3GPP TSG RAN Meeting#101
Bangalore, India, September 11 - 15, 2023

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Views on Channel Modeling Study for Rel-19

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Channel Modeling for Integrated Sensing and Communications (ISAC)

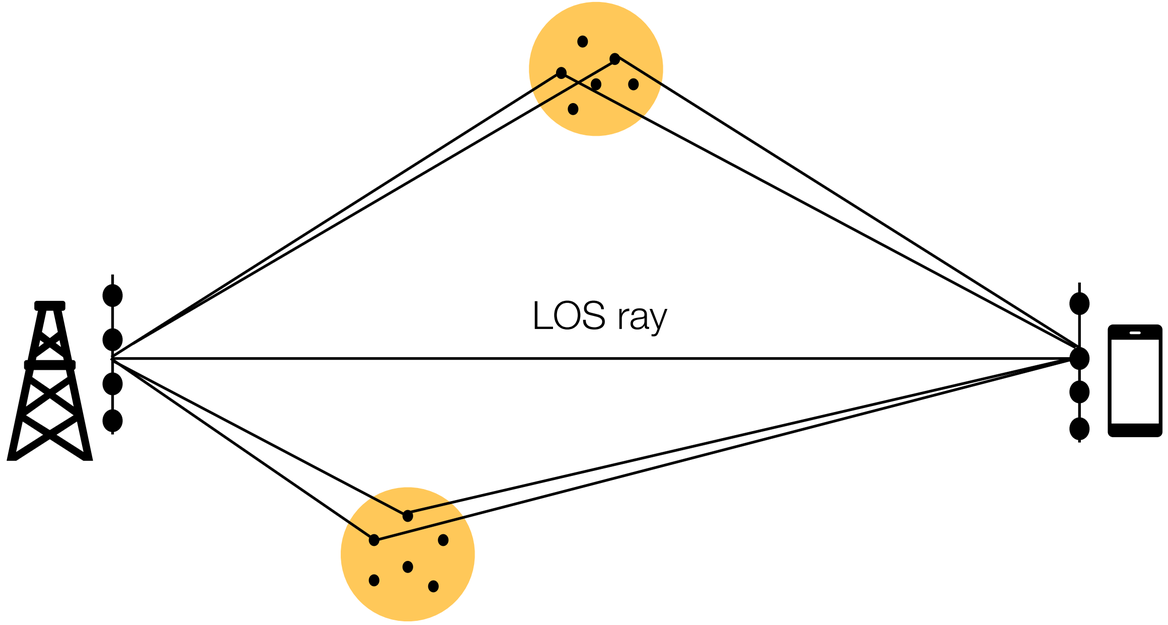
ISAC Overview | Integrated Sensing and Communications (ISAC)

- Justification:
  - New category of use-cases: enable co-existence of sensing and communication in the same frequency band or hardware for new use cases identified in SA1 study
    - Both functions coexist by sharing the resources within the same band with a goal of minimizing the interference between each other and improving the coexistence efficiency.
  - NR based signal sensing: Enable 3GPP system (UE and RAN) to detect characteristics of the environment/object using NR RF signals where (a) target object does not transmit signal and/or (b) target object is not a 3GPP system entity
  - Non-NR based signal sensing: Enable 3GPP system to utilize non-NR based sensing within its framework

- **P1:** RAN plenary-level study on Spectrum and regulatory aspects and RAN1 study item on all other aspects of study
  - Study covering at least topics in Option 1. Topics in Option 2 should also be considered:
    - Option 1: Spectrum, Scenarios, Use cases, Metrics/KPIs, Requirements, ISAC Modes, Channel Modeling
    - Option 2: Evaluation methodologies, Sensing Architecture, Potential Solutions for ISAC

Channel Modeling | TR 38.901

- 3GPP TR 38.901 supports stochastic and deterministic channel modeling for a communications channel between a gNB and UE (and vice versa)
  - In the stochastic channel model the geometric description covers arrival angles from the last bounce scatterers and respectively departure angles to the first scatterers interacted from the transmitting side.
  - The propagation between the first and the last interaction is not defined and we model multiple interactions with the scattering media. Also, the delay of a multipath component cannot be determined by the geometry
  - For a sensing target, the channel model should contain information (stochastic or deterministic) to enable sensing of the target



Communications Channel Model

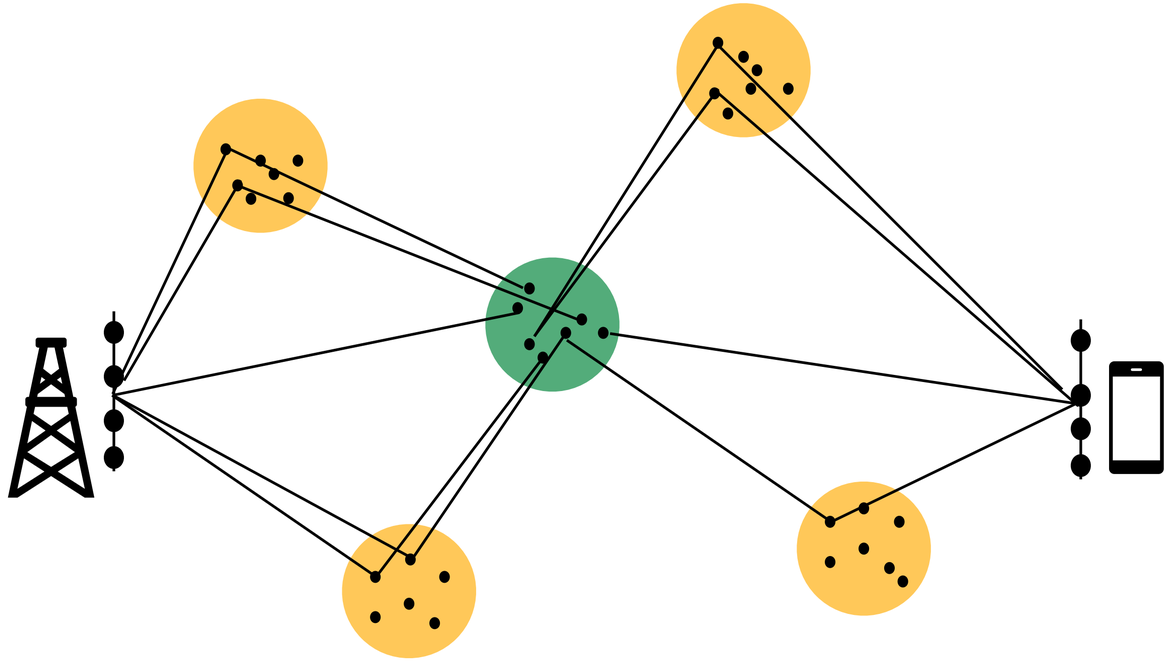
Communications cluster

Channel Modeling | Gaps in 38.901 for Sensing

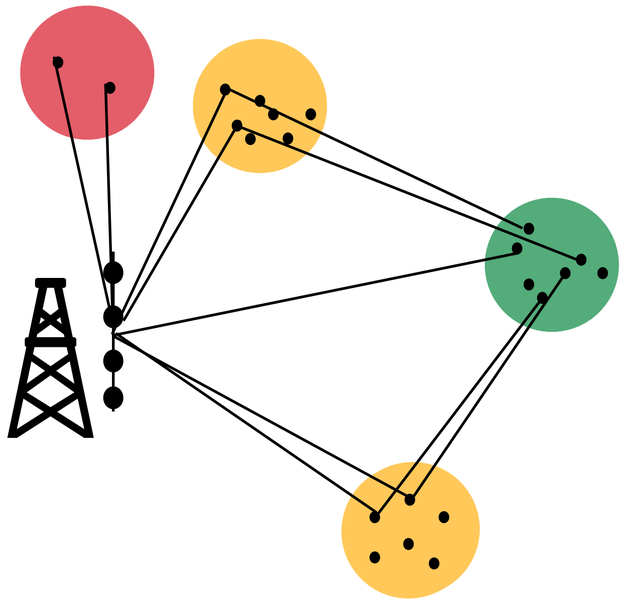
	Support	Update
mono-static sensing support	Not supported	• mono-static gNB sensing • mono-static UE sensing
bi-static sensing support	Not supported	• bi-static gNB-to-UE sensing • bi-static UE-to-gNB sensing • bi-static UE-to-UE sensing • bi-static gNB-to-gNB sensing

sensing target modeling	Not supported	• Stochastic vs deterministic sensing target modeling
		• Clutter/Cluster modeling
		  • Communications clusters, sensing clusters, target clusters, joint communications/sensing clusters
		• LOS/NLOS modeling
		  • Path loss in LOS vs NLOS environment
		• Single-hop vs multi-hop channel modeling
		• Effect of mobility
		  • Device (gNB/UE) mobility
		  • target mobility
		• Consistency
		  • Spatial Consistency
		  • Temporal Consistency

Channel Model | Sensing Modeling



Bi-static Sensing Model



Mono-static Sensing Model

Target cluster

Sensing cluster

Sensing Interference cluster

- **Conclusion:** Updates needed to 38.901 model to accommodate sensing
  - May need validation of model using measurements

Study Details (Option 1) | Scenarios, Metrics, Requirements

- **P2:** Identify use cases, scenarios and Positioning/Localization/Sensing requirements for ISAC in Rel-19 [RAN1].
  - Map use cases identified in SA to specific scenarios: e.g. Transportation/traffic management, Health monitoring, XR/ Immersive experience, Smart home, Smart Factory etc.
  - Map KPIs identified in SA to specific metrics and accuracy requirements:

	Uu Positioning	Sidelink Positioning	NR Sensing
3GPP NR Release	Rel-16/Rel-17/Rel-18/Rel-19	Rel-18/Rel-19	Rel-19
Metrics	Absolute Horizontal Position Absolute Vertical Position Latency	Absolute Horizontal Position Absolute Vertical Position Latency Relative Horizontal Position Relative Vertical Position Local Coordinate System (LCS)/Global Coordinate System (GCS) Angle	Absolute Horizontal Position Absolute Vertical Position Latency Relative Horizontal Position Relative Vertical Position LCS/GCS Angle Speed/Doppler target detection/discrimination pattern detection/discrimination
Accuracy Requirements	Absolute Positioning Accuracy (Horizontal or Vertical), latency	Ranging Accuracy, Relative/Absolute Positioning Accuracy (Horizontal or Vertical), latency	Ranging Accuracy, Relative/Absolute Positioning Accuracy (Horizontal or Vertical), latency, speed accuracy, target detection/discrimination accuracy, pattern detection/discrimination accuracy,

Study Details (Option 1) | Spectrum, ISAC Modes, Channel Modeling

- **P3:** Consider the regulatory aspects related to spectrum access for non-communication use [RAN]

- **P4:** Study the relationship between the use cases/scenarios and the ISAC modes and identify representative ISAC modes for modeling and evaluation [RAN1]:
  - For NR-based sensing, supporting mono-static sensing mode in Rel-19 may be quite challenging and only the bi-static mode would be feasible due to lack of support for full duplex transmission.
  - For non-NR based sensing, both mono-static and bi-static modes are possible

- **P5:** Study and define a statistical/deterministic channel model for both sensing and communications based on TR 38.901 [RAN1]
  - Update stochastic and deterministic models in 38.901 to accommodate sensing
  - Enhance Link Level Simulation models
  - Update CDL and TDL for communications, target sensing or both
  - Enhance system level simulation models
  - Update system level simulation channel modeling for communications, target sensing or both

Study Details (Option 2) | Evaluation, Architecture

- **P6:** Define a representative number of evaluation scenarios for indoor and outdoor [RAN1]
- **P7:** Define evaluation methodologies considering the evaluation scenarios [RAN1]
- **P8:** Study the sensing architecture for sensing services, functional interfaces, protocols, and procedures to support NR based sensing technologies [RAN2, RAN3, SA]
  - A Sensing Management Function (SensMF) with an associated sensing protocol similar to or merged with the Location Management Function (LMF) and LPP/NRPPa can be used as a starting point.
  - Solutions should consider the privacy and security implications of sensing

Study Details (Option 2) | Potential Solutions

- **P9:** Study and evaluate potential solutions of sensing technologies based on the identified requirements, evaluation scenarios and methodologies [RAN1, RAN2, RAN3]
  - Study NR-based sensing, non-NR based sensing and Hybrid Schemes [RAN1,RAN2]
    - NR-based sensing uses existing NR architecture with NR signals, channels, and higher layer signaling for sensing
    - non-NR based sensing uses other technologies (e.g. radar) within the existing NR framework for sensing (similar to RAT-independent positioning)
      - Study at what layer the non-NR based sensing is incorporated into the NR network.

    - The solutions should consider support for sensing in both FR1 and FR2.
    - The solutions should consider the use of existing or new (if needed) signals and existing or new (if needed) measurements, measurement data and reporting to support ISAC.
      - Overhead of any new sensing signal (if needed) or increase in overhead of existing signals for sensing (if any) should be considered
    - The solutions should consider the interaction between communications and sensing
      - Communications capacity and sensing accuracy: immersive experience applications require high reliability and low latency type communications while supporting high positioning accuracy, velocity accuracy, and range resolution with low latencies and refreshing rates
      - For Joint communications and sensing, interference between communication and sensing signals should also be considered

Study Details (Option 2) | Potential Solutions

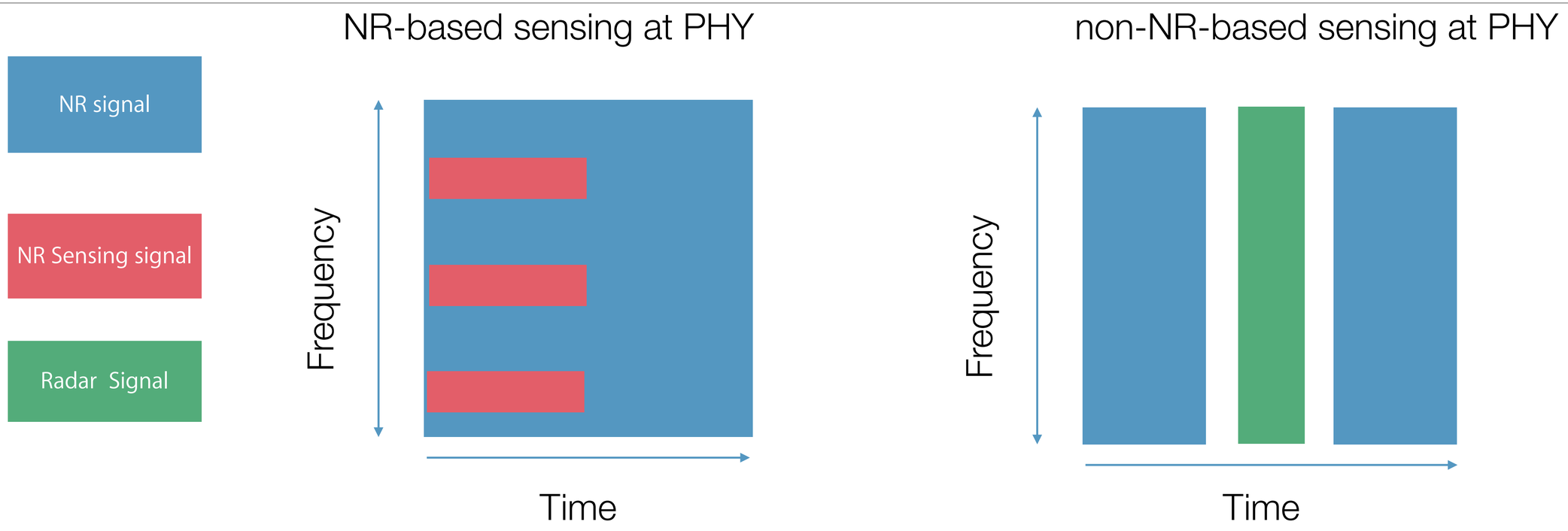


Table 5.7.4-1: Standardized 5QI to QoS characteristics mapping : TS 23.501

5QI Value	Default Priority Level	Packet Delay Budget (NOTE 3)	Packet Error Rate	Example Services
80	68	10 ms	10^{-6}	Low Latency eMBB applications Augmented Reality

Communications characteristics for AR

Scenario	Sensing service area	Confidence level [%]	Accuracy of positioning estimate		Accuracy of velocity estimate		Sensing resolution		Max sensing service latency[ms]	Refreshing rate [s]	Missed detection [%]	False alarm [%]
Immersive experience	Indoor	95	0.5	0.5	0.1	N/A	0.5	N/A	250	0.25	5	5

Sensing Characteristics for Immersive Experience, e.g. AR (agreed SA1 KPI)

Channel Modeling for FR3 (7-24 GHz)

Overview | Channel Modeling for 7-24 GHz

- Channels in the 7-24 GHz range are modeled by 3GPP TR 38.901
  - 3GPP TR 38.901 supports channel models from 0.5 GHz to 100 GHz
  - Current focus of use cases, measurements, evaluations, and performance validation has been on FR1 (sub-6 GHz) and FR2 (24 GHz to 71 GHz)
- **Proposal**: Validate the channel model in 3GPP TR 38.901 for channels in the 7-24 GHz range
  - The study should be carried on concurrently with the ISAC channel model study as a RAN1-led study item

