3GPP TSG RAN Rel-19 workshop
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Agenda Item: 5
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Integrating Sensing and Communication for Rel-19

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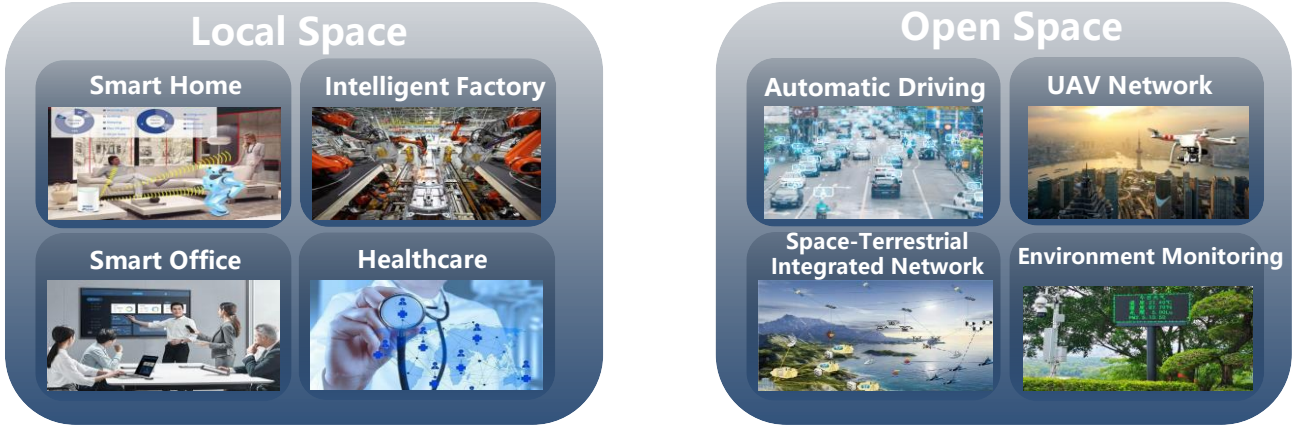
Motivation

- 5G New Radio (NR) systems are deployed to offer high data rates and ultra-reliable low latency services. Vertical industries start to apply 5G to improve the industry automation and digitalization, in many scenarios, the **Integrated Sensing and Communication(ISAC)** is a key enabler to provide high quality services. The ISAC can extend the capability of network from “listen and talk” to “see and feel” and create a digital sense augmenting human intelligence.
- With ISAC, the smart devices will have the capability to sense their surroundings, and exchange their observations through communication. In addition, with Artificial Intelligence (AI) combined with sensing capability, the network will have the cognitive ability to fuse the physical and biological worlds with cyber worlds and provide various intelligent services for consumers and industry customers.



Diverse applicable scenarios for wireless sensing

Motivation

- Many new emerging businesses require sensing capability to provide accurate and timely services, however, traditional radar technology is high cost to deploy and not flexible enough to extent to current diverse services.
- Although 5G already offer the positioning functions, but the positioning function applies only to UEs, not for non-UE objectives such as CARs, UAVs. Studies show that ISAC can provide more richer sensing content than the 5G existing sensing capability.
- With the use of higher frequency bands (from mm-Wave to THz), wider bandwidth, and denser distribution of massive arrays in 5G and future 6G systems, it is possible to enable the integration of wireless sensing and communication in a single system and mutually enhance each other.
  - **Sensing exploration**: With sensing capability, the 5G system as a whole can serve as a sensor and explore the radio wave transmission, reflection, and scattering to sense and better understand the physical world, providing a broad range of new services.
  - **Communication enhancement**: The capabilities of high-accuracy localization, imaging, and environment reconstruction obtained from sensing could help improve the communication performance such as more accurate beamforming, better resource allocation, reducing network congestion.
- As the process of industrial automation and digitalization has begun in 5G, the research of 5G ISAC is very meaningful for promoting 5G network to provide more intelligent services to consumer and industrial customers, at the same time, it can also make technical preparations for 6G ISAC design. So, **it is proposed to start a study item of ISAC in 5G-A to study the integrating sensing and communication on the existing 5G network**.

Promising use cases for sensing

- Integrated Sensing and Communication has been studied in SA1 on the use cases, the requirements and the KPIs. It is specified in TR 22.837 with various typical scenarios and use cases;

1. Unmanned Aerial Vehicle:

2. Intruder detection:

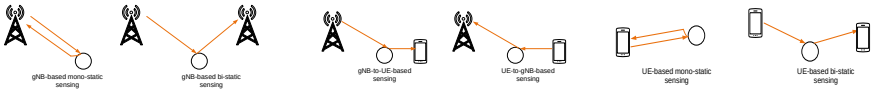
3. Autonomous vehicles:

4. Ultra-high precision positioning:

5.Weather or air pollution monitoring:

Use cases and sensing modes

- Use cases can be achieved via different sensing modes: BS-based sensing, BS-UE based sensing, UE-based sensing.



