**3GPP TSG RAN WG1 Meeting #103-e** [**R1-200**](file:///E:\1%20Meetings\RAN1\2020%2010_TSGR_103e\Docs\R1-200xxxx.doc)**9314**

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

**Source: Moderator (CATT)**

**Title: FL Summary 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    3. Enhancements of UL AoA and DL-AoD    4. Methods for reducing positioning latency    5. Methods for reducing timing measurement errors    6. Enhancements on E-CID positioning    7. Enhancements related to Measurement gap    8. UE-based positioning    9. SRS transmission time    10. UE positioning in DRX state    11. Beam-management of positioning    12. Additional proposals related to signalling enhancements    13. On-demand UL SRS for positioning    14. Additional positioning methods 5. 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] can be considered for normative work**" (instead of "[X] can be considered/investigated in Rel-17 WI) for a proposed enhancement that we are not sure whether it should be supported at this moment, but want to have a further discussion in Rel-17 WI;
  + **"[X] is (are) left for further 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) Proposal 3:
  + Rel-17 should support at least intra-band contiguous and non-contiguous frequency aggregation with phase continuity.
* (CATT)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)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)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) Proposal 6:
  + Do not to support the aggregation of multiple positioning frequency layers for positioning enhancement in Rel-17.
* (Sony) Proposal 3:
  + Support aggregating multiple DL positioning frequency layers of the same or different bands for positioning accuracy enhancements
* (Qualcomm)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) 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 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 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 normative work
  + Option 4: Not support aggregating multiple DL positioning frequency layers in Rel-17.

Comments

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| **Company** | **Comments** |
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## 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) Proposal 1:
  + Rel-17 should support 1-symbol PRS at least for comb 12 and comb 4.
* (ZTE) 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)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)Proposal 1
  + Support Comb-4 and Comb-6 for two symbols DL PRS resource configuration
* (Intel)Proposal 2
  + Support new DL PRS transmission schedules aiming to randomize a set of TRPs/gNBs transmitting in the same set of resources
* (Samsung)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) 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) Proposal 2:
  + Support partial staggering and non-staggering PRS RE mapping with different combinations of comb-factors and symbol lengths.
* (Sony)Proposal 4:
  + Support PRS configuration with 1 symbol PRS transmission.
* (Sony) Proposal 10:
  + Support coordinated PRS transmission to mitigate interference of PRS transmission.
* (LGE)Proposal 11:
  + Support 1-symbol PRS resource for Rel-17 NR positioning.
* (Qualcomm) 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) 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 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

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## 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) Proposal 2:
  + Rel-17 should support RB-level multiplexing of PRS and SSB
* (vivo) 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) 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) Proposal 1:
  + DL PRS FDMed multiplexing with other DL signals/channels in a PRB level should be supported in Rel-17.
* (CMCC) Proposal 2:
  + The priority of DL PRS, at least that of the on-demand DL PRS, should be defined in Rel-17.
* (Xiaomi) Proposal 6:
  + The priority of PRS should be differentiated for different latency requirement.
* (Sony) 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) Proposal 2:
  + 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) 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 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

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## 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)Proposal 6:
  + Frequency domain muting should be studied
* (OPPO) 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

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## 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)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.
* (LGE)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) 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

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# 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:

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| 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) Proposal 4:
  + Rel-17 should support all combinations of comb size and number of symbols for SRS for positioning.
* (ZTE) 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) Proposal 4:
  + Support Comb-4 for one symbol SRS resource configuration for positioning.
* (OPPO) Proposal 8:
  + Study to support larger Comb size(s) in SRS resource for positioning to support larger transmission bandwidth.
* (OPPO) 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 signaling for addressing potential time-domain aliasing due to the partial/non-staggering RE mapping) are left for further normative work.

