Supporting Joint Communication and Sensing in 6G

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***Abstract*—The idea with Joint Communication And Sensing (JCAS) is to use the radio resources for communication also to locate or trace objects in the cell. Different modes of sensing is anticipated, e.g. using characteristics of Sounding Reference Signals (SRS) to identify objects or introducing a radar-like procedure to measure the distance to objects. Several studies, especially on the physical layer procedures, exist. Studies have been proposed in different standardization bodies, e.g. 3GPP to study sensing for 5G. In this paper we describe work on how to enable sensing in future advanced 5G or 6G networks. We describe the Network Functions (NF) that are needed to execute sensing in cellular networks and show a sequence diagram on how these NFs interact. The results also include a description of new network nodes and procedures needed to make use of them.**

Keywords—Joint communication and sensing; 6G; architecture

I. INTRODUCTION (*Heading 1*)

The key characteristic of cellular networks is that users' devices can move within the coverage area of a base station. In addition to this, the device can move to another cell without losing the connection. Given this characteristic an obvious service is to locate devices within the network. Localization or positioning has been part of cellular technology probably since networks were first made available. Note that positioning by a cellular network involves a device connected to the network.

In previous generations of cellular systems, the accuracy of positioning has been limited primarily by frequency and bandwidth. With mmWave dense deployment at higher frequencies have given the possibility to improve positioning accuracy drastically.

With JCAS as a new emerging technology, there is an opportunity to find objects that are not connected to the network (passive objects), in addition to connected devices of course. This principle is by itself not unique since, for instance, vehicles can be equipped with radar or Lidar technology to detect objects and then pass this information to the network. What is new is the network involvement in the sensing procedure by reusing the same resources used for communication, and the ability to perform sensing even entirely without extra devices [1]. As networks already use high frequency spectrum for communication, the same spectrum and communication equipment can be reused.

In this presentation there is a description of relevant network nodes and signaling that are expected for advanced 5G or 6G.

II. JOINT COMMUNICATION AND SENSING

Network-based sensing standardization in larger fora has begun quite recently [3][4]. The ongoing work in 3GPP is about use cases, requirements, and channel models. We expect that in 6G JCAS will be fully integrated in the system [2]. This may provide performance advantages.

Sensing can be implemented in different ways. In WiFi most applications appear to rely on changes of the radio channel when movement changes the environment. There are already commercial applications that use WiFi sensing [5]. There is also a recently established task group 802.11bf that works with standardization of WiFi Sensing [4]. Another method to do sensing is to transmit a radar-like pulse using a beam in the direction of the area of interest. The pulse will reflect on the object and travel back to a receiver. By analyzing the travel-time it is possible to calculate the distance to the object (direction comes is known from the beam). A suitable radar pulse can be generated from the communication signal [7][8].

For 6G maximum frequencies just below THz bands have been discussed. At 6G frequencies, beamforming of the transmitted signals is a must to concentrate and direct the signal energy to a specific geographical area where the intended receiver is located. Therefore, the mechanisms for beamforming will be available in 6G, possible to be used also for sensing. Although higher frequencies result in increased accuracy the possibility to interfere the signals increases. However, systems in the millimeter-wave range from 30–300 GHz are not that severely affected by poor weather [6].

III. ARCHITECTURE

One way to add sensing is to utilize the existing network. Required changes would involve dedicated sensing-focused processing of received signals already present for the communication and some additional processing at the receiver side. Another way to add sensing can be seen as integrating an existing radar-based system into the network. In both approaches, some rules for how to share resources will be needed, e.g., how to share the available resources in time, frequency, available antennas, transmission power, processing capabilities, etc. There will be a performance trade-off between the communication capacity and the sensing capabilities.

Sensing involves actions on the radio interface as well as several processing steps, see Figure 1. A baseline system comprises, the RAN, a processing function, and a way to expose the results. Generalized sensing functions are: control and authorization, signal transmission, reception, analysis as well as passing results to an application.

For JCAS to work the below NFs are needed.

1) Service exposure

There must exist a way for an application to initiate the procedure that determines whether there is, e.g., movement in an area or there is an object in a certain location. The application may be external, i.e. an entity requests information from the network, or internal, i.e. the network itself requests the information. The application is probably an application programming interface (API) running on top of an existing exposure framework, existing data distribution or a new function.

2) Handling of Sensing requests

To support various kinