3GPP TSG RAN Meeting #102
Edinburgh, GB, December 11-15, 2023
Agenda item: 9.1.1.7
RP-233423

Views on Rel-19 study on integrated sensing and communication (ISAC)

CMCC

Baseline Objectives for ISAC SI in RP-232745

- References: RWS-230488, RP-231540, RP-232617
- RAN to select a small number of ISAC use cases from TR22.837, and to identify appropriate corresponding information needed for the point below, i.e. scenarios, frequency ranges and sensing modes.
  - Also consider the ongoing SA1 TS22.137
- Potential objectives:
  1. A RAN1-led study objective to define channel modelling details for sensing using 38.901 (if applicable to the selected use cases) as a starting point, and taking into account relevant measurements, including:
     - a. modelling of sensing targets and background environment, including, for example (if needed by the selected use cases), radar cross-section (RCS), mobility and clutter/scattering patterns;
     - b. spatial consistency.

     ~~This objective to start after completion of the first (RAN-led) objective if not already done in SID.~~
  - Anything else?

Scenarios and Requirements for ISAC

Scenarios and Requirements

- **32 use cases have been studied in SA1 and captured in TR 22.837. The use cases are further grouped into 3 scenarios in TR22.837 and TS 22.137.**
- Based on the requirements from the government and industries, UAV detection and tracking has attracted lots of attention for low altitude economy and security. Pedestrian/animal intrusion detection on a highway/railway and sensing at crossroads with/without obstacles are important for intelligent transportation systems.
- The use cases in 'Object detection and tracking' have a commonality in channel modeling, and the channel models in TR 38.901 can be extended to this scenario with some enhancement. However, the characteristics of the 'Environment monitoring' scenario and 'Motion monitoring' scenario are different from the channel characteristics in TR 38.901, and how to model the rainfall or breathing may need more discussion.

Proposal 1: Prioritize the scenario 'Object detection and tracking' from TR22.837/TS 22.137 for ISAC channel modeling.

Scenario	Sensing service category	Sensing service area	Example Services
Object detection and tracking	1 (use cases 5.1; 5.13 – level1)	Object to be detected indoor: Human, object to be detected outdoor: UAV	intruder detection in smart home, UAV intrusion detection
	2 (use cases 5.13 – level2, 5.6, 5.14)	Object to be detected outdoor: Human, UAV	UAV flight route intrusion detection, intruder detection in surroundings of smart home, tourist spot monitoring
	3 (use cases 5.2, 5.7, 5.10, 5.11, 5.12, 5.23)	Factory (100m2), crossroad, highway, railway [air] Object to be detected: Animal, Human, UAV, Vehicle	pedestrian/animal intrusion detection on a highway/railway, sensing at crossroads with/without obstacle, UAV flight trajectory tracing, UAV collision avoidance, AMR collision avoidance in smart factories
	4 (use cases 5.20, 5.22, 5.25, 5.32)	Factory. Object to be detected: Animal, Human, UAV, AGV/AMR, Vehicle	Parking Space Determination, UAVs/vehicles/pedestrians detection near Smart Grid equipment, immersive experience based on sensing, integrated sensing and positioning in factory hall
	5 (use cases 5.27, 5.28)	ADAS. Object to be detected: Vehicle Public area safety,	public safety search and rescue or apprehend, ADAS
Environment monitoring	6 (use cases 5.3 and 5.5.)	Rainfall monitoring and flooding. Object to be detected: Rain	rainfall monitoring, flooding monitoring
Motion monitoring	7 (use cases 5.15, 5.24)	Indoor human motion -sleep monitoring, sports monitoring,	sleep monitoring, sports monitoring
	8 (use case 5.29)	Hand gesture recognition	Hand gesture recognition

Frequency ranges for ISAC

Frequency Ranges

- As the millimeter-wave (mmWave) band provides abilities of more accurate estimation and lower interference levels, the mmWave ISAC has attracted more explorations.
- The sub-6 GHz sensing network has incomparable advantages from the perspective of industrial development. The sensing functionality at sub-6 GHz may be implemented on current BSs by software and hardware upgradation, while there is no mmWave deployment for 5G/5G-A in many countries/regions. Sensing under sub-6 GHz is an exceptional incentive to promote the industrialization process of ISAC for 5G-A and beyond.

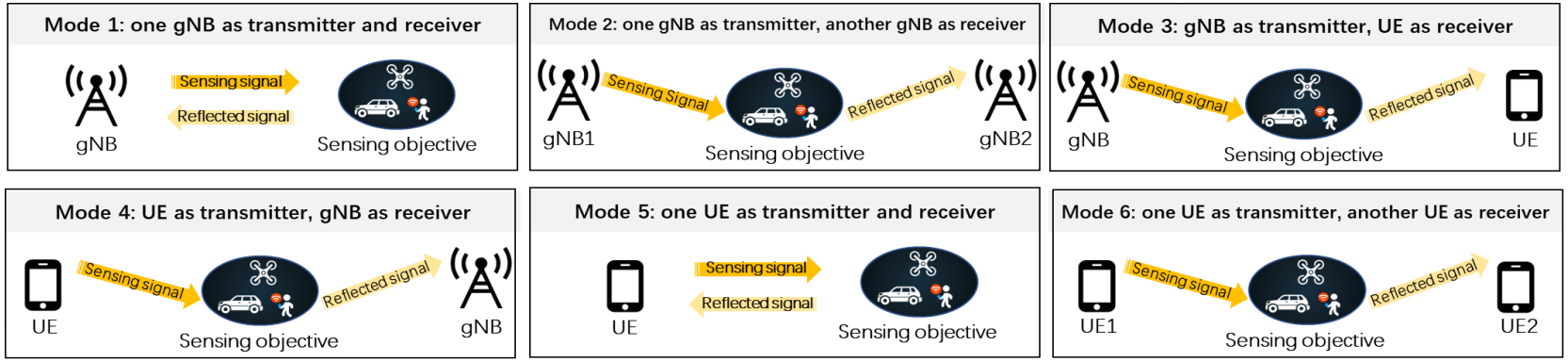
Proposal 2: Study the ISAC channel modeling for both FR1 and FR2.

Sensing Modes for ISAC

Diversified Modes

- **Six modes have been discussed for ISAC, which could be classified into two categories based on whether the transmitter and receiver are physically co-located.**
  - **Mono-static:** Mode 1: gNB mono-static; Mode 5: UE mono-static.
  - **Bi-static:** Mode 2: gNB-to-gNB bi-static; Mode 3: gNB-to-UE bi-static; Mode 4: UE-to-gNB bi-static; Mode 6: UE-to-UE bi-static.
- **From the aspect of channel modeling, a similar channel modeling mechanism could be used for both mono- and bi-static modes, such as**
  - Modeling of sensing targets, including a transmitter to sensing target channel model, sensing target to receiver channel, and RCS.
  - Modeling of background environment.
- **However, different modes have different channel parameters, such as**
  - Height, velocity, antenna configuration of gNB and UE
  - Pathloss, LoS probability, K factor modification of different modes.

Proposal 3: Both mono-static and bi-static modes can be considered for ISAC channel modeling.



