**3GPP TSG RAN WG1 Meeting #102-e** [**R1- 200697**](file:///E:\1%20Meetings\RAN1\2020%2008_TSGR_102e\Inbox\docs\R1-%20200697.doc)**2**

**e-meeting, 25th May – 5th June 2020**

**Source: Moderator (CATT)**

**Title: FL Summary for Potential Positioning Enhancements (Part 1)**

**Agenda item: 8.5.3**

**Document for: Discussion and Decision**

# Introduction

This document provides the **part 1** of the a summary of the issues and proposals for “AI 8.2.3 Potential positioning enhancements [1-26]) for the following discussion:

[102-e-NR-Pos-Enh-Pot-Pos-Enh] Email discussion/approval on potential positioning enhancements until 8/21; address any remaining aspects by 8/27 – Ren Da (CATT)

It covers the following aspects:

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| --- |
| 1. Enhancements of DL positioning reference signals    1. New DL PRS transmission patterns and additional DL PRS configuration    2. Simultaneous transmission and reception DL PRS with other signals/channels    3. DL PRS processing with aggregated DL PRS resources    4. DL PRS muting enhancements    5. New DL reference signals for positioning    6. Multi-port DL PRS transmission 2. Enhancements of UL positioning reference signals    1. New UL SRS transmission patterns    2. Simultaneous transmission of UL SRS for positioning with other signals/channels    3. UL SRS transmission with aggregated SRS resources    4. Enhancement of SRS cyclic shift patterns    5. Power control for SRS for positioning    6. Mitigation of interference between UL SRSs    7. New UL reference signals for positioning    8. 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 |

The following highlights will be used in this summary:

* The Pink highlights are proposals and issues for discussion with high priority in this email discussion
* The Yellow highlights are proposals and issues for discussion with medium priority in this email discussion
* The Dark Yellow highlights are proposals and issues for discussion with low priority in this email discussion
* The Turquoise highlights are offline consensus/conclusion based on offline discussion or comments
* The Grey sections are issues that have been discussed/revised/ resolved in this meeting email discussion

Note: The fact that a proposal is listed with a priority in this summary for this meeting should not be interpreted as a suggestion that the proposal will have the same priority in other meetings.

# Enhancements of DL positioning reference signals

## New DL PRS transmission patterns and additional DL PRS configuration

Background

In Rel-16, full staggering patterns are supported 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 propose supporting partial staggering and non-staggering DL PRS transmission pattern, e.g., 1-symbol PRS transmission, and smaller DL PRS transmission bandwidth in Rel-17.

Submitted Proposals

* (Huawei) Proposal 1:
  + The enhancement of PRS should include studying
    - Partial staggering and non-staggering PRS RE mapping
* (Sony)Proposal 3:
  + Support PRS configuration with 1 symbol PRS transmission.
* (Sony)Proposal 4:
  + A mechanism to control or to mitigate interference of PRS transmission in a densified network shall be studied.
* (CATT)Proposal 1:
  + 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:
  + RAN1 to study new DL PRS transmission schedules aiming to randomize set of TRPs/gNBs transmitting in the same set of resources
* (OPPO) Proposal 2:
  + Study to enhance the RE mapping of DL PRS resource to resolve the interference issue and increase the capacity of DL PRS resource.
* (CMCC) Proposal 1:
  + The following DL PRS enhancements should be considered:
    - Non-full staggering DL PRS resource pattern
    - Comb-N size enhancements
* (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
* (Fraunhofer)Proposal 5:
  + Consider interference for Rel-17 NR positioning including interference from positioning RSs or other interference sources.
* (LGE)Proposal 8:
  + Support 1-symbol PRS resource for Rel-17 NR positioning.
* (Ericsson) Proposal 10:
  + Allow configuration of DL-PRS with any combination of comb-factor and symbol length, including symbol length 1.

Feature lead’s view

Considering the potential benefits for positioning enhancements (e.g., reduction of the latency) and the relatively small impact on the speciation, suggest investigating this issue with high priority in this meeting.

### Proposal 2-1

* Partial staggering and non-staggering PRS RE mapping with different combinations of comb-factors and symbol lengths will be investigated in Rel-17.
  + FFS: the additional PRS RE mapping patterns (e.g., 1-symbol DL PRS transmission)

Comments

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| **Company** | **Comments** |
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## Simultaneous transmission and reception of DL PRS with other signals/channels

Background

For Rel-16, it was agreed in RAN1#99 that UE is not expected to process DL PRS in the same OFDM symbol where other DL signals and channels are transmitted to the UE. For reducing the positioning latency and improving the network and UE efficiency, many companies propose 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 postioning scenarios.

Submitted Proposals

* (Huawei) Proposal 1:
  + The enhancement of PRS should include studying
    - Simultaneous reception of PRS along with other signals/channels
* (Huawei) Proposal 4:
  + The enhancement of UE procedure of receiving PRS should include studying
    - Flexible PRS multiplexing with other signals/channels
* (vivo) Proposal 3:
  + Introduce the priority indications of PRS for low latency positioning in Rel-17.
* (vivo) Proposal 4:
  + PRS FDM multiplexing with other DL signals and channels at RB level outside of PRS time-frequency grid should be studied in Rel-17 .
* (vivo) Proposal 18:
  + Priority rules for positioning measurement and report can be considered in Rel-17 positioning.
* (CATT) Proposal 9:
  + Introduce the PRS measurement restriction. Those DL PRS resources within the measurement restriction may not be measured by UE.
* (Intel) Proposal 12:
  + RAN1 to study mechanisms for prioritization of transmissions carrying reference signals and channels w/ control signaling for positioning vs other NR reference signals and channels
* (Lenovo) Proposal 2:
  + Priority indications can be considered as potential enhancements in order to reduce the positioning latency for high priority scenarios.
* (CAICT)Proposal 1:
  + The priority of PRS for low latency positioning could be considered in Rel-17, and implicitly or explicitly indicated to the positioning UEs based on the positioning service latency requirement.
* (InterDigital) Proposal 1:
  + Study mechanisms supporting prioritized transmission of PRS and SRS for positioning
* (InterDigital) Proposal 2:
  + Rel-16 URLLC prioritization mechanisms is used as a baseline for prioritized transmission of PRS and SRS for positioning.
* (Qualcomm) Proposal 15:
  + For the purpose of enhanced efficiency, study further PRS processing without MG and DL/UL PRS prioritization over other channels and procedures.

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 in most scenarios. There is a need to support simultaneous transmission and reception of DL PRS with other signals/channels and define the corresponding priority rules, which allow the network to use different configurations to support different scenarios. Thus, suggest investigating this issue with high priority in this meeting.

### Proposal 2-2

* Simultaneous transmission of DL PRS and other signals/channels in the same OFDM symbol will be investigated in Rel-17
* Priority rules will be investigated for the processing of DL PRS and other signals/channels when DL PRS and other signals/channels are transmitted in the same OFDM symbol

Comments

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| **Company** | **Comments** |
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## DL PRS processing with aggregated DL PRS resources

Background

The positioning measurement accuracy is tightly related to the available DL PRS resources in both the time and frequency domain. In NR Rel-16, the maximum bandwidth is 272 PRBs within a frequency layer and up to 4 frequency layers can be configured. However, Rel-16 does not provide the mechanism to support the coherent reception of the DL PRS from multiple frequency layers. Thus, the effective bandwidth of the received PRS is still limited to individual frequency layers. Many companies propose to investigate DL PRS processing with the aggregated DL PRS resources to increase the effective bandwidth of the received PRS for the enhancement of positioning accuracy.