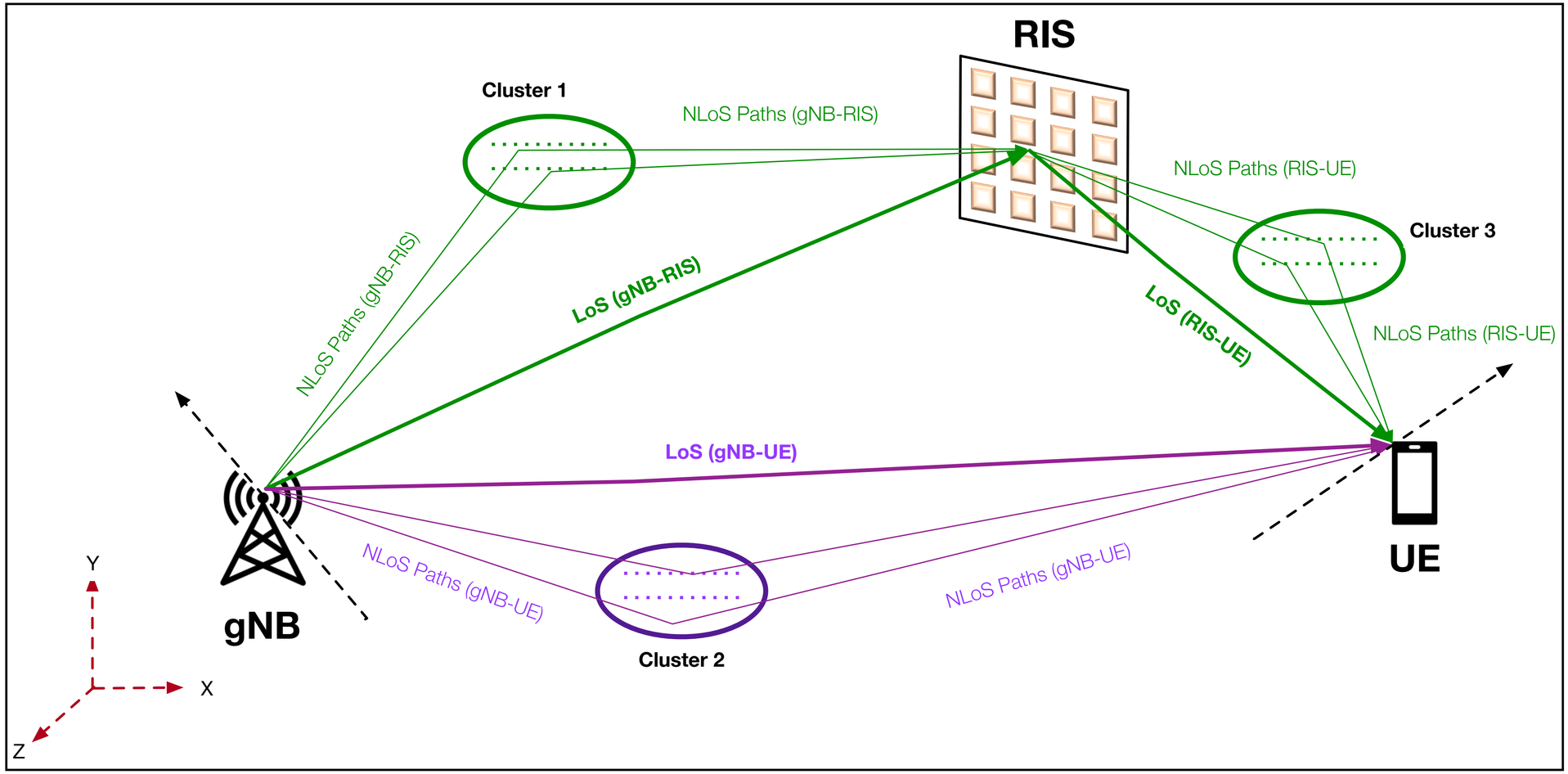
Channel Modeling for Reconfigurable Intelligent Surfaces

Rel-19 WS Overview | RIS

- Around 20 companies submitted contributions to Rel-19 workshop that discussed reconfigurable intelligent surfaces (RIS) for a potential new study/work item in Rel-19
- Following key topics have been proposed in Rel-19 workshop:
  - Channel modeling
  - Evaluation methodology
  - Control interface/signaling & framework
  - Mobile RIS
  - Multi-RIS cooperation
- Among the proposed topics, following categorization of support can be done:
  - *High-support*: Channel modeling is proposed by majority of the organizations
  - *Mid-support*: Evaluation methodology and control interface framework are also proposed by reasonable number of organizations
  - *Low-support*: Other topics are proposed by only handful of organizations
- **Based on the above, for further consideration on a potential study on RIS in Rel-19, we propose to focus on channel modeling**

Overview | RIS Channel Modeling

- Components that need to be modeled with RIS-assisted systems include both:
  - Paths without RIS - existing modeling aspects under TR 38.901 applicable
  - Paths with RIS - existing modeling aspects under TR 38.901 may need to be updated



RIS Location/Distribution | RIS Channel Modeling

- RIS has wide variety of use-cases including outdoor coverage extension, outdoor dead spot coverage, indoor dead spot coverage, outdoor-to-indoor coverage extension, increased system capacity with MIMO and diversity schemes, etc.
- Considering these different use-cases, most of the current scenarios considered for channel modeling in TR 38.901 (section 7.2) can be considered for RIS-assisted systems as well
  - UMi-street canyon and UMa
  - Indoor-Office
  - Indoor-factory
- For all the applicable scenarios, parameters for RIS location and distribution in the environment could be determined considering that RIS will be carefully planned and deployed in the network
- At least the following parameters could to considered for RIS
  - Minimum BS-RIS distance (2D)
  - Minimum RIS-UE distance (2D)
  - RIS height (from center-point of RIS)
  - RIS location: outdoor, indoor, edge of outdoor-indoor

RIS Modeling | RIS Channel Modeling

- RIS is typically designed as a 2-D periodic structure of unit-cells, where each unit-cell can be programmed with one of the supported phase shifts to result in desired radiation pattern from the RIS
- For RIS structure, following parameters are considered:
  - Number of row elements
  - Number of column elements
  - Size of each elements
  - Distance between each element
  - Polarization
- For each of the RIS element or jointly for entire surface, radiation pattern need to be modeled
  - Vertical cut of the radiated power pattern
  - Horizontal cut of the radiated power pattern
  - 3D radiation power pattern
  - Maximum gain (attenuation) of radiated power
    - Depending on the meta-material, corresponding absorption/reflection coefficient is considered for signal attenuation

LoS Probability Modeling | RIS Channel Modeling

- For the BS-RIS link and RIS-UE link, LoS probability modeling is needed
- Depending on the scenarios, the current LoS probability modeling may need to be updated for links including RIS because
  - Different height parameters for RIS
    - For BS-RIS link, height of RIS maybe different compared to height of UE in a BS-UE link
      - This could impact the LoS and NLoS components
    - Similarly for RIS-UE link, the height of RIS maybe different compared to height of BS in a BS-UE link
      - This could also impact the LoS and NLoS components
  - Different distance parameters for RIS
    - Compared to the minimum distance between BS and UE, the minimum distance between BS-RIS and/or RIS-UE could be much shorter
      - This could also impact the LoS and NLoS components

Far-Field/Near-Field Modeling | RIS Channel Modeling

- For RIS, near-field modeling might be needed
  - It can be expected that extremely large number of elements would be needed to have comparable performance as other technologies such as NCR, especially for FR2
  - Furthermore, RIS can be considered to be deployed quite close to other nodes, especially UE for increased performance gains
- Key difference between far-field and near-field impact is the assumption of planar wave or specular wave
  - In the far-field, planar wave can be assumed and therefore, response from all the elements can be jointly modeled
    - Distance between individual elements is negligible and therefore, parameters such as path-loss, propagation delay, can be modeled jointly for entire RIS
  - In the near-field region, specular wave is assumed and therefore, response from each element needs to modeled individually
    - Distance between individual elements is not negligible anymore and parameters such as path-loss, propagation delay, need to be modeled separately corresponding to the ray from each element of RIS
    - Furthermore, for near-field region, additionally, deterministic (ray-tracing) and/or hybrid channel model could be considered for more accurate representation

Proposals | RIS Channel Modeling

- Study channel modeling enhancements for RIS considering at least following aspects:
  - Applicable deployment scenarios
  - RIS modeling
  - Near-field modeling (if justified)
    - Considering proximity to UE and/or gNB and frequency range of interest
  - Others (if justified) including RIS specific parameterization for different scenarios including LoS probability, path loss computation, etc.
  - Cascaded model for BS-RIS-UE

Proposals

ISAC Study | Proposals

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