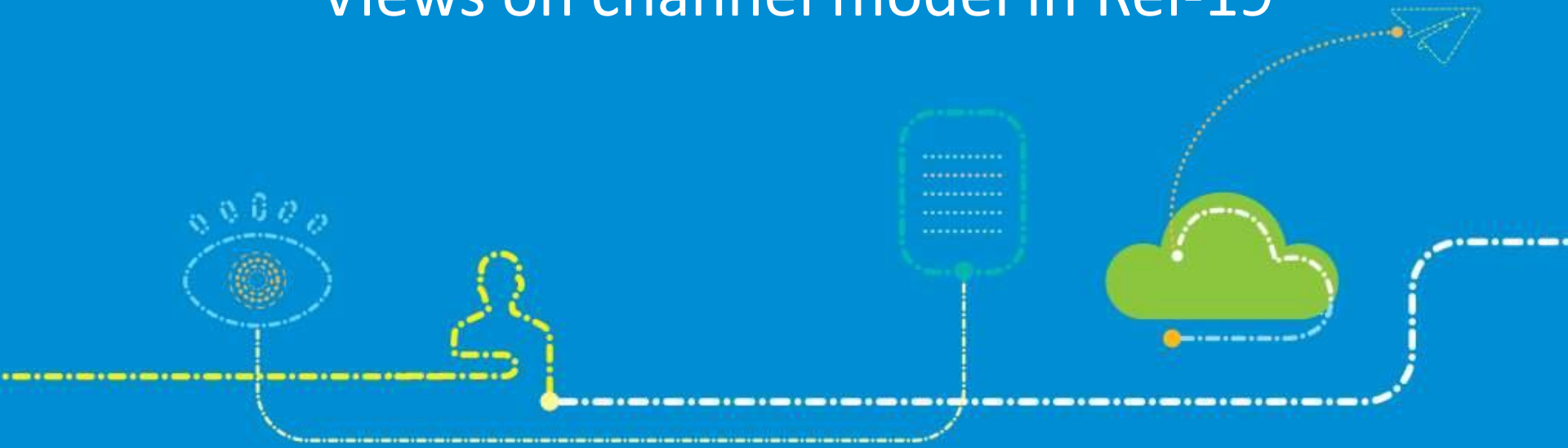
3GPP TSG RAN Rel-19 workshop
Taipei, June 15 - 16, 2023

RWS-230293

ZTE
Tomorrow never waits

Source: ZTE, Sanechips
Agenda: 5

Views on channel model in Rel-19



Overview

- Highlights for the existing channel model:
  - Study for 5G channel is triggered in Rel-14 from 2015-09, and focus on the following two aspects:
    - General channel model:
      - Develop the whole set of parameters and methodology (statistic and hybrid method) to address the needs of new spectrum
        - » Support above 6G in TR 38.900 and extended from 0.5-100 GHz in 38.901
        - » Extensive inputs are collected to consolidate the value and model for each parameter
    - Specific feature: Add-on component to satisfy the needs for evaluation of specific technology, e.g.,
      - Blockage, spatial consistency, CDL to TDL, etc: used for Beam management related evaluation;
      - Industrial IoT channel model: Developed in Rel-16, e.g., more scenarios and features
- In 5G-A, additional efforts on channel model are mainly driven by the potential new use case (e.g., ISAC, RIS) and development of RF techniques (e.g., eLAA), which will lead to the new component in channel model along with potential updates on the procedure for channel realization.
- The required updates on channel model parameters including parameter set for new or existing spectrum can be considered if inconsistency has been identified for the existing frequency-dependent approximation.

