different enhancements related to on-demand DL PRS based on my understanding from the contributions. Please feel free to make the corrections if any. Based on the feedback, we may have the consensus for the support of on-demand periodict DL PRS.

Proposal 5-2b (Revision 2)

15 companies (Futurewei, Huawei, vivo, CATT, TCL, Lenovo, CMCC, Xiaomi, OPPO, Nokia, Sony, InterDigital, LGE, Qualcomm, CEWiT, Fraunhofer) have provided investigations on the semi-persistent, a-periodic, and on-demand transmission and reception of DL PRS for both DL and Multi-RTT positioning methods of UE-based and UE-assisted positioning solutions, especially the benefits of reducing the positioning latency and network efficiency. In general, all these companies consider it is beneficial to support on-demand DL PRS in general. More specifically, we have:

* [x] sources (Futurewei, CATT, vivo, OPPO, Nokia, Fraunhofer) consider it is beneficial to support the on-demand DL PRS for UE-assisted and UE-based positioning
* [x] sources ((Futurewei, CATT, vivo, TCL, Lenovo, OPPO, Sony, InterDigital, Fraunhofer) consider it is beneficial to support the on-demand DL PRS for DL positioning and Multi-RTT;
* [x] sources (Futurewei, vivo, Lenovo, Xiaomi,CEWiT) consider it is beneficial to support the on-demand DL PRS transmissions triggered by the UE;
* [x] sources (Huawei, vivo, CATT, Lenovo, Xiaomi, Fraunhofer, CEWiT) consider it is beneficial to support the periodic, semi-persistent, and aperiodic on-demand DL PRS triggered by the network;
* [x] sources (vivo, Xiaomi, Sony,CEWiT) consider it is beneficial to configure semi-persistent on-demand DL PRS with MAC CE or DCI.

Based on the investigation, on-demand transmission and reception of DL PRS is recommended for normative work, which includes ***at leas***t the following

* + UE-initiated on-demand DL PRS
  + LMF(network)-initiated on-demand DL PRS
  + Periodic on-demand DL PRS
* Above enhancements are recommended for both DL and Multi-RTT positioning methods and both UE-based and UE-assisted positioning solutions.

Comments

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| **Company** | **Comments** |
| Xiaomi | We support Proposal 5-1b-1, Proposal 5-1b-2 and Proposal 5-1b-3. |
| Sony | Support the proposals. However, we would still prefer to have UL-based positioning as well. |
| **Company** | **Comments** |
| Nokia/NSB | Support the proposal. Thanks to FL for the great effort to manage the inputs.As a more general comment we think that on a case by case basis we can consider if it is needed to list all companies providing input on a particular topic. We think this approach can be used just for the cases where no consensus can be reached. |
| CATT | Thanks Nokia for the suggestion. Yes, we may remove the sourses once we reach the consensus. |
| Fraunhofer | We are fine with the approach, added our views although we didn’t provide a proposal on this topic. |
| MTK | We are okay for the proposal. But we hope the wording can be more general:  “for both DL and Multi-RTT positioning methods” 🡨 if “multiple-RTT” shold be kept here, we suggest to modify as “for DL, DL+UL and Multi-RTT positioning methods” |
| vivo | First of all, we definitely support on-demand PRS，but we don’t know why aperiodic and semi-persistent is disappear in our discussion as the benefit is clear |
| OPPO | Support in principle. We share similar view as vivo that AP/SP DL PRS should also be included. |
| Huawei/HiSilicon | Since Huawei is listed in the following observation, we would like to clarify the understanding in the following statement   * [x] sources (Huawei, vivo, CATT, Lenovo, Xiaomi, Fraunhofer) consider it is beneficial to support the periodic, semi-persistent, and aperiodic on-demand DL PRS triggered by the network;   We are actually saying that LMF requests gNB to start/stop transmitting PRS, and it has nothing to do with semi-persistent PRS or aperiodic PRS, which is why we added 5GC semi-persistent, and 5GC aperiodic in our t-doc. We assume the intention is different other companies, and thus we suggest the following change  15 companies (Futurewei, Huawei, vivo, CATT, TCL, Lenovo, CMCC, Xiaomi, OPPO, Nokia, Sony, InterDigital, LGE, Qualcomm, CEWiT, Fraunhofer) have provided investigations on the semi-persistent, a-periodic, and on-demand transmission and reception of DL PRS for both DL and Multi-RTT positioning methods of UE-based and UE-assisted positioning solutions, especially the benefits of reducing the positioning latency and network efficiency. In general, all these companies consider it is beneficial to support on-demand DL PRS in general. More specifically, we have:   * [x] sources (Futurewei, CATT, vivo, OPPO, Nokia, Fraunhofer) consider it is beneficial to support the on-demand DL PRS for UE-assisted and UE-based positioning * [x] sources ((Futurewei, CATT, vivo, TCL, Lenovo, OPPO, Sony, InterDigital, Fraunhofer) consider it is beneficial to support the on-demand DL PRS for DL positioning and Multi-RTT; * [x] sources (Futurewei, vivo, Lenovo, Xiaomi) consider it is beneficial to support the on-demand DL PRS transmissions triggered by the UE; * [x] sources (vivo, CATT, Lenovo, Xiaomi, Fraunhofer) consider it is beneficial to support the periodic, semi-persistent, and aperiodic on-demand DL PRS triggered by the network; * [x] sources (vivo, Xiaomi, Sony) consider it is beneficial to configure semi-persistent on-demand DL PRS with MAC CE or DCI. * [x] sources (Huawei/HiSilicon) consider it is beneficial to support the 5GC semi-persistent, and 5GC aperiodic on-demand DL PRS triggered by LMF, where   + 5GC semi-persistent on-demand PRS triggered by LMF refers to PRS with fixed periodicity/offset whose transmission can only be switched on/off by gNB as requested by LMF   + 5GC aperiodic on-demand PRS triggered by network refers to PRS without fixed periodicity/offset whose transmission can be almost any time by gNB as requested by LMF |
| Xiaomi | Support in principle. We share similar view as vivo that AP/SP DL PRS should also be included. |
| Lenovo, Motorola Mobility | Supportive of updated proposal from FL’s collection of company inputs, AP/SP DL PRS may require further clarification due to the omission in the revised proposal. |
| Intel | It seems Intel’s views are not reflected in the proposal. We are supportive of on-demand DL PRS (at least for network initiated), aperiodic and semipersistent DL PRS |
| CEWiT | CEWiTs view was not reflected in proposal. Added CEWiT in the list of sources. |

FL’s Comments

For Nokia’s comments, yes, we may remove the name of the sources in case when it is not necessary;

For MTK’s comments, Multi-RTT is changed to DL+UL;

For vivo, OPPO and Xiaomi’s comments on SP/AP DL PRS, the reason for not includes them into proposal is that there are concerns to support them;

For Intel’s comment, I don’t see “on-demand” in the proposals of Intel’s contribution. Based on Intel’s comment, I assume the following proposal from “Support both semi-persistent and aperiodic DL PRS allocation for DL-TDOA, DL-AoD, Multi-RTT positioning methods” is for on-demand DL PRS.

Proposal 5-2b (Revision 3)

The following sources (Futurewei, Huawei, vivo, CATT, TCL, Lenovo, CMCC, Xiaomi, OPPO, Nokia, Sony, InterDigital, LGE, Qualcomm, CEWiT, Fraunhofer, Intel) have provided investigations on the semi-persistent, a-periodic, and on-demand transmission and reception of DL PRS for both DL and Multi-RTT positioning methods of UE-based and UE-assisted positioning solutions, especially the benefits of reducing the positioning latency and network efficiency. In general, all these companies consider it is beneficial to support on-demand DL PRS in general. More specifically, we have:

* The following sources (Futurewei, CATT, vivo, OPPO, Nokia, Fraunhofer) consider it is beneficial to support the on-demand DL PRS for UE-assisted and UE-based positioning
* The following sources ((Futurewei, CATT, vivo, TCL, Lenovo, OPPO, Sony, InterDigital, Fraunhofer) consider it is beneficial to support the on-demand DL PRS for DL positioning and Multi-RTT;
* The following sources (Futurewei, vivo, Lenovo, Xiaomi, CEWiT) consider it is beneficial to support the on-demand DL PRS transmissions triggered by the UE;
* The following sources (vivo, CATT, Lenovo, Xiaomi, Fraunhofer, CEWiT) consider it is beneficial to support the periodic, semi-persistent, and aperiodic on-demand DL PRS triggered by the network;
* The following sources (vivo, Xiaomi, Sony, CEWiT) consider it is beneficial to configure semi-persistent on-demand DL PRS with MAC CE or DCI.
* The following sources (Huawei/HiSilicon) consider it is beneficial to support the 5GC semi-persistent, and 5GC aperiodic on-demand DL PRS triggered by LMF, where
  + 5GC semi-persistent on-demand PRS triggered by LMF refers to PRS with fixed periodicity/offset whose transmission can only be switched on/off by gNB as requested by LMF
  + 5GC aperiodic on-demand PRS triggered by network refers to PRS without fixed periodicity/offset whose transmission can be almost any time by gNB as requested by LMF

Based on the investigation, on-demand transmission and reception of DL PRS is recommended for normative work, which includes ***at leas***t the following

* + UE-initiated on-demand DL PRS
  + LMF(network)-initiated on-demand DL PRS
  + Periodic on-demand DL PRS
* Above enhancements are recommended for both DL and DL+UL positioning methods and both UE-based and UE-assisted positioning solutions.

|  |
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| Agreement:  Capture the following in the TR:  From a physical layer perspective, on-demand transmission and reception of DL PRS, which includes at least the following is recommended   * + UE-initiated request of on-demand DL PRS transmission   + LMF (network)-initiated request of on-demand DL PRS transmission * Above enhancements are recommended for both DL and DL+UL positioning methods and both UE-based and UE-assisted positioning solutions. |

FL’s Comments

While we have reached the agreement for on-demand DL PRS. We may still want to consider the AP-PRS and SP-PRS. Based on the previous agreement, “On-demand corresponds to the UE-initiated or network-initiated request of PRS and/or SRS. So, it is NOT the same as whether PRS is DCI-triggered or MAC-CE triggered. It is about UE or LMF request/suggesting/recommending specific PRS pattern, ON/OFF, periodicity, BW, etc.” In addition, consider companies may have different views on A-periodic PRS and SP-PRS, it would be better to separate Proposal 5-2a to two separate proposals.

Proposal 5-2a-1

* A-periodic transmission and reception of DL PRS is recommended for normative work;
* Notes:
  + Aperiodic would correspond to DCI-triggered

Comments

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| --- | --- |
| **Company** | **Comments** |
| Huawei/HiSilicon | Due to extra ignalling effort among gNBs/LMF to enable “flexible PRS transmission/reception” with RAN3 involvement and also due to the timing match between neighbouring gNB transmission and UE reception, we think it needs further study, and thus we suggest to revise it to  A-periodic transmission and reception of DL PRS can be considered for normative work. |
| Vivo | Support.  To Huawei, some responses for your previous comments:   * PHY latency is also our target, it is logical for us to evaluate latency from physical layer perspective, additional signaling exchange latency between LMF and neighbouring TRPs is not our scope. * We think the latency of MG needs to be reduced is our consensus. How to reduce and perform measurement is another problem. * If you check our evaluation, you can find only decoding the LPP request information will need 10ms, which exceeds our target. So we don’t think the latency can be achieved only by LPP-activated PRS.   In addition, it is really weird that aperiodic SRS is supported, but aperiodic PRS not. |
| Lenovo, Motorola Mobility | Support. |
| Intel | Support. |
| CATT | Support. |
| Qualcomm | Support.  To HW/HiSi: It is up to RAN2 to decide whether they want to add the extra ignalling. From RAN1 perspective, even signle-BS (e.g. M-TRP, SFN scenario) can exploit the Aperiodic PRS triggering. Even if Ran2/RAN3 decide it is too much work to extend it within this release, they can introduce it a later release. We would like to keep the discussion RAN1 specific/centric (as we are doing for the latency discussion).  As a reminder, similar discussion/debate happened about AP-SRS. Some companies were arguing for several meetings that AP-SRS will not be specified due to the Ran2/3 implications; and eventually it just worked out fine. |
| CMCC | Support |
| Huawei/HiSilicon | To vivo, we agreed that “decoding the LPP request information will need 10ms”, but for AP-PRS, I guess some RRC configurations on DCI codepoints and the corresponding report also need to be considered for latency analysis. What is the latency assumption for UE processing RRCReconfiguration message that replace LPP-RequestLocationInformation? It is agreed that physical layer latency analysis starts with gNB Tx of LPP-RequestLocationInformation, so we assume processing LPP-RequestLocationInformation is anyway needed.  To QC: From our aspects, we think supporting AP-PRS would require a lot of discussion in RAN1, and we wish to secure that the benefit claimed by RAN1 at the cost of time spent is less likely to be compromised by other WGs. Currently whether AP-PRS will be successful is highly dependent on the reactions on other WGs.  For AP-SRS, QC thinks it works just fine, but to our understanding, the additional work on AP-SRS delayed RAN3 completion by a quarter, and the latency reduction claimed by AP-SRS is still in question. I copy-paste our previous comment on the latency for AP-SRS.  For example, LMF needs to send activation request to the serving gNB, receive the activation response containing the activation slot, and then forward the timing of the SRS to the TRPs. Due to the lack of latency information for NRPPa transport via gNB 🡪 AMF 🡪LMF 🡪AMF🡪 TRP, the serving gNB needs to be very conservative when it comes to deciding the AP-SRS triggering. For example, serving gNB receives the activation request in slot X, and considering the activation response to LMF, and further measurement request from LMF to the TRP may take at least 26ms, serving gNB would consider it safe to activate UE to transmit AP SRS in slot X+52. Is there any latency gain for AP-SRS?  One major difference between AP-CSI and AP-PRS/Positioning is that AP-CSI is used by gNB itself, while AP-PRS/positioning is used by Core network. |
| Apple2 | Support |
| Xiaomi | Support |
| vivo2 | To Huawei, for R16 evaluation, we agree that “physical layer latency analysis starts with gNB Tx of LPP-RequestLocationInformation”. But it doesn’t mean R17 enhancement also starts with gNB Tx of LPP-RequestLocationInformation, the components of R17 are dependent on R17 research and our efforts. |
| CEWiT | Support |
| LG | Support |
| Sony | Support |
| Qualcomm | To HW: If RAN2/3 do not have the Tus or the time, they can inform RAN1, or it can be discussed during the WID drafting how to handle it. In the worst case, RAN1 would introduce a feature that will be limited to single-base station positioning in a first release, and RAN2/RaN3 will pick it up later. I do feel we are debating similar topics like the AP-SRS discussions in Rel-16.  We would like to ask HW to suggest a wording to try to address their concerns. All the concenrs seems to be high-layer-perspective, evne though from Ran1 perspective the latency gains are obvious based on the Ran1 agreements on what PHY-layer latency includes. What if we add, “from RAN1 perspective”, and send an LS to RAN2 to be aware of it?  Finally, I though single-base station positioning is something that HW was interested in, and such a feature, together with the AP-SRS, could enable it even further. |
| InterDigital | Support |
| ZTE | Support |
|  |  |

FL Comments

Based on the discussion, the main concern on supporting a-periodic transmission and reception of DL PRS is the impact on higher-layer complexity, especially for the DL PRS transmission from neighboring cells. In the following, two options are proposed to resolve the issue.

Proposal 5-2a-1 (Revision 1)

Capture the following in TR:

The benefits of a-periodic transmission and reception of DL PRS are investigated:

* [14] sources (Futurewei, vivo, Lenovo, Intel, CATT, Qualcomm, CMCC, Apple, Xiaomi, CEWiT, LG, Sony, InterDigital, ZTE) consider it is beneficial to support a-periodic transmission and reception of DL PRS for reducing positioning latency;
* [1] source (Huawei/HiSilicon) has the concern that supporting a-periodic transmission and reception of DL PRS may introduce extra signaling effort among gNBs/LMF and the timing match between neighbouring gNB transmission and UE reception.

Select one of the following options:

Option 1: A-periodic transmission and reception of DL PRS from the TRPs of the serving gNBs are recommended for normative work for the TRPs in the serving gNB. A-periodic transmission and reception of DL PRS from the TRPs of the neighbouring gNBs *can be studied further and if needed, specified* during normative work;

* Note: Aperiodic would correspond to DCI-triggered

Option 2: A-periodic transmission and reception of DL PRS *can be studied further and if needed, specified* during normative work;

* Note: Aperiodic would correspond to DCI-triggered

Comments (Please indicate which of the options are acceptable, and also the preference if multiple options are acceptable)

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| --- | --- |
| **Company** | **Comments** |
| Huawei/HiSilicon | Thanks for the compromise solution.  After a few rounds of checking, we can be fine with either Option 1 or Option 2, but Option 1 preferred. However, we would like to note that aperiodic “transmission” and aperiodic “reception” are totally different. Aperiodic transmission would mean a flexible transmission opportunity at TRPs, which is somehow related to on-demand PRS, and based on the description, it seems RAN1 only focus on aperiodic reception at UE, as we are discussing DCI triggering aspects. In other words, it should not be precluded that the transmission of PRS can be periodic, but the UE reception can be DCI-triggered.  In summary, we offer the following revised Option 1 and Option 2, and from Huawei/HiSilicon perspective, we can be fine with Option 1.  Option 1: A-periodic reception by the UE of DL PRS from the TRPs of the serving gNBs are recommended for normative work for the TRPs in the serving gNB. A-periodic reception by the UE of DL PRS from the TRPs of the neighbouring gNBs *can be studied further and if needed, specified* during normative work;   * Note: Aperiodic reception would correspond to DCI-triggered   Option 2: A-periodic reception by the UE of DL PRS *can be studied further and if needed, specified* during normative work;   * Note: Aperiodic reception would correspond to DCI-triggered |
| Vivo | For us, option 1 should be supported at least as the majority of companies agree that it is beneficial for reducing latency. |
| Xiaomi | Support Option 1 |
| ZTE | Support option 2. Considering option 2 may lead to additional high layer latency, we can support option 1 as a second preference. |
| CATT | We prefer option 1. A-periodic DL PRS from the serving gNBs should be easy to be implemented and specified, and its benefits also are obvious to save the positioning latency and overhead. We also agree that a-periodic DL PRS from the non-serving gNBs needs more study. |
| CMCC | From RAN1 perspective, option 1 would be a good start. |
| Ericsson | We do not agree with the proposal in the current form, however, we do support the principle of aperiodic transmission of RS for the purpose of positioning. We think the normative work should consider what RS to use (e.g. CSI-RS / TRS or DL PRS) and what protocol to use (RRC or LPP) as this has large consequences both on the specification impact and the latency of the aperiodic solution.  Our alternative proposal is as follow: Proposal 5-2a-1bis (Revision 1) Capture the following in TR:  The benefits of a-periodic transmission and reception of DL PRS are investigated:   * [14] sources (Futurewei, vivo, Lenovo, Intel, CATT, Qualcomm, CMCC, Apple, Xiaomi, CEWiT, LG, Sony, InterDigital, ZTE) consider it is beneficial to support a-periodic transmission and reception of DL PRS for reducing positioning latency; * [1] source (Huawei/HiSilicon) has the concern that supporting a-periodic transmission and reception of DL PRS may introduce extra signaling effort among gNBs/LMF and the timing match between neighbouring gNB transmission and UE reception.   Select one of the following options:  Option 1: Study of Mechanisms for A-periodic transmission and reception of reference signals ~~DL PRS~~ from the TRPs of the serving gNBs to support positioning methods is ~~are~~ recommended for normative work for the TRPs in the serving gNB. A-periodic transmission and reception of reference signals ~~DL PRS~~ from the TRPs of the neighbouring gNBs *can be studied further and if needed, specified* during normative work;   * + RS may include CSI-RS/TRS or DL PRS   + Mechanisms includes configuration and reporting of the RS (RRC or LPP/NRPPa) * Note: Aperiodic would correspond to DCI-triggered   Option 2: Study of Mechanisms for A-periodic transmission and reception of reference signals ~~DL PRS~~ *can be studied further and if needed, specified* during normative work;   * + RS may include CSI-RS/TRS or DL PRS   + Mechanisms includes configuration and reporting of the RS (RRC or LPP/NRPPa) * Note: Aperiodic would correspond to DCI-triggered |
| OPPO | Prefer Option 1 |
| Lenovo, Motorola Mobility | Support Option 1 for further consideration. |
| InterDigital | Support Option 1 |
| FL | For Huawei’s comments, while I agree the aperiodic “transmission” and aperiodic “reception” are different, I assume many companies want to support both aperiodic “transmission” and aperiodic “reception”, but not limited to aperiodic “reception”. I would interpret the aperiodic “transmission” as DCI-triggered “transmission”, which in most case should be “on-demand”.  For Ericsson’s comments, I would like to understand a little more of the suggested modifications:   * For example, Option 2 has already used the term “*can be studied further and if needed, specified”,* why do we need to add “Study of Mechanisms …” * What does it mean by “reporting of the RS”. * Not sure if we want to explicitly mention CSI-RS/TRS now. DCI-triggered CSI-RS/TRS is most likely to be used for supporting on-demand DL PRS. However, so far we have not reach the agreement to support CSI-RS/TRS for positioning and have not discussed the DCI-triggered CSI-RS/TRS for positioning. |
| Sony | Support Option 1 |
| Huawei/HiSilicon | Our understanding of aperiodic reception is more suited for the case of UE PRS Rx based on DCI triggering, while aperiodic transmission is more suited for the case of UE SRS Tx based on DCI triggering. To avoid further confusion with on-demand PRS, we hope it should be OK to remove aperiodic transmission of DL PRS from the context.    To our understanding, it is clear that when we develop AP-PRS in RAN1, we are actually caring about UE Rx of DCI and Rx of PRS based on DCI. How gNB/TRP transmits the AP-PRS to match the UE Rx time is out of RAN1 scope. |
| FL | Agree with Huawei’s comment that “How gNB/TRP transmits the AP-PRS to match the UE Rx time is out of RAN1 scope”. RAN1’s specs do not define the requirements on how DL signals are transmitted from gNB. Thus, it seems to be sufficient only mentioning DCI-triggered DL PRS reception without the need to mention DCI-triggered DL PRS transmission. |

FL Comments

Proposal 5-2a-1 (Revision 1) is revised as follows based on the comments and the discussions, i.e., changing “A-periodic transmission and reception of DL PRS” to “A-periodic reception of DL PRS”.

(Closed) Proposal 5-2a-1 (Revision 2)

Option 1: A-periodic reception of DL PRS from the TRPs of the serving gNBs are recommended for normative work . A-periodic reception of DL PRS from the TRPs of the neighbouring gNBs *can be studied further and if needed, specified* during normative work;

* Note: Aperiodic reception would correspond to DCI-triggered reception

Option 2: A-periodic reception of DL PRS *can be studied further and if needed, specified* during normative work;

* Note: Aperiodic reception would correspond to DCI-triggered reception

*If we cannot reach the consensus on above proposal, suggest capturing the following in TR as an alternative:*

The benefits of a-periodic transmission and reception of DL PRS were investigated:

* [14] sources (Futurewei, vivo, Lenovo, Intel, CATT, Qualcomm, CMCC, Apple, Xiaomi, CEWiT, LG, Sony, InterDigital, ZTE) consider it is beneficial to support a-periodic transmission and reception of DL PRS for reducing positioning latency;
* [1] source (Huawei/HiSilicon) has the concern that supporting a-periodic transmission and reception of DL PRS may introduce extra signaling effort among gNBs/LMF and the timing match between neighbouring gNB transmission and UE reception.

Comments (Please indicate which of the options are acceptable, and also the preference if multiple options are acceptable)

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Intel | Option 1. |
| CATT | Option 1 |
| LG | Option 1 |
| Huawei/HiSilicon | Option 1. It seems a little bit redundant by saying TRPs of/in the serving gNB twice. |
| Vivo | Option 1 |
| ZTE | Option 1 |
| Intel | Option 1. |
| Xiaomi | Option 1 |
| Lenovo, Motorola Mobility | Option 1, also agree with Huawei that mentioning “TRPs of/in the serving gNBs” twice is redundant. The statement “A-periodic reception of DL PRS from the TRPs of the serving gNBs are recommended for normative work” should be sufficient. |
| OPPO | Option 1 |
| InterDigital | We have a question for clarification. What is the assumption for transmitted PRS? Is it on-demand PRS or not-on-demand periodic PRS? A note can be added to describe the transmitted PRS assumed here. |
| FL | For Huawei and Lenovo’s comments, the proposal is modified to remove the redundancy.  For InterDigital’s comment, the assumption here is that the DL PRS is available for A-periodic reception of DL PRS for the UE. However, it does not mean DL PRS has to be AP and/or on-demand. |

### (Closed) Proposal 5-2b-1 (Revision 3)

* Semi-persistent transmission and reception of DL PRS is recommended for normative work for not on-demand DL PRS;
* Notes:
  + Semi-persistent means MAC-CE triggered

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Huawei/HiSilicon | We do not think the gain of SP DL PRS is well justified. |
| Vivo | Support |
| Lenovo, Motorola Mobility | Support. |
| Intel | Support. |
| CATT | Support. |
| Qualcomm | Support. |
| CMCC | Support |
| Apple2 | Support (although in theory the triggering can be done by DCI as well) |
| Xiaomi | Support |
| CEWiT | Support |
| InterDigital | Support |
| Fraunhofer | Support |
| Ericsson | We have the same comment as above for aperiodic signals. We don’t necessarily see that PRS is the most suitable solution for SP transmission for positioning. |

FL Comments

Suggest adopting the similar approach as DL PRS aggregation to have a comprised resolution.

Proposal 5-2a-2 (Revision 1)

Capture the following in TR:

The benefits of semi-persistent transmission and reception of DL PRS are investigated:

* [11] sources (vivo, Lenovo, Intel, CATT, Qualcomm, CMCC, Apple, Xiaomi, CEWiT, InterDigital, Fraunhofer) consider it is beneficial to support semi-persistent transmission and reception of DL PRS for reducing positioning latency;
* [1] sources (Huawei/HiSilicon) consider it is not beneficial to support semi-persistent transmission and reception of DL PRS.

Semi-persistent transmission and reception of DL PRS *can be studied further and if needed, specified* during normative work;

* Semi-persistent means MAC-CE triggered

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Huawei/HiSilicon | We can be fine with the compromised WF with the similar suggested changes as AP-PRS.  The second bullet from the observation can be updated as follows.  The benefits of semi-persistent reception of DL PRS are investigated:   * [11] sources (vivo, Lenovo, Intel, CATT, Qualcomm, CMCC, Apple, Xiaomi, CEWiT, InterDigital, Fraunhofer) consider it is beneficial to support semi-persistent reception of DL PRS for reducing positioning latency; * [1] sources (Huawei/HiSilicon) do not see the benefit of semi-persistent reception of DL PRS over periodic reception of DL PRS.   Semi-persistent reception of DL PRS *can be studied further and if needed, specified* during normative work;   * Semi-persistent reception means MAC-CE triggered   Just to note that we have not identified any latency gain of MAC-CE trigger DL PRS reception, and the reception is anyway triggered via LPP RequestLocationInformation message. Some companies may argue that the starting time can be different between Rel-16 and Rel-17, but agreement reads otherwise.  To us, we assume AP-PRS can be happening potentially in any DL symbols, which may reduce latency for PRS “alignment delay”, but SP-PRS from UE side is simply additional switch-on/off or a fine-tuning of the assistance data. How it can be used for latency is not justified, or evaluated. In our understanding, semi-persistent CSI/CSI-RS/SRS is also not used for latency reduction. |
| Vivo | For the second bullet, we suggest using the similar wording as 5-2a-1 option1. |
| Xiaomi | Support the proposal |
| ZTE | Suggest to have two separate options as 5-2a-1. Maybe it’s easy to get common ground on supporting semi-persistent DL PRS from the TRPs of the serving gNBs. |
| CATT | Support the proposal. |
| CMCC | Similar as AP-PRS, SP-PRS also includes RAN2/3 works. Agree with vivo’s suggestion that Proposal 5-2a-2 (Revision 1) can be refined using the similar wording of Proposal 5-2a-1 (Revision 1), and option 1 is preferred. |
| Ericsson | We have the same comment as above for aperiodic signals. We don’t necessarily see that PRS is the most suitable solution for SP transmission for positioning. |
| Lenovo, Motorola Mobility | Support the revised proposal. |
| InterDigital | Support |
| Sony | Support |

FL Comments

Proposal 5-2a-2 (Revision 1) is revised as follows based on the similar discussion of Proposal 5-2a-1 with the consideration of the comments to include the two options as Proposal 5-2a-1.

Proposal 5-2a-2 (Revision 2)

Capture one of the following options in TR:

Option 1: Semi-persistent reception of DL PRS from the TRPs of the serving gNBs are recommended for normative work . Semi-persistent reception of DL PRS from the TRPs of the neighbouring gNBs *can be studied further and if needed, specified* during normative work;

* Note: Semi-persistent reception would correspond to MAC-CE -triggered reception

Option 2: Semi-persistent reception of DL PRS *can be studied further and if needed, specified* during normative work;

* Note: Semi-persistent reception would correspond to MAC-CE -triggered reception

*If we cannot reach the consensus on above proposal, suggest capturing the following in TR as an alternative:*

The benefits of semi-persistent transmission and reception of DL PRS were investigated:

* [11] sources (vivo, Lenovo, Intel, CATT, Qualcomm, CMCC, Apple, Xiaomi, CEWiT, InterDigital, Fraunhofer) consider it is beneficial to support semi-persistent transmission and reception of DL PRS for reducing positioning latency;
* [1] sources (Huawei/HiSilicon) do not see the benefit of semi-persistent reception of DL PRS over periodic reception of DL PRS.

Comments (Please indicate which of the options are acceptable, and also the preference if multiple options are acceptable)

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Intel | Option 1. |
| CATT | Option 1. |
| Huawei/HiSilicon | Option 2. Can proponents clarify how to claim the latency gain by using semi-persistent PRS? |
| vivo | Option 1.  To Huawei, from PHY layer latency perspective, the latency for decoding MAC CE is smaller than decoding RRC/LPP message. |
| ZTE | Option 2. Further advantages need to be justified in WI phase. |
| Intel | Option 1. |
| Xiaomi | Option 1 |
| Lenovo, Motorola Mobility | Option 1 (similar redundancy related comment as in Proposal 5-2a-1 (Revision 5)) |
| InterDigital | We have the same question as in Proposal 5-2a-1. What is the assumption for transmitted PRS? Is it on-demand PRS or not-on-demand periodic PRS? A note can be added to describe the transmitted PRS assumed here. |

FL Comments

Proposal 5-2a-2 (Revision 2) revised with the consideration of the agreement made related to 5-2a-1.

### (Closed) Proposal 5-2b-2 (Revision 3)

Capture the following in the TR:

Semi-persistent reception of DL PRS from the TRPs of the serving gNB and Semi-persistent reception of DL PRS from the TRPs of the neighbouring gNBs *can be studied further and if needed, specified* during normative work.

* Note: Semi-persistent reception would correspond to MAC-CE triggered reception

Comments

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| **Company** | **Comments** |
| CATT | Support. |
| CMCC | Support. |
| Xiaomi | Support |

## Enhancements of UL AoA and DL-AoD

Background

For positioning methods based on the angular measurements, the positioning accuracy depends directly on the accuracy of the angular measurements. For example, the DL AoD and UL AoA measurement accuracy are related to the orientation uncertainties of the gNB Tx/Rx beams. The positioning accuracy can be improved if the LMF (network-based) and UE(UE-based) can calibrate the orientation uncertainties of the gNB Tx and Rx beams from the angular measurements. Also, the multipath signals may cause significant errors in the UL AoA measurements since the reflected signals may reach the receiver antenna at completely different angles than the LOS angle. In RAN1#102e, we have the following agreements:

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| Agreement:  The scenario, benefits, and methods for improving the accuracy of the UL AoA and DL-AoD methods for both UE-based and network-based (including UE-assisted) positioning can be investigated in Rel-17. |

Submitted Proposals

* (Futurewei R1-2007552) Proposal 4:
  + Additional measurements definition of the DL PRS including relative power to the first detected path should be supported to improve the positioning accuracy, specifically for DL-AoD positioning methods.
* (Huawei R1-2007577) Proposal 12:
  + Rel-17 should support enhanced AoA defined with respect to the ULA antenna direction.
* (Huawei R1-2007577) Proposal 13:
  + Rel-17 should support the following DL-AoD procedure enhancement
    - LMF requests AoD (AoA) measurement for the gNB based on RSRP report from the UE
    - gNB provides detailed beam information to facilitate LMF to calculate the angle based on RSRP
      * E.g. DFT beam coefficients, beam response
* (vivo R1-2007666) Proposal 29
  + The combination of Rel-16 technique as an implementation algorithm can improve the accuracy of angle-based positioning, and no specification change is needed.
* (CATT R1-2007755) Proposal 9:
  + LMF can provide the estimated UE position and the uncertainty associated with the estimated UE position to UE/gNB for aiding the UE/gNB in the reception of the DL/UL reference signals and proving reliable NR timing and angular positioning measurements.
* (Nokia R1-2008301) Proposal 14:
  + RAN1 to study beam orientation errors and potential correction mechanisms in order to improve the positioning accuracy achievable with DL-AoD.
* (LG R1-2008417) Proposal 5:
  + As a potential enhancement of Rel-17 NR positioning, timing measurement based DL-AoD technique needs to be considered.
* (MTK R1-2008519) Proposal 5-1:
  + Define another type of RSRP measurement by measuring the power of the first-arrival path in work item phase. Moreover, the restriction of fixed measurement window across beams in time domain under CIR observation may also be specified.
* (MTK R1-2008519) Proposal 5-2:
  + The look up table for deriving the direction based on RSRP reports needs to consider entire angle range, because the beam responses with different steering direction may not be cyclically identical.
* (Qualcomm R1-2008619) Proposal 4:
  + Support the reporting from the gNB to the LMF, within a single report, multiple UL-AOAs from a single UE and multiple corresponding Timing measurements for each UL-AoA (e.g. RTOA and/or gNB Rx-Tx), together with their associated time-stamps.
* (Fraunhofer R1-2008841) Proposal 5:
  + Consider the following enhancements of the DL-AoD method during Rel. 17:
    - Reporting of radiation characteristics (i.e. main lobe power level, sidelobe level, etc.)
    - Association of timing difference measurements (e.g. using DL-PRS resources from the same resource set) with RSRP reports on beams.
    - FFS: reporting of additional UE antenna characteristics for the measured PRS resources.

Feature lead’s view

It seems we have quite diverged proposals for the methods for improving the accuracy of the UL AoA and DL-AoD methods. It may be difficult to have converged views on which of the proposed enhancements should be adopted in Rel-17. One possible solution is to have the agreement for the need of the enhancements in this meeting, and leave the discussion of the solutions to WI phase.

Proposal 5-3

* The enhancements of the method, measurements, report, and signalling for improving the accuracy of the UL AoA and DL-AoD measurements are recommended for normative work, including
  + UE-based and network-based (including UE-assisted) positioning solutions
* The details of the solutions are left for further discussion in normative work, which may include, but not limited to the following aspects:
  + AoA definition with respect to ULA antenna direction
  + RSRP measurement of the first-arrival path with specified restriction of fixed measurement window across beams
  + Multiple UL-AOA reporting together with corresponding timing measurements for a UE
  + Timing measurement based DL-AoD technique
  + Association of timing difference measurements (e.g. using DL-PRS resources from the same resource set) with RSRP reports on the same set of beams.
  + LMF provides the estimated UE position and the uncertainty associated with the estimated UE position to UE.
  + gNB provides detailed Tx/Rx beam information to LMF (i.e. main lobe power level, sidelobe level, etc.)
  + Beam orientation errors correction mechanisms
  + LMF requests AoD (AoA) measurement for the gNB based on RSRP report from the UE

Comments

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| **Company** | **Comments** |
| Nokia/NSB | While we support some of the sub-bullets we are not sure how productive having a large list with very different proposals is for an agreement at this stage. Some of the proposals are related to timing measurements/enhancements, some are related to RSRP/ current AoA definition, and some are related to the beam information. Perhaps we could try to group these in different buckets and see if any progress could be made on a specific bucket. One attempt here (please feel free to suggest a different way):  Group 1:   * Multiple UL-AOA reporting together with corresponding timing measurements for a UE * Timing measurement based DL-AoD technique * Association of timing difference measurements (e.g. using DL-PRS resources from the same resource set) with RSRP reports on the same set of beams.   Group 2:   * RSRP measurement of the first-arrival path with specified restriction of fixed measurement window across beams * LMF requests AoD (AoA) measurement for the gNB based on RSRP report from the UE * AoA definition with respect to ULA antenna direction   Group 3:   * gNB provides detailed Tx/Rx beam information to LMF (i.e. main lobe power level, sidelobe level, etc.) * Beam orientation errors correction mechanisms * LMF provides the estimated UE position and the uncertainty associated with the estimated UE position to UE.   At least from Nokia side we would support group 3 and be open to discussing group 1 further. |
| Qualcomm | This is again a big list of items, and there needs to be an additional effort to understand what is needed and what can be recommended for normative work. Somehow the proposals needs to be further categorized. Maybe consider proposals for UL-AoA, UE-A/B DL-AoD separately?  I am not sure how the grouping of the proposals was done by Nokia. Can you provide more information on how these are being categorized?  A couple of first questions on a few bullets:   * “gNB provides detailed Tx/Rx beam information to LMF**/UE** (i.e. main lobe power level, sidelobe level, etc.)”. In UE-B DL-AoD, the UE needs this information.   How is the bullet: “LMF provides the estimated UE position and the uncertainty associated with the estimated UE position to UE. ” related to Angle methods? This is related to all methods. |
| MTK | 1, The “timing measurement based DL-AoD technique” by LGE would be quite similar to “RSRP measurement of the first-arrival path with specified restriction of fixed measurement window across beams” for improving accuracy under NLOS condition  2, for gNB provides detailed Tx/Rx beam information to LMF (i.e. main lobe power level, sidelobe level, etc.) 🡨 we suggest to either to remove i.e part or to additional add “full beam response”  3, For nokia’s proposal: “Beam orientation errors correction mechanisms”, we expect more explanations. Our question is, DL-AoD is to measure several beams, each with different beam direction. So the orientation error is random among beams? Or all the beams would be shifted uniquely?  4, We suggest the following grouping, and there is no need to MUTE/KILL a whole group   * For accuracy improvement, downlink * “Timing measurement based DL-AoD technique” and “RSRP measurement of the first-arrival path with specified restriction of fixed measurement window across beams” 🡨 maybe able to merge both * Beam orientation errors correction mechanism * For accuracy improvement, uplink   + Multiple UL-AOA reporting together with corresponding timing measurements for a UE * For signaling enhancement: * AoA definition with respect to ULA antenna direction * Association of timing difference measurements (e.g. using DL-PRS resources from the same resource set) with RSRP reports on the same set of beams * LMF provides the estimated UE position and the uncertainty associated with the estimated UE position to UE * gNB provides detailed Tx/Rx beam information to LMF * For procedure enhancement:   + LMF requests AoD (AoA) measurement for the gNB based on RSRP report from the UE |
| CATT | Support Proposal 5-3 |
| CMCC | Support |
| Vivo | Thank FL for summarizing the big list, I think Nokia’s opinion is great. Ler try to group it and it is better if group naming is based on the classification method, For example,   * The details of the solutions are left for further discussion in normative work, which may include, but not limited to the following aspects:   + AoA definition with respect to ULA antenna direction   + The enhancement of reporting     - Multiple UL-AOA reporting together with corresponding timing measurements for a UE     - gNB provides detailed Rx beam information to LMF (i.e. main lobe power level, sidelobe level, etc.)   + The enhancement of the measurement     - RSRP measurement of the first-arrival path with specified restriction of fixed measurement window across beams     - Timing measurement based DL-AoD technique     - Association of timing difference measurements (e.g. using DL-PRS resources from the same resource set) with RSRP reports on the same set of beams.   + The enhancement of assistance data     - LMF provides the estimated UE position and the uncertainty associated with the estimated UE position to UE.     - Beam orientation errors correction mechanisms     - gNB provides detailed Tx beam information to LMF (i.e. main lobe power level, sidelobe level, etc.)   + The enhancement of procedure     - LMF requests AoD (AoA) measurement for the gNB based on RSRP report from the UE   In addition, we think the bottleneck of AoA and AoD needs be identified first. And details solutions are left for further discussion in normative work. For this, if I remember correctly, only angle error, and ULA performance is identified by Huawei. So, for us, the big list is not needed, and the wording as below:   * The enhancements of the method, measurements, report, and signalling for improving the accuracy of the UL AoA and DL-AoD measurements in the presence of the angle errors, and/or respect to ULA antenna direction are recommended for normative work, including   + UE-based and network-based (including UE-assisted) positioning solutions * The details of the solutions are left for further discussion in normative work |
| LG | To FL, our proposal related to this issue (Proposal #5) of our contribution was not captured, so please capture the following proposal in the submitted proposals above.  Proposal 6:   * In Rel-17, RAN1 needs to study how to use the UE’s RX beam index reporting for positioning.   In our view, for DL-AoD, even if the Rx beam index reporting was introduced in Rel-16, the LMF is difficult to meaningfully utilize the beam index information. In Rel-17, we need to discuss this to make this feature meaningful. We have a modified proposal as follows:   * The enhancements of the method, measurements, report, and signalling for improving the accuracy of the UL AoA and DL-AoD measurements are recommended for normative work, including   + UE-based and network-based (including UE-assisted) positioning solutions * The details of the solutions are left for further discussion in normative work, which may include, but not limited to the following aspects:   + AoA definition with respect to ULA antenna direction   + RSRP measurement of the first-arrival path with specified restriction of fixed measurement window across beams   + Multiple UL-AOA reporting together with corresponding timing measurements for a UE   + Timing measurement based DL-AoD technique   + Association of timing difference measurements (e.g. using DL-PRS resources from the same resource set) with RSRP reports on the same set of beams.   + LMF provides the estimated UE position and the uncertainty associated with the estimated UE position to UE.   + gNB provides detailed Tx/Rx beam information to LMF (i.e. main lobe power level, sidelobe level, etc.)   + Beam orientation errors correction mechanisms   + LMF requests AoD (AoA) measurement for the gNB based on RSRP report from the UE   + UE Rx beam index information for DL-AoD technique |
| ZTE | The lists are too big. The groups from MTK can be a starting point, at least we need to identify some enhancements with common interests. |
| Huawei/HiSilicon | Support. |
| Fraunhofer | Support the changes added by LG |
| Intel | The scope of the proposal is too broad. |
| Ericsson | We agree with the first bullet, but we think that the second bullet list of items is too detail at this stage. We suggest to remove the list of enhancements and leave the identification spec enhancements to the WI phase. |
| Futurewei | Support |
| Sony | It is a long list. Hence, the grouping as suggested by Nokia makes sense. We support particularly Group 1 and Group 3. |
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FL Comments

Based on the comments, it seems companies are all fine with the first bullet, but have different views on which of the proposed enhancements for the second bullets should be supported or how to group them. Most of the comments are for the second bullets. Given that the 2nd bullet is for information purpose, i.e., the list of the potential enhancements can be considered, and we may not have the time to discuss them one-by-one in this meeting, the Proposal 5-3 is revised, as suggested by Ericsson, by removing the second bullet list of enhancements and leave the identification spec enhancements to the WI phase.

### (Closed) Proposal 5-3 (Revision 1)

* The enhancements of the procedure, measurements, reporting, and signalling for improving the accuracy of the UL AoA and DL-AoD measurements are recommended for normative work for both UE-based and network-based (including UE-assisted) positioning solutions.

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| **Company** | **Comments** |
| Huawei/HiSilicon | Support. At least this is common ground for the interested companies. |
| Vivo | Support |
| Lenovo, Motorola Mobility | Support |
| CATT | Support. |
| Qualcomm | We are generally supportive, a few questions to understand the scope:   * Can we clarify whether “enhancements in Reference Signals” are within scope? My understanding is no. * What does the word “method” refer to? From what I see in the previous list, I don’t see a new method being proposed. * Does the word “measurement” refer to the strict sense of RAN1 (impact in 38.215)? |
| FL | For Qualcomm’s comments on the scope:   * “Reference Signals” is not mentioned in the proposal; y understanding is no. * The “method” here is related to how the enhancement is done here. We could use “procedure” * Enhancements of the measurements, in my understanding is that there might be potential impact on the measurement definition in TS 38.215. In addition, my understanding of UE/gNB measurement enhancements also covers the information reported together with the UE/gNB measurements, which are defined in 38.215. |
| MTK | To QC:  Our understanding is,   * We may probably agree on 1-symbol DL PRS, and this is for general case. We don't consider any specific RS design for AoD AoA * For “measurement”, we think it is for 38.215. For example, several companies also identify the accuracy enhancement under NLOS for AoD when first path RSRP is used. Then the RSRP definition for measurement needs to be speficied in 215 |
| Huawei/HiSilicon | To QC, we understanding that the wording currently used may not be in the strictest sense complied with specification language. We are fine with the changes from the FL. |
| CEWiT | Support |
| LG | Support |
| Qualcomm | Thanks to FL, MTK, and HW with sharing their views. With these clarifications, we are OK. |
| Nokia/NSB | We support the proposal but want to note that it will be useful for WID drafting and WI phase in general if we can include some addition information on the potential enhancements so we should try to capture that in the TR even though this level proposal may be the one in Section 10. |
| InterDigital | Support |
| ZTE | We are supportive of the proposal. |
| Fraunhofer | Ok with the proposal. |

## Methods for reducing positioning latency

Background

In RAN1#102e, the following agreements were made on the signaling & procedures for reducing the latency and improving the efficiency:

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| Agreement:   * For reducing NR positioning latency, more efficient signaling & procedures will be investigated to enable a device to request and report positioning information, which may include, but not limited to, the following aspects:   + DL PRS/UL SRS configuration, activation or triggering.   + The request for positioning information (the assistance data, etc.).   + The report of positioning information (the measurement report, etc.). * Note: It is not within RAN1 scope to analyze positioning architecture enhancements to enable such more efficient signaling & procedures.   Note: RAN1 does not make any assumptions on whether the LCS architecture specified in TS 23.273 is enhanced or not. |

Submitted Proposals

* (Huawei R1-2007577) Proposal 15:
  + Rel-17 should consider UL E-CID positioning methods as the starting point for RRC configured procedure for positioning
* (vivo R1-2007666) Proposal 2:
  + The enhancements are needed for positioning latency, network efficiency, and device efficiency
* (vivo R1-2007666) Proposal 22:
  + Priority rules for positioning measurement and report can be considered in Rel-17 positioning
* (Intel R1-2007946) Proposal 15:
  + Discuss and support proposed above enhancements for low-latency NR positioning working in cooperation with RAN WG2
* (Lenovo R1-2007998) Proposal 3:
  + Study the benefits for defining a UE positioning processing timeline in the context physical layer procedures, priority indications and UL grant availability for low latency measurement, processing and reporting
* (Nokia R1-2008301) Proposal 15:
  + UE could request the expected measurement report resource from the serving gNB via RRC signaling to minimize the positioning measurement report delay.
* (Sony R1-2008365) Proposal 9:
  + Physical layer latency reduction in downlink-based positioning can be facilitated at least by introducing DL-PRS transmission triggered by L1-procedure, configured grant for positioning measurement report, and skipping SR transmission.
* (LG R1-2008417) Proposal 12:
  + In Rel-17, RAN1 needs a study on the reporting latency reduction considering the physical layer procedure for scheduling request and positioning performance impact if additional latency is required when the measurement reporting is not available at once.
* (MTK R1-2008519) Proposal 4-1:
  + At least for the periodic measurement reports, the configured grant may be considered to shorten the report latency
* (MTK R1-2008519) Proposal 4-2:
  + NW can also configure shorter reporting interval to reduce latency. For example, the reporting interval can be the same as the PRS transmission period
* (MTK R1-2008519) Proposal 4-3:
  + The UE may indicate to NW the transmission of periodic measurement reports. It is up to NW to determine whether the configured grant is activated
* (TCL R1-2007886) Proposal 4
  + Support transmission of assistance information to UEs switching between positioning systems to reduce position acquisition delay.
* (Qualcomm R1-2008619) Proposal 7:
  + With regards to the PHY-layer latency targets, NR Rel-17 should target, at least in some scenarios, a PHY-layer latency of the order of .
* (Qualcomm R1-2008619) Proposal 8:
  + Support Low-layer (e.g., unicast/group-common DCI, MAC-CE) triggering of DL PRS transmission/muting for DL-only and DL/UL methods.
* (Qualcomm R1-2008619) Proposal 9:
  + Support DCI/MAC-CE triggering of Measurement gaps (MG) for the purpose of positioning measurements.
* (Qualcomm R1-2008619) Proposal 10:
  + Support reporting location information to the serving gNB using MAC-CE or UCI.
* (Qualcomm R1-2008619) Proposal 11:
  + Support enhancements in the reporting of the positioning measurements (from the UE and the gNB) to enable reporting measurements of each Measurement Occasion (MO):
    - Introduce additional reporting periodicities,
    - Enable multiple measurement reporting from different timestamps derived on the same TRP/PRS resources
* (CEWiT R1-2008718) Proposal 5:
  + Lower layer (MAC-CE and /or DCI based) DL-PRS configuration triggering should be allowed in Rel 17 positioning enhancement.
* (CEWiT R1-2008718) Proposal 6:
  + Lower layer (MAC-CE and /or DCI based) DL triggered measurement gap should be allowed in Rel 17 positioning enhancement.
* (CEWiT R1-2008718) Proposal 7:
  + NG-RAN based positioning estimation should be configured to reduce the latency.
* (Ericsson R1-2008765) Proposal 23:
  + Assume Rel-16 single-DCI based Multi-TRP architecture for IioT scenario in order to reduce latency associated with positioning.
* (Ericsson R1-2008765) Proposal 24:
  + In Rel-17 positioning, consider configuration of positioning measurement reports via RRC to reduce latency.

Feature lead’s view

The methods for reducing positioning latency, especially the triggering, processing, and reporting of the positioning measurements. Should be investigated with high priority in this meeting. Some of the proposed enhancements are tightly related to on-demand DL PRS transmission and reception

Proposal 5-4

* The enhancement of signaling & procedures for reducing NR positioning latency are recommended for normative work, including
  + DL, UL DL+UL, and Multi-RTT positioning methods
  + UE-based and UE-assisted positioning solutions
* The details of the solutions are left for further discussion in normative work, which may include, but not limited to the following aspects:
  + Priority rules for positioning measurement and report
  + DL PRS configuration and activation via RRC signaling and/or physical layer procedure (MAC-CE and /or DCI)
  + UL SRS configuration and activation via RRC signaling and/or physical layer procedure (MAC-CE and /or DCI)
  + The request for positioning information (the assistance data, etc.) via RRC signaling and/or physical layer procedure (MAC-CE and /or DCI)
  + The report of positioning information (the measurement report, etc.) via RRC signaling
  + The request for DL measurement gap via lower layer procedure (MAC-CE and /or DCI)
  + Shorter reporting DL PRS/SRS transmission and reporting intervals
  + Measurement gaps (MG) configuration and activation via physical layer procedure (MAC-CE and /or DCI)

Comments

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| **Company** | **Comments** |
| Nokia/NSB | Support in principle but listing all the potential enhancements may lead to a long list which is not that usable when it comes to WI phase. Perhaps we could start by listing the potential enhancements and then see if we could trim the list before the end of RAN1#103-e. |
| InterDigital | Support |
| Qualcomm | We are generally supportive, but we need to try to agree on a few basic features that can be enhanced within the scope of the first bullet. Otherwise, it is too big of an item that RAN1 would recommend for normative work.  It may help to look at the latency analysis provided by the companies to identify which enhancements can reduce the PHY-layer latency the most.  A couple of quick first comments:   * there is already a separate proposal on AP/SP DL-PRS, why is it repeated again here? * UL SRS is already possible to be triggered/activated with MAC-CE/DCI, why it is repeated here?   The report of positioning information is an NAS container in RRC; why it would help with the latency if it is “RRC ignalling”? Shouldn’t that be evaluated in RAN2? |
| MTK | 1, we suggest to add the item of “configured grant at least for periodic measurement reporting”. This has also been proposed by some companies in RAN2. So what RAN1 can do is agree in principle on the solution, and leave RAN2 for normative work |
| CATT | Support Proposal 5-4. |
| CMCC | Support in principle.  For the bullets regarding DL PRS configuration and activation, it seems to be covered by the 2nd bullet of Proposal 5-2a, which is reproduced here:   * The signalling and procedures for enabling semi-persistent and a-periodic transmission and reception of DL PRS, including the configuration, transmission, reception and measurement reporting etc. are left for further discussion in normative work. |
| OPPO | Support |
| Xiaomi | Support the proposal |
| Vivo | Generally agree. In addition, we think some other enhancements should also be captured such as (DCI-based) BWP switching for PRS measurement. So we prefer the wording as below   * The enhancement of signaling & procedures for reducing NR positioning latency are recommended for normative work, including   + DL, UL DL+UL~~, and Multi-RTT positioning~~ methods   + UE-based and UE-assisted positioning solutions * The details of the solutions are left for further discussion in normative work, which may include, but not limited to the following aspects:   + Priority rules for positioning measurement and report   + ~~DL PRS configuration and activation via RRC signaling and/or physical layer procedure (MAC-CE and /or DCI)~~   + ~~UL SRS configuration and activation via RRC signaling and/or physical layer procedure (MAC-CE and /or DCI)~~   + The request for positioning information (the assistance data, etc.) via RRC signaling and/or physical layer procedure (MAC-CE and /or DCI)   + The report of positioning information (the measurement report, etc.) via RRC signaling and/or physical layer procedure   + The request for DL measurement gap via lower layer procedure (MAC-CE and /or DCI)   + Shorter reporting DL PRS/SRS transmission and reporting intervals   + Measurement gaps (MG) configuration and activation via physical layer procedure (MAC-CE and /or DCI)   + Positioning measurement without measurement gaps (MG) |
| LG | Support in principle |
| ZTE | We don’t think this proposal is necessary, some enhancements overlap the discussion of proposal 5-2 and 5-7. |
| Huawei/HiSilicon | We have questions on how this will impact UL methods, and why UE-based positioning is listed. |
| Lenovo, Motorola Mobility | Support FL’s proposal and share MTK’s view as well. |
| Intel | We prefer to have agreement on specific work directions to reduce latency.  It is not a good idea to leave whole discussion to the normative phase in terms of work item objectives and future discussions.  Also, some details on signalling may require input from or even driven by RAN2. |
| Ericsson | For PRS configuration over RRC, we believe a more efficient solution would be to configure CSI-RS for positioning, since the signal is already available and suitable for the deployments considered in this SI.  We also agree with nokia on the need to trim the list during the meeting. |
| Apple | Support the intention, details can be left to WI as the proposal says. |
| Sony | Support. We prefer to update this sub-bullet point: ○ The report of positioning information (scheduling request, the measurement report, etc.) via RRC signaling |
| CEWiT | Support |

FL Comments

It looks that the companies are supportive for the enhancement of signaling & procedures for reducing NR positioning latency in general. However, the companies also think the list of the potential enhancements should be trimmed. The proposed is revised with the consideration of the comments. By the way, some of the enhancements mentioned in this enhancement may have some overlapping with the on-demand PRS already agreed, and also the AP-PRS that is under discussion in a separate proposal.

Proposal 5-4 (Revision 1)

* The enhancements of signaling & procedures for reducing NR positioning latency are recommended for normative work, including
  + DL, UL and DL+UL positioning methods
  + UE-based and UE-assisted positioning solutions
* The details of the solutions are left for further discussion in normative work, which may include, but not limited to the following aspects:
  + Latency reduction related to the positioning assistance (e.g., via RRC signaling and/or physical layer procedure)
  + Latency reduction related to the reception of DL PRS (e.g., priority rules for the reception of DL PRS)
  + Latency reduction related to the measurement configuration (e.g., measurement gaps (MG) configuration via physical layer procedure, or the support of the DL PRS measurement without MG)
  + Latency reduction related to the measurement reporting (e.g., via RRC signaling and/or physical layer procedure)

Comments

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| **Company** | **Comments** |
| Vivo | Support in principle. And we think physical layer procedure for measurement reporting should not be excluded. So we propose to change related descriptions as follows:   * + Latency reduction related to the measurement reporting (e.g., via RRC signaling and/or physical layer procedure) |
| Lenovo, Motorola Mobility | Support proposal 5-4 (revision 1) and inclusion of Vivo’s additional example. |
| Intel | Support. |
| CATT | Support. |
| Qualcomm | Support |
| FL | Modified based on vivo’s suggestion |
| MTK | We support in general, and we also propose to add one thing in 4-th bullet:  Latency reduction related to the measurement reporting (e.g., via RRC signalling, or configured grant, or shorter report interval )  We are fine for vivo’s version if our lists are part of physical layer procedure (and we think so) |
| Huawei/HiSilicon | We do not think UL should be included. To be more specific, we suggest to enumerate the positioning methods under consideration.  We do not think that UE-based solutions needs to be included.  We do not think MG configuration via physical layer is feasible, nor should be covered by positioning SI/WI.  We should add the note that we made in the previous meeting.  In summary, we propose the following compromised way-forward for the sake of progress   * The enhancements of signaling & procedures for reducing NR positioning latency are recommended for normative work, including   + DL positioning methods, Multi-RTT positioning, and E-CID positioning   + No assumptions are made on whether the LCS architecture specified in TS 23.273 is enhanced or not. * The details of the solutions are left for further discussion in normative work, which may include, but not limited to the following aspects:   + Latency reduction related to the positioning assistance (e.g., via RRC signaling and/or physical layer procedure)   + Latency reduction related to the reception of DL PRS (e.g., priority rules for the reception of DL PRS)   + Latency reduction related to the measurement configuration (e.g., the support of the DL PRS measurement without MG)   + Latency reduction related to the measurement reporting (e.g., via RRC signaling and/or physical layer procedure) |
| Apple2 | Support |
| Xiaomi | Support |
| vivo2 | Support  To Huawei, we think this enhancement is needed at least for MT-LR UE-based case (which may have procedures similar to UE-assisted positioning). Besides, considering measurement gaps (MG) configuration via physical layer procedure is beneficial for latency in our evaluation, we shouldn’t exclude it. Furthermore, we want to emphasize the list only means that solutions that we **may** consider in R17. |
| CEWiT | Support |
| LG | We prefer to keep the first sub-bullet of the second main-bullet of the original proposal 5-4, which is “Priority rules for positioning measurement and report”. If it is difficult to be captured, we suggest adding one more example in the fourth sub-bullet of the second main bullet, as follows:  Latency reduction related to the measurement reporting (e.g., via RRC signaling and/or physical layer procedure, and/or priority rules) |
| Nokia/NSB | We are mostly okay with the proposed main bullet from HW. We guess we should mention specifically that we are aiming to enhance the PHY layer latency (as defined in previous meeting), right? If so, we should be explicit about that. We think the list in the second bullet may be better to take into account the final observations and analysis being done om 8.5.2 thread. Suggest to just agree the main bullet first. |
| InterDigital | Generally ok with the proposal with the following modification in the examples   * The enhancements of signaling & procedures for reducing NR positioning latency are recommended for normative work, including   + DL, UL and DL+UL positioning methods   + UE-based and UE-assisted positioning solutions * The details of the solutions are left for further discussion in normative work, which may include, but not limited to the following aspects:   + Latency reduction related to the positioning assistance (e.g., via RRC, MAC signaling and/or physical layer procedure)   + Latency reduction related to the reception of DL PRS (e.g., priority rules for the reception of DL PRS)   + Latency reduction related to the measurement configuration (e.g., measurement gaps (MG) configuration via physical layer procedure, or the support of the DL PRS measurement without MG)   + Latency reduction related to the measurement reporting (e.g., via RRC, MAC signaling and/or physical layer procedure) |
| ZTE | 1.The second sub-bullet in second main bullet is already covered by proposal 2-3.  2.Agree with Huawei on MG configuration. By the way, the MG related topic is covered by proposal 5-7.  3. Not sure what “ positioning assistance” stands for? Does it have RAN1 impact ? |
| Sony | Support |
| Intel | Support |

FL comments

For MTK’s comments, the understanding here is to use any enhancement that is related to physical layer.

For Huawei’s comments, it is unclear to me why UL positioning needs to be excluded. Maybe Huawei can provide further explanation. For the comment, Note: RAN1 does not make any assumptions on whether the LCS architecture specified in TS 23.273 is enhanced or not.

It seems there are different views (e.g., Huawei and ZTE’s comments) on the list of potential enhancements listed under the 2nd bullet. One potential solution is to adopt Nokia’s suggestion to just agree the main bullet first, we could have the discussion in online meeting.

Also, the proposal here is related to other enhancements under discussion, e.g., on-demand DL PRS. Here is more the enhancement related to the request and report positioning information.

Proposal 5-4 (Revision 2)

* The enhancements of signaling & procedures for reducing NR positioning latency are recommended for normative work, including
  + DL and DL+UL (including E-CID) positioning methods
* The details of the solutions are left for further discussion in normative work, which may include, but not limited to the following aspects:
  + 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)
  + Latency reduction related to the measurement configuration (e.g., measurement gaps (MG) configuration via physical layer procedure, or the support of the DL PRS measurement without MG)
  + Latency reduction related to the measurement reporting (e.g., via RRC signaling, MAC-CE and/or physical layer procedure, and/or priority rules)
* No assumptions are made on whether the LCS architecture specified in TS 23.273 is enhanced or not.

*If we cannot reach the consensus on above proposal, suggest capturing the following in TR as an alternative:*

More efficient signaling & procedures were investigated to enable a device to request and report positioning information, including

* DL PRS/UL SRS configuration, activation or triggering.
* The request for positioning information (the assistance data, etc.).
* The report of positioning information (the measurement report, etc.).

During the investigation, multiple sources consider it is beneficial to support the more efficient signaling & procedures for reducing positioning latency, and improve network efficiency, and device efficiency. More specifically,

* One source (Huawei R1-2007577) proposed to consider UL E-CID positioning methods as the starting point for RRC configured procedure for positioning;
* [3] sources (vivo R1-2007666, Qualcomm R1-2008619, CEWiT R1-2008718) proposed to support low layer (MAC-CE and /or DCI) triggered measurement gap
* [1] source (vivo R1-2007666) proposed to:
  + Support the priority rules for positioning measurement and report;
  + Consider the aperiodic positioning measurement report
  + Consider BWP switching as an alternative to using measurement gap
  + Support low layer triggering Positioning requesting/ positioning reporting for reducing positioning latency
* [1] source (Intel R1-2007946) proposed the enhancements for low-latency NR positioning working in cooperation with RAN WG2;
* [1] source (Lenovo R1-2007998) proposed to define a UE positioning processing timeline in the context physical layer procedures, priority indications and UL grant availability for low latency measurement, processing and reporting;
* [1] source (Nokia R1-2008301) proposed UE could request the expected measurement report resource from the serving gNB via RRC signaling to minimize the positioning measurement report delay.
* [3] source (Sony R1-2008365, LG R1-2008417, MTK R1-2008519) proposed introducing configured grant for positioning measurement report, and skipping SR transmission,
* [1] source (MTK R1-2008519) proposed to
  + configure shorter reporting interval to reduce latency.
  + for the UE to indicate to NW the transmission of periodic measurement reports.
* [1] source (TCL R1-2007886) proposed to support transmission of assistance information to UEs switching between positioning systems to reduce position acquisition delay.
* [1] source (Qualcomm R1-2008619) proposed to support
  + reporting location information to the serving gNB using MAC-CE or UCI.
  + enhancements in the reporting of the positioning measurements (from the UE and the gNB) to enable reporting measurements of each Measurement Occasion (MO)
  + introduce additional reporting periodicities,
  + enable multiple measurement reporting from different timestamps derived on the same TRP/PRS resources
* [1] source (CEWiT R1-2008718) proposed to support NG-RAN based positioning estimation should be configured to reduce the latency.
* [1] source (Ericsson R1-2008765) proposed to support
  + single-DCI based Multi-TRP architecture for IIoT scenario in order to reduce latency associated with positioning.
  + configuration of positioning measurement reports via RRC to reduce latency.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CATT | Support. |
| LG | Support |
| Huawei/HiSilicon | To FL: Based on the description, we can hardly see any impact on UL positioning, because the whole bullets are discussing MG, report configuration to the UE, etc. For UL, we already have SRS configuration by RRC, with possibly additional activation by MAC CE/DCI.  Thanks for the compromised solution. We just wish to clarify that E-CID positioning is included by “DL and DL+UL positioning methods”, because in Rel-16, RAN1 in SI concluded E-CID is DL+UL, but later RAN1 in WI seemed only treating it as DL positioning, and later RAN3 introduced gNB AoA measurement to finally make it DL+UL. |
| vivo | Support proposal 5-4 (revision 2).  In addition, we hope the alternative choice is not needed, otherwise, some of our proposals are missed, such as   * One source (vivo R1-2007666) proposed to consider the aperiodic positioning measurement report * One source (vivo R1-2007666) proposed to consider low layer triggering measurement gap * One source (vivo R1-2007666) proposed to consider BWP switching as an alternative to using measurement gap * One source (vivo R1-2007666) consider it is beneficial to support low layer triggering Positioning requesting/ positioning reporting for reducing positioning latency |
| ZTE | Agree the main bullet first. Some enhancements in sub-bullets are already covered by other proposals. Alternatively, we are also fine to only agree the TP in TR. |
| Intel | Support. Can you please clarify, why “UL methods” have been removed from the first bullet above? |
| Lenovo, Motorola Mobility | Support. |
| OPPO | Support the main bullet. All the sub-bullets are the potential topics for WI. However, we don’t ensure we will have one new scheme for each sub-bullet, especially compared to other proposals. In order to avoid such kind of misunderstanding, we suggest to add “may” before “including” (highlighted by Yellow)   * The enhancements of signaling & procedures for reducing NR positioning latency are recommended for normative work, may including   + DL and DL+UL positioning methods * The details of the solutions are left for further discussion in normative work, which may include, but not limited to the following aspects:   + 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)   + Latency reduction related to the measurement configuration (e.g., measurement gaps (MG) configuration via physical layer procedure, or the support of the DL PRS measurement without MG)   + Latency reduction related to the measurement reporting (e.g., via RRC signaling, MAC-CE and/or physical layer procedure, and/or priority rules) * No assumptions are made on whether the LCS architecture specified in TS 23.273 is enhanced or not. |
| Nokia/NSB | We support the main bullet but think the scope may be too large for the other bullets. Some of the proposed enhancements are not so clear to us and we have not had sufficient time to discuss/analyse them. It might be better to agree on the main bullet separately and continue discussing the potential solutions/enhancements this week. |
| FL | For Huawei’s comment, E-CID is added to DL+UL positioning method.  For vivo’s comment, the proposals are added into the alternative TP.  For ZTE and Nokia’s comment, yes, we can try to see if we can get the main bullet to be agreed first.  For Intel’s comment, I assume Huawei’s reply has address the concerns  For OPPO’s comment, we may need to add “may” in the main bullet, since the intention is to include both DL and DL+UL.  For the proposals in the alternative TP,   * I changed “to study” to “to support” since the proposals should be made based on the results of the study. * Removed the proposals related to reducing transmission of DL PRS since it is already covered in Section 5.2 * Combined some similar proposals. |
| CATT | Support the revised proposal. |
| CMCC | Support. |

Agreement:

Capture the following in the TR:

* The following 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 (e.g., via RRC signaling, MAC-CE and/or physical layer procedure, and/or priority rules)
    - Latency reduction related to measurements
* 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.

FL comments

The above agreement may need to be modified for consistency because:

1. First main bullet says “The following enhancements of signaling & procedures for reducing NR positioning latency are recommended for normative work, including DL and DL+UL positioning methods”. However, the following subbullet is not “enhancements” but “The details of the solutions are left for further discussion in normative”.
2. The meaning of the sub-bullet “Latency reduction related to measurements” is unclear, since the previous two subnultes are also related to measurements

### Proposal 5-4a (Revision 3)

Make the following changes to the previous agreement:

* 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 (e.g., via RRC signaling, MAC-CE and/or physical layer procedure, and/or priority rules)
    - Latency reduction related to measuring the reference signals
* 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.

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| **Company** | **Comments** |
| CATT | Support. |
| ZTE | Would it be better to revise third bullet as following?   * + Latency reduction related to buffer and process reference signals |
| vivo | We are okay for that, but worry it will kill more online time |
| LG | OK |
| Huawei/HiSilicon | We do not think deleting “The details of the solutions are left for further discussion in normative work, which may include the following aspects:” is the correct interpretation for the agreement. Only deleting “following” in the first main bullet should be sufficient. |
| FL | For ZTE’s comment, the buffer size is more related to UE’s implementation. Maybe we can change “obtaining measurements from reference signals” to “measurements  For Huawei’s comment, if we remove the “following”, the first part of the agreement will be correct. But, it could make the two sub-bullets become more important that the three sub-sub-bullets in the first part of the agreement. |

## Methods for reducing timing measurement errors

Background

Network time synchronization errors have a direct impact on the positioning accuracy of DL-TDOA and UL-TDOA. For multi-RTT, although the precise network time synchronization is not a requirement, the group delays in the Tx and Rx RF trains of the UE and TRPs also impact directly on the positioning accuracy of multi-RTT. For supporting sub-meter positioning accuracy in Rel-17, it is a necessity to remove or compensate these timing errors.

In RAN1#102e, we made the following agreements regarding UE/gNB Rx/Tx transmission delays.

|  |
| --- |
| Agreement:  The scenario, benefits, methods and Signalling for improving positioning accuracy in the presence of the UE Rx/Tx transmission delays, and/or and gNB Rx/Tx transmission delays, will be investigated for UE-based and network-based (including UE-assisted) positioning in Rel-17. |

Submitted Proposals

* (Huawei R1-2007577) Proposal 7:
  + Rel-17 should support calibration/reference UE that participates in the conventional NR positioning method and has its location information with very high confidence for the purpose timing calibration (group delay, clock sync error) and angle calibration (UL-AoA).
* (vivo R1-2007666) Proposal 30
  + The enhancement of Rel-16 technique (UL-TDOA+AoA) can be the method for improving the accuracy in the presence of Rx/Tx transmission delays and sync error.
* (vivo R1-2007666) Proposal 31
  + The differential positioning technique can be studied as the method for improving the accuracy in the presence of Rx/Tx transmission delays and sync error.
* (ZTE R1-2007755) Proposal 4:
  + Enable network measurement to calibrate synchronization offset, e.g. support RSTD measurement between positioning nodes
* (ZTE R1-2007755) Proposal 5:
  + Network can deliver some prior channel information to UE, the information will assist UE to perform better positioning.
* (CATT R1-2007755) Proposal 7:
  + A receiver should eliminate the impact of the Rx group delay when providing NR positioning measurements, e.g., UE should eliminate the Rx group delay in UE Rx-Tx time difference measurements
* (CATT R1-2007755) Proposal 8:
  + For network-based positioning, the information of the UE Tx group delay should be sent to LMF for eliminating the impact of the Tx group delay on NR positioning. For UE-based positioning, the information of the gNB Tx group delay should be sent to UE for eliminating the impact of the Tx group delay on NR positioning.
* (CATT R1-2007755) Proposal 14:
  + RAN1 should investigate the use of the RAT-dependent network synchronization techniques for NR positioning, where the precise network synchronization can be achieved by monitoring the reference signals transmitted from TRPs.
* (CATT R1-2007755) Proposal 15:
  + Consider supporting the differential operations for eliminating TRP synchronization errors for high-accuracy NR positioning in Rel-17.
* (Intel R1-2007946) Proposal 11:
  + Support network based (inter-gNB) and UE based TX/RX timing errors estimation and measurement report signaling.
* (CMCC R1-2008015) Proposal 5:
  + The methods and signaling for the estimation and compensation on the network synchronization errors should be investigated in Rel-17.
* (MTK R1-2008519) Proposal 3-1:
  + For UE based mode, support the combining of downlink (DL-RSTD) and uplink (UL-RTOA) measurement.
* (MTK R1-2008519) Proposal 3-2:
  + For UE based mode, the measurement results at gNB side (UL-RTOA values) can provide to the UE as assistance information to cancel the synchronization error and to reduce the impact of transmission delay.
* (Qualcomm R1-2008619) Proposal 3:
  + Support signaling, reporting and PHY-layer procedural enhancements to mitigate the degradation of the positioning accuracy in timing-based methods due to gNB and UE timing errors.
* Qualcomm) Proposal 1:
  + Support the following enhancements for UE-based positioning:
    - UE-based DL & UL methods (i.e., UE-Based Multi-RTT)
    - Enhancements on the assistance data
      * Per PRS-resource RTD assistance data
      * Per PRS-resource beam-shape assistance data
* (CEWiT R1-2008718) Proposal 2:
  + Proposal 2: Deployment of reference UE in IioT and indoor office scenario should be adopted for determination of the network synchronization error.
* (CEWiT R1-2008718) Proposal 3:
  + New measurement and reporting field should be introduced for the network synchronization error estimation both in LPP and NRPPa for DL positioning and UL positioning, respectively.
* (Ericsson R1-2008765) Proposal 13:
  + Study and specify methods to estimate UE RX and TX timing errors per UE antenna panel (due to filter group delays etc.) in order to enhance UL TDOA, DL TDOA and RTT positioning accuracy. Potential methods may include both reporting of what antenna panel has been used by the UE for a measurement or a SRS transmission and network control of what antenna panel the UE shall use for a measurement or a SRS transmission
* (Ericsson R1-2008765) Proposal 14:
  + RAN1 should study techniques needed to mitigate the impact of UE TX timing errors for multiple UE antenna panels on UL TDOA/RTT positioning, such as e.g. 1. Restricting which UE antenna panel to use for SRS transmission through SRS configuration. 2. Beam and panel sweeping of the SRS. 3. Interpretation of spatial relations when the UE is restricted to utilize a certain antenna panel. 4. Reporting of which UE antenna panel that is used for each SRS transmission. 5. Reporting of UE antenna panel configuration and capabilities. 6. TX timing difference error mitigation as an integrated part of UL TDOA/RTT positioning. 7. TX timing difference estimation as an integrated part of UL TDOA/RTT positioning. 8. TX timing difference estimation in a separate timing error calibration procedure.
* (Ericsson R1-2008765) Proposal 15:
  + RAN1 should study techniques needed to mitigate the impact of UE RX timing errors for multiple UE antenna panels on DL TDOA/RTT positioning, such as e.g. 1. UE performing and reporting multiple UE RSTD/UE Rx – Tx time difference measurements based on PRS/PRSs transmitted from the same TRP but utilizing different UE antenna panels. 2. Interpretation of QCL relations when the UE is restricted to utilize a certain antenna panel. 3. Configuration of which antenna panel the UE should use for a UE RSTD/UE Rx – Tx time difference measurements. 4. Reporting of which UE antenna panel that was used for each UE RSTD/UE Rx – Tx time difference measurement. 5. UE Inter Panel Time Difference measurements and measurement reporting, i.e. UE estimation of the difference in TOA utilizing different antenna panels based on PRS/PRSs transmitted from the same TRP. 6. Reporting of UE antenna panel configuration and capabilities 7. UE compensation for estimated inter panel RX time differences in UE RSTD/UE Rx – Tx time difference measurements. 8. RX timing difference error mitigation as an integrated part of DL TDOA/RTT positioning 9. RX timing difference estimation as an integrated part of DL TDOA/RTT positioning 10. RX timing difference estimation in a separate timing error calibration procedure
* (Ericsson R1-2008765) Proposal 16:
  + RAN1 should study the following additional techniques for mitigation of the impact of UE RX+TX timing errors for multiple UE antenna panels on RTT positioning: 1. Combined RX+TX timing difference error mitigation as an integrated part of RTT positioning 2. Combined RX+TX timing difference estimation as an integrated part of RTT positioning 3. Combined RX+TX timing difference estimation in a separate timing error calibration procedure

Feature lead’s view

To obtain the sub-meter positioning accuracy for Rel-17, it is clear that the measurement errors, including the errors caused by the network synchronization and the Tx/Rx group delays, need to be reduced to sub-meter level. Thus, based on the investigation and the submitted proposals, the methods for reducing these timing errors should be considered in Rel-17.

Proposal 5-5a

* The methods, measurements, signaling, and procedures for improving positioning accuracy in the presence of the UE Rx/Tx transmission delays, and/or and gNB Rx/Tx transmission delays are recommended for normative work, including
  + DL, UL and DL+UL positioning methods
  + UE-based and UE-assisted positioning solutions
* Note: The details of the solutions are left for further discussion in normative work.

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Nokia/NSB | Okay in principle. From our side we think it would be beneficial to have a better definition of what is/isn’t included in the timing delay. The model we agreed for simulations was clear on applying per panel, but we should be clear what problems we aim to solve with the normative work. |
| Qualcomm | Support |
| MTK | 1, to say DL, UL and DL+UL would be sufficient |
| CATT | Support Proposal 5-5a. |
| CMCC | Support |
| vivo | Okay |
| ZTE | Support |
| Huawei/HiSilicon | Support. |
| Intel | Support, if an impact on the specification is identified and justified, which needs to be discussed and decided first. |
| Ericsson | Support. |
| Apple | Support |
| Fraunhofer | Support |
| CATT2 | Support the updated proposal. |
| Sony | DL |

FL’s Comments

For MTK’s comment, yes, we can remove the Multi-RTT.

For Nokia’s comments on whether to consider per panel delays, yes. it should be per panel. But, I assume this level of details may be considered during the WI.

For Intel’s comment on the impact on the specification, yes, it would be great if we have the time to discuss the impact on the specification now. The concern is that we may not have the time to do so in this meeting.

### (Closed) Suggested Offline Consensus (5-5a)

Capture the following in the TR:

* The methods, measurements, signaling, and procedures for improving positioning accuracy in the presence of the UE Rx/Tx transmission delays, and/or and gNB Rx/Tx transmission delays are recommended for normative work, including
  + DL, UL and DL+UL positioning methods
  + UE-based and UE-assisted positioning solutions
* Note: The details of the solutions are left for further discussion in normative work.

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CATT | Support. |
| vivo | Support |
| ZTE | OK. |
| Nokia/NSB | Okay. |
| Intel | Support. |

Proposal 5-5b

* The methods, measurements, signaling, and procedures for improving positioning accuracy in the presence of the network synchronization errors are recommended for normative work, including
  + DL, UL and DL+UL positioning methods
  + UE-based and UE-assisted positioning solutions
* Note: The details of the solutions are left for further discussion in normative work.

Comments

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| --- | --- |
| **Company** | **Comments** |
| MTK | 1, We support the handling of network synchronization error. Even though IIOT scenario could have smaller sync error, the general scenario still suffers  2, we think all the potential solutions may not mandate the infra vendor to finetune sync error based on well synchronization to gps satellite. As we know, the operators also care about the sync error problem. We expect the infra vendors to be open-minded for considering this |
| CATT | Support Proposal 5-5b. |
| CMCC | Support |
| vivo | Support in principle, but we doubt whether the accuracy of Multi-RTT positioning methods is affected by synchronization. If not, do we need list multi-RTT here? |
| ZTE | Support |
| Huawei/HiSilicon | Support. |
| Ericsson | We do not support this proposal. As mentioned during RAN1#102e, we believe that, for use cases within the scope of this SI, the issue can be dealt with by a combination of enhancements to UE positioning measurements report and network implementation. |
| Qualcomm | Support |
| LG | Support. |
| Fraunhofer | Support |
| Ericsson 2 | Reiterating our position, we cannot agree to recommending this for normative work as in our view, this can be mitigated via network implementation. But we are open to capture proposal 5-5b (Alternative) if our views are captured as part of the observation. |
| Nokia/NSB | We do not support this proposal as there already exist methods in Rel-16 that do not suffer from synchronization errors and we agree with Ericsson’s comments that it can be handled with network implementation. |

FL’s Comments

It seems most companies are supportive to Proposal 5-5b, except two company. Proposal 5-5b (Alternative) is prepared in case we cannot reach the consensus for Proposal 5-5b.

**To all companies:** please feel free to add/remove your companies’ names to the supporting/not supporting sources when you review the proposal.

Proposal 5-5b (Alternative)

[8] sources (Huawei/HiSilicon, vivo, ZTE, CATT, CMCC, MTK, Qualcomm, CEWiT) have investigated and/or evaluated the techniques for improving positioning accuracy under the presence of the network synchronization errors. In general, these sources consider it is beneficial to support calibration and/or elimination of the network synchronization errors for improving positioning accuracy. More specifically,

* + One source (Huawei, CEWiT) consider it is beneficial to support calibration/reference UE that participates in the conventional NR positioning method and has its location information with very high confidence for the purpose timing calibration (group delay, clock sync error) and angle calibration (UL-AoA).
  + One source (vivo R1-2007666)consider it is beneficial to enhancement of Rel-16 technique (UL-TDOA+AoA) for improving the accuracy in the presence of Rx/Tx transmission delays and sync error.
  + Two sources (vivo, CATT) consider it is benefitial to use differential positioning technique for improving the accuracy in the presence of Rx/Tx transmission delays and sync error.
  + Seven sources (ZTE, CATT, CMCC, MTK, Qualcomm, Huawei/HiSilicon, CEWiT, vivo) consider it is beneficial to estimate and calibrate network synchronization techniques based on the DL/UL measurements from the NR DL/UL signals.
  + One source (Ericsson R1-2008765) considers that implementation-based solutions can address this issue and no specification enhancements are needed.

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CATT | Support. |
| Huawei/HiSilicon | We think Huawei/HiSilicon can also be added to the last bullet.   * + Six sources (ZTE, CATT, CMCC, MTK, Qualcomm, Huawei/HiSilicon) consider it is benefitial to estimate and calibrate network synchronization techniques based on the DL/UL measurements from the NR DL/UL signals. |
| LG | Thanks for FL’s effort to make this proposal considering overall companies’s proposal and evaluation results. However, from our side, the previous proposal seems more appropriate to discuss potential enhancement, but we are okay to capture this as an observation. |
| ZTE | Support but prefer previous proposal. It’s recommended for normative work. |
| CEWiT | Support. We support the first sub bullet. Included CEWiT in the source list. I request you to add CEWiT in last bullet too. |
| Ericsson | We can be ok with this formulation. But please add the following sub-bullet to capture Ericsson’s view:   * One source (Ericsson) considers that implementation-based solutions can address this issue and no specification enhancements are needed. |
| vivo | We think vivo can also be added to the fourth bullet.   * + Seven sources (ZTE, CATT, CMCC, MTK, Qualcomm, Huawei/HiSilicon, CEWiT,vivo) consider it is beneficial to estimate and calibrate network synchronization techniques based on the DL/UL measurements from the NR DL/UL signals. |
| CMCC | We think that, same as the UE/gNB Rx/Tx transmission delay, the NW sync error should be recommended for normative work as well. |
| MTK | Support |

FL comments

It seems all companies share the same view that network synchronization errors have significant impact on the NR positioning accuracy. The difference is whether it should be addressed by implementation-based solutions or need also to be addressed as the positioning enhancement wok in Rel-17 specification.

Again, the suggestion is to see if we can have compromise by adopting “*can be studied further, and if needed, specified during normative work*”.

### Proposal 5-5b (Revision 1)

Capture the following in the TR

[8] sources (Huawei/HiSilicon, vivo, ZTE, CATT, CMCC, MTK, Qualcomm, CEWiT) have investigated and/or evaluated the techniques for improving positioning accuracy under the presence of the network synchronization errors.

In general, these sources consider it is beneficial to support calibration and/or elimination of the network synchronization errors for improving positioning accuracy. More specifically,

* + [2] sources (Huawei, CEWiT) consider it is beneficial to support calibration/reference UE that participates in the conventional NR positioning method and has its location information with very high confidence for the purpose timing calibration (group delay, clock sync error) and angle calibration (UL-AoA).
  + [1] source (vivo) consider it is beneficial to enhancement of Rel-16 technique (UL-TDOA+AoA) for improving the accuracy in the presence of Rx/Tx transmission delays and sync error.
  + [2] sources (vivo, CATT) consider it is beneficial to use differential positioning technique for improving the accuracy in the presence of Rx/Tx transmission delays and sync error.
  + [8] sources (ZTE, CATT, CMCC, MTK, Qualcomm, Huawei/HiSilicon, CEWiT, vivo) consider it is beneficial to estimate and calibrate network synchronization techniques based on the DL/UL measurements from the NR DL/UL signals.
  + [1] source (Ericsson) considers that implementation-based solutions can address this issue and no specification enhancements are needed.

The methods, measurements, signaling, and procedures for improving positioning accuracy in the presence of the network synchronization errors *can be studied further, and if needed, specified during normative work*, including

* DL, UL and DL+UL positioning methods
* UE-based and UE-assisted positioning solutions
* Note: The details of the solutions are left for further discussion in normative work.

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| vivo | Support |
| ZTE | Support |
| CMCC | Support |
| Ericsson | Do not support. We agreed with the previous version of the proposal without the last statement, so we could still support proposal 5-5b (alternative) |
| Nokia/NSB | Do not support. We already have a solution to the network synchronization problem and we have much more pressing issues/enhancements to resolve during Rel-17 (with limited time of course). |
| CEWiT | Support |
| CATT | Support.  In our point of view, the methods and signalling for the estimation and calibration of the network synchronization errors are critical to satisfy the requirements of higher positioning accuracy in Rel-17. From the simulation results from companies in this meeting, it was observed that network sync error will degrade the positioning accuracy a lot, compared with perfect gNB sync. Therefore, it had better to study the methods to mitigate the impact of sync error on the accuracy. |
| LG | We are not supportive of this proposal. In the current specification, the LMF can provide the UE of the time synchronization information between TRPs as assistance data |

FL comments

It seems there are different views on whether the proposed enhancements should be supported. Further discussion is needed.

## Enhancements on E-CID positioning

Background

In Rel-16, E-CID is supported based on the Rel-15 RRM measurements. Several companies propose further enhancements of E-CID positioning based on Rel-15/Rel-16 NR reference signals for improving positioning accuracy and efficiency.

Submitted Proposals

* (Huawei R1-2007577) Proposal 14:
  + Rel-17 should support E-CID to include RTT (UE/gNB Rx – Tx time difference) measurement for the serving cell using communication link.
* (CMCC R1-2008015) Proposal 4:
  + Enhancement on E-CID positioning should be supported:
    - Supporting E-CID based on RTT + UL-AoA measurements
    - Supporting E-CID using Rel-16 DL/UL positioning reference signals
* (DCM R1-2008550) Proposal 1:
  + TA based positioning scheme (e.g. reusing LTE positioning scheme based on TA Type1 and TA Type2) should be consider for Rel-17 NR positioning to reduce positioning latency.
* (Ericsson R1-2008765) Proposal 26:
  + Support reuse of Rel-15 SRS resource set for gNB Rx-Tx and UE Rx-Tx measurements for positioning in NR.
* (Ericsson R1-2008765) Proposal 27:
  + Send an LS to RAN4 regarding UE Rx-Tx requirements
  + Note: There is no impact to specifications managed by RAN1

Feature lead’s view

The enhancement was discussed in RAN1#102e without the consensus. The enhancements have relatively low impact on the standard work, but may offer significant benefits for reducing the positioning latency and improve E-CID accuracy.

### Proposal 5-6

* Enhancements for E-CID positioning based on NR Rel-15 reference signals (e.g., Rel-15 CSI-RS and SRS) and Rel-16 reference signals (e.g., PRS and SRS for positioning) with timing related measurements (e.g., UE/gNB Rx-Tx measurements) and angular measurements (e.g., DL-AoD and UL AoA) for the potential of improving positioning accuracy and device efficiency are recommended for normative work.

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CATT | Support Proposal 5-6. |
| Huawei/HiSilicon | Support. |
| Apple | Do not support, the scope is already big |
| NTT DOCOMO | Support |
| CMCC | Support |
| ZTE | We understand that the proposal is both for UL ECID and DL ECID? If yes, it should be discussed separately. |

Comments

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| --- | --- |
| **Company** | **Comments** |
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|  |  |

## Measurement gap

Background

In Rel-16, UE is not expected to process DL PRS if the measurement gap is not configured. UE measurement gap is configured through RRC signaling. In this meeting, the following enhancements related to measurement gap for positioning are proposed.

Submitted Proposals

* (vivo R1-2007666) Proposal 23:
  + BWP switching can be considered in Rel-17 as an alternative to using measurement gap.
* (vivo R1-2007666) Proposal 24:
  + PRS measurement within active DL BWP should be supported in Rel-17
* (vivo R1-2007666) Proposal 25:
  + Support to introduce on-demand measurement gap for on-demand PRS in Rel-17.
    - LMF requests measurement gap should be supported.
* (vivo R1-2007666) Proposal 26:
  + Low layer triggering measurement gap should be considered in Rel-17 for NR positioning enhancement.
* (vivo R1-2007666) Proposal 27:
  + Measurement gap enhancement for concurrent processing multiple positioning frequency layers should be considered, if DL PRS processing with aggregated DL PRS resources is supported.
* (vivo R1-2007666) Proposal 27:
  + Measurement gap related indication should be included in positioning measurement report.
* (CATT R1-2007755) Proposal 16:
  + Aperiodic and SPS measurement gap for positioning should be introduced to achieve low positioning latency in Rel-17.
* (Xiaomi R1-2008083) Proposal 5:
  + BWP switching can be used for PRS measurement instead of measurement gap.
* (InterDigital R1-2008491) Proposal 1:
  + Measurement gap-less reception of PRS should be adopted to minimize latency
* (InterDigital R1-2008491) Proposal 2:
  + Mechanisms to allow measurement gap-less should be studied
* (InterDigital R1-2008491) Proposal 3:
  + Pre-configuration of measurement gaps and activation of pre-configured measurement gaps should be adopted for faster configuration of measurement gaps
* (Qualcomm R1-2008619) Proposal 9:
  + Support DCI/MAC-CE triggering of Measurement gaps (MG) for the purpose of positioning measurements.
* (Qualcomm R1-2008619) Proposal 17:
  + Support within-Active-BWP Positioning Processing without MG, but within a PRS processing time-window which enables priotizing location measurements over other data, control and CSI-related procedures withing the active BWP.

Feature lead’s view

It is clearly undesirable that a measurement gap has to be configured whenever a UE needs to measure DL PRS. Thus, there is a need to the enhancement of the measurements without depending on the configuration of the measurement gap, or the enhancements related to the configuration of measurement gap for reducing the positioning latency and improving UE and network efficiency.

### Proposal 5-7

* The enhancements related to UE measurement gap are recommended for normative work.
* Note: The details of the solutions are left for further discussion in normative work, which may include, but not limited to the following aspects:
  + DL PRS reception within active DL BWP without the configuration of the measurement gap
  + BWP switching for positioning measurement without the configuration of the measurement gap
  + Measurement gap indication in positioning measurement report.
  + Enhancements in MG configuration & triggering (e.g., DCI/MAC-CE triggered MG, Positioning-specific MG, band-specific/layer-specific MG)

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| InterDigital | Support |
| CATT | Support Proposal 5-7. |
| Xiaomi | Support the proposal |
| vivo | Support.  Firstly, PRS measurement within active BWP should be recommended for normative work. It can be observed in our paper [R1-2007666], only using MG for PRS measurement has following problems: long time data interruption;the mismatch of the period/length between measurement gap and PRS may lead to larger latency, lower accuracy or waste of resources; the latency of measurement gap request and configuration is long ; in some cases, the benefits brought by measurement gap do not match the restrictions brought by measurement gap.  While for PRS measurement in active BWP, the above problems do not exist. When PRS location is within the scope of active BWP, UE can measurement PRS within active BWP.  Besides, PRS measurement via BWP switching as alternative to using measurement gap should also be recommended for normative work. Comparing with PRS measurement using MG, BWP switching only interrupts data service during switching time and has short switching latency due to low layer triggering. In addition, supporting BWP switching brings enough flexibility of the serving gNB. It is up to serving gNB to choose the suitable method to assist PRS measurement for different cases. For example, considering the interruption caused by the MG, the gNB can reject the MG request of the UE and trigger the BWP switching instead.  In addition, MG related enhancement should also be recommended for normative work. Enhancement of PRS measurement within MG is the key point that cannot be bypassed in positioning enhancement. For example, if ap/sp PRS/on-demand PRS is introduced, related ap/sp/on-demand MG should also be considered.  Finally, due to PRS measurement within active BWP is not entirely within the scope of MG related enhancement, we support proposal 5-7 with following minor changes: Proposal 5-7  * The enhancements related to PRS measurement within active BWP and using ~~UE~~ measurement gap are recommended for normative work. * Note: The details of the solutions are left for further discussion in normative work, which may include, but not limited to the following aspects:   + DL PRS reception within active DL BWP without the configuration of the measurement gap   + BWP switching for positioning measurement without the configuration of the measurement gap   + Measurement gap indication in positioning measurement report.   + Enhancements in MG configuration & triggering (e.g., DCI/MAC-CE triggered MG, Positioning-specific MG, band-specific/layer-specific MG, on-demand MG) |
| Huawei/HiSilicon | The entire motivation of introducing this feature is unclear. In our understanding, measurement without MG should be the main focus, since we do not want to interrupt communication when performing positioning measurement. |
| Qualcomm | Support. We have different view from HW. MG-based PRS is legacy and it should be the baseline. A UE in either case would need some type of a “gap” to process all the PRS resources; we are open to not calling it “MG” if that is what HW refers as “without MG processing”; but a guarantee is needed that the UE can prioritize the PRS processing over any other procedures (PDSCH, PDCCH, CSI, etc). |
| Apple | Support the intention |
| MTK | The title of “The enhancements related to UE measurement gap” may cause confusion.  We think there are 2 topics related to measurement gap,  1, measurement WITHOUT gaps: or just small pair of gaps needed to facilitate UE for RF re-tuning  2, enhancing the existing measurement gap, for example the triggering mechanism, whether to have separate MG for RRM and for positioning |
| ZTE | We think measurement without MG will be better for latency and efficiency rather than design new MG. |
| Huawei/HiSilicon | Reply to QC, I guess it can be a MTC, similar to SMTC in Rel-15 where potential scheduling restrictions may apply, or only define the priority of PRS processing over other signals and channels on an OFDM symbol, which is somehow covered in the second bullet of Proposal 2-3.  If so, why are we spending time discussing this? |
| LG | In the third sub-bullet, we would like to add “positioning measurement report indication in measurement gap configuration”, as follows   * + Measurement gap indication in positioning measurement report and/or positioning measurement report indication in measurement gap configuration. |

## UE-based positioning

Background

UE-based DL positioning is supported in Rel-16 with the broadcast of location assistance data. Enhancements for UE-based positioning are proposed to further reduce the positioning latency and accuracy.

Submitted Proposals

* (Lenovo R1-2007998) Proposal 6:
  + Consider positioning measurement and reporting support for DL-based positioning methods.
* (Qualcomm R1-2008619) Proposal 1:
  + Support the following enhancements for UE-based positioning:
    - UE-based DL & UL methods (i.e., UE-Based Multi-RTT)
    - Enhancements on the assistance data
      * Per PRS-resource RTD assistance data
      * Per PRS-resource beam-shape assistance data

Feature lead’s view

UE-based positioning may offer the benefits of reducing positioning latency and improving positioning accuracy. Several agreements in the RAN1#102e have already covered the enhancements for both UE-assisted and UE-based positioning. Some enhancements may be related specifically to UE-based positioning.

