3GPP TSG RAN #102
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Document for: Discussion

RP-233538

Study on Chanel Model for ISAC

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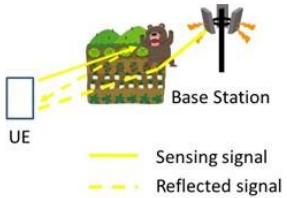
Introduction

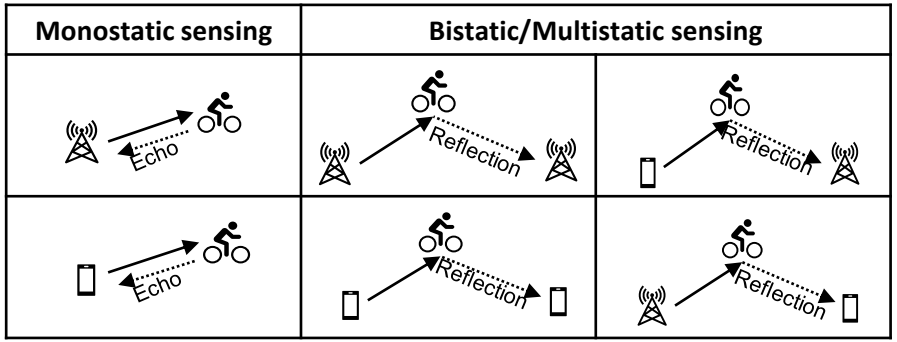
Time to start treating wireless sensing in 3GPP RAN

- **Motivation:**
  - » Good sensing performance by using various frequencies and cellular NW equipment
  - » Realizing new/enhanced services
  - » Optimizing NW parameters by analyzing real-time sensing data
- **Background: SA1 study on ISAC (integrated sensing and communication) in Release 19**
  - » Use cases and potential requirements for enhancement of the 3GPP system to provide sensing services addressing different target verticals/applications.
  - » Some use cases could also include non-3GPP type sensors (e.g. Radar, camera).



Human/intruder/vehicle/obstacle detection/counting in indoor/outdoor scenario

Use case examples



sensing methods examples

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ISAC scenarios and requirements - TS22.137 V1.0.0

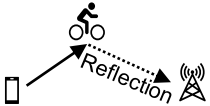
Scenario	Sensing service category	Confidence level [%]	Accuracy of positioning estimate by sensing (for a target confidence level)		Accuracy of velocity estimate by sensing (for a target confidence level)		Sensing resolution		Max sensing service latency [ms]	Refreshing rate [s]	Missed detection [%]	False alarm [%]	Sensing service description in a target sensing service area
			Horizontal [m]	Vertical [m]	Horizontal [m/s]	Vertical [m/s]	Range resolution [m]	Velocity resolution (horizontal/ vertical) [m/s x m/s]					
Object detection and tracking	1	95	10	10	N/A	N/A	10	10	1000	1	5	2	Indoor/outdoor (e.g., detection of human, UAV)
	2	95	5	1	1	1	1	1	1000	1	5	5	Outdoor (e.g., detection of human, UAV) requiring higher performance than category 1
	3	95	1	N/A	1	N/A	1	1 x 1	100 (NOTE 2), or 1000 (NOTE 3)	0.1	2	2	Indoor/outdoor (e.g., detection tracking of human, animal, UAV)
	4	99 for public safety, otherwise, 95	0.5	0.5	1.5 for pedestrian, 15 for vehicle, otherwise, 0.1	1.5 for pedestrian, otherwise, N/A	0.5	5 x 5 for factories 0.5 may be needed	250	0.25	1	5	Indoor/outdoor (e.g., detection tracking of human, animal, UAV, AGV, vehicle) requiring higher performance than category 3
	5	95	short range radar; 0.02, otherwise; 0.1	0.5	0.03	N/A	0.4	0.1 x 0.6	50	0.05	1	1	Indoor/outdoor (e.g., detection tracking of human, animal, UAV, AGV, vehicle) requiring higher performance than category 4
Environment monitoring	6	95	10	0.2	N/A	N/A	N/A	N/A	6000	60	10	3	Nature of environments monitored by sensing.
Motion monitoring	7	95	N/A	N/A	N/A	N/A	N/A	N/A	60000	60	5	5	Human motions and activities obtained by sensing (NOTE 4).
	8	95	0.2	0.2	0.1	0.1	0.375	0.3	5	0.1	5	5	Human hand gestures obtained by sensing

NOTE 1: The additional information on some of the performance requirements can be found in [2].
NOTE 2: The value 100 ms is sourced from [3] and is valid for sensing at crossroads.
NOTE 3: To realize 1m granularity tracking, when the velocity resolution is 1 m/s, the maximum corresponding sensing service latency is 1 s.
NOTE 4: Additional KPI on human motion rate accuracy is defined for contactless sleep/sports monitoring [2].

Editor's note: TBD if sensing service categories 5 and 8 are included in Rel-19.

- **Observation: "Environment monitoring" and "Motion monitoring" require high sensing performance and may require advanced techniques compared to "Object detection and tracking" which can be the basic scenario to begin with.**

Sensing methods

	Sensing method	Suitable scenario	Capability requirement	Sensing performance
Monostatic sensing	**gNB Monostatic sensing**	• Sensing target near to sensing BS/UE - High or medium SNR of the echo signal	• Full duplex at BS or UE (High requirement) • [UE sensing]: High UE positioning accuracy	• [gNB sensing] High precision due to no quantization • [UE sensing] Medium precision due to quantization of the feedback values • The precision is related to the SNR of echo signal • Short latency
	UE Monostatic sensing			
Bistatic/Multi-static sensing	**gNB1-to-gNB2 sensing**	• No/few communication UE around the target w/ high UE positioning accuracy	• Half duplex • Synchronization among BSs	• High precision due to no quantization • The precision is related to the synchronization error • Medium latency
	UE-to-gNB sensing 	• There is communication UE around the target	• Half duplex • High UE positioning accuracy • Synchronization among BS-UE	• [UE-to-gNB sensing] High precision due to no quantization • [gNB-to-UE/UE1-to-UE2 sensing] Medium precision due to quantization of the feedback values • The precision is related to the allocated resources and UE location • Long latency
	gNB-to-UE sensing		• Half duplex • UE with high computation resources/ detection of reflection signal • High UE positioning accuracy • Synchronization among BS-UE/UEs	
	UE1-to-UE2 sensing			

■ **Observations:**

- **Monostatic sensing requires full duplex capability.**
- **Each sensing mode (gNB-only/gNB-UE sensing) may have each suitable target use case/deployment scenario.**

■ **Bistatic (both gNB-only and gNB-UE) sensing can be the basic mode.**

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Carrier frequency for ISAC

	FR1 0.41-7.125GHz	**FR3** 7.125-24.25GHz	**FR2**	
			FR2-1 24.25-52.6GHz	FR2-2 52.6-71 GHz
Sensing accuracy/resolution	• Less velocity/localization resolution due to the long wavelength: cannot track the difference smaller than half-wavelength • Less range resolution due to the difficulty to ensure the large BW	• Medium sensing resolution compared to FR1/2	• Better velocity/ localization accuracy/ resolution thanks to the short wavelength • Improved angle accuracy by narrow beam • Improved range estimation accuracy by large BW for sensing RS	
Coverage	• Large coverage	• Medium coverage	• Less coverage	
Impact on existing communication NW	• Relatively large impact for existing communication system	• No existing deployment for communication	• Relatively small impact for existing communication system	

- **Observations: Each frequency range has pros/cons.**
  - FR1 can be utilized for use cases which require large coverage, e.g., outdoor scenario.
  - FR2 can be utilized for use cases which require finer sensing accuracy.
  - Less impact on communication is expected for FR2 compared to FR1.
- **Given that both indoor and outdoor scenario are the scope for the study, both FR1 and FR2 should be considered as the study target.**

ISAC Channel Modeling

- For 3GPP sensing, the stochastic channel modeling should be the baseline and starting point for enhancement.
  - Parameters for enhancement: Path loss, LOS probability, fast fading model
  - New parameter: RCS (Radar cross section)
- The channel modeling of sensing target and sensing environment could be carried out independently or jointly.
  - Sensing environment may not be necessary to be modeled as same level as sensing target
- The parameter/required enhancements on channel model would be different depending on sensing type (localization, size, tracking, gesture recognition, counting number of objects), sensing environment (urban/rural/aerial etc.), sensing coverage (macro/micro) etc.

Channel modeling		Existing TR38.901	Updates for ISAC
7.4 Large-scale channel modeling	7.4.1 Path loss	One-way (Tx-Rx) path loss	Enhancement for sensing: - Cascaded modeling for path loss: Tx-Target, Target-Rx - Special case: Double path loss for monostatic sensing
	7.4.2 LOS probability	Different for various scenarios	Enhancement for sensing: - Cascaded modeling for LOS probability: Tx-Target, Target-Rx - Special case: Same LOS probability for Tx-Target and Target-Rx link in monostatic sensing
	7.4.3 Penetration loss	Depending on the material	Special case: No penetration loss for LOS-based sensing
	7.4.4 Shadow fading	Gaussian distribution	Reuse the shadow fading model in TR38.901
	RCS	None	New for sensing: - RCS is related to the size, material and shape of the target, as well as the FOV, frequency and polarization of the sensing signal, etc.
7.5 Fast fading model		CDL, TDL channel model: Cluster-based, ray-based	Enhancement for sensing: - Cascaded modeling for fast fading channel - Correlation between communication clusters and sensing clusters

For section 7.2 in TR38.901, it may need clarification whether the existing scenarios cover the target sensing scenario clarified in TSG-level study.

Proposals on objectives in Rel-19

- **Observations**
  - To facilitate ISAC discussion in 3GPP RAN, enhancement on the channel model is necessary.
    - » The existing channel model in TR 38.901 is not designed to assess a link between Tx and Rx considering the reflection by sensing target and non-sensing target.
- **Proposals**
  - **Clarify target ISAC deployment scenarios and corresponding KPIs in RAN.**
    - » Clarify the discussion scope of deployment scenario(representative use cases, indoor/outdoor, sensing methods, spectrum) based on TR 22.837 and TS 22.137, towards WG-level SI for channel modeling.
      - – Selected ISAC use cases from TS 22.137: At least Object detection and tracking should be considered.
      - – Frequency ranges: Existing frequency ranges, i.e., FR1 and FR2 should be considered.
        - ✓ FFS: FR3
      - – Sensing modes: At least bistatic sensing should be considered, but open to discuss monostatic sensing.
  - **Study channel model in RAN1**
    - » Support potential objectives in RP-232745.

> 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.

    - » Normative works to specify basic functionalities of ISAC is expected to be in Rel-20 or later.

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