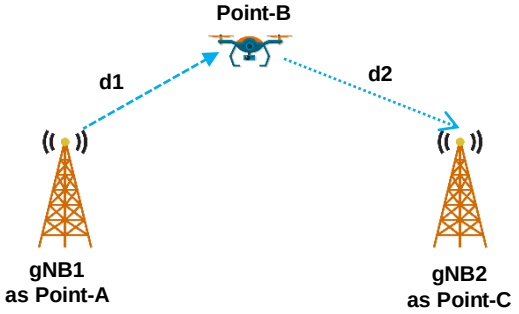
Potential direction for channel model

- Topic-1: Channel model for ISAC
  - As mentioned in the [1], up to 32 use cases have been identified for sensing to cove the different application, e.g., detection/position/tracking, motion recognition, etc. From the perspective of channel, all these cases can be categorized as following:
    - Cat-1: Object (cluster) identification: This aspect can be used to cover the use case for detection/positioning, tracking and environment re-construction.
      - The main efforts of this model is to construct the proper model to reflect the impact objects in the environment under different scenario (e.g., crossroad for vehicle, clear sky for UAV) with focus on the LoS or one bounce scenario.
      - Details including cluster type, impacts of RCS on the spread of cluster including time-variant feature are essential for performance evaluations (PL model can be considered for LoS case).
    - Cat-2: For health monitoring:
      - In-body channel model is expected for near range model (e.g., device based sensing) and far-range model (AP or BS based on sensing);
    - Cat-3: For weather monitoring:
      - Typically focus on the large scale channel model, e.g., path loss with consideration on the additional small scale analysis including reflection-based model to reflect the impact of different whether condition on radio wave, e.g., dense of cloud;
    - Cat-4: Others ,e.g., imaging: In this case, different methodology, such as Electromagnetic simulation, e.g., FDTD (finite difference time domain method), FEM(Finite. Element Method), is required compared to the legacy channel model.
  - Given the significant difference among above categories for channel modelling, stage-wise work based on the output of RAN-level study for the use case should be considered.
    - The Cat-1 can be the focus with prioritized scenario for smart transportation, UAV and smart factory.

[1] 3GPP TR 22.837, Feasibility Study on Integrated Sensing and Communication, V0.4.0, 2023-03.

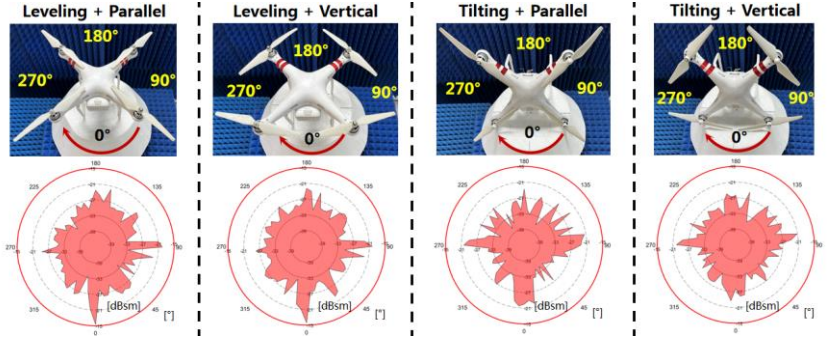
Channel model for ISAC

- Details of modelling for Cat-1:
  - In Cat-1, the propagation is mainly abstracted as: The radio signal is sent from point A, scattered by the sensed object (point B), and received at point C.
  - Methodology:
    - As captured in the TR 38.901, both stochastic based and hybrid mode with RT are supported. For Cat-1, both methodologies can be considered.
  - **Large scale model**: To model the whole procedure of propagation, mainly three components are considered to construct the PL model:
    - PL between Point-A and Point-B
    - PL between Point-B and Point-C
      - ❖ The selection of these two PL model highly depends on the scenario, e.g., UAV based on TR36.777 to reflect the height-dependent feature including LoS/NLoS distribution
    - The impact of "scattered by the sensed object", which is normally approximated by the parameter as "RCS" **given the irregular shape of object**.
      - ❖ The RCS for each objection will be varied upon the angle for Tx and Rx. The proper modelling is preferred since it's essential to performance evaluation for the moving object.



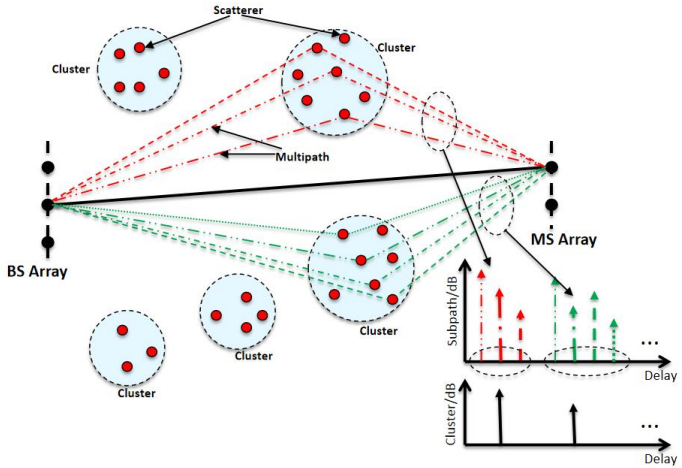
$$PL = PL(d_1) - 10\lg_{10}(\sigma) + PL(d_2) + 10\log_{10}\left(\frac{\lambda^2}{4\pi}\right)$$

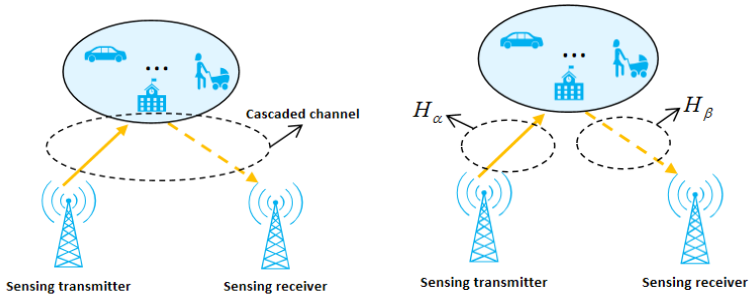
Type of target	Typical value of RCS（m^2）
Insect or Bird	$10^{-5} - 10^{-2}$
Human	0.5-2
Small drone	0.01-0.5
Car or truck	100-300



Channel model for ISAC

- **Small scale model (fast fading)**:
  - Part-1: Introduction of additional object. In the sensing scenarios, the distribution of cluster mainly includes two aspect:
    - Legacy cluster to reflect the background environment: This is part is already well reflected based on the existing channel model.
    - New cluster to reflect the target object:
      - ❖ In stochastic channel model, more cluster should be added with considering the spatial consistency (e.g., for moving object).
      - ❖ In hybrid channel model, additional entity should be added as part of setup.
  - Part-2: Association of ray for sensing link. The association among the rays in two links (send-object and object-receiver) can be considered in following two types:
    - Cascaded channel realization as whole: This method is more suitable for hybrid channel model and all interaction of object are realized as a whole.
    - Segmented with additional mapping: The small scale parameter are generated independently with additional criteria for association.

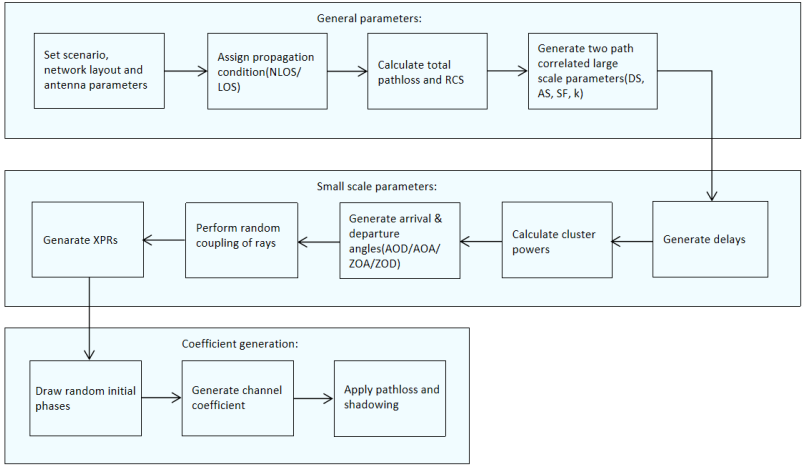




Cascaded channel modeling **Segmented channel modeling**

Channel model for ISAC

- **Channel realization:**
  - For ISAC, the legacy procedure of channel realization for stochastic channel model can be reused with additional updates, for example:
    - The ray association should be considered as part of generation of angle parameters;
    - For the apply of pathloss, different model should be considered to for sensing-link and background channel.
- **Other aspects:**
  - The depolarization effect of scattering.
  - The approximation of changes of RCS with spatial consistency;
  - The additional ray due to the interaction between target object and background environment (e.g., essential for indoor)

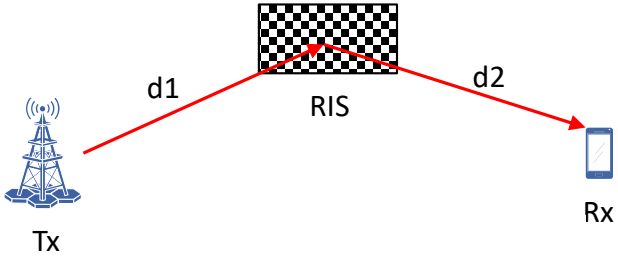


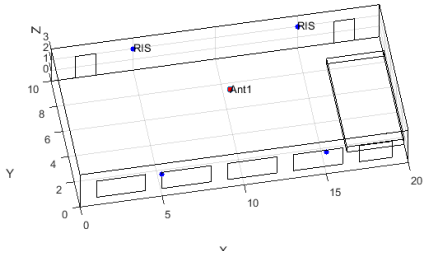
The final channel response will be approximated as:

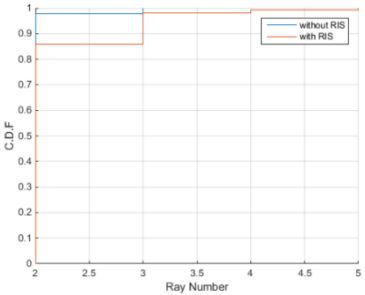
$$\mathrm{H} = \sum H_{obj} + H_{environment} + Noise$$

Channel model for RIS

- Topic-2: Channel model for RIS
  - As mentioned in the [2], the use case of RIS is converged, which is normally considered as one additional entity in the environment to manipulate the propagation **with tunable response per RIS unit** (e.g., via different codebook).
  - From the perspective of channel, to reflect the whole procedure of RIS-involved propagation (**i.e., independent from the applied codebook**), the propagation is mainly abstracted:
    - ❖ The radio signal is sent from Tx, scattered at RIS by multiple Units (in regular shape, e.g., rectangular), and received at Rx.
  - Details of modelling:
    - ❖ Methodology:
      - ➢ As captured in the TR 38.901, both stochastic based and hybrid mode with RT are supported.
      - ➢ Given the deployment of RIS (e.g., close to UE/mounted in the typical environment):
        - » The hybrid mode is accurate to construct the interaction between RIS and background environment (e.g., essential for indoor)
        - » For stochastic mode, the increased number of cluster should be considered.



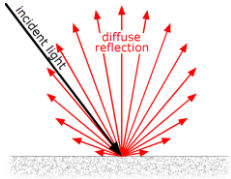




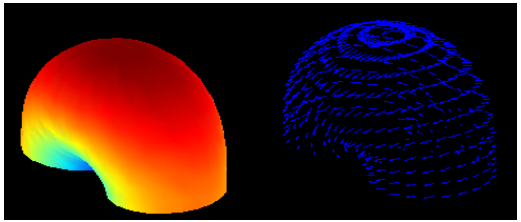
[2] RWS-230292 Views on NCR and RIS in Rel-19

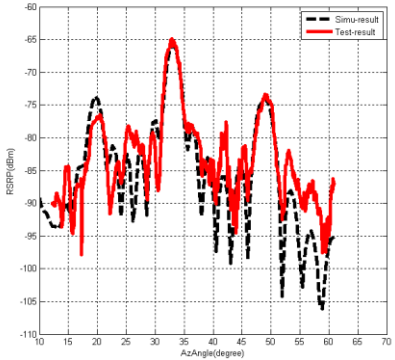
Channel model for RIS

- Details of modelling:
  - ❖ RIS modelling:
    - ➢ The scattering effect of RIS should be modelled as pattern per Unit instead of approximation of whole surface given following reason:
      - ✓ The RIS is consist of multiple-unit with regular shape and consistency among units.
      - ✓ Per Unit model will be easily used to emulate the response from different the Tx/Rx direction.
      - ✓ Per Unit model is friendly to evaluate the performance of different implementation, e.g., codebook.
    - ➢ Potential pattern:
      - ✓ Stochastic pattern to emulate the scattering, e.g., Lambertain pattern[1].
      - ✓ Mathematically model to reflect the impact of polarization, frequency dependence



Normalized Polarization Pattern of RIS element in Pol1(45°)

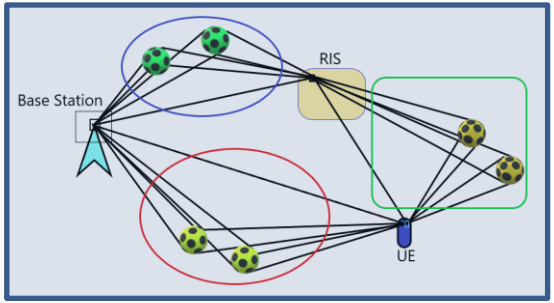




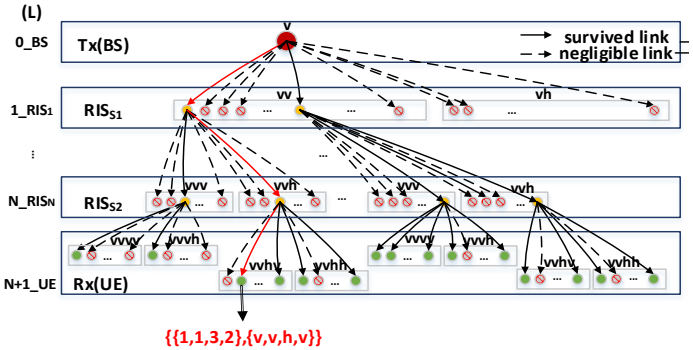
[1] Ref: Channel mode report from IMT2030
[2] Figure from Wiki https://en.wikipedia.org/wiki/Lambertian_reflectance#/media/File:Lambert6.gif

Channel model for RIS

- Details of modelling:
  - ❖ Large scale channel model: To model the whole procedure of propagation, mainly three components are considered to construct the PL model:
    - PL between Tx and RIS
    - PL between RIS and RX
      - ❑ The selection of these two PL model highly depends on the scenario, and will be approximated to the product the d1 and d2
    - Scattering effect of the RIS: The effective aperture of RIS should be considered.
  - ❖ Small scale channel model: Instead of introduce additional "cluster" in the channel realization, it's more preferred to add the RIS as part of environment set-up. Then,
    - For stochastic model
      - » The independent generation of small scale parameter by assuming the RIS as either Tx or Rx
      - » Association among the ray between Tx-RIS and RIS-Rx link
    - For hybrid model
      - » The cascaded channel generation can be considered;
      - » Threshold for ray selection can be introduced to reduce the complexity



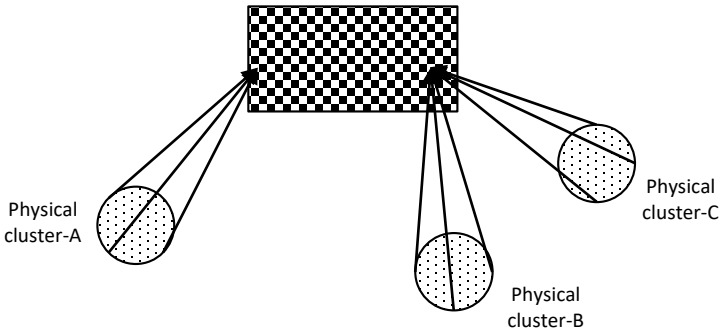
Stochastic model with ray association

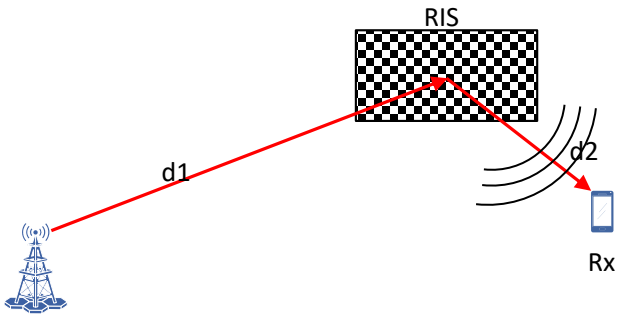


Hybrid model based approach

Channel model for RIS

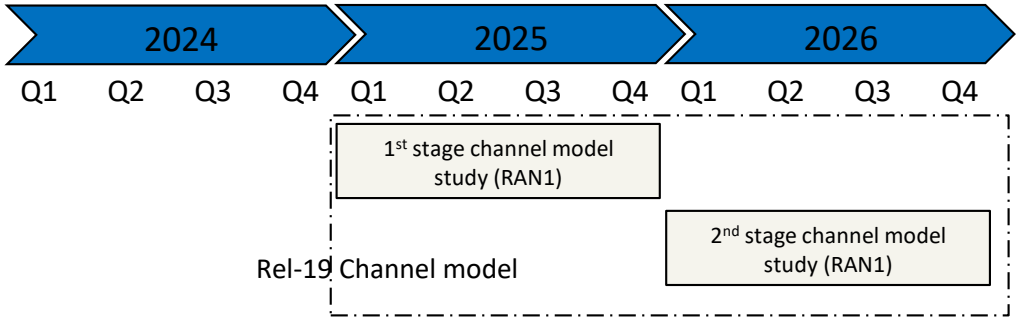
- Details of modelling:
  - Spatial non-stationary & spherical wave-front (Shared for RIS and eLAA)
    - With increased number of antenna element or larger size of RIS, the spatial feature of channel will be impacted.
    - For the spatial non-stationary: It refers the case that,
      - Different number of clusters which contribute the channel for partial of Tx/Rx
      - Different large scale parameter, e.g., observed angular spread of multiple path from same physical cluster
      - Without modelling of this feature, the accuracy CSI/codebook side will be impacted.
    - For spherical wave-front:
      - For the radio transmission in the near-field region (e.g., Fresnel region), the approximation of wave-front should be considered as spherical wave instead of plane.
      - This case will be more typical given the introduction of eLAA and RIS.





Conclusion and workplan

- Given the analysis above, the following observation can be drawn:
  - ***Observation-1:*** *Different channel for should be considered for ISAC to support different use case.*
  - ***Observation-2****: Similarity between channel for RIS and ISAC for the use case of object identification can be observed, e.g., association of rays from different links.*
- Considering the aspects from both technology and project organization, the following proposal is provided along with the workplan:
  - ***Proposal-1:*** *The dedicated channel mode to cover all interested aspects should be considered for Rel-19 with two stages based on the priority of scenarios for each techniques*



  - ***Proposal-2:*** *The channel model study of ISAC for the use case of object identification and the channel model study of RIS should be considered in the 1st stage of channel model study in Rel-19.*
  - ***Proposal-3:*** *Channel model updates for the new or existing band can be considered if inconsistency has been identified.*

Thanks

Tomorrow never waits