Channel modeling study on ISAC (1)

Channel Modeling

- **Motivation:** To enable ISAC for V2X, UAV, and indoor intrusion detection use cases with higher requirements from government and industries, potential enhancement may include signal design, resource allocation, measurements based on existing waveform and reference RS, and sensing architecture for supporting sensing application.
  - A detailed design of potential solutions requires a reliable and comprehensive understanding of the sensing channel.
  - Compared with traditional communication, the ISAC channel model should adequately represent sensing signals related to the sensing target and background environment for performance evaluation for different sensing modes and scenarios.
- **Using TR38.901 as a starting point, there are two possible modeling schemes:**
  - **Concatenation-based channel modeling:** cascade of the “double link” large-scale and small-scale fading from point A to the sensing target and from the sensing target to point B
    - Large-scale and small-scale models from point A to the sensing target and from the sensing target to point B could use TR 38.901 as a starting point, with potential modifications such as
      - Modification of the height of point A, sensing target, and point B, where the UAV channel model in TR 36.777 could be used as a reference.
      - LoS probability, K factor, etc
    - Large-scale and small-scale fading caused by the background environment could be modeled additionally.
  - **Non-concatenation-based channel modeling:** sensing target is modeled as a cluster in TR 38.901
    - The position and velocity of the sensing target need to be explicitly described in this modeling scheme.
    - Large-scale and small-scale fading caused by the background environment could be modeled jointly with the sensing target.

Channel modeling study on ISAC (2)

Channel Modeling

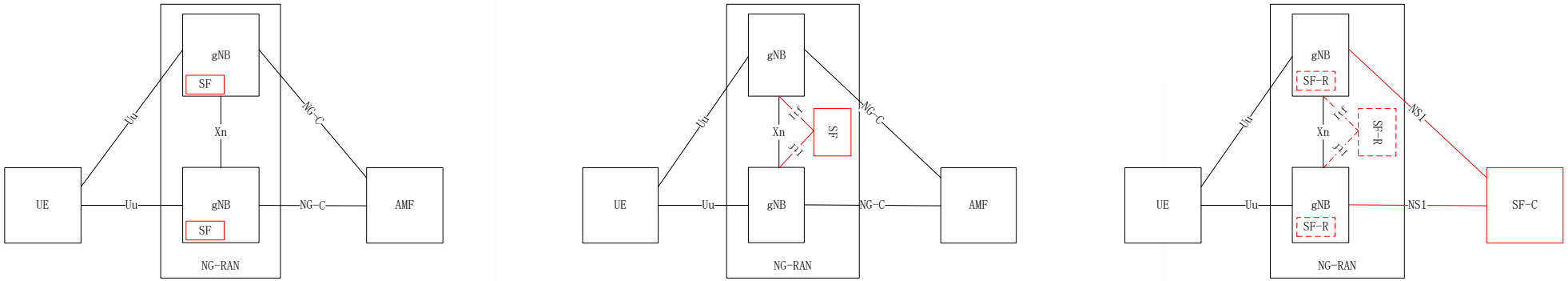
- **RCS modeling:** RCS may be considered to characterize the power loss caused by reflecting on the sensing target.
    - RCS per target: Typical values, uniform distribution, Gaussian distribution, or other methods.
    - Directionally RCS: RCS is relative with AOA and AOD of sensing target.

- ***Proposal 4: Study the channel modeling for integrated sensing and communication for both FR1 and FR2 [RAN1]***
    - ***Modeling of a sensing target correlated channel***
        - ***Large-scale fading modeling related to sensing target, includes***
            - ***Pathloss modeling, RCS modeling, LoS probability, K factor, etc.***
        - ***Small-scale fading modeling related to sensing target, including***
            - ***Dopplor related to sensing target velocity and other potential modifications of small-scale fading factors related to scenarios and modes***
        - ***Mobility and spatial consistency modeling***
    - ***Background environment modeling related to scenarios and modes***

RAN side sensing architecture for ISAC

Sensing Architecture

- Low latency requirement is proposed in some use cases, such as ≤100ms for V2X. RAN side sensing architecture is needed to process the sensing measurements at RAN side to satisfy low latency requirement.



Proposal 5: Study of RAN side sensing architecture, including functional interfaces, protocol, and procedures, e.g. measurement processing is within RAN node, or measurement data is directly delivered from RAN node to non-3GPP entity [RAN3]

THANK YOU !