Comments

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## 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]

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| 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) Proposal 3:
  + Rel-17 should support at least intra-band contiguous and non-contiguous frequency aggregation with phase continuity
* (CATT)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)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) Proposal 9:
  + Support reception by the gNB of the SRS for positioning across multiple CCs and multiple slots
* (OPPO) Proposal 6:
  + Do not to support the aggregation of multiple positioning frequency layers for positioning enhancement in Rel-17.
* (Qualcomm)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 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 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 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

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| **Company** | **Comments** |
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## 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) Proposal 15:
  + Introduce the priority indications of SRS-PosResource for low latency positioning in Rel-17
* (Intel) 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) 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) Proposal 4 :
  + Prioritization of PRS or **SRS** for positioning with respect to other signals and channels should be studied for reducing latency
* (InterDigital) 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

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| **Company** | **Comments** |
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## 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) Proposal 5:
  + Rel-17 should support the enhancement to reduce the issue caused by cyclic shifts for Rel-16 SRS for positioning
* (CATT) 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) Proposal 2-1:
  + The phase rotation pattern for Rel-16 staggered SRS structure should be defined in work item phase
* (MTK)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

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

* (MTK) 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) 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) 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) 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) 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

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| **Company** | **Comments** |
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## 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) 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)Proposal 16:
  + PHR based on SRS-PosResource should be introduced in Rel-17
* (vivo)Proposal 17:
  + Introduce the priority indications of SRS-PosResource for transmission power reductions in Rel-17
* (TCL) Proposal 3:
  + Support Closed-loop power control for the transmission of SRS for positioning.
* (OPPO) 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)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) 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 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

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| **Company** | **Comments** |
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## 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) 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) Proposal 6:
  + The SRS for POS coordination should be studied
* (Fraunhofer) 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 concensus, 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

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| **Company** | **Comments** |
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## 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) Proposal 7:
  + Rel-17 should support SRS frequency hopping
* (CATT) Proposal 13:
  + Frequency hopping of SRS-Pos for positioning is recommended for normative work in order to obtain better positioning accuracy.
* (OPPO) 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.

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| **Company** | **Comments** |
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## 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) 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 normative work.

Comments

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| **Company** | **Comments** |
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## 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)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

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| **Company** | **Comments** |
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# 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:

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| 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)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) 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) Proposal 8:
  + Rel-17 should support angle information report associated with multi-paths.
* (Huawei) Proposal 9:
  + Rel-17 should support LOS/NLOS identification to improve the positioning accuracy.
* (vivo) Proposal 1:
  + The enhancements to improve positioning accuracy are needed for the NLOS scenario
* (vivo) Proposal 18:
  + LOS/NLOS detection/identification should not be considered in Rel-17.
* (vivo) 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)Proposal 1:
  + Study mechanisms to assist determination of LOS & NLOS communication links. For example, coherence bandwidth can be attached in positioning measurement report.
* (Intel) 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) 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) Proposal 7:
  + Study potential benefits of the multi-path measurements, clarify how these measurements can be potentially used in the positioning equations
* (Lenovo) 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.
* (Samsung)Proposal 4:
  + Angle based LOS/NLOS differentiation with joint measurement should be studied.
* (Samsung)Proposal 5:
  + In addition to the measurement reporting of RSRP, RSTD, RX-TX time difference, UE reports indication of LOS/NLOS.
* (OPPO) Proposal 13:
  + For multipath mitigation, only focus on the implementation-based solutions in Rel-17.
* (Nokia)Proposal 7
  + RAN1 to study NLOS identification and reporting from the UE to the LMF during at least UE-A DL positioning.
* (Nokia)Proposal 8:
  + RAN1 to study NLOS identification and reporting from the LMF to the UE during at least UE-B DL positioning.
* (Nokia)Proposal 9:
  + RAN1 to study both LOS/NLOS identification methods computed in PHY layer processing and LMF localization processing.
* (Sony) Proposal 5:
  + Support LOS & NLOS detection and measurement report mechanism, particularly to mitigate multipath issue in IIoT use-cases.
* (LGE) Proposal 3:
  + For the improvement of positioning accuracy, a method and signalling should be considered to identify the NLoS using the polarization characteristics.
* (LGE) 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) Proposal 13:
  + Study LOS and NLOS identification methods
* (InterDigital) Proposal 14:
  + Consider path identification mechanism
* (InterDigital) Proposal 15:
  + Study dynamic update of spatial information for SRS for positioning for multi-RTT positioning methods
* (Qualcomm) 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)Proposal 1:
  + Support enhanced CIR reporting for NR-Positioning in Rel-17.
* (Fraunhofer)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)Proposal 1:
  + LOS confidence, power level and angle information of LOS path should be reported along with timing measurements in Release-17.
* (Ericsson) 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) 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) Proposal 3:
  + Magnitude, SNR, Doppler frequency, angle of arrival of every path should be reported.
* (Ericsson) Proposal 4:
  + It shall be unambiguously defined what additional paths a UE shall report.
* (Ericsson) Proposal 5:
  + The UE shall always report both the first path and the strongest path
* (Ericsson) 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) Proposal 7:
  + RAN1 should specify reporting of the strongest peak in rel. 17
* (Ericsson) Proposal 8:
  + We propose that RAN1 should study LOS detection techniques and reporting of LOS indicators for potential specification in Rel. 17.
* (Ericsson) 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 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.

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## 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) 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) 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) Proposal 19:
  + Consider supporting the carrier phases measurements from two or more carrier frequencies for fast resolution of the integer ambiguity.
* (Fraunhofer) Proposal 4:
  + Consider carrier phase measurements for positioning in both UL and DL timing-based methods at least in FR1.
* (Ericsson) 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

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## 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) Proposal 33:
  + Introduce 10 ms level granularity for the response time and reporting intervals in *CommonIEsRequestLocationInformation*.
* (vivo) Proposal 36:
  + For UE power saving perspective, support to introduce positioning measurement window in Rel-17.
* (vivo) 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
* (LGE)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)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) Proposal 12:
  + Support Enhanced PRS processing capabilities:
    - Increased number of PRS resources processing per unit of time.
* (Qualcomm) Proposal 16:
  + For the purpose of enhanced efficiency, support reusing SRS for MIMO for the purpose of Positioning measurements.
* (Ericsson) 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) 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) Proposal 17
  + In order to maintain accuracy, the target latency must factor the need for tracking measurement, i.e. UE mobility
* (Ericsson) 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) 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.

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### 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.

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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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### 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).

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# 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

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| 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)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) 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) Proposal 17:
  + Rel-17 should support paging trigger non-periodic SRS transmission in INACTIVE state.
* (vivo)Proposal 2:
  + The enhancements are needed for positioning latency, network efficiency, and device efficiency
* (vivo) 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) Proposal 21:
  + For idle/inactive positioning, DL positioning method, UL positioning method and DL+UL positioning method should be supported
* (CATT) 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)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) Proposal 1:
  + Support positioning in RRC\_IDLE/INACTIVE states.
* (Intel) Proposal 12:
  + Support NR positioning techniques for UEs in the RRC\_INACTIVE state
    - FFS: enhancements for RRC\_IDLE state
* (Intel) Proposal 13:
  + Enhance a two-step RACH mechanism to facilitate accurate low-latency NR positioning for UEs in RRC\_INACTIVE state
* (Lenovo) 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) Proposal 8:
  + Consider physical layer enhancements for lowering the DL-PRS configuration latency while in RRC\_IDLE/RRC\_INACTIVE state.
* (CMCC) 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) 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) Proposal 9:
  + Consider to pre-configure the PRS for idle/inactive UE when UE is in connected mode.
* (Xiaomi) Proposal 10:
  + Random access procedure can be reused for UL and DL&UL positioning of Idle/Inactive UE.
* (Xiaomi) Proposal 11:
  + Random access preamble can be reused as UL reference signal for Idle/Inactive UE.
* (Samsung)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)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) 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)Proposal 1:
  + Support RRC inactive and idle mode positioning for at least DL and UL RAT-dependent positioning methods.
* (Nokia)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)Proposal 3:
  + Support use of small data transmission for DL PRS measurement reports (e.g., RSTD and PRS-RSRP).
* (Nokia)Proposal 4:
  + RAN1 to study how UL RAT-dependent positioning methods can also be supported in RRC inactive and idle modes.
* (Nokia)Proposal 5:
  + RAN1 to consider the impacts of assistance data changing over time in the design of inactive mode positioning support.
* (Sony) Proposal 6:
  + Support both DL-TDOA and UL-TDOA Positioning in RRC idle/inactive.
* (LGE) 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) Proposal 9:
  + Adopt IDLE/INACTIVE mode positioning
* (InterDigital) Proposal 10:
  + Study mechanisms to support timing alignment during idle/inactive mode positioning
* (InterDigital) Proposal 11:
  + Study measurement reporting mechanism for idle/inactive mode positioning
* (InterDigital) Proposal 12:
  + Study configuration mechanism for PRS or SRS for mobility during positioning in idle/inactive mode
* (MTK) Proposal 6-1:
  + For RRC idle state, the downlink only measurement with UE based mode is considered
* (MTK) 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) 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) Proposal 2:
  + RACH preamble (i.e. TA based positioning) can be considered for NR positioning of UEs in RRC idle/inactive state.
* (Qualcomm) 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) 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) Proposal 9:
  + In inactive mode, UE will report its positioning measurement in MsgA of RACH.
* (CEWiT) 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) 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, 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 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).

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### 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 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).

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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) 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) 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) 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)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)Proposal 5:
  + Configuring on-demand PRS within a flexible window as a specific PRS pattern can be considered in Rel-17.
* (vivo)Proposal 6:
  + Periodic, aperiodic, and semi-persistent on-demand PRS should be supported.
* (vivo)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)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)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)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)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)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)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)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)Proposal 34:
  + Aperiodic positioning measurement report can be considered in Rel-17.
* (CATT)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)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) Proposal 2:
  + Study and support aperiodic and on-demand PRS transmission.
* (Intel) Proposal 3:
  + Support both semi-persistent and aperiodic DL PRS allocation for DL-TDOA, DL-AoD, Multi-RTT positioning methods
* (Lenovo) Proposal 1:
  + Support On-demand DL-PRS procedures based on UE-initiated and network-triggered requests.
* (Lenovo) Proposal 2:
  + Support On-demand DL-PRS procedures for DL-based and DL+UL-based positioning methods.
* (CMCC) Proposal 2:
  + The priority of DL PRS, at least that of the on-demand DL PRS, should be defined in Rel-17.
* (Xiaomi) 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) Proposal 2:
  + Support UE to recommend the PRS configuration parameter set ID by PUSCH during RA procedure or scheduled responding to SR.
* (Xiaomi) Proposal 3:
  + Support gNB to indicate the PRS configuration parameter set ID by MAC CE/DCI.
* (Xiaomi) 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) 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) 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) Proposal 12:
  + On-demand and dynamic PRS should be supported for both UE-assisted and UE-based positioning.
* (Sony) 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) 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)Proposal 6:
  + Adopt on-demand PRS for flexibility in configuration of PRS, latency reduction and positioning with high accuracy
* (InterDigital)Proposal 7:
  + Timing of sending on-demand PRS in the multi-RTT positioning method should be studied
* (LGE)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)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) 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 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 normative work.