Submitted Proposals

* (Huawei) Proposal 1:
  + The enhancement of PRS should include studying
    - PRS aggregation
* (ZTE)Proposal 1:
  + Rel-17 enhancements should consider joint measurement based on different frequency units, e.g. allow joint measurement based on DL PRS from different positioning frequency layers.
* (Intel)Proposal 5:
  + RAN1 to study scenarios and performance benefits of aggregating multiple DL positioning frequency layers by UEs
* (BUPT)Proposal 2:
  + NR positioning should support the Carrier Aggregation for PRS.
* (CEWiT)Proposal 5:
  + Simultaneous reporting or processing of multiple frequency layers can improve the positioning accuracy.
* (MTK) Proposal 3-1
  + Study the impact of channel spacing, timing offset and power imbalance among CCs to the positioning performance for intra-band contiguous CA
* (MTK) Proposal 3-2
  + Study whether interband CA can be utilized for LOS detection due to different path loss and reflection properties over different bands
* (MTK)Proposal 3-3:
  + Study whether intra-band non-contiguous CA can be utilized under conventional receiver and under advanced receiver providing super resolution, and the corresponding requirement on timing offset and power imbalance among CCs.
* (Qualcomm)Proposal 2:
  + For the purpose of improved accuracy, study further DL PRS bundling in frequency domain, with considerations for both licensed and unlicensed operation and “PRS stitching” in both intra-band and inter-band scenarios.

Feature lead’s view

Considering the potential for the enhancement in positioning accuracy with the aggregating DL PRS resources, suggest investigating this issue with high priority in this meeting.

### Proposal 2-3

* The benefits and the issues associated with 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 include
  + the scenarios and performance benefits of aggregating multiple DL positioning frequency layers by UEs
  + the impact of channel spacing, timing offset and power imbalance among CCs to the positioning performance for intra-band contiguous/ non-contiguous and inter-band scenarios
    - FFS: unlicensed bands

Comments

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| **Company** | **Comments** |
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## New DL reference signals for positioning

Background

For improving the positioning performance (e.g., reducing the interference), several companies propose introducing new DL positioning reference in Rel-17.

Submitted Proposals

* (CATT)Proposal 13:
  + Consider supporting NR carrier phase DL positioning in Rel-17. The reference signals for DL carrier phase measurements can be:
    - C-PRS (sinusoidal signals)
* (ZTE)Proposal 3:
  + To better manage the interference, introduce orthogonal cover code (OCC) for positioning reference signals can be considered in Rel-17.
* (LGE)Proposal 7:
  + 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 13:
  + cyclic shifts for DL PRS is considered in rel17, with configurable cyclic shifts and configurable maximum number of cyclic shift.
* (Ericsson) Proposal 17:
  + TRS is a candidate for positioning in release 17.

Feature lead’s view

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. Suggest further investigating the benefits of introducing new DL positioning reference signals if we have the time to do so in this meeting.

### Proposal 2-4

* The benefits and the need of introducing new DL positioning reference signals for positioning enhancements can be investigated.

Comments

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| **Company** | **Comments** |
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## DL PRS muting enhancements

Background

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

* (OPPO) Proposal 3:
  + Study to support DL PRS resource-specific muting.
* (Samsung)Proposal 5:
  + Frequency domain muting should be studied

Feature lead’s view

DL PRS muting is an effective approach to reduce DL PRS interference. DL PRS muting with the granularity of DL RS resource and/or the frequency domain may further reduce the DL PRS interference. Suggest further investigating the benefits of introducing new DL PRS muting enhancements if we have the time to do so in this meeting.

### Proposal 2-5

* The enhancements of DL PRS muting, e.g., DL PRS resource-specific muting and Frequency domain muting can be further investigated

Comments

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| **Company** | **Comments** |
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## Multi-port DL PRS transmission

Background

In Rel-16, DL PRS is transmitted on one antenna port only. For Rel-17, there are proposals to support DL PRS transmission from more than 1-port with the potential to improve the measurement accuracy (e.g., multipath mitigation).

Submitted Proposals

* (Futurewei)Proposal 2:
  + For the purpose of improving accuracy, methods to identify NLOS and the corresponding mitigation methods should be studied including the usage of polarization transmissions and measurements
* (Sony)Proposal 2:
  + Support the study on enhanced beam operation for positioning, including PRS transmission with more than one antenna port (i.e. 2 antenna ports) and the usage of legacy reference signal for positioning (TRS, CSI-RS).
* (Spreadtrum)Proposal 2:
  + For Rel-17 positioning enhancement, 2-port PRS should be further studied.

