**3GPP TSG RAN WG1 Meeting #104-E R1-210zzzz**

**e-Meeting, January 25th – February 5th, 2021**

**Source: Moderator (Intel Corporation)**

**Title: Feature Lead Summary #1 for NR Positioning UL-AoA Enhancements**

**Agenda item: 8.5.2**

**Document for:** **Discussion and Decision**

Introduction

In this document, we provide summary of contributions [1]-[19]submitted for the AI 8.5.2 on enhancements for UL-AOA positioning method as a part of the Rel.17 NR Positioning Enhancements work item. In addition, we provide initial set of proposals for RAN WG1 discussions/decisions at the RAN1#104E meeting.

# Summary of Proposed Enhancements

In this section, we provide summary of the major topics that have been identified based on review of the submitted contributions:

* Reporting and measurements enhancements for UL-AOA NR Positioning
  + [OPPO, [1]], [Huawei, [2]], [ZTE, [3]], [CATT, [4]], [vivo, [5]], [Futurewei, [6]], [InterDigital, [11]], [Sony, [12]], [CMCC, [13]], [Qualcomm, [17]], [DOCOMO, [18]], [[Ericsson, [19]]](#_Toc61904130)
* Support of different antenna array configurations (e.g. ULA, different antenna spacing)
  + [Huawei, [2]], [vivo, [5]], [Futurewei, [6]], [Intel, [9]], [Ericsson, [19]]
* Calibration of gNB angle error and reference UE
  + [Huawei, [2]], [vivo, [5] - FFS], [CATT, [4], [BUPT,[7]]
* LOS/NLOS identification for UL-AOA measurements
  + [OPPO, [1]] (by implementation), [CATT, [4]], [Futurewei, [6]], [Intel, [9]]
* Assistance signaling for UL-AOA measurements (LMF assistance to gNB)
  + [CATT, [4]], [Nokia, [8]]
* SRS physical structure enhancements (sequence, RE mapping, multi-port SRS)
  + [LGE, [10]], [Fraunhofer, [14]]
* Power control enhancements of SRS for positioning
  + LGE, [10]], [Samsung, [15]]
* gNB/UE beamforming related aspects
  + [Nokia, [8]], [Samsung, [15]]
* SRS for positioning transmission priority
  + [InterDigital, [11]]
* Enhancements for UE timing advance
  + LGE, [10]]
* DL PRS-RSRP measurements enhancements
  + [Apple, [16]]

# Discussion on Proposed Enhancements

## Reporting and measurements enhancements

There are a lot of various proposals for gNB reporting and measurements enhancements as listed below:

* Study implementation based solution vs reporting of multiple AOA, associated UL-RTOA, associated SRS-RSRP [OPPO, [1]]
  + Motivation:
    - Improve the performance of UL AOA
* Per path UL AOA measurements/reporting [Huawei, [2]]
  + Motivation:
    - Positioning via reflections and spatial consistency checks
* Additional beam information reporting [ZTE, [3]] (e.g. antenna layout, beam width, beam vectors and corresponding gains etc.)
  + Motivation:
    - LMF can search for a right direction in an angle range, handling of sidelobes
* AOA & RTOA measurements associated to multi-paths to LMF for AOA positioning [CATT, [4]]
  + Motivation:
    - Discriminate AOA measurements corresponding to the LOS path from AOA measurements corresponding to the NLOS path
    - Use of advanced algorithms potentially to achieve a higher positioning accuracy
* Additional angle information of multiple paths [vivo, [5]] (RSRP, timing information per each angle)
  + Motivation:
    - Helps LMF to decide which angle is better for accurate positioning
* Detailed Tx/Rx beam information [Futurewei, [6]]
  + Motivation:
    - LMF to decide which angle is better for accurate positioning
* Reporting of UE orientation information from the UE [InterDigital, [11]
  + Motivation:
    - Network may be able to determine angle of transmission of SRSp depending on the UE orientation information and configured SRSp resource set and resource ID
* Uncertainty of the AOA and SRS Resource ID [Sony, [12]]
  + Motivation:
    - Helps to filter out some unreliable AOA measurements
    - Filter out undesired report from certain gNB
* Multiple UL AOA with associated ToA measurements [CMCC, [13]]
  + Motivation:
* Report multiple tuples (UL-AOA, UL-RSRP, RTOA/gNB Rx-Tx) within a single report [Qualcomm, [17]]
  + Motivation:
    - Helpful in advanced fusing algorithms
* Reporting multiple UL-AOAs w/ timing measurements [DOCOMO, [18]]
  + Motivation:
    - Single UL-AOA reporting may be insufficient to achieve a certain positioning accuracy for especially for NLOS
* Velocity of the UE should be reported to the network [Ericsson, [19]]
  + Motivation:
    - For estimation of AOA at TRPs

### Round – 1

**Proposal 1-1**

* NR supports combination of {UL-AOA, UL-RTOA or gNB Rx-Tx time difference, UL-RSRP} gNB/TRP measurements defined per channel path
  + FFS reporting details etc.