Comments

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## 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) 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) Proposal 12:
  + Rel-17 should support enhanced AoA defined with respect to the ULA antenna direction.
* (Huawei) 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) 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) 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) Proposal 14:
  + RAN1 to study beam orientation errors and potential correction mechanisms in order to improve the positioning accuracy achievable with DL-AoD.
* (LGE) Proposal 5:
  + As a potential enhancement of Rel-17 NR positioning, timing measurement based DL-AoD technique needs to be considered.
* (MTK) 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)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)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) 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 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

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## 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

* (vivo)Proposal 2:
  + The enhancements are needed for positioning latency, network efficiency, and device efficiency
* (vivo)Proposal 22:
  + Priority rules for positioning measurement and report can be considered in Rel-17 positioning
* (Intel) Proposal 15:
  + Discuss and support proposed above enhancements for low-latency NR positioning working in cooperation with RAN WG2
* (Nokia) 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) 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.
* (LGE)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) Proposal 4-1:
  + At least for the periodic measurement reports, the configured grant may be considered to shorten the report latency
* (MTK)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)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
* (Qualcomm)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) 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) Proposal 9:
  + Support DCI/MAC-CE triggering of Measurement gaps (MG) for the purpose of positioning measurements.
* (Qualcomm) Proposal 10:
  + Support reporting location information to the serving gNB using MAC-CE or UCI.
* (Qualcomm)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) Proposal 5:
  + Lower layer (MAC-CE and /or DCI based) DL-PRS configuration triggering should be allowed in Rel 17 positioning enhancement.
* (CEWiT) Proposal 6:
  + Lower layer (MAC-CE and /or DCI based) DL triggered measurement gap should be allowed in Rel 17 positioning enhancement.
* (CEWiT) Proposal 7:
  + NG-RAN based positioning estimation should be configured to reduce the latency.
* (Ericsson) Proposal 23:
  + Assume Rel-16 single-DCI based Multi-TRP architecture for IIoT scenario in order to reduce latency associated with positioning.
* (Ericsson) 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, and Multi-RTT positioning methods
  + UE-based and UE-assisted positioning solutions
* The details of the solutions are left for further 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)

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## 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.

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| Agreement:  The scenario, benefits, methods and signaling 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) 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) 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) 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) Proposal 4:
  + Enable network measurement to calibrate synchronization offset, e.g. support RSTD measurement between positioning nodes
* (ZTE) Proposal 5:
  + Network can deliver some prior channel information to UE, the information will assist UE to perform better positioning.
* (CATT) 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) 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) 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) Proposal 15:
  + Consider supporting the differential operations for eliminating TRP synchronization errors for high-accuracy NR positioning in Rel-17.
* (Intel) Proposal 11:
  + Support network based (inter-gNB) and UE based TX/RX timing errors estimation and measurement report signaling.
* (CMCC) Proposal 5:
  + The methods and signaling for the estimation and compensation on the network synchronization errors should be investigated in Rel-17.
* (MTK)Proposal 3-1:
  + For UE based mode, support the combining of downlink (DL-RSTD) and uplink (UL-RTOA) measurement.
* (MTK)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)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)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)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) 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) 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) 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) 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 Multi-RTT positioning methods
  + UE-based and UE-assisted positioning solutions
* Note: The details of the solutions are left for further normative work.

Comments

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### 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 Multi-RTT positioning methods
  + UE-based and UE-assisted positioning solutions
* Note: The details of the solutions are left for further normative work.

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## 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) 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) 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) 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) Proposal 26:
  + Support reuse of Rel-15 SRS resource set for gNB Rx-Tx and UE Rx-Tx measurements for positioning in NR.
* (Ericsson) 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.