### Proposal 5-8

* Enhancements of UE-based DL, UL DL+UL, and Multi-RTT positioning methods for improving positioning performance can be considered for normative work, which may include, but not limited to the following aspects.
  + Enhancements on the assistance data
    - Per PRS-resource RTD assistance data
    - Per PRS-resource beam-shape assistance data

Comments

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| --- | --- |
| **Company** | **Comments** |
| InterDigital | Support |
| CATT | Support Proposal 5-8. |
| Qualcomm | Support |
| MTK | Support. We also see the potential improvement on DL-TDOA UE based, by measuring UL-RTOA through UL-TDOA technique and serving as the assistance data to the UE to facilitate the cancellation of sync error |
| Fraunhofer | Unclear what beam-shape assistance means |
| Huawei/HiSilicon | For per PRS-resource RTD assistance data, we wonder why RTD can be resource-specific. Is it because of resource specific ARP? Should we also consider RTD on different SRS resources from UE side? |
| Qualcomm | The timing of each beam can be different or panel. This is also related to the timing error enhancements in Proposal 5-5a. Yes the UE has a similar problem, and it could be considered as enhancement in the report related to proposal 5-5a. |
| ZTE | We would like to have another sub-bullet,   * Prior information of UE (e.g. coarse location, channel information, etc.) in assistance data |

## SRS transmission time

Background

A number of issues related to the timing of the SRS transmission and reception are discussed in [17], and the following proposals are submitted:

Submitted Proposals

* (LG R1-2008417) Proposal 2:
  + In Rel-17, RAN1 needs to study the advantage of Average TA method which enables the gNB to receive SRS resource at an intentional reception timing.
* (LG R1-2008417) Proposal 7:
  + In Rel-17, RAN1 needs a study to find solution(s) to minimize accuracy degradation according to the transmission timing change between SRS transmission occasions especially for UL-TDOA technique.
* (LG R1-2008417) Proposal 9:
  + In Rel-17, RAN1 needs to study on cell/TRP-specific TA considering interference problem at a neighbour cell.

Feature lead’s view

For above proposals, the last two were discussed in RAN1#102e without conclusion. In Rel-16 the timing advance of SRS transmission is based on the serving cell, which may cause an interference problem at a neighbor cell due to the different distances from UEs to the serving and the neighbor cell. In addition, the gNB needs to receive a SRS resource at the intended reception timing, so the gNB needs to indicate the UE to send the SRS resource at an intentional transmission timing, and the network would need more precise TA indication. Furthermore, the timing measurement accuracy may be degraded seriously if the UE changes the SRS transmission time between SRS resources in the same RTOA measurement.

### Proposal 5-9

* The following enhancements related to SRS transmission and reception can be considered for normative work:
  + Enable the gNB to receive SRS resource at an intentional reception timing by averaging TA
  + Minimize the accuracy degradation according to the transmission timing change between SRS transmission occasions
  + Minimize the UL interference with Cell Cell/TRP-specific TA

Comments

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| --- | --- |
| **Company** | **Comments** |
| CATT | Support Proposal 5-9. |
| LG | Support. From our side, the second sub-bullet is important. For the high measurement accuracy, gNB obtains multiple measurements for a periodic SRS resource. However, the transmission timing of the UE can be changed during SRS transmission occasions due to TA indication or autonomous TA change, then the gNB obtains different timing measurement for a periodic SRS resource. |
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## UE positioning in DRX state

Background

In Rel-16, UE positioning is not supported for UE in DRX state. The following proposal is submitted to consider the support of PRS measurement in DRX configuration.

Submitted Proposals

* (vivo R1-2007666) Proposal 35
  + For reducing power consumption, PRS measurement impacted by DRX configuration and related signalings should be considered for NR positioning enhancement

Feature lead’s view

UE positioning in DRX state was discussed in RAN1#102e without consensus although may companies supported the investigation. Supporting UE positioning in DRX state may potentially offer significant advantages for reducing UE power consumption.

### Proposal 5-10

* UE positioning in DRX state can be considered for normative work.

Comments

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| --- | --- |
| **Company** | **Comments** |
| CATT | Support Proposal 5-10. |
| vivo | Support. In this email thread, we find that Proposal 5-10 is the only solution for positioning power consumption enhancement. Power consumption for positioning is part of the SID as below and DRX related enhancement is one of the most important solutions. And in our contribution, it is observed that PRS measurement impacted by DRX configuration can obtain large power saving gain. In Rel-17, power consumption related enhancements should at least be optionally supported. If no power consumption related enhancement is considered in normative work, why do we take power consumption as one of our objectives?  Study enhancements and solutions necessary to support the high accuracy (horizontal and vertical), low latency, network efficiency (scalability, RS overhead, etc.), and device efficiency (power consumption, complexity, etc.) requirements for commercial uses cases (incl. general commercial use cases and specifically (I)IoT use cases as exemplified in section 3 above (Justification)):… |
| LG | Support |
| MTK | We also support under C-DRX state. Is it more like RAN4 issue by defining different level of requirement? |
| ZTE | We think it should be discussed in RAN2. |
|  |  |

## Beam-management of positioning

Background

The use of the beam related information for supporting NR positioning is carefully considered in Rel-16 NR positioning, Further enhancements of beam-management of the positioning reference signals may further reducing the overhead, latency, and power consumption.

Submitted Proposals

* (OPPO R1-2008226) Proposal 8:
  + Study to enhance the multi-beam operation on DL PRS resource and support UE-specific beam configuration.
* (Nokia R1-2008301) Proposal 10:
  + RAN1 to study complexity reductions for RAT-dependent positioning techniques with a focus on FR2 operations.
* (Nokia R1-2008301) Proposal 11:
  + RAN1 to study methods to address the SRS-Pos overhead in the case of overlapping spatial TX beams from the UE across multiple SRS-Pos resources.
* (Nokia R1-2008301) Proposal 13:
  + New positioning-specific measurement/reporting configuration should be used, aiming to cover all neighboring gNBs/TRPs that the UE can hear for positioning purposes.
* (LG R1-2008417) Proposal 8:
  + In Rel-17, RAN1 needs to study TX/RX beam optimization for the timing measurements for the improvement of positioning accuracy
* (LG R1-2008417) Proposal 6:
  + Rel-17 NR positioning SI needs to study how to use the UE's RX beam index reporting for positioning.
* (Lenovo R1-2007998) Proposal 4:
  + Consider lower layer dynamic signalling mechanisms to enable rapid TRP addition/removal/switching for DL-PRS transmissions to enable the LMF and UE to better adapt to changes in the radio environment, especially in relation beam-failure and upon NLOS identification.
* (Lenovo R1-2007998) Proposal 5:
  + Study various DL-PRS transmission overhead reduction techniques from the network and UE perspective based on a priori information including dynamic DL-PRS transmission on a subset/group of TRPs and reception using a single beam.
    - FFS details such as the a priori information required by the network
    - FFS how to define the TRP/beam group.
* (Fraunhofer R1-2008841) Proposal 6:
  + Enhancements on SRS beam management for positioning shall be considered in Rel-17. These enhancements shall include reporting additional information on DL-RS measurements.

Feature lead’s view

Enhancements to the beam-management for the transmission and reception of the DL PRS and UL SRS may offer the benefits of improving UE positioning accuracy, reducing the measurement delay, and reducing UE power consumption. However, the proposed enhancements for beam management may be tightly related to other proposed enhancements. It may be better to have a general agreement for supporting beam-related enhancements, and leave the discussion of details to WI phase.

### Proposal 5-11

* Enhancements of the beam managements for the transmission and reception of the DL PRS and UL SRS for improving UE positioning accuracy, reducing the measurement delay, and reducing the UE power consumption can be considered for normative work, including
  + DL, UL DL+UL, and Multi-RTT positioning methods
  + UE-based and UE-assisted positioning solutions
* More details of the enhancements, which may include, but not limited to the following aspects, are left for further discussion in normative work:
  + the multi-beam operation on DL PRS resource and support UE-specific beam configuration
  + complexity reductions for RAT-dependent positioning techniques with a focus on FR2 operations.
  + Reduction of SRS-Pos overhead in the case of overlapping spatial TX beams from the UE across multiple SRS-Pos resources.
  + New positioning-specific measurement/reporting configuration should be used, aiming to cover all neighboring gNBs/TRPs that the UE can hear for positioning purposes.
  + TX/RX beam optimization for the timing measurements for the improvement of positioning accuracy
  + UE's RX beam index reporting for positioning.
  + lower layer dynamic signalling mechanisms to enable rapid TRP addition/removal/switching for DL-PRS transmissions to enable the LMF and UE to better adapt to changes in the radio environment, especially in relation beam-failure and upon NLOS identification.
  + DL-PRS transmission overhead reduction techniques from the network and UE perspective based on a priori information including dynamic DL-PRS transmission on a subset/group of TRPs and reception using a single beam.
  + Enhancements on SRS beam management for positioning, including reporting additional information on DL-RS measurements.

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CATT | Support Proposal 5-11. |
| Xiaomi | Support the proposal |
| LG | Support in principle. |
| Fraunhofer | Support |
| ZTE | The lists are too big. We can leave details in WI phase. |
| Lenovo, Motorola Mobility | Support. |
| Sony | Support |
| LG2 | If the list is too big, we prefer to support at least the main bullet. |
| vivo | The list is too big and the main bullet is too general, online meetings are also difficult to reach an agreement |

Feature lead’s view

Enhancements to the beam-management for reducing the latency may be included in Section 5.4.

## Additional proposals related to signalling enhancements

Background

Submitted Proposals

* (Huawei R1-2007577) Proposal 15:
  + Rel-17 should consider UL E-CID positioning methods as the starting point for RRC configured procedure for positioning
* (Lenovo R1-2007998) Proposal 3:
  + Study the benefits for defining a UE positioning processing timeline in the context physical layer procedures, priority indications and UL grant availability for low latency measurement, processing and reporting
* (Qualcomm R1-2008619) Proposal 6:
  + Support the reporting of additional motion state / kinematics constraints information for both UE-based and UE-assisted including, but not limited to, signaling of side information/constraints on potential trajectory, path, velocity, direction of the target device.











## On-demand UL SRS for positioning

Background

Rel-16 has already supported semi-periodic and a-periodic SRS for positioning. For Rel-17 positioning enhancements, there are proposals to extend the support to on-demand UL SRS for positioning, due to the potential in reducing the positioning latency and improving device efficiency (e.g., reducing the resource usage and power saving).

Submitted Proposals

* (InterDigital R1-2008491) Proposal 8:
  + Study benefits of on-demand SRS for positioning

Feature lead’s view

On-demand UL SRS for positioning were discussed in RAN1#102e without the consensus, where many companies consider it a low priority.

### Proposal 5-13

* on-demand SRS for positioning can be considered for normative work.

Comments

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| --- | --- |
| **Company** | **Comments** |
| InterDigital | There is a difference between on-demand SRS and aperiodic SRS, where the first is triggered by UE while the latter is triggered by the network. On-demand SRS will contribute to reducing latency for both UL based or DL&UL method. |
| CATT | Support Proposal 5-13. |
| OPPO | The benefit is not clear. |
| ZTE | Don’t support. |
|  |  |

## Additional positioning methods

Background

Two companies proposed the additional positioning methods.

Submitted Proposals

* (Samsung R1-2008168) Proposal 6:
  + Uplink transmission-based relative positioning should be studied
* (CEWiT R1-2008718) Proposal 4:
  + Release-17 should support reporting of measurements by a UE performed on the SRS transmitted by other UEs. Release-16 CLI measurement mechanism can be baseline.

Feature lead’s view

The proposals were discussed in RAN1#102e with a conclusion. The proposed methods require a UE to receive the SRS transmitted by another UE, which is out of the scope of the SI. Suggest no further discussion on above-proposed positioning methods in this meeting.

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CATT | Agree to FL’s view. |
|  |  |
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|  |  |

# Other proposals

## Performance evaluation

Background

There are proposals related to the evaluation of the proposed positioning enhancements.

Submitted Proposals

* (Nokia R1-2008301) Proposal 16:
  + RAN1 to study UE antenna array phase center offset impact on UE positioning estimation accuracy and potential correction mechanisms with aim to improve the positioning accuracy achievable especially for the high accuracy IIoT use cases.
* (Samsung R1-2008168) Proposal 8:
  + Evaluation of IIoT OTDoA positioning performance should include a consideration of a sub-set of PRS and SRS possible parameter values for periodicity, slot offset and repetition rate, which conform to a dynamic TDD setting in the IIoT network.

Feature lead’s view

These proposals may be further discussed in AI 8.5.1/2 for performance evaluation.

Comments

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| --- | --- |
| **Company** | **Comments** |
| CATT | Agree to FL’s view. |
|  |  |

## Positioning algorithms

Background

Using advanced signal processing and positioning algorithms is critical for a high-performance positioning system. There is a proposal related to the use of the positioning algorithms.

Submitted Proposals

* (Intel R1-2007946) Proposal 10
  + Support angular-based and timing-based super resolution methods to improve positioning accuracy
    - Send LS to RAN4 for potential study of benefits for these methods.

Feature lead’s view

The proposal seems closely related to the UE/gNB implementation. 3GPP normally does not define which algorithms are used by UE/gNB.

Comments

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| --- | --- |
| **Company** | **Comments** |
| CATT | Agree to FL’s view. |
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# 

# Proposed enhancements

This section presents the positioning enhancements that were proposed for Rel-17, but a consensus has not been reached during the Study Item.