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## Support of different antenna array configurations

The following issues were raised for specific antenna configurations, e.g. Unilateral Linear Arrays (ULA):

* Ambiguity of angle measurements (e.g. due to different antenna spacings)
* Bias in angle measurements when gNB/TRP antenna array and UE are located at different heights

In order to address these issues, the following was proposed

* Firstly the use cases and scenarios for ULA antenna array should be discussed and confirmed [vivo, [5]]
* Reporting of multiple angle values per path or indication of the TRP antenna array orientation in the local coordinate system [Intel, [9]]
* Angle measurement defined with respect to the ULA antenna direction [Huawei, [2]]
* Enhanced AOA measurement with respect to the ULA antenna orientation [Futurewei, [6]]
* Reporting of the true AOA for ULA antenna configuration is supported by rel17 NR positioning enhancements [Ericsson, [19]]

### Round – 1

**Proposal 2-1**

* In case of UL-AOA measurements ambiguity,
  + gNB reports multiple values of UL-AOA measurements per path
* In case of ULA,
  + gNB reports UL-AOA measurement which is a function of the actual azimuth and zenith angles of arrival
* FFS details

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## Calibration of gNB angle error and reference UE

The following options were proposed to support calibration of gNB angle error measurements:

* Introduce a calibration/reference UE [Huawei, [2]], [vivo, [5] - FFS], [CATT, [4]
  + Motivation:
    - Use known location to mitigate the gNB angle error
* Support LMF assisted angle calibration [Huawei, [2]]
  + Motivation:
    - Calibrating the phase/amplitude error across antenna elements
* Correction of the fixed phase deviation between channels of gNB antenna [BUPT,[7]]
  + Motivation:
    - Accurate UL AOA measurements

### Round – 1

**Proposal 3-1**

* Further study the following two alternatives for gNB/TRP antenna array calibration to facilitate accurate UL-AOA measurements:
  + Alt.1: NR supports reference UE with known coordinates/orientation for UL-AOA measurement calibration
  + Alt.2: Procedure for calibration of UL-AOA measurements is up to gNB/TRP implementation

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## LOS/NLOS identification for UL-AOA measurements

The following proposals were discussed for with respect to LOS/NLOS identification to improve accuracy of UL-AOA positioning.

* AOA measurements associated with LOS/NLOS identifier and a confidence level [CATT, [4]]
  + Motivation:
    - Accuracy of AOA positioning
* LOS indicators as soft values to the network or LMF [Futurewei, [6]]
  + Motivation:
    - To improve positioning accuracy using regularization techniques
* NLOS link rejection by polarization [Futurewei, [6]]
  + Motivation:
    - Improve accuracy, identify NLOS direction (relative changes in their polarization orientation)
* Indication of link propagation type (LOS/NLOS) and reliability metric [Intel, [9]]
  + Motivation:
    - Improved UL-AOA positioning accuracy

### Round – 1

**Proposal 4-1**

* gNB/TRP reports estimate of LOS/NLOS link type identification to facilitate accurate UL-AOA positioning
  + FFS details for LOS/NLOS link type identification and signaling

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## Assistance signaling for UL-AOA measurements

The following options were proposed to assist UL-AOA measurements:

* Indication of expected AOA parameters [Nokia, [8]]
  + Motivation: Assist non-serving cell TRPs in UL-AOA measurements
* Indication of estimated UE position and the uncertainty [CATT, [4]]
  + Motivation: Aid the UE/gNB in the reception of the DL/UL reference signals and providing reliable NR timing and angular (especially AOA) measurements

### Round – 1

**Proposal 5-1**

* NR supports assistance signaling from LMF to gNB/TRP to facilitate UL-AOA measurements
  + FFS details of LMF assistance signaling

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## SRS physical structure enhancements

The following options were proposed to enhance SRS physical structure:

* Long ZC sequence (Length = existing sequence length \* comb size) [LGE, [10]]
  + Motivation:
    - More cyclic shifts and root indexes can be used => cross-correlation can be improved
* Enhanced SRS sequence mapping rule [LGE, [10]]
  + Motivation:
    - Adjustment of phase are not necessary
* Multi-port SRS for positioning [Fraunhofer, [14]]
  + Motivation:
    - Reduced time-frequency resource overhead. TRP may take advantage of the multipath components received from multiple SRS resources coherently transmitted

### Round – 1

The proposed above enhancement seems to be a general one i.e. applicable to all UL NR positioning measurements.