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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) Proposal 23:
  + BWP switching can be considered in Rel-17 as an alternative to using measurement gap.
* (vivo) Proposal 24:
  + PRS measurement within active DL BWP should be supported in Rel-17
* (vivo) Proposal 25:
  + Support to introduce on-demand measurement gap for on-demand PRS in Rel-17.
    - LMF requests measurement gap should be supported.
* (vivo) Proposal 26:
  + Low layer triggering measurement gap should be considered in Rel-17 for NR positioning enhancement.
* (vivo) 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) Proposal 27:
  + Measurement gap related indication should be included in positioning measurement report.
* (CATT) Proposal 16:
  + Aperiodic and SPS measurement gap for positioning should be introduced to achieve low positioning latency in Rel-17.
* (Xiaomi) Proposal 5:
  + BWP switching can be used for PRS measurement instead of measurement gap.
* (InterDigital) Proposal 1:
  + Measurement gap-less reception of PRS should be adopted to minimize latency
* (InterDigital) Proposal 2:
  + Mechanisms to allow measurement gap-less should be studied
* (InterDigital) Proposal 3:
  + Pre-configuration of measurement gaps and activation of pre-configured measurement gaps should be adopted for faster configuration of measurement gaps
* (Qualcomm) Proposal 9:
  + Support DCI/MAC-CE triggering of Measurement gaps (MG) for the purpose of positioning measurements.
* (Qualcomm) 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 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)

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## 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)Proposal 6:
  + Consider positioning measurement and reporting support for DL-based positioning methods.
* (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

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 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

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## 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

* (LGE)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.
* (LGE)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.
* (LGE)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

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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) 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.

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## 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

* (Xiaomi) Proposal 7:
  + To indicate the first arrival path by reporting the arrival time of each beam in beam measurement report.
* (OPPO) Proposal 8:
  + Study to enhance the multi-beam operation on DL PRS resource and support UE-specific beam configuration.
* (Nokia) Proposal 10:
  + RAN1 to study complexity reductions for RAT-dependent positioning techniques with a focus on FR2 operations.
* (Nokia) 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) 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.
* (LGE)Proposal 8:
  + In Rel-17, RAN1 needs to study TX/RX beam optimization for the timing measurements for the improvement of positioning accuracy
* (LGE)Proposal 6:
  + Rel-17 NR positioning SI needs to study how to use the UE's RX beam index reporting for positioning.
* (Lenovo) 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) 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) 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, in this meeting, we may not have the time to discuss each of the proposals one -by-one. Suggest continue the discussion during WI.

### 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, and Multi-RTT positioning methods
  + UE-based and UE-assisted positioning solutions

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## Additional proposals related to signalling enhancements

Background

Rel-16 NR positioning adopts the LMF-centred architecture, including capability transfer, assistance data transfer, location information transfer, and measurement exchange. To improve the positioning enhancements, especially reducing the positioning delay and increase the network efficiency, the existing signalling can be further enhanced. Also, hybrid positioning may significantly increase positioning accuracy and reliability. Hybrid positioning is supported in Rel-16 positioning signalling.

Submitted Proposals

* (Huawei) Proposal 15:
  + Rel-17 should consider UL E-CID positioning methods as the starting point for RRC configured procedure for positioning
* (TCL) Proposal 4
  + Support transmission of assistance information to UEs switching between positioning systems to reduce position acquisition delay.
* (Lenovo) 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)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.

Feature lead’s view

Efficient architecture and signalling are important for supporting very-low latency positioning. Separate discussions are needed for above proposed enhancements.

### Proposal 5-12a

* + UL E-CID positioning methods as the starting point for RRC configured procedure for positioning can be considered for normative work.

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### Proposal 5-12b

* + UL E-CID positioning methods as the starting point for RRC configured procedure for positioning can be considered for normative work.

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### Proposal 5-12c

* + 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 can be considered for normative work.

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### Proposal 5-12d

* + 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, can be considered for normative work.

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## 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)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.

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## Additional positioning methods

Background

Two companies proposed the additional positioning methods.

Submitted Proposals

* (Samsung)Proposal 6:
  + Uplink transmission-based relative positioning should be studied
* (CEWiT)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.

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# Other proposals

## Performance evaluation

Background

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

Submitted Proposals

* (Nokia) 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) 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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## 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) 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.

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# Summary

TBD

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