|  |  |
| --- | --- |
| **List of the proposed enhancements** | **Comments from interested companies**  (The companies are encouraged to check their proposals and may make changes with trace mark directly to their proposals in the left column when necessary) |
| Proposal 2-2 (Alternative) **[7.x.y] Enhancements of DL PRS patterns and configuration**  In Rel-16, full staggering patterns are used for DL PRS transmission, with at least 2 OFDM symbols per DL PRS resource. The minimum DL PRS transmission bandwidth is 24 PRBs. The following enhancements were proposed related to partial staggering and non-staggering DL PRS transmission pattern with different combinations of comb-factors and symbol lengths:   * + [4] sources (Huawei R1-2007577, Sony R1-2008365, LG R1-2008417, Ericsson R1-2008765) proposed to support 1-symbol PRS at least for comb 12 and comb 4.   + [1] sources (ZTE R1-2007755) proposed to support new relative RE offsets to reduce/mitigate the collision of DL PRS.   + [1] sources (CATT R1-2007755) proposed to support DL PRS bandwidth smaller than 24 PRBs   + [1] sources (Intel R1-2007946) proposed to support Comb-4 and Comb-6 for two symbols DL PRS resource configuration   + [1] sources (Intel R1-2007946) proposed to support new DL PRS transmission schedules aiming to randomize a set of TRPs/gNBs transmitting in the same set of resources   + [1] sources (Samsung R1-2008168) proposed to support new PRS patterns and two PRS patterns can be configured simultaneously and separated in time, frequency or space domain   + [3] sources (OPPO R1-2008226, Qualcomm R1-2008619, Ericsson R1-2008765) proposed to support partial staggering and non-staggering PRS RE mapping   + [1] sources (Sony R1-2008365) proposed to support coordinated PRS transmission to mitigate interference of PRS transmission |  |
| Proposal 2-3 (Alternative) **[7.x.y] Enhancements of reception of DL PRS with other signals**  For Rel-16, UE is not expected to process DL PRS in the same OFDM symbols where other DL signals and channels (e.g., SS/PBCH) are transmitted to the UE. The following enhancements were proposed for reducing the positioning latency and improving the network and UE efficiency:   * [4] sources (Huawei R1-2007577, vivo R1-2007666, CMCC R1-2008015, Sony R1-2008365) proposed to support RB-level multiplexing of PRS with other DL signals/channels (e.g., SSB) * [5] sources (vivo R1-2007666, CMCC R1-2008015, Xiaomi R1-2008083, Sony R1-2008365, InterDigital R1-2008491) proposed to define the priority rules of the reception of PRS for low latency positioning. * [1] source (Intel R1-2007946) proposed to study the mechanisms for prioritization of transmissions carrying reference signals and channels with control signaling for positioning vs other NR reference signals and channels. |  |
| Proposal 2-4 (Alternative) **[7.x.y] Enhancements of DL PRS muting pattern**  In Rel-16 DL PRS muting pattern is supported with the granularity of DL RS resource set in time-domain. The following enhancements were proposed related to DL PRS muting:   * [1] source (OPPO R1-2008226) proposes to support DL PRS muting with the granularity of DL RS resource. * [1] source (Samsung R1-2008168) proposes to support to the DL PRS muting in the frequency domain. |  |
| Proposal 2-5 (Alternative) **[7.x.y] New DL reference signals for positioning**  The following enhancements were proposed for DL reference signals for positioning:   * [1] source (ZTE R1-2007755) proposed introducing orthogonal cover code (OCC) for positioning reference signals especially for PRS patterns with time domain repetition. * [1] source (LG R1-2008417) proposed cyclic shift based SFN transmission of PRS. * [1] source (Ericsson R1-2008765) proposed to use TRS is a candidate reference signal for positioning. |  |
| Proposal 3-3 (Alternative) **[7.x.y] Transmission of UL SRS for positioning together with other signals/channels**  In Rel-16, the transmission of PUSCH has higher priority than the transmission of SRS for positioning. The following enhancements were proposed to address the possible collision of the transmission of SRS for positioning with other UL signals/channels in the same OFDM symbol(s):   * [1] source (vivo R1-2007666) proposed to introduce the priority indications of SRS-PosResource for low latency positioning * [1] source (Intel R1-2007946) proposed to study mechanisms for prioritization of transmissions carrying reference signals and channels with control signaling for positioning vs other NR reference signals and channels * [1] source (Sony R1-2008365) proposed to support the operation of DL PRS and UL SRS with prioritization (high/low) to support low latency positioning and high accuracy positioning * [1] source (InterDigital R1-2008491) proposed prioritization of PRS or SRS for positioning with respect to other signals and channels for reducing latency * [1] source (InterDigital R1-2008491) proposed to study co-existence of SRS for positioning with prioritized PUSCH and PUCCH to achieve latency reduction. |  |
| Proposal 3-4 (Alternative) **[7.x.y] Cyclic shift patterns of SRS for positioning**  Rel-16 SR for positioning reuses the formula of the legacy SRS cyclic shifts. The following enhancements were proposed related to the cyclic shifts for Rel-16 SRS for positioning:   * + [1] source (Huawei R1-2007577) proposed to support the enhancement to reduce the issue caused by cyclic shifts for Rel-16 SRS for positioning;   + [1] source (CATT R1-2007755) proposed to support symbol-specific cyclic shifts for SRS for positioning in order to keep phase continuities when a staggered SRS-Pos pattern is de-staggered for the detection of the SRS for positioning detection;   + [1] source ((MTK R1-2008519) proposed the phase rotation pattern for Rel-16 staggered SRS structure, including the general formulation for cyclic shift operation on all the symbols for a SRS resource;   + [1] source ((MTK R1-2008519) proposed to increase the maximum cyclic shift number under the staggered SRS structure;   + [1] source (Fraunhofer R1-2008841) proposed to support: a) phase correction for the staggered SRS; b) maintaining the cyclic shift step size of Rel-15; and extending the range of the cyclic shift.   + [1] source (Ericsson R1-2008765) proposed that the cyclic shift of the UL SRS with staggered pattern can be configured to be 1) the same in each symbol, according to REL-15 behavior or 2) per SRS resource, across all symbols in the SRS resource, and   + [1] source (Ericsson R1-2008765) proposed that the maximum number of available cyclic shifts for the SRS for positioning is configurable by the gNodeB as part of the RRC configuration. |  |
| Proposal 3-5 (Alternative) **[7.x.y] Power control of SRS for positioning**  In Rel-16, open-loop power control is supported for SRS for positioning. The following enhancements were proposed related to the power control of SRS for positioning:   * [4] sources (Huawei R1-2007577, TCL R1-2007886, Nokia R1-2008301) proposed to support closed-loop power control of SRS for positioning * [1] sources (Huawei R1-2007577) proposed to support the neighbouring TRP sending SRS power adjustment to the LMF and LMF sending the SRS power adjustment to the serving gNB * [2] sources (Huawei R1-2007577, vivo R1-2007666) Power headroom report for SRS for positioning. * [1] source (vivo R1-2007666) proposed to support to introduce the priority indications of SRS-PosResource for transmission power reductions in Rel-17 * [1] source (OPPO R1-2008226) Support per SRS resource configuration of power control parameters * [1] source (Fraunhofer R1-2008841) proposed to consider power control of SRS for positioning when a spatial relation is not configured |  |
| Proposal 3-6 (Alternative) **[7.x.y] Coordinated transmission of SRS for positioning**  In Rel-16, each serving gNB decides the configuration of the transmission of SRS for positioning, and there is no support of the coordination among adjacent gNB/TRPs and LMF.   * + [2] source (CATT R1-2007755, CMCC R1-2008015) proposed to support the coordination of the resources of the SRS for positioning to achieve orthogonal resource assignment to eliminate mutual interference of SRS for positioning   + [1] source (Fraunhofer R1-2008841) proposed to consider UL interference coordination for Rel-17 NR positioning including interference from positioning RSs or other interference sources. |  |
| Proposal 3-7 (Alternative) **[7.x.y] Frequency hopping of UL SRS for positioning**  Rel-16 UL SRS for positioning does not support frequency hopping. For minimizing the interference,   * [2] resources (Huawei R1-2007577, CATT R1-2007755) proposed to support frequency hopping of SRS for positioning for improving positioning accuracy. * [1] resource (OPPO R1-2008226) proposed to study frequency-hopping in SRS resource for positioning to support larger transmission bandwidth. |  |
| Proposal 3-8 (Alternative) **[7.x.y] Frequency hopping of UL SRS for positioning**  In Rel-16 SRS for MIMO is not used for the positioning measurements. For improving positioning efficiency,   * [1] source (Qualcomm R1-2008619) proposed to support reusing SRS for MIMO for the purpose of Positioning measurements. |  |
| Proposal 3-9 (Alternative) **[7.x.y] 3.9 Multi-port transmission of UL SRS for positioning**  In Rel-16, SRS for positioning is transmitted on a single antenna port. For improving network efficiency, positioning accuracy and UE low power transmission,   * [1] sources (Fraunhofer R1-2008841) proposed to study multi-port SRS transmission for positioning. |  |
| Proposal 4-2 (Alternative) **[7.x.y] Additional UE/gNB measurements**  Additional positioning measurements were proposed for improving the positioning accuracy:   * + [2] sources (CATT R1-2007755, Fraunhofer R1-2008841) proposed to support carrier phase measurements from NR DL reference signals (e.g., DL PRS) and UL reference signals (e.g., UL SRS for positioning) for NR positioning;   + [1] source (Ericsson R1-2008765) proposed to support absolute time reporting measurement reports for NR positioning |  |
| Proposal 4-3 (Alternative) **[7.x.y] Additional enhancements related to UE/gNB measurements**  The following enhancements were proposed related to the UE/gNB measurement reporting for increasing positioning accuracy, reducing the latency and improving the efficiency:   * [1] source (vivo) proposed the following enhancements for UE power saving perspective:   + Introducing positioning measurement window   + Extending PRS period   + Reducing the number of TRPs to be measured   + Reducing the number of positioning frequency layers to be measured * [1] source (LG R1-2008417) proposed the enhancement of the method/signalling to enable the UE and gNB to use the same measurement averaging rule for Rx-Tx time difference for periodic PRS resource(s) and SRS resource(s) for the improved positioning accuracy; * [1] source (Qualcomm R1-2008619) proposed the enhancements in the reporting of the positioning measurements (from the UE and the gNB), including   + additional motion state / kinematics constraints information for both UE-based and UE-assisted including, but not limited to, signaling of side information/constraints on potential trajectory, path, velocity, direction of the target device   + additional reporting periodicities   + multiple measurement reporting from different timestamps derived on the same TRP/PRS resources * [1] source (Ericsson R1-2008765) proposed to introduce signaling of a threshold relative to the strongest peak for the UE search of the first peak and define the DL RSTD and UE RX-TX time difference measurements based on the first identified peak which is stronger than the strength of the strongest peak multiplied with the signaled relative threshold factor. * [1] source (Ericsson R1-2008765) proposed to study network control of thresholds for the UE search for the first peak including threshold relative to the estimated noise level (aimed at avoiding noise peaks), threshold relative to the strongest peak (aimed at avoiding channel peaks with delay longer than the measurement range) and delay dependent thresholds (aimed at avoiding side peaks). |  |
| Proposal 5-5b (Alternative) **[7.x.y] Network time synchronization errors**  Network time synchronization errors have a direct impact on the positioning accuracy of DL-TDOA and UL-TDOA. The following enhancements are proposed for improving positioning accuracy in the presence of Network time synchronization errors:   * [x] source (Huawei R1-2007577) proposed to support calibration/reference UE that participates in the conventional NR positioning method and has its location information with very high confidence for the purpose timing calibration (group delay, clock sync error) and angle calibration (UL-AoA). * [x] source (vivo R1-2007666) proposed to study differential positioning technique as the method for improving the accuracy in the presence of Rx/Tx transmission delays and sync error. * [x] source (ZTE R1-2007755) proposed to enable network measurement to calibrate synchronization offset, e.g. support RSTD measurement between positioning nodes * [x] source (CATT R1-2007755) proposed to investigate the use of the RAT-dependent network synchronization techniques for NR positioning, where the precise network synchronization can be achieved by monitoring the reference signals transmitted from TRPs. * [x] source (CATT R1-2007755) proposed to support differential operations for eliminating TRP synchronization errors for high-accuracy NR positioning. * [x] source (CMCC R1-2008015) proposed to investigate the methods and signaling for the estimation and compensation on the network synchronization errors. * [x] source (MTK R1-2008519) proposed to provide the measurement results at gNB side (UL-RTOA values) to the UE as assistance information together with UE RSTD to cancel the synchronization error and to reduce the impact of transmission delay. * [x] source (Qualcomm R1-2008619) proposed to support signaling, reporting and PHY-layer procedural enhancements to mitigate the degradation of the positioning accuracy in timing-based methods due to gNB and UE timing errors. * [x] source (CEWiT R1-2008718) proposed to support deployment of reference UE in IIoT and indoor office scenario for determination of the network synchronization error. * [x] source (CEWiT R1-2008718) proposed to introduce new measurement and reporting field for the network synchronization error estimation both in LPP and NRPPa for DL positioning and UL positioning, respectively. |  |
| Proposal 5-6 (Alternative) **[7.x.y] Enhancements on E-CID positioning**  In Rel-16, E-CID is supported based on the Rel-15 RRM measurements. The following enhancements of E-CID positioning are proposed for improving positioning accuracy and efficiency. More specifically,   * [1] source (Huawei R1-2007577) proposed to support E-CID to include RTT (UE/gNB Rx – Tx time difference) measurement for the serving cell using communication link. * [1] source (CMCC R1-2008015) proposed to support the enhancement on E-CID positioning based on RTT + UL-AoA measurements, using Rel-16 DL/UL positioning reference signals. * [1] source (DCM R1-2008550) proposed to support TA based positioning scheme (e.g. reusing LTE positioning scheme based on TA Type1 and TA Type2) for Rel-17 NR positioning to reduce positioning latency. * [1] source (Ericsson R1-2008765) proposed to support reuse of Rel-15 SRS resource set for gNB Rx-Tx and UE Rx-Tx measurements for positioning in NR. |  |
| Proposal 5-7 (Alternative) **[7.x.y] Enhancements on the measurement gap for positioning**  In Rel-16, UE is not expected to process DL PRS unless the measurement gap is not configured. The following enhancements were proposed for the enhancements related to the measurement gap.   * [2] sources (vivo R1-2007666, Xiaomi R1-2008083) proposed to consider BWP switching as an alternative to using measurement gap. * [1] sources (vivo R1-2007666) proposed to   + support PRS measurement within active DL BWP   + introduce on-demand measurement gap for on-demand PRS, including LMF requested measurement gap.   + support low layer triggering measurement gap for NR positioning.   + support measurement gap enhancement for concurrent processing multiple positioning frequency layers should be considered, if DL PRS processing with aggregated DL PRS resources is supported.   + include measurement gap related indication in positioning measurement report. * [1] sources (CATT R1-2007755) proposed to introduce aperiodic and SPS measurement gap for positioning to achieve low positioning latency. * [1] sources (InterDigital R1-2008491) proposed to   + adopt measurement gap-less reception of PRS to minimize latency   + adopt pre-configuration of measurement gaps and activation of pre-configured measurement gaps for faster configuration of measurement gaps * [1] sources (Qualcomm R1-2008619) proposed to   + support DCI/MAC-CE triggering of measurement gaps (MG) for the purpose of positioning measurements.   + support within-Active-BWP positioning processing without MG, but within a PRS processing time-window which enables priotizing location measurements over other data, control and CSI-related procedures withing the active BWP. |  |
| Proposal 5-8 (Alternative) **[7.x.y] Enhancements related to UE-based positioning**  The following enhancements were proposed related to UE-based positioning:   * + [1] source (Lenovo R1-2007998) proposed to consider positioning measurement and reporting support for DL-based positioning methods.   + [1] source (Qualcomm R1-2008619) proposed to support the following enhancements for UE-based positioning:     - UE-based DL & UL methods (i.e., UE-Based Multi-RTT)     - Enhancements on the assistance data       * Per PRS-resource RTD assistance data       * Per PRS-resource beam-shape assistance data |  |
| Proposal 5-9 (Alternative) **[7.x.y] Enhancements related to transmission time of SRS for positioning**  The following enhancements were proposed related to timing of the SRS transmission:   * [1] source (LG R1-2008417) proposed to study:   + the advantage of Average TA method which enables the gNB to receive SRS resource at an intentional reception timing.   + the solution(s) to minimize accuracy degradation according to the transmission timing change between SRS transmission occasions especially for UL-TDOA technique.   + cell/TRP-specific TA considering interference problem at a neighbour cell. |  |
| Proposal 5-10 (Alternative) **[7.x.y] Enhancements related to UE positioning in DRX state**  The following enhancements were proposed related to UE positioning in DRX state:   * [1] source (vivo R1-2007666) proposed to consider PRS measurement impacted by DRX configuration and related signalings should be considered for reducing power consumption and positioning enhancements |  |
| Proposal 5-11 (Alternative) **[7.x.y] Enhancements related to beam-management for positioning**  The following enhancements were proposed related to the enhancements to the beam-management for UE positioning:   * [1] source (OPPO R1-2008226) proposed to study to enhance the multi-beam operation on DL PRS resource and support UE-specific beam configuration. * [x] source (Nokia R1-2008301) proposed to study complexity reductions for RAT-dependent positioning techniques with a focus on FR2 operations. * [x] source (Nokia R1-2008301) proposed to study methods to address the SRS-Pos overhead in the case of overlapping spatial TX beams from the UE across multiple SRS-Pos resources. * [x] source (Nokia R1-2008301) proposed new positioning-specific measurement/reporting configuration should be used, aiming to cover all neighboring gNBs/TRPs that the UE can hear for positioning purposes. * [x] source (LG R1-2008417) proposed to study TX/RX beam optimization for the timing measurements for the improvement of positioning accuracy * [x] source (LG R1-2008417) proposed to study how to use the UE's RX beam index reporting for positioning. * [x] source (Lenovo R1-2007998) proposed to consider lower layer dynamic signalling mechanisms to enable rapid TRP addition/removal/switching for DL-PRS transmissions to enable the LMF and UE to better adapt to changes in the radio environment, especially in relation beam-failure and upon NLOS identification. * [x] source (Lenovo R1-2007998) proposed to study various DL-PRS transmission overhead reduction techniques from the network and UE perspective based on a priori information including dynamic DL-PRS transmission on a subset/group of TRPs and reception using a single beam. * [x] source (Fraunhofer R1-2008841) proposed the enhancements on SRS beam management for positioning shall be considered in Rel-17. These enhancements shall include reporting additional information on DL-RS measurements. |  |
| Proposal 5-13 (Revision 1) **[7.x.y] On-demand UL SRS for positioning**   * One source (InterDigital R1-2008491) proposed to study benefits of on-demand SRS for positioning for reducing latency for both UL based or DL&UL method. |  |
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# Summary

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