**Proposal 6-1**

* FFS physical structure enhancements of SRS for positioning

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## Power control enhancements of SRS for positioning

The following open-loop power control enhancements were proposed

* Multiple DL RS resources as path-loss reference to each SRS resource set. [LGE, [10]]
* Association between the multiple path-loss reference RSs and SRS resource within a SRS resource set. [LGE, [10]]
  + Motivation:
    - Improve reception at neighbour gNBs/TRPs
* Power control enhancements [Samsung, [15]]
  + Motivation:
    - Reliable reception at neighbour TRPs/gNBs that are far from UE

### Round – 1

The proposed above enhancements seem to be general ones, i.e. applicable to all UL NR positioning measurements.

**Proposal 7-1**

* FFS association of pathloss reference RSs and SRS resources for positioning within an SRS resource set
* FFS power control enhancements for SRS for positioning

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## gNB/UE beamforming related aspects

The following beamforming related techniques were proposed for study to improve UL-AOA performance:

* Differential beamforming technique for UL-AOA positioning method [Samsung, [15]]
  + Motivation:
    - Accuracy enhancements, latency reduction, overhead reduction
* Beam interpolation based AOA estimation [Nokia, [8]]
  + Motivation:
    - Accurate measurement of UL-RSRP

### Round – 1

**Proposal 8-1**

* Further study performance of differential beamforming and beam interpolation-based AOA estimation for UL-AOA positioning and particular design aspects for specification work

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## SRS for positioning transmission priority

The SRS for positioning prioritization was discussed:

* Prioritization of SRS for positioning with respect to other signals and channels [InterDigital, [11]]
  + Motivation:
    - SRS for positioning transmission may be dropped when the UE has another data for UL transmission => degradation of low latency positioning services

### Round – 1

The proposed above enhancement seems to be a general one i.e. applicable to all UL NR positioning measurements.

**Proposal 9-1**

* Further study prioritization of SRS for positioning with respect to other signals and channels

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## Enhancements for UE timing advance

The following enhancements were proposed with respect to the SRS for positioning transmission timing:

* SRS resource-specific TA configuration [LGE, [10]]
  + Motivation:
    - For transmission intended to a neighbour cell, TA of the SRS resource should also be intended to the target neighbour cell.

### Round – 1

The proposed enhancements were discussed in Rel.16 and there was no consensus to introduce such functionality for NR SRS for positioning.

**Proposal 10-1**

* FFS support of SRS resource-specific TA configuration

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## DL PRS-RSRP measurements enhancements

* Association of DL-PRS-RSRP measurements with a time window, determined by UE [Apple, [16]]
  + Motivation:
    - PRS for DL-AoD, is not tied with the first detected path in time. Report may be often biased toward the NLOS path
  + NOTE: Proposal relates to DL-AoD enhancement and thus should be covered under another AI 8.5.3

### Round – 1

**Proposal 11-1**

* Discuss proposal under AI 8.5.3 unless the same approach is suggested for UL-AOA by proponent

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Conclusions

In this contribution, we have provided review of the submitted contributions for NR Positioning UL-AOA enhancements and prepared initial set of proposals to facilitate further discussion/decision.

References

1. R1-2100129 Enhancements for UL AOA Positioning OPPO
2. R1-2100237 Enhancement for UL AOA positioning Huawei, HiSilicon
3. R1-2100294 Accuracy improvement for UL-AOA positioning solutions ZTE
4. R1-2100386 Discussion on accuracy improvements for UL-AOA positioning solutions CATT
5. R1-2100446 Discussion on potential enhancements for UL-AOA method vivo
6. R1-2100488 Discussion on improving the accuracy of UL AOA positioning solutions FUTUREWEI
7. R1-2100497 Accuracy improvements for UL-AOA positioning solutions BUPT
8. R1-2100549 Initial views on enhancing UL AOA Nokia, Nokia Shanghai Bell
9. R1-2100658 NR positioning enhancements for UL-AOA method Intel Corporation
10. R1-2100709 Discussion on accuracy improvement for UL-AOA positioning LG Electronics
11. R1-2100753 Discussions on techniques to improve accuracy for UL-AOA positioning solutions InterDigital, Inc.
12. R1-2100863 Discussion on accuracy improvements for UL-AOA positioning method Sony
13. R1-2101047 Discussion on UL-AOA enhancement CMCC
14. R1-2101132 UL-AOA positioning enhancements Fraunhofer IIS, Fraunhofer HHI
15. R1-2101211 Discussion on accuracy improvements for UL-AOA positioning solutions Samsung
16. R1-2101388 Accuracy enhancements for DL-AoD positioning technique Apple
17. R1-2101469 Potential Enhancements on UL-AOA positioning Qualcomm Incorporated
18. R1-2101617 Discussion on UL-AOA positioning enhancements NTT DOCOMO, INC.
19. R1-2101755 Enhancements of UL-AOA positioning solutions Ericsson