	BS-based sensing	BS-UE based sensing	UE-based sensing
Unmanned Aerial Vehicle (★★★)	√	√	
Intruder detection (★★★)	√	√	√
Autonomous vehicles (★★)	√	√	
Ultra-high precision positioning (★★)	√	√	√
Weather or air pollution monitoring (★)	√		√
Health Monitoring (★)		√	√

Sensing mode priority

- The sensing modes can be divided into two categories: those that depend solely on BS (Base Station) and those that depend on both BS and UE in terms of sensing function support. The pros and cons of each type are as follows:

1) BS-based ISAC

➢Pros:

- Relatively easy to implement compared with BS and UE based ISAC;
- Sensing function applied for both legacy UEs and new UEs;
- Easy for operator deployment, only need to update RAN and CN;

➢ Cons

- Not support some sensing use cases, such as Health Monitoring;
- Relative low sensing accuracy;

2) BS and UE based ISAC

3) UE-based ISAC implementation

➢Pros:

- Support more sensing use cases such as Health Monitoring;
- More accurate sensing ability;

➢Cons:

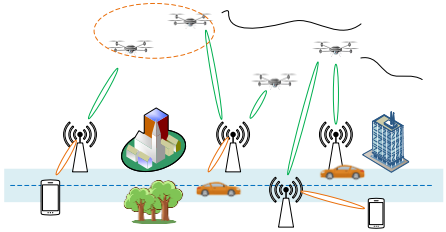
- High implementation complexity, both BS and UE need to be implemented;
- Sensing function can not be rapidly applied, depends on not only BS upgrade but also sensing UE penetration;

- Based on above analysis, the BS-based ISAC is easier to deploy and can enable the sensing function for the entire network, therefore, it should have higher priority for ISAC study in 5G-A.

BS-based ISAC enabling vertical industries

- **Supporting promising vertical use cases**
  - Unmanned Aerial Vehicle
  - Intruder detection
  - Autonomous vehicles
  - Intelligent industrial
  - ……

- **BS-based sensing for UAV**
  - Intrusion detection
  - Flight trajectory tracing
  - Collision avoidance



The rapid rise of low altitude economy

- In 2023, CAAC has been issued the Approval Letter for the Trial Operation of UAVs and the general aviation Enterprise Business License for Meituan UAVs, to allow UAVs can carry out logistics distribution in the airspace below 120 meters.
- In 2023, Shenzhen Government has claimed to build a low-altitude economic center

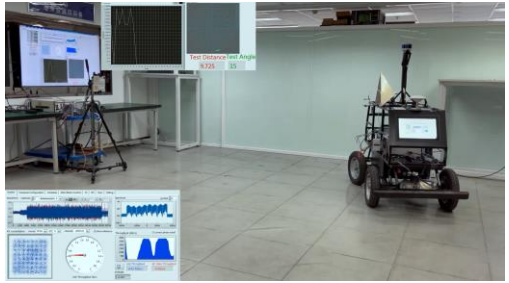
中国民用航空局
Civil Aviation Administration of China
特定类无人机试运行批准函
Specific Unmanned Aircraft Pilot Operation Approval Letter
批准函编号(Number):AC-92-2019-01-0005
日期(Date):2023-1-11

BS-based ISAC that enables low altitude economy has the potential to bring new service and new revenue growth for operators

Performance of BS-based ISAC

Lab and field tests have shown BS-based sensing can support typical use cases including UAV&Vehicle positioning, intrusion detection, etc.

- BS-based sensing in lab test



Resolution of ranging	Ranging accuracy	Resolution of angle	Accuracy of angle	Throughput
0.488 m	± 0.4m(long distance) ± 0.1m(short distance)	5°	±5°	2.86Gbps

- BS-based UAV&Vehicle detection/positioning field tests

UAV positioning test

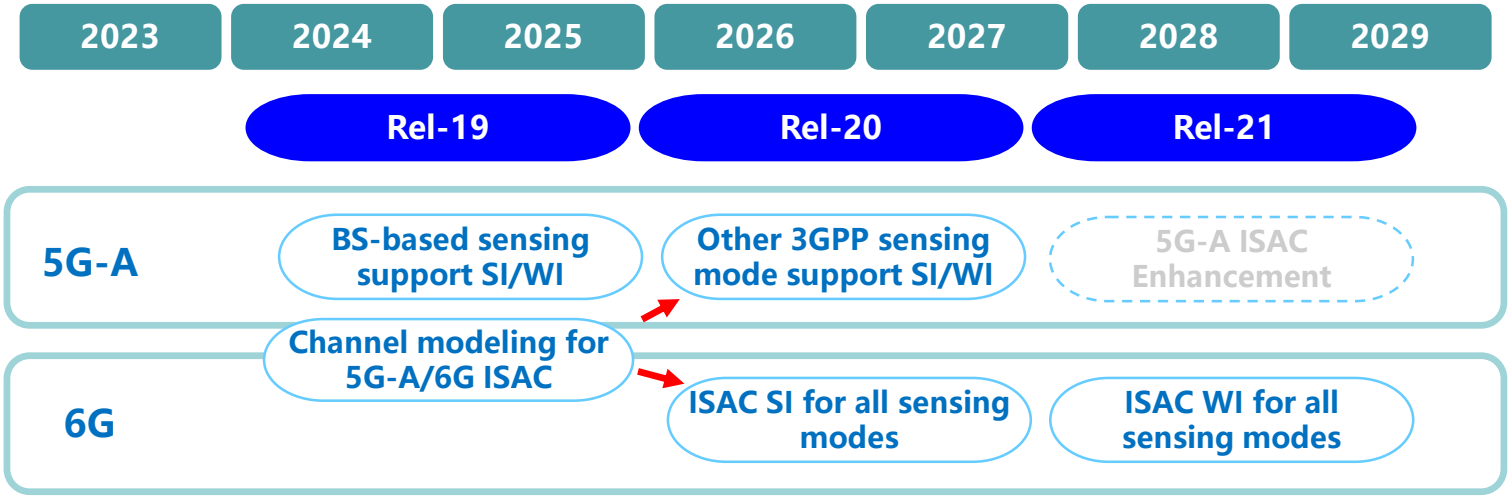
matrices	values
UAV velocity	21.8km/h
Ranging error	<0.1m@90%
Positioning error	<1.04m@90%
gNB coverage	>1.2km

Vehicle detection test

matrices	values
Veh detection	Lane-level
intrusion detection	100%
gNB coverage	>0.5km

Possible RAN Timeline for ISAC

To meet near-term commercial requirement and long-term evolution requirement, the following time plan is proposed.



- **BS-based sensing support (R19):**
  - Enabling promising use cases, e.g. UAV, Intruder detection;
  - Reusing the existing RS signals and mechanisms as much as possible;
  - More common/adaptable message design for data collection for all sensing modes;
  - Coordinating with and aligning with other WGs, e.g. SA2, SA5;
- **Channel modeling study (R19):**
  - should future proof for 5G-A and 6G,
  - should a wide variety of sensing modes and deployment scenarios,

- **5G-A BS-UE and UE based sensing mode support (R20):**
  - Performance Evaluation of BS-UE/UE based sensing modes for more uses cases based on new Rel-19 sensing channel model;
  - Enabling more sensing modes for more use cases;
  - Designing new sensing mechanism between BS and UE by reusing the existing RS signals;
  - Coordinating with other WGs, e.g. SA2, SA5;
- **6G ISAC SI (R20):**
  - Sensing performance evaluation for 6G uses cases based on new Rel-19 channel model and new sensing signals;
  - Studying new sensing mechanism based on the new sensing RS signals;
  - Studying new sensing data collection mechanism cooperated with 6G core network;

- **6G ISAC WI (R21):**
  - Defining new sensing RS signals for 6G;
  - Designing/Specifying new sensing mechanism based on the new sensing RS signals;
  - Designing/Specifying new sensing data collection and service providing mechanism cooperated with 6G core network;

Potential ISAC objectives in Rel-19

On BS-based sensing function support in Rel-19

- Now, the replacement cycle of an smart Phone is about 2-3years.
- Considering from a practical perspective and 3GPP timeline, BS-based sensing is more suitable for 5G-A; It has the clear use cases and be easy to be applied to vertical industries;

Scope:

- Identify **use cases** that BS-based ISAC could well applies for, with selecting suited sensing modes;
- Study standardization impacts on the sensing service **interfaces and procedures** towards sensing establishment, control and data reporting, the **message design** for data reporting should be common and **easy extension for future extension** to support more sensing modes and algorithms;
- Study standardization impacts on the **interference handling** between sensing signals and between sensing and communication signals;
- Study standardization impacts on the support for Multi-BS **collaborative sensing** functions;
- Study standardization impacts on the support for sensing service continuity in mobility scenario, if any;
- Study the necessity to introduce local sensing function within NG-RAN node from e.g. latency point.

The studies should be focused on the existing NG-RAN architecture and interfaces to enable sensing functions, reducing the impact on 5G current system as much as possible.

Channel modeling in Rel-19

Study of channel modeling for ISAC in Rel-19

- Models for sensing channels and communication channels should be spatially consistent and coherent and future proof for both 5G-A and 6G;
- The channel model must support a wide variety of sensing modes and deployment scenarios;
- Design the channel characteristics for the sensing signal transmitted from the transmitter and reflected by the detection target and the environment, including:
  - The cluster characteristics (e.g. Angle/DS, the number of clusters and the spatial relation);
  - The correlations amongst the sensing channels/clusters;
  - Design the RCS distribution of the sensing targets and the environment, considering the substance materials, the velocity, the shape of the reflection object, sensing frequency and so on.
- Studying on channel model in Rel-19 to lay a foundation for 6G;
- If there are additional TUs after the sufficient study of channel modeling for ISAC, the performance studies could be carried out for UE related sensing modes.

Thanks!