**3GPP TSG RAN WG1 #105-e R1-210abcd**

**e-Meeting, May 10th – 27th, 2021**

**Source: Moderator (Nokia)**

**Title: Feature Lead Summary #1 for Potential multipath/NLOS mitigation**

**Agenda item:** **8.5.5**

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

# Introduction

In the WID, [1], for ePos the following objective was added at RAN#91:

* Study and specify, if agreed, the enhancements of information reporting from UE and gNB for multipath/NLOS mitigation [RAN1, RAN2, RAN3]

In this contribution, we provide summary of the potential enhancements for information reporting from UE and gNB for multipath/NLOS mitigation proposed by companies in contributions [2]-[21]. We also make some initial proposals to facilitate RAN1 discussion. This document provides the summary of the following email discussion in RAN1#105-e:

[105-e-NR-ePos-05] Email discussion/approval on potential enhancements of information reporting from UE and gNB for multipath/NLOS mitigation with checkpoints for agreements on May 25, May 27 – Ryan (Nokia)

Overview of proposals in contributions

The following list of proposed enhancements/areas was identified based on submitted contributions [2]-[21]:

1. Specification Change
2. LoS/NLoS Indicator
3. Additional Reporting from UE and TRP/gNB to LMF
4. Soft/Hard Indicators
5. LoS/NLoS Identification methods
6. UL-AoA Related Topics
7. DL-AoD Related Topics
8. Specific PRS resources
9. Additional Paths
10. CIR reporting
11. Measurement Time Window
12. UE-based Proposals
13. Others

Issues for discussion

## Issue #1: Specification Change

From the WID, [1], the objective has a study component to see if specification effort is needed on this topic. Based on the FL review of contributions almost all companies seem in favor of specification effort on this topic:

* Support for specification work/changes: Proposed by 17 companies
* Support for implementation-based solutions only (i.e., no specification change): Proposed by 2 companies ([4],[8])

Proposals by companies supporting specification work/changes are captured in individual sub-sections later in this document. Proposals by companies supporting implementation-based solutions only are:

* [4]
  + Proposal 1: Implementation-based solution should be considered to solve NLOS problems.
* [8]
  + Proposal 1: For multipath/NLOS mitigation, only focus on the implementation-based solutions in Rel-17.

### Round #1 Discussion

Feature Lead View

Almost all companies seem to be supportive of some specification changes related to enhancements of information reporting from UE and gNB for multipath/NLOS mitigation. Two companies (vivo, OPPO) prefer implementation-based solutions but seem to agree that the NLOS/multipath is a problem that needs to be solved for positioning. Other companies point out in their contributions that some of the proposed enhancements can be combined with implementation-based solutions to further improve the performance. As such perhaps their concerns could be alleviated.

**Proposal 1.1**

* Enhancements of information reporting from UE and TRP/gNB for multipath/NLOS detection and mitigation will be supported.
* FFS: Specific enhancements including:
  + LoS/NLoS indicators
  + Additional reporting from UE and TRP/gNB to LMF

Companies views:

|  |  |
| --- | --- |
| Company Name | Comments |
| Fraunhofer | Support |
| vivo | Not support.  First of all, we have concern on this proposal which seems too broad to cover any “enhancements of information reporting from UE and TRP/gNB for multipath/NLOS detection and mitigation”.  On the performance benefits of LOS/NLOS detection, as we discussed and showed in our contribution, depends on the LOS/NLOS detection methods, there could be performance loss instead of gain compared to implementation based method. There’re also several other companies provide evaluation results on LOS/NLOS detection indicator in this meeting. Most of them actually show minor/marginal performance gain on top of UE implementation based method. We see little value for a standard solution on this matter.  On the FFS bullet, we note LOS/NLOS indicator and additional reporting are discussed in proposal 2.2 and proposal 3.1 already. Furthermore, we’re not clear if any performance benefit verification of additional information reporting. We don’t think the sub-bullet of additional reporting is well justified.  In summary, we object this proposal and don’t think such high level proposal is needed. |
| Qualcomm | We prefer not to agree on a so-broad blank statement; there needs to be a consensus what broad direction of enhancement we are going to specify. The LOS/NLOS vs the multipath reporting are very different features. |
| OPPO | Not support  We share the same understanding as vivo and Qualcomm. We should not agree such a high level proposal. |
| CATT | Support.  NR R17 should support reporting of LOS/NLOS identification information indicating whether a measurement is associated with LOS or NLOS, or the probability of the measurement being associated with LOS or NLOS. |
| ZTE | We think multipath mitigation and NLOS detection should be discussed separately.  Since this is the first meeting to study multipath/NLOS mitigation, we’re OK to agree high level proposal first. At least we should decide whether to specify corresponding enhancements or not in this meeting. After we decide to enhance multipath/NLOS mitigation, we can further discuss what’s in scope for further study. From our point of view, we support to enhance multipath/NLOS mitigation. |
| China Telecom | We share the similar view as ZTE. Even in the LOS scenario, the multipath still exists. Multipath and LOS/NLOS are concepts of different dimension. We should support the detection of LOS/NLOS, and mitigation of the multipath. |
| Lenovo, Motorola Mobility | Support FL’s proposal. This proposal serves an initial basis for progress within the group to at least agree on the need for multipath/NLOS detection and mitigation enhancements in Rel-17 based on all previous discussions thus far including in other AIs on this aspect. |
| Samsung | Although this proposal seems no harm, but we can wait a bit further to see more details on the design. |
| Xiaomi | Support  Information for multipath/NLOS detection and mitigation can improve the accuracy |
| LG | Support. |
| Intel | Support FL’s proposal. |
| InterDigital | We need to discuss details of solutions and their effectiveness (e.g., LOS/NLOS identification and reporting, multipath reporting, etc.) to agree on the first bullet. |

## Issue #2: LoS/NLoS Indicator

One issue discussed by many companies is the introduction of an indicator of a LoS/NLoS indicator. These indicators could be reported by the UE and/or TRP to the LMF when making positioning measurement reports. Specific proposals from other companies are:

* [2]
  + Proposal 1: To improve positioning accuracy by regularization techniques, use of LOS indicators as soft values for each link for UE-assisted and UE-based positioning should be supported.
  + Proposal 1a: For UE-assisted positioning, the determination of the LOS indicator can be done at the gNB/LMF or at the UE. For the latter, the LOS indicator is additionally reported back to the gNB/LMF.
  + Proposal 1c: For UE-based positioning, the LOS indicator can be signaled to the UE. The UE can request the LOS indicator for specific path(s) associated with a gNB or TRP to be signaled to the UE by the LMF/gNB.
* [3]
  + Proposal 5: Support reporting the NLOS identification results along with the corresponding measurement results.
* [5]
  + Proposal 1: NR R17 should at least support reporting of LOS/NLOS identification information indicating whether a measurement is associated with LOS or NLOS, or the probability of the measurement being associated with LOS or NLOS.
* [9]
  + Proposal 2: Support the UE to report LOS/NLOS indicator together with the RSRP measurement of first arriving path.
  + Proposal 4: The UE may take advantage of the measurement of NLOS scenario to mitigate the multi-path in LOS scenario.
* [11]
  + Proposal 1: For the UL-TDOA / UL-AOA / Multi-RTT positioning method support introduction of the LOS/NLOS identifier associated with the UL-RTOA time / UL-AOA angle / gNB Rx-Tx time difference measurements
  + Proposal 2: For the DL-AOD / Multi-RTT positioning method support introduction of the LOS/NLOS identifier associated with the RSRP / UE Rx-Tx time difference measurements
  + Proposal 3: For the DL-TDOA positioning method support introduction of the LOS/NLOS identifier associated with the DL RSTD time measurement using the following format:
    - (LOS/NLOS identifier #1, LOS/NLOS identifier #2) – LOS/NLOS identifier #1 corresponds to the link associated with a reference cell and LOS/NLOS identifier #2 corresponds to the link associated with a neighbor cell
  + Proposal 4: Support introduction of the LOS/NLOS identifier in the format:
    - Alt 1: LOS/NLOS identifier may be equal to 0 or 1, where 0 indicates the LOS channel and 1 indicates the NLOS channel
    - Alt 2: LOS/NLOS identifier may be equal to variable u distributed in the range from 0 to 1 and has a meaning of probability for NLOS link detection
    - The u = 0 corresponds to the case of a pure LOS channel with a single channel tap in time domain and zero NLOS components
    - Conversely, the u = 1 corresponds to the case of a pure NLOS channel with a multi-path channel structure and zero LOS component
* [13]
  + Proposal 1: Support UE positioning measurement report with LOS/NLOS identification.
* [14]
  + Proposal 1: Support UE/TRP sending to the LMF an NLOS/LOS indication associated with the measurements for positioning if the LOS/NLOS could be reliably differentiated.
* [16]
  + Proposal 2: RAN1 to study NLOS identification reporting from the UE/TRP to the LMF during at least UE-A positioning.
* [19]
  + Proposal 2: Support UE reporting of RSTD, UE Rx-Tx time difference and/or PRS RSRP associated with LOS/NLOS indicators. FFS further details such as how these indicators are mapped, e.g. per beam, etc and granularity of the indicators.

### Round #1 Discussion

Feature Lead View

Many companies (at least 9) seem interested in introducing LoS/NLoS indicators calculated by the measuring nodes (UE/TRP) and reporting to LMF as part of location reports. Some companies propose additional details related with these indicators and those are discussed in subsequent sections. With that in mind the follow proposal may be a good starting ground:

**Proposal 2.2**

* LoS/NLoS indicators should be reported for DL, UL, and DL+UL positioning measurements taken at both UE and TRP at least for UE assisted positioning.
  + FFS: Details of indicators
  + FFS: UE based positioning

Companies views:

|  |  |
| --- | --- |
| Company Name | Comments |
| Fraunhofer | Can we clarify the LOS/NLOS indicator, it is not a 0/1 Flag since that is captured in P4.1.  LoS/NLoS indicators: The LOS/NLOS identification can provide information (for example probability) that First Arriving Path (FAP) is in LOS or a NLOS condition.  The LoS/NLoS indicator can include an indication on the quality of the FAP.  The motivation is that for LOS scenarios, the FAP may be come from to the LOS in addition to other near reflection (referred to OLOS in [20]). A UE or TRP can identify the quality of the FAP which is useful for the LMF to identify TOA offsets (LOS with near reflections). |
| vivo | As we comment toward proposal 1.1, we’re not in favour of standard solution for LOS/NLOS mitigation to begin with.  In order to obtain the performance benefit of reporting LOS/NLOS indicator, at least the associated LOS/NLOS identification method(s) and error rate should be studied before we agree to support LOS/NLOS indicator reporting. |
| Qualcomm | We are not supportive of this feature.  Using multipath reporting would enable the LMF to do any method it wants, whereas having LOS/NLOS just restricts the applicability to a feature of low understanding on what is happening “under the hood”.  To be more specific, there will not be a consensus on which/what LOS/NLOS algorithm is being used (and should not be such algorithm details in the spec), nor will there be any tests/minimum requirements, so the practicality of a feature where a device reports a 0/1 or a [0,1] number is debatable (it could even be coming from a random generator from what one could try to verify).  Reporting multipath characteristics is a feature that includes “low-level” channel characteristics, it has already been supported up to an extend in LTE and rel-16, and can be better understood/verified how it works and what is supposed to be doing. |
| OPPO | Not support  From our evaluation, it is observed that we shall focus on implementation-based method for NLOS mitigation. We have discussed a lot during study item and specification supported method does not have sufficient justification. |
| CATT | Support.  LOS/NLOS indicator can be defined as a function of the Rice factor in the time domain, the variance of CFR in the frequency domain, or the combination of the above two parameters. |
| Huawei/HiSilicon | Support.  We listed the following benefits in our contribution that cannot be achieved by implementation-based methods.   * Improving the calibration performance based on the reference device. * Improving positioning accuracy for limited LOS measurement scenario. * Reducing the complexity at the LMF * Improving the uncertainty estimate accuracy   Regarding the testability, we think this can be further studied whether we need such requirement for UE or TRP.  In our view, LOS/NLOS identification can even be working with implementation-based methods to reduce the LMF computation complexity. |
| ZTE | This can be further details when high level proposal is agreed. |
| China Telecom | Support.  The indicator of LOS/NLOS identification doesn’t affect the details for mitigation of multipath, conversely, it is kind of the fundamental of multipath mitigation. How to identify whether the scenario is LOS/NLOS needs further study, but the indicator itself should be support. |
| Lenovo, Motorola Mobility | Support, We view that the UE can use a variety of implementation and non-implementation based approaches to derive LOS/NLOS indicators. The LOS/NLOS indication increases the efficacy of the reported measurement and can be used by the LMF as assistance information. |
| Samsung | As we discussed in the tdoc, if the LOS/NLOS can accurately achieved, such indication could be very helpful. However, it seems the details on how it achieved can be FFS. |
| NTT DOCOMO | Support  We think LOS/NLOS indicator is helpful regardless of LOS/NLOS detection method. |
| Intel | Support.  As it was shown by simulation analysis in R1-2104909 introduction of LOS/NLOS indication allows to improve the performance of the implementation-based methods significantly and achieve the required performance accuracy for the I-IoT use case.  At the same time, it does not introduce additional overhead associated with the multi-path information reporting. Note, that limiting the number of channel taps in the multi-path report compromises the ultimate performance.  The required specification change is small, just introduction of the LOS/NLOS indicator associated with the measurement. The particular implementation of the LOS/NLOS classification algorithm can be left up to implementation. |
| InterDigital | Support |

## Issue #3: Additional reporting from UE and TRP/gNB to LMF

Many companies also propose enhancing the reporting from UE/TRP during positioning sessions in order to enable the LMF to determine the LoS/NLoS status. Some companies seem to view this as an alternative to UE/TRP reporting LoS/NLoS indicators while other companies support both enhancements. Some specific proposals are included in other sub-sections, in particular those aimed at specific positioning methods, while other more general ones are captured here:

* [2]
  + Proposal 1b: For UE-assisted positioning, at least support the baseline case where needed measurements are reported back to the gNB/LMF for the determination of the LOS indicator at the gNB/LMF. The algorithm to compute the LOS indicator hence becomes a matter of network implementation.
* [7]
  + Proposal 4: In the multipath reporting framework, the UE/gNB can also include an indication of which additional path is the strongest path measured per PRS/SRS resource.
* [16]
  + Proposal 3: RAN1 to study NLOS enhanced reporting from the UE/TRP to the LMF to enable the LMF to calculate the probability of NLOS.
* [17]
  + Proposal 2: To report some information for LoS/NLoS identification from UE.
  + Proposal 3: To discuss which information will be reported from UE for LoS/NLoS identification.
* [20]
  + Proposal 2 Define list of metrics/signal quality data for LOS/NLOS detection by LMF
* [21]
  + Proposal 5 NLOS/LOS detection should be done by the LMF by using CIRs from the UE and gNBs.
  + Proposal 7 Following measurements should be specified in Rel-17 to support LOS identification methods. These measurements can be part of rich reporting.
    - a. Location and magnitude of the first and additional paths.
    - b. Location and magnitude of the highest peak.
    - c. Components of PDP/CIR around first/highest peak.

### Round #1 Discussion

Feature Lead View

Overall, many companies seem to propose additional reporting elements as part of UE/TRP reports to LMF which will enable the LMF to determine LoS/NLoS status. The specific elements may need more time to converge and the details could potentially be discussed as part of some subsequent proposals in this document.

**Proposal 3.1**

* Reporting enhancements for DL, UL, and DL+UL positioning should be supported to enable LoS/NLoS identification and mitigation at the LMF for UE-assisted positioning.
  + FFS: Details of the enhancements.

Companies views:

|  |  |
| --- | --- |
| Company Name | Comments |
| vivo | Not support.  First of all, is there any performance evaluation to justify/demonstrate the benefit(s) of additional information reporting on top of LOS/NLOS indicator?  We don’t support this proposal without solid justification. |
| Qualcomm | Seems to general to me again. I thought the debate is about LOS/NLOS vs multipath reporting. This proposal does not provide a progress in either direction. |
| OPPO | Similar view as Qualcomm, this proposal is too general. |
| CATT | Support. |
| ZTE | This can be further details when high level proposal is agreed. |
| China Telecom | Similar view as ZTE. |
| Lenovo, Motorola Mobility | Support the intention of FL’s proposal, but it may still be too general at this stage for an agreement. |
| Samsung | Similar view as ZTE. |
| Xiaomi | We are not clear what enhancements will be. |
| LG | We are on the same page with Qualcomm. |
| Intel | These are the second order details, but if LOS/NLOS identification is agreed, we are open to discuss it. |
| InterDigital | Support |

## Issue #4: Soft/Hard Indicators

* [14]
  + Proposal 2: The NLOS/LOS indicator can be either a hard decision (binary values) or a soft decision (real values such as the probability of the path being NLOS/LOS).
* [15]
  + Proposal 2: In order to increase the positioning accuracy, followings can be studied.
    - UE does not necessarily to report positioning measurement (e.g., RSTD(s), UE Rx-Tx time difference, and etc.) corresponding to certain TRP determined with NLOS, or
    - LOS-likelyhood value can be reported in conjunction with positioning measurement.

### Round #1 Discussion

Feature Lead View

Some companies seem to implicitly discuss this topic in their contributions without specific proposals. It would be good for companies to exchange further views in order to move towards some consensus and better understand companies’ understanding of this topic.

**Proposal 4.1**

* Study the following options of LoS/NLoS indicators
  + Option 1: Binary (i.e., hard) value indicators
  + Option 2: Soft value indicators (i.e., [0,1]).
    - FFS: Format and criteria for determination

Companies views:

|  |  |
| --- | --- |
| Company Name | Comments |
| Fraunhofer | Do not support |
| vivo | Seems to us, this proposal should be part of proposal 2.2 and no need to have a separate proposal. |
| Qualcomm | Need a resolution on whether LOS/NLOS will be supported first. |
| OPPO | Need to discuss if we support LOS/NLOS reporting first |
| CATT | Support.  To FL, CATT had also provided the discussions and observation about the hard and soft decision methods in our contribution [5], we prefer to include CATT’s scheme into the background descriptions of section 3.4, as follows,  ***Observation 2: Based on the reported LOS/NLOS identification information corresponding to each measurement, the positioning engine (in LMF or UE) can reduce the influence of NLOS and multipath and achieve higher accuracy and reliability, by a soft decision method such as weighted measurement information, or a hard decision method where only the measurements with LOS/NLOS identification information higher than a certain threshold are used for positioning.*** |
| Huawei, HiSilicon | Agree to either to agree 3.2 first or merge the proposal in 3.2 |
| ZTE | This can be further details when high level proposal is agreed. |
| Lenovo, Motorola Mobility | Agree with Huawei that we could merge this proposal as FFS example points in Issue#2 of 3.2:   * LoS/NLoS indicators should be reported for DL, UL, and DL+UL positioning measurements taken at both UE and TRP at least for UE assisted positioning.   + FFS: Details of indicators (e.g. binary, soft-value)   + FFS: UE based positioning |
| Xiaomi | Discuss it after proposal 2.2 |
| NTT DOCOMO | This proposal should be merged with section 3.2. In addition, if LOS/NLOS indictor is supported, the detail design (e.g. soft/hard indicators) should be discussed. |
| LG | We agree with the intention of the proposal. But, we also similar view with other companies. It seems proper to merge the proposal into 3.2. |
| Intel | Option 2.  Agree to consider the proposal 3.2 first and then decide based on the outcome of discussion. |
| InterDigital | We need to discuss if we support LOS/NLOS reporting first. |

## Issue #5: LoS/NLoS identification methods

Many different methods have been proposed for determining LoS status. The related proposals are discussed here. This section focuses on algorithms that would be run at UE/TRP to determine a LoS/NLoS indicator. The proposals related to this topic are:

* [2]
  + Proposal 2: At least the gNB beam/antenna bores-sight information can be provided to the LMF by the gNB and to the UE for UE-based positioning.
* [4]
  + Proposal 3: Before discussing detailed enhancements of information reporting for supporting multipath/NLOS mitigation, the method of LOS identification and the LOS identification error should be studied.
  + Proposal 4: The intention and benefit of information to be reported for multipath/NLOS mitigation should be further clarified since the correct rate of LOS detection is different with different scenarios and different LOS identification methods.
  + Proposal 5: Whether different LOS identification method should be applied to different positioning method should be confirmed.
* [6]
  + Proposal 1：Support UE and TRP to report coherence bandwidth of measured reference signal to LMF for NLOS mitigation.
* [13]
  + Proposal 2: The method/techniques of obtaining LOS/NLOS identification is left for UE implementation.
  + Proposal 3: Support gNB to provide gNB/TRP antenna polarization to LMF and subsequently, LMF to provide gNB/TRP antenna polarization information to UE.
* [15]
  + Proposal 1: For LOS/NLOS identification, RAN1 needs to consider at least following method based on:
    - Polarization characteristic
    - Propagation time difference threshold/window between a reference and a target TRP.
* [16]
  + Proposal 5: RAN1 to study both LOS/NLOS identification methods computed in PHY layer processing and LMF localization processing.
* [19]
  + Proposal 1: Scope of Multipath/NLOS reporting should initially cover a general and a low complexity solution across DL-based, UL-based and (DL+UL) positioning methods to increase the quality of positioning measurements provided to the LMF.
* [21]
  + Proposal 1: Support NLOS/LOS detection mechanisms in release 17
  + Proposal 6: UEs and gNBs should indicate the method they are using to detect NLOS/LOS nature of the links to the LMF.

### Round #1 Discussion

Feature Lead View

Some of the proposal on this topic seem related also with the discussion in AI 8.5.3 on DL-AoD enhancements so alignment with that AI may be needed. There are quite a few proposals to study/support different LoS/NLoS identification methods.

**Proposal 5.1**

* RAN1 to study the following options of LoS/NLoS detection
  + Option 1: Polarization based detection.
  + Option 2: Coherence bandwidth based detection.
  + Option 3: Implementation based solutions
  + Option 4: Propagation time difference based

Companies views

|  |  |
| --- | --- |
| Company Name | Comments |
| vivo | We support to study LOS/NLOS detection methods in general as they have impacts on the detection error rate and hence positioning performance. |
| Qualcomm | Not support. The WID just talks about what reporting enhancements to do. There is no need to discuss methods of LOS/NLOS detection. |
| OPPO | Not support. The proposal is out of the scope of WID:   * Study and specify, if agreed, the enhancements of information reporting from UE and gNB for multipath/NLOS mitigation [RAN1, RAN2, RAN3] |
| CATT | Support to study LOS/NLOS detection methods, and we prefer Option 5 described in our contribution [5]. And the updated Proposal 5.1 as follows,  **Proposal 5.1**   * RAN1 to study the following options of LoS/NLoS detection   + Option 1: Polarization based detection.   + Option 2: Coherence bandwidth based detection.   + Option 3: Implementation based solutions   + Option 4: Propagation time difference based   + Option 5: Rice factor and variance of CFR based solution.   To FL: CATT had also provided the discussions and observation about the LOS/NLOS detection methods in our contribution [5], we prefer to include CATT’s scheme into the background descriptions of section 3.4, as follows,  ***Observation 1: LOS/NLOS identification information, which is defined as a function of the Rice factor in the time domain, the variance of CFR in the frequency domain, or the combination of the above two parameters, can help the positioning engine (in LMF or UE) to select LOS links between TRP and UE to obtain a more precise position by mitigating the influence of NLOS and multipath.*** |
| ZTE | Support this proposal after we have decided to enhance NLOS detection. |
| China Telecom | Support. |
| Lenovo, Motorola Mobility | It is perhaps a bit early to agree to a general LOS/NLOS detection solution, we can rather focus on an agreeable reporting solution at this stage. |
| Samsung | Is the intention to find a method to be supported by specification? |
| LG | Support. |
| Intel | We believe that the particular implementation of the LOS/NLOS identification algorithm can be left up to implementation. |
| InterDigital | In multipath channels, channels become frequency selective and the PRS RSRP may change across frequencies. Thus, averaging across frequencies may not provide sufficient information for the network to determine characteristics of the multipath channel. Thus, we proposed to add another option in the proposal. We also prefer to leave the door open for other options to study.  **Proposal 5.1**   * RAN1 to study the following options of LoS/NLoS detection   + Option 1: Polarization based detection.   + Option 2: Coherence bandwidth based detection.   + Option 3: Implementation based solutions   + Option 4: Propagation time difference based   + Option 5: Rice factor and variance of CFR based solution.   + Option 6 : RSRP reporting with finer granularity   + Other options are not precluded |

## Issue #6: UL-AoA Related Topics

Quite a few companies brought proposals specific to enhancing reporting of UL-AoA for at least LoS/NLoS detection. Some of the proposals extend to more positioning techniques. Some alignment may be needed with AI 8.5.2 but the common view in RAN1#104-b seemed to be that these topics were more related to LoS/NLoS discussion. The specific proposals were:

* [2]
  + Proposal 4: NR supports reporting to LMF of N ≥ 1 UL-AOA measurement values per additional path for the same timestamp.
* [3]
  + Proposal 1: Support the same number of UL AoA measurements per additional path.
  + Proposal 2: Support gNB to report the path-specific association among TOA, AoA (multiple), and strength with same timestamp. Liaise RAN3 on the support of the feature with the following information.
    - RAN1 sees the necessity to introduce the information in the measurement response/report in NRPPa indicating that TOA, multiple AoAs, and path strength are measured from the same path, where different paths can be measured via the same SRS resource and associated with the same time stamp.
    - RAN3 is encouraged to provide solution in NRPPa.
* [7]
  + Proposal 3: Support a gNB to report multiple tuples (UL-AoA, UL-RSRP, RTOA/gNB Rx-Tx) within a single report, such that
    - The UL-RSRP corresponds to a relative RSRP associated to the reported path in the angle/delay domain.
    - The RTOA/gNB-Rx-Tx corresponds to the delay of the associated reported path in the angle/delay domain
    - The UL-AoA corresponds to the received angle (potentially 2-dimensional) of the associated reported path in the angle/delay domain
    - FFS: Max number of (UL-AoA, UL-RSRP, RTOA/gNB Rx-Tx) tuples that can be sent in a single report
* [13]
  + Proposal 4: Support UL-AoA measurement report from gNB to LMF that contain the statistical property (e.g., standard deviation of AoA) of the measured AoA for multipath/NLOS mitigation.
* [16]
  + Proposal 7: Further clarify and enhance the prior agreemtn of multiple measurements of M > 1 UL-AOA (AoA/ZoA) measurement values associated with the first arrival path and corresponding to the same timestamp by stating that:
    - M is the number of UL-AoA (AoA/ZoA) measuremnets that a UL receiver can measure in the same time stamp.
    - A UL receiver measures UL-AoA (AoA/ZoA) on a first arrival path at a measurement timing.
    - Corresponding to one UL-AoA measurement, a UL receiver may be requested to report additional information such as ToA of the measured path or beamforming to LMF.
    - Multiple measurements at a same time stamp are requested up to gNB measurement capability.

### Round #1 Discussion

Feature Lead View

It seems like many companies are interested in further enhancing at least the UL-AoA reports to help enable LoS/NLoS detection. It is not fully clear if there is common understanding how this should be done but the below proposal can be a starting point for discussion:

**Proposal 6.1**

* For UL-AoA reporting from TRP to LMF support reporting angle, timing, and power for the first arrival path and additional N paths.
  + FFS: Value of N.

Companies views:

|  |  |
| --- | --- |
| Company Name | Comments |
| vivo | We’re open to discuss reporting enhancement for UL-AoA. However, we prefer not to duplicate discussion which happen in 8.5.2 as well especially the enhancement in this proposal is for the first arrival path. |
| Qualcomm | Support.  To vivo: This proposal is for the additional paths. |
| OPPO | Shall this be discussed under sub-agenda 8.5.2? The additional path was also discussed in 8.5.2 too. |
| CATT | We share the same view with vivo and prefer this topic had better to be forwarded to 8.5.2. |
| Huawei, HiSilicon | Support to conclude that anything related to additional path should be discussed in 8.5.5 or discussed in each respective agenda (AoA, AoD).  In our view, we think it should be better treated here, and the general increase of multi-path measurements including TOA, AoA, path strength can be resolved altogether. |
| Lenovo, Motorola Mobility | Prefer that these enhancements be discussed under a general measurement framework in AI 8.5.5. |
| LG | We are generally fine with FL’s proposal. But, to avoid duplicated discussion, we hope that the issue is discussed in either 8.5.2 or 8.5.5. |
| InterDigital | Share the view with Vivo and CATT that this feature can be discussed in 8.5.2. |

## Issue #7: DL-AoD Related Topics

Quite a few companies brought proposals specific to enhancing reporting of DL-AoD for at least LoS/NLoS detection. Some of the proposals extend to more positioning techniques. Some alignment may be needed with AI 8.5.3. The specific proposals brought were:

* [3]
  + Proposal 3: For multi-path DL-AOD, support reporting for each path
    - TOA information defined relative to the first path (only for the additional paths)
    - A Rx beam index
    - A list of path powers measured from different PRS resources for the path measured via the Rx beam indicated by the Rx beam index
* [6]
  + Proposal 2: Rel-17 should support UE to report angular differences between Rx beams when receiving reference signals for UE-assisted DL-AOD.
* [9]
  + Proposal 1: Only the RSRP measurement of the LOS path can be used for DL-AoD positioning.
* [10]
  + Proposal 1: Support RSRP reporting with configured granularity of RSRP for timing/angle based solutions when additional paths observed by the UE are received within the cyclic prefix
  + Proposal 2: In the presence of multipath, uncertainty and expected AoD should be transferred to the UE from the LMF for DL based techniques
* [12]
  + Proposal 2: For both UE-based and UE-assisted methods of DL-AoD technique, the relative power of the first detected path to the measured RSRP is also measured and reported.

### Round #1 Discussion

Feature Lead View

The proposals are quite diverse, so the following 2 proposals are made. For the ExpectedAoD related proposal the feature lead view is that this should be discussed under 8.5.3 but if the proponent wishes to further explain the relation to LoS/NLoS that may be helpful.

**Proposal 7.1**

* Support the relative power and timing of multiple paths as part of DL-AoD reporting.
  + FFS: number of paths

Companies views.

|  |  |
| --- | --- |
| Company Name | Comments |
| vivo | We prefer not to duplicate discussion which happen in 8.5.3 as well. We’re open to discuss reporting for multipath, but think it’s too early to agree on relative power for multiple paths. On the timing part, our understanding is that timing information for DL-AoD is discussed in 8.5.3 and has not been agreed even for single path. |
| Qualcomm | This should be clarified a bit further.  Does it refer to relative time of paths observed for a single PRS resource? (e.g. UE measures one PRS resources, goes in time domain and determines the main paths for the PRS resource, and then reports the time difference of the 2nd over the 1st and the 3rd of the 2nd, etc, etc). However, the absolute timing of the first path is not reported since it does not carry any information right? What matters is the relative time between paths and the relative power of those paths per PRS resource. |
| OPPO | Similar to proposal 6.1: shall this be discussed under sub agenda 8.5.3? |
| CATT | We share the same view with vivo and prefer this topic had better to be forwarded to 8.5.3. |
| Huawei, HiSilicon | Support to conclude that anything related to additional path should be discussed in 8.5.5 or discussed in each respective agenda (AoA, AoD).  In our view, we think it should be better treated here, and the general increase of multi-path measurements including TOA, AoA, path strength can be resolved altogether.  To QC: We think the intention here is that the first path TOA reporting is not supported for DL-AoD positioning, but serves as the common reference timing for the additional paths. |
| China Telecom | Support to discussion this proposal here. The reporting method and the first arriving path of DL-AoD method can be discussed in 8.5.3, but this proposal is about the multipath issue for DL-AoD, which should be concluded in 8.5.5. Also in the 104bis-e, the proposals about multipath were not discussed in 8.5.2/8.5.3, then in my understanding these proposals should be discussed in 8.5.5 naturally. |
| Lenovo, Motorola Mobility | Prefer that these enhancements be discussed under a general measurement framework in AI 8.5.5. |
| LG | It is similar to issue #6. We have same comment in 3.6.1. |
| InterDigital | Share the view with Vivo and CATT that this feature can be discussed in 8.5.3. |

**Proposal 7.2**

* RAN1 to study angle difference reporting between UE Rx beams for NLOS identification in DL-AoD.

Companies views.

|  |  |
| --- | --- |
| Company Name | Comments |
| LG | We are fine to discuss it. |
|  |  |
|  |  |
|  |  |
|  |  |

## Issue #8: Specific PRS resources

Related proposals:

* [2]
  + Proposal 3: UE can be requested to measure and report on specific PRS resources by the gNB.
* [4]
  + Proposal 2: The potential impact of LOS/NLOS identification on UE selecting PRS resources/paths to report should be clarified.
* [20]
  + Proposal 1: Support signaling enhancements for the Tx/Rx LOS beam selection procedure in case of positioning OLOS and NLOS scenarios.

### Round #1 Discussion

Feature Lead View

The relevance of these proposals to mitigating NLOS/multipath is unclear to the feature lead. The proposals seem more related to beam management and PRS prioritization. Suggest the proponent to explain further the motivation and usefulness for NLOS/multipath mitigation.

**Proposal 8.1**

* RAN1 to continue discussion on specific PRS resources and beam management related proposals for NLOS mitigation.

Companies views:

|  |  |
| --- | --- |
| Company Name | Comments |
| Fraunhofer | It’s not clear why this “continue discussion” mean. If the LMF knows that the PRS resources from multi-TRPs are in LOS conditions then the UE can directly use this information in UE-A as well in UE-B. Even environment related information may be available at the LMF from Ray-Tracing and positioning RF-planning tools.  With this motivation, we propose to reformulate the proposal:  “Support providing a UE with AD for the measurement of specific PRS resources for NLOS mitigation.” |
| vivo | We’re okay to study further on this aspect. |
| OPPO | We might not need this proposal. The proposal is not clear. And agree with the FL’s view, we do not see this proposal is relevant with the NLOS issue. |
| CATT | This topic seems to be more related to adjacent beams of PRS resource which is discussed in 8.5.3. We prefer to forward this topic into 8.5.3. |
| Xiaomi | We are fine to discuss it |
|  |  |
|  |  |

## Issue #9: Additional Paths

Many companies brought proposals related to extending the number of additional paths or related topics. The proposals were:

* [3]
  + Proposal 4: Extend the number of paths for a measurement to 8, in which each path may be associated with its
    - TOA
    - Strength (Path RSRP)
      * Multiple values for DL, with each associated with a DL PRS resource
      * Single values for UL
    - Single or Multiple AoA values (UL)
    - Rx beam index (DL)
* [7]
  + Proposal 1: Support a UE to report to the LMF additional time-domain paths (beyond 2 paths which is already specified) and their corresponding relative powers
    - Applicable to both RTT and DL-TDOA methods
    - Support at least [8] total paths to be provided per PRS resource
  + Proposal 2: Support a gNB to report to the LMF additional time-domain paths (beyond 2 paths which is already specified) and their corresponding relative powers
    - Applicable to both RTT and UL-TDOA methods
    - Support at least [8] total paths to be provided per SRS resource
* [10]
  + Proposal 4: When additional paths are observed, support multiple SRSp resources associated with the reference PRS resource to compute multiple Rx-Tx values.
  + Proposal 5: An indication of multiple paths and number of paths (e.g., first path only, all of measured paths) used to compute location information for UE based DL positioning methods should be supported
* [17]
  + Proposal 1: To indicate the first arrival path by reporting the arrival time in the PRS measurement report when there is no LoS path.
  + Proposal 4: Support to reuse PRS for identifying LoS/NLoS.
* [21]
  + Proposal 8: Magnitude, SNR, Doppler frequency, angle of arrival of every path should be reported.
  + Proposal 9: It shall be unambiguously defined what additional paths a UE shall report.
  + Proposal 10: The UE shall always report both the first path and the strongest path
  + Proposal 11: For enabling good accuracy in Machine learning based LOS/NLOS detection, information of as many peaks as possible should be reported.

### Round #1 Discussion

Feature Lead View

The extension of the number of paths has some relation to the UL-AoA proposal discussed above and in 8.5.2. However, companies seem to want to extend the number of paths for all positioning techniques.

**Proposal 9.1**

* Support up to N additional paths in the measurement reports for at least DL-TDOA, UL-TDOA, and multi-RTT, where N>2.
  + FFS: Exact value of N.
  + FFS: reporting the power of the paths in addition to the timing.

Companies views:

|  |  |  |
| --- | --- | --- |
| Company Name | Comments | |
| vivo | We’re not sure about the intention of N additional paths. Are they for the purpose of LOS/NLOS detection? Not agreeable without understanding the motivation. | |
| Qualcomm | Support and include the power information (as it is done for issue 6). Merge with Issue 10, no need to discuss it separately.  The feature is for multipath/LOS/NLOS mitigation. | |
| OPPO | Not support. Reporting additional path is already supported in rel16, thus we do not need this proposal.  Here is the specification in 37.355 of additional path reporting in Dl TDOA: | |
| CATT | We can support this proposal in principle, since reporting the power of the paths for time-based positioning methods maybe benefits the identifications of NLOS/LOS. However, if current specs had supported this proposal as mentioned by OPPO, we don’t need to discuss this issue any more. |
| Qualcomm2 | To OPPO/CATT: yes up to 2 paths are already supported, that’s why the feature lead says: N>2 in the proposal. The topic here is to go beyond 2 and add the per-path powers also. | |
| China Telecom | Similar view as CATT | |
| Lenovo, Motorola Mobility | Generally supportive of reporting power (and existing timing) per path. | |
| Xiaomi | We are fine to report the indication of the first arrival path. | |
| LG | Agree. | |
| InterDigital | We have a question for clarification. We understand the intention of the proposal to increase additional path reporting beyond N=2. Is the intention to increase N for the AdditionalPathList-r16 the main measurement? Or does the increase in N apply to the main measurement and AdditionalPathList-r16 under additional measurements also (e.g., highlighted in yellow in OPPO’s example)? | |

## Issue #10: CIR reporting

Some proposals were related to the CIR. They were:

* [9]
  + Proposal 3: Support UE to measure and report the phase of the CIR corresponding to the LOS path to LMF.
* [20]
  + Proposal 4 Support the UE to measure and report phase information over multiple time instants
  + Proposal 5 Report a part of the complex valued CIR including the FAP with a resolution of 1/fs (fs is the sampling frequency according the bandwidth of the carrier)
* [21]
  + Proposal 2 The CIR generated at both gNB and at the UE should be corroborated using reciprocity principle for ensuring correct NLOS/LOS detection.
  + Proposal 3 The UE and the gNB report the impulse responses used in NLOS detection with many peaks to the LMF to validate or improve the detection.
* [16]
  + Proposal 6: Introduce LoS/NLoS identification assistance information for both DL and UL channels from LMF to UE/gNB.
    - Define both NRPPa and LPP messages
    - Format of the assistance information/status report is FFS (i.e. hard bit indication, quality metric or probability)
    - PHY/L1 can monitor CIR corresponding to the assistance information and report it back to LMF optionally.

### Round #1 Discussion

Feature Lead View

The CIR and phase information has also been discussed under the 8.5.3 AI. In addition, it is not fully clear if these company proposals would be covered by reporting timing and power information (e.g., in proposal 9.1). Some further exchange of views is likely needed.

**Proposal 10.1**

* RAN1 to study reporting of CIR from the UE to the LMF for positioning.
  + FFS: which part of the CIR is reported.

Companies views:

|  |  |
| --- | --- |
| Company Name | Comments |
| Fraunhofer | Support |
| vivo | Not support.  We prefer not to duplicate discussion in 8.5.3. Furthermore, we have strong concern on the feasibility of CIR/phase information reporting given the issues and performance evaluations we showed in our contribution to AI 8.5.3. |
| Qualcomm | It should be clarified whether this is different than Proposal 9. Is it really phase reporting? If yes, we are not supportive. If it is Power delay profile like Proposal 9, we are supportive. |
| OPPO | Not support  Reporting CIR and phase information was already discussed in 8.5.3 for DL AoD. It is not feasible to report such information. For example, the phase information does not give us any meaningful information because the phase at the UE side contains many factors, including the RF hardware distortions. |
| CATT | This topic seems to be more related to “Aspect #1 reporting of first arrival path” which is discussed in 8.5.3. We prefer to forward this topic into 8.5.3. |
| LG | Do not support. The issue has been already discussed in 8.5.3. |
|  |  |

## Issue #11: Measurement time window

This topic has some relation to the discussion in 8.5.1. Some companies propose using the time window to assist with LoS/NLoS identification. The proposals are:

* [12]
  + Proposal 1: For DL-AoD technique, support PRS-RSRP measurement within a configured time window wherein the power of paths out of the window, if any, does not contribute in PRS-RSRP.
    - Alternatively, or additionally, for DL-AoD technique, support PRS-RSRP for the first arrival path only that is measured within a configured time window.
* [14]
  + Proposal 3: Support the indication of the uncertainty range of the first arrival LOS path to UE/TRP.
* [15]
  + Proposal 1: For LOS/NLOS identification, RAN1 needs to consider at least following method based on:
    - Polarization characteristic
    - Propagation time difference threshold/window between a reference and a target TRP.
* [19]
  + Proposal 3: Specify a LOS/NLOS measurement window of duration, ‘T’, where the applicable LOS/NLOS positioning measurement is valid. FFS further details such as length of the measurement window(s), configuration of periodic/aperiodic measurement window(s).
* [21]
  + Proposal 4: The LMF can provide configuration for FFT window placement while doing positioning measurements or generating measurements for NLOS detection.

### Round #1 Discussion

Feature Lead View

This discussion seems quite tied to any progress under AI 8.5.1 and the prior agreement there. As such it is proposed to discuss under 8.5.1 and wait to discuss under this AI if there are any LoS/NLoS specific details. Since there may be dependency on if RAN1 decides to introduce that feature.

**Proposal 11.1**

* Discuss measurement time window related proposals under 8.5.1 and wait for further progress.

Companies views:

|  |  |
| --- | --- |
| Company Name | Comments |
| vivo | OK to discuss under AI 8.5.1. |
| Qualcomm | OK |
| CATT | OK to discuss this issue in 8.5.1. |
| Huawei, HiSilicon | We would like to clarify the understanding on proposal from [12]. This measurement window should be treated as a small scale window to filter out the necessary additional path so that a path-specific power can be measured. It is not like the window we discussed in 8.5.1, which can last hundreds of milli-seconds; instead the window size can be couple of sampling period.  If that is the case, we suggest not to mix those windows in the discussion. |
| China Telecom | OK |
| Lenovo, Motorola Mobility | Similar to Huawei we think that the discussed measurement window for LOS/NLOS is different to AI 8.5.1. Our understanding is the that this window is necessary to accurately capture LOS/NLOS behaviour over a configured duration of time, which is different from the measurement instance time stamp reporting discussed in AI 8.5.1. This separate LOS/NLOS measurement window should be discussed in AI 8.5.5. |
| Xiaomi | Support the proposal |
| LG | Agree. |

## Issue #12: UE-based proposals

Two proposals specific to UE-based LoS/NLoS methods were brought:

* [10]
  + Proposal 6: Support reporting of multiple positing information derived based on different criteria for UE-based DL positioning methods
* [16]
  + Proposal 1: RAN1 to consider if enhanced signaling between LMF and UE is needed for BLADE or other NLOS mitigation techniques for UE-based operation

### Round #1 Discussion

Feature Lead View

More discussion seems to be needed. Suggest RAN1 to discuss this topic and companies to provide additional views

Companies views on the above UE-based proposals.

|  |  |
| --- | --- |
| Company Name | Comments |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## Issue #13: Others

Feature Lead View

The following topics were only brought by a single company. As this is the first meeting with this AI Suggest companies to provide feedback and input to the proposals to see if any consensus can be reached.

### Round #1 Discussion

* [10]
  + Proposal 3: Support spatial relationship where multiple SRSp resources can be associated with the one PRS resource

FL View

This seems already supported by the current spec. Perhaps the proponent can explain the intention below.

Companies views:

|  |  |
| --- | --- |
| Company Name | Comments |
| InterDigital | According to spatialRelationInfoPos in TS 38.331, spatial relationship ties one reference RS (which can be DL-PRS) and the target SRS. We believe what the FL meant by “This seems already supported by the current spec” is that the gNB can configure multiple spatial relationships, e.g., DL-PRS resource #1-SRS resource #2 and DL-PRS resource #1-SRS resource #3.  In the presence of multipaths, the UE may observe multiple copies of PRS (one for LOS and another for NLOS) separated spatially. In that case, one PRS resource may be associated with more than one PRS resources. The motivation behind this proposal is to have an enhanced spatial relationship signalling to covey to the UE that one PRS beam may be spatially associated with multiple SRS beams due to the multipath channel. Thus, RRC can be enhanced to indicate DL-PRS resource #1 -{SRS resource #2, SRS resource #3}. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

* [19]
  + Proposal 4: Triggering criteria for the on-demand PRS procedure should be based on LOS/NLOS measurement quality indication. Requires further co-ordination with RAN2.

FL View

Suggest discussing this proposal under 8.5.6 with other on-demand PRS related proposals.

Companies views:

|  |  |
| --- | --- |
| Company Name | Comments |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

* [20]
  + Proposal 3: Support UE to provide the LMF with Motion Information reports with the same timestamp of the measurements or transmitted SRS.

FL View

Suggest proponent to explain how this information is useful for NLOS/multipath mitigation.

Companies views:

|  |  |
| --- | --- |
| Company Name | Comments |
| Fraunhofer | In reply on FL comment.  The use of IMU information for multipath and NLOS mitigation is one of the main established approaches in GNSS.  LPP supports IMU information since LTE and this information can be used identify for example if a change in orientation or displacement corresponds to the ToA/Phase/Doppler-measured displacement. For a NLOS the displacement will be as resulting from a virtual TRP.    An example of the track information along with the measurements over a track in InF LOS scenarios is shown below: |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

Proposals for GTW

Suggested Proposals for 1st GTW

To be filled after discussion

Conclusion

In this contribution, we provided review of the submitted contributions for NR Positioning AI 8.5.5 on potential enhancements for information reporting from UE and gNB for multipath/NLOS mitigation and prepared initial set of proposals to facilitate further discussion/decision by RAN1 during the RAN1#105–e meeting.

References

1. RP-210903, Revised WID on NR Positioning Enhancements, CATT, Intel Corporation, Ericsson.
2. R1-2104198, NLOS Mitigation Enhancements, Futurewei.
3. R1-2104281, Enhancements to support multi-path and NLOS mitigation, Huawei, HiSilicon.
4. R1-2104363, Discussion on potential enhancements for multipath/NLOS mitigation, vivo.
5. R1-2104524, Discussion on potential enhancements of information reporting from UE and gNB for multipath/NLOS mitigation, CATT.
6. R1-2104594, Enhancements on NLOS mitigation for NR positioning, ZTE.
7. R1-2104675, Multipath Reporting in NR Positioning, Qualcomm Incorporated.
8. R1-2104743, Discussion on multipath/NLOS mitigation for NR positioning, OPPO.
9. R1-2104856, Potential enhancements of information reporting from UE for multipath/NLOS mitigation, China Telecom.
10. R1-2104875, Discussion on multipath/NLOS mitigation for positioning, InterDigital Inc.
11. R1-2104909, Mitigation of NLOS Problem for NR Positioning, Intel Corporation.
12. R1-2105109, Views on potential enhancements for NLOS mitigation in Rel-17 positioning, Apple.
13. R1-2105172, Discussion on enhanced reporting from UE and gNB for Multipath/NLOS mitigation, Sony.
14. R1-2105314, Discussion on potential enhancements of information reporting from UE and gNB for multipath/NLOS mitigation, Samsung.
15. R1-2105486, Discussion on multipath/NLOS mitigation for positioning, LG Electronics.
16. R1-2105516, Views on LoS/NLoS Identification and Mitigation, Nokia, Nokia Shanghai Bell.
17. R1-2105565, Potential enhancements for multipath/NLOS mitigation, Xiaomi.
18. R1-2105702, Discussion on multipath/NLOS mitigation for NR positioning, NTT DOCOMO, INC.
19. R1-2105862, Accuracy enhancements based on NLOS/Multipath Information Reporting, Lenovo, Motorola Mobility.
20. R1-2105865, Potential positioning enhancements for multipath/NLOS mitigation, Fraunhofer IIS, Fraunhofer HHI.
21. R1-2105912, Potential enhancements of information reporting from UE and gNB for multipath/NLOS mitigation, Ericsson.