Feature lead’s view

The multi-port transmission of the positioning reference signals was discussed in Rel-16, but without a clear conclusion of the potential benefits. The main motivation for proposing multi-port DL PRS transmission again seems related to the support of the multipath mitigation. Thus, the multi-port DL PRS transmission may be investigated as part of the investigation of the multipath mitigation.

Comments

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| **Company** | **Comments** |
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# Enhancements of UL positioning reference signals

## New UL SRS transmission patterns

Background

In Rel-16, full staggering patterns are supported for UL SRS for positioning. For reducing the positioning latency, minimizing the interference, and optimizing the resource usage, several companies propose supporting partial staggering and non-staggering UL SRS transmission patterns as well as the frequency hopping in Rel-17.

Submitted Proposals

* (Huawei) Proposal 2:
  + The enhancement of SRS should include studying
    - Partial staggering and non-staggering SRS RE mapping
* (CMCC) Proposal 4:
  + The non-full staggering UL SRS for pos resource pattern should be considered.
* . (OPPO) Proposal 4:
  + Study the enhancement of SRS resource for positioning to support larger transmission bandwdith, e.g., support frequency-hopping, larger Comb size
* (OPPO) Proposal 6:
  + 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.
* (CATT) Proposal 5:
  + Frequency hopping of SRS-Pos for positioning should be supported in Rel-17 in order to obtain better positioning accuracy.

Feature lead’s view

Considering the potential benefits for positioning enhancements and the relatively small impact on the speciation, suggest investigating this issue with high priority in this meeting.

### Proposal 3-1

* Partial staggering and non-staggering RE mapping and frequency hopping of SRS for positioning will be investigated 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

* (CMCC) Proposal 5:
  + The collision rule of PUSCH and AP SRS for pos should be studied.
* (vivo) Proposal 8:
  + Introduce the priority indications of SRS-PosResource for low latency positioning in Rel-17.
* (InterDigital) Proposal 1:
  + Study mechanisms supporting prioritized transmission of PRS and **SRS** for positioning
* (InterDigital) Proposal 2:
  + Rel-16 URLLC prioritization mechanisms is used as a baseline for prioritized transmission of PRS and SRS for positioning.

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. Thus, suggest investigating this issue with high priority in this meeting.

### Proposal 3-2

* Simultaneous transmission of UL SRS for positioning together with other UL signals/channels in the same OFDM symbol will be investigated in Rel-17
* Priority rules will be investigated for the transmission of UL SRS for positioning and other UL signals/channels in the same OFDM symbol

Comments

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| **Company** | **Comments** |
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## UL SRS transmission with aggregated SRS resources

Background

The positioning measurement accuracy is tightly related to the available RF resources in time and frequency. To further improving positioning accuracy, several companies propose to support the UL SRS transmission and reception with larger bandwidth and longer duration (inter-slot SRS repetition).

Submitted Proposals

* (Huawei) Proposal 2:
  + The enhancement of PRS should include studying
    - Simultaneous SRS transmission across CCs
* . (OPPO) Proposal 4:
  + Study the enhancement of SRS resource for positioning to support larger transmission bandwdith, e.g., support frequency-hopping, larger Comb size
* (Qualcomm)Proposal 3:
  + For the purpose of improved accuracy, study further SRS for Positioning bunding in time domain & inter-slot SRS repetition.

Feature lead’s view

Considering the potential for providing a significant enhancement in positioning accuracy with the aggregating multiple UL positioning frequency layers, suggest investigating this issue with high priority in this meeting.

### Proposal 3-3

* The benefits and the issues associated with simultaneous transmission and reception of the SRS for positioning across multiple CCs and multiple slots can be investigated in Rel-17.

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 also discussed during Rel-16 WI without reaching a consensus. Many companies propose to resolve the problem in Rel-17.

Submitted Proposals

* (Huawei) Proposal 2:
  + The enhancement of SRS should include studying
    - Enhancement on cyclic shift pattern considering staggering
* (CATT) Proposal 4:
  + 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 9-1
  + Increase the maximum cyclic shift number for each comb for the staggering SRS structure:
* (MTK) Proposal 9-2
  + The amount of the phase rotation applied to the REs across symbols with SRS transmission may follow the order of occupied subcarriers
* (Fraunhofer) Proposal 6:
  + For Rel-17 update the sequence generation by modifying the equations as

configured via   and

is configurable (range for *cyclicshift* is extended)

Note: the maximum value of cyclic shift is not changed

* (Fraunhofer) Proposal 7:
  + For Rel-17 SRS enhancement support:
    - a phase correction for the staggered SRS, and
    - maintain the cyclic shift step size of Rel-15.
    - Extend the range of the cyclic shift
* (Ericsson) Proposal 14:
  + 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 15:
  + 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 in Rel-16 SRS for positioning were identified and the potential solutions were also intensively discussed in Rel-16, but the issue is not resolved. Suggest resolving this issue in Rel-17.

### Proposal 3-4

* The cyclic shift patterns for SRS for positioning will be further investigated in Rel-17 to increase the maximum cyclic shift number for each comb for the staggering SRS structure as well as make the phase rotation applied to the REs across symbols with SRS transmission following the order of occupied subcarriers.
  + FFS: the detailed formula for the cyclic shift pattern
  + FFS: whether the maximum number of available cyclic shifts for the SRS for positioning is configurable

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 close-loop for SRS for positioning in Rel-17.

Submitted Proposals

* (Huawei) Proposal 5:
  + The enhancement of UE procedure of transmitting SRS should include studying
    - Closed-loop power control of SRS for positioning
* (vivo)Proposal 7:
  + PHR based on SRS-PosResource should be introduced in Rel-17.
* (OPPO) Proposal 5:
  + Study the enhancement of uplink power control of SRS for positioning
    - Support closed-loop power control on SRS for positioning.
    - Support configuring power control parameter per SRS resource for positioning
* (Spreadtrum) Proposal 3:
  + For Rel-17 positioning enhancement, close loop power control can be further studied
* (Nokia)Proposal 4:
  + RAN1 to study enhancements on transmit power control for UL and UL+DL positioning methods, e.g., study a new procedure for how serving gNB gets TPC parameters from neighbor gNBs/TRPs.
* (TCL) Proposal 3:
  + Support Closed-loop power control for the transmission of SRS for positioning.

Feature lead’s view

Without the close-loop power control on SRS for positioning, the UE closes to a cell may create a significant interference for the reception of the UL signals/channel from other UEs by the same cell. The issue may get worse when the number of positioning UEs increases. Suggest investigating this issue with high priority in this meeting.

### Proposal 3-5

* Close-loop power control of SRS for positioning will be investigated in Rel-17.
  + FFS: whether the TPC is generated from the serving gNB/TRP only, or also from the neighbor gNBs/TRPs

Comments

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| **Company** | **Comments** |
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## Mitigation of interference between UL SRSs

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. 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 3:
  + 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
* (CAICT)Proposal 3:
  + Support positioning SRS resource muting or coordination to achieve interference cancellation among different cells in Rel-17.

Feature lead’s view

Support the coordination of the configurations the SRS for positioning among adjacent gNB/TRPs and LMF may avoid the potential collisions of the SRS for positioning and reduce the UL interference.

### 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 investigated.

Comments

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| **Company** | **Comments** |
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## New UL reference signals for positioning

Background

For improving the positioning performance, there are proposals for the enhancements of Rel-16 UL reference signals

Submitted Proposals

* (vivo) Proposal 10
  + Support to reuse low PAPR RS agreed in Rel-16 MIMO for SRS sequence generation for positioning in Rel-17
* (CATT)Proposal 14:
  + Consider supporting NR carrier phase UL positioning in Rel-17. The reference signals for UL carrier phase measurements can be:
    - C-PRS (sinusoidal signals)

Feature lead’s view

The design of the UL positioning reference signals is of the key importance for all positioning methods that use the UL SRS measurements. Significant efforts were spent in Rel-16 for the development UL SRS for positioning. In Rel-17, new UL positioning reference signals may be introduced if it can provide significant benefits for positioning enhancements.

### Proposal 3-7

* New UL positioning reference signals may be further investigated for positioning enhancements.

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 multi-port transmission of the positioning reference signals was discussed in Rel-16, but without a clear conclusion of the potential benefits. The main motivation for proposing multi-port positioning RS transmission again seems related to the support of the multipath mitigation. The multi-port positioning RS transmission may be investigated 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. To further address the problem, many companies propose different solutions for Rel-17 positioning enhancements.

Submitted Proposals

* (Huawei) Proposal 3:
  + The enhancement of measurement should include studying
    - Multi-path measurements associated with angle/power measurements
    - NLOS/LOS identification
* (Futurewei)Proposal 2:
  + For the purpose of improving accuracy, methods to identify NLOS and the corresponding mitigation methods should be studied including the usage of polarization transmissions and measurements.
* (Futurewei) Proposal 3:
  + Additional measurement relative to the first detected path should be studied including its feasibility to improve AoD positioning accuracy.
* (vivo) Proposal 1:
  + The enhancements to improve positioning accuracy are needed for the NLOS scenario.
* (Sony) Proposal 5:
  + Support the study on LOS & NLOS detection mechanism at the UE and the associated signalling procedure.
* (CATT) Proposal 1:0
  + Each measurement would be associated with a LOS/NLOS identifier
* (Intel) Proposal 6:
  + RAN1 to support signaling indicating the LOS/NLOS propagation type or conditions for each link used for positioning
* (Intel) Proposal 7:
  + RAN1 to study an impact of the NLOS offset on the positioning accuracy and make a conclusion whether the NLOS offset reporting is a valuable mechanism or not
* (Intel) Proposal 8:
  + RAN1 to study benefits of the additional measurements for the first arrival path of the CIR component
    - First arrival path (FAP) power, K-factor, Doppler shift, etc
* (Samsung)Proposal 3:
  + Angle based LOS/NLOS differentiation with joint measurement should be studied
* (MTK) Proposal 5-1:
  + Study RSRP measurement for first-arriving path as accuracy improvement for DL-AoD technique
* (Spreadtrum) Proposal 3:
  + Support UE to report the RSRP value corresponding to the PRS resource transmitted with the beam covering the first arrival path
* (Spreadtrum) Proposal 4:
  + In Rel-17, study the LOS/NLOS condition measurement and reporting mechanism
* (Nokia) Proposal 5:
  + RAN1 to study NLOS identification and reporting.
* (Fraunhofer)Proposal 1:
  + Support enhanced CIR reporting for NR-Positioning in Rel-17.
* (Fraunhofer)Proposal 3:
  + Study LOS/NLOS /OLOS channel state detection methods, their associated measurements and impacts on procedures.
* (CEWiT)Proposal 1:
  + Reporting of LOS confidence and angle information of LOS path should be studied in Release-17.
* (CEWiT)Proposal 6:
  + New KPIs such as priority, time-to-alarm, the false alarm rate and number of detectable false transmitters should be considered in Release-17 study.
* (Xiaomi)Proposal 5:
  + We suggest to find the LOS path during beam management procedure.
* (Ericsson) Proposal 1:
  + 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 2:
  + Magnitude, SNR, Doppler frequency, angle of arrival of every path should be reported.
* (Ericsson) Proposal 3:
  + It shall be unambiguously defined what additional paths a UE shall report.
* (Ericsson) Proposal 4:
  + LOS detection mechanisms should be studied within the Rel. 17 positioning enhancement study item.
* (Ericsson) Proposal 5:
  + 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.
* (Ericsson) Proposal 10:
  + 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 11:
  + 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

Effective multipath mitigation techniques are essentially important to achieve high-positioning accuracy, especially for IIoT scenarios. Thus, suggesting investigating this issue with high priority in this meeting.

### Proposal 4-1

* Multipath mitigation techniques will be investigated in this SI for improving positioning accuracy, which may include, but not limited to the following:
  + The methods for the LOS/NLOS detection and identification, e.g.,
    - Based on the reference signals from multi-antenna ports
    - Based on beam associated information
    - Based on channel state detection
    - Based on the reference operation
  + The measurements for supporting the multipath mitigation, e.g.,
    - Timing, angle, power K-factor, Doppler shift measurement of the first path
    - The timing, angle, power, SNR, Doppler shift, measurements of the additional paths
    - Location and magnitude of the first peak, the highest peak, components of PDP/CIR around first/highest peaks.
    - The LOS/NLOS indication and associated confidence level
  + The procedure and signaling for supporting the multipath mitigation, e.g.,
    - The assistance from the network (e.g., the possible number of paths and the number of beams, detection thresholds, etc.)

Comments

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| **Company** | **Comments** |
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## Additional enhancements of 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

* (Huawei) Proposal 3:
  + The enhancement of measurement should include studying
    - CSI measurements
    - Rx/Tx diversity based reporting
* (CATT) Proposal 13:
  + Consider supporting NR carrier phase DL positioning in Rel-17. The reference signals for DL carrier phase measurements can be:
    - DL PRS
* (CATT) Proposal 14:
  + Consider supporting NR carrier phase UL positioning in Rel-17. The reference signals for DL carrier phase measurements can be:
    - UL SRS for positioning
* (CATT) Proposal 15:
  + Consider supporting the carrier phases measurements from two or more carrier frequencies for fast resolution of the integer ambiguity.
* (MTK) Proposal 6-1
  + Study the feasibility of carrier phase measurement at least starting from Rel-17
* (BUPT)Proposal 1:
  + NR should enhance PRS to support carrier phase measurement.
* (Intel) Proposal 9:
  + RAN1 to support received waveform reporting to enable precise UE positioning
* (Intel) Proposal 10
  + RAN1 to study whether additional physical layer measurements can benefit/support integrity of RAT-dependent positioning solutions
* (Fraunhofer) Proposal 4:
  + Consider carrier phase measurements for positioning in both UL and DL timing-based methods at least in FR1.
* (Apple)Proposal 2:
  + RAN1 to study any need of physical layer enhancements, e.g. additional measurements, in regard to enhancing positioning reliability.
* (Ericsson) Proposal 6:
  + Consider absolute time reporting in release 17 measurement reports

Feature lead’s view

Introduce new positioning measurements may offer significant enhancements to the positioning performance. Suggest investigating this issue, especially the new measurements based on existing Rel-16 NR signals, with high priority in this meeting.

### Proposal 4-2

* New UE/gNB measurements will be investigated to improve positioning performance, especially positioning accuracy. The new UE/gNB measurements to be investigated may include the following:
  + CSI measurements
  + Carrier phase measurements
  + received waveform reporting
  + absolute time reporting

Comments

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| **Company** | **Comments** |
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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 that are not covered in previous sections.

Submitted Proposals

* (vivo) Proposal 1:
  + Introduce 10 ms level granularity for the response time and reporting intervals in *CommonIEsRequestLocationInformation*
* (Apple)Proposal 1:
  + RAN1 to further study reusing/adopting other DL RS signals for DL positioning measurements.
* (Qualcomm) Proposal 17:
  + For the purpose of enhanced efficiency, study further Positioning measurements derived on other reference signals and channels.
* (Ericsson) Proposal 7:
  + 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 9:
  + In order to maintain accuracy, the target latency must factor the need for tracking measurement, i.e. UE mobility

Feature lead’s view

Suggest further investigating the proposed measurement enhancements if we have the time to do so in this meeting.

### Proposal 4-3

* The following enhancements related to UE measurements can be investigated:
  + the use of other DL RS signals for DL positioning measurements
  + smaller granularity for the response time and reporting intervals measurement report
  + the support of tracking measurements
  + two (or multiple) sets of requirements for UE measurement accuracy

Comments

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| --- | --- |
| **Company** | **Comments** |
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# Summary (Part 1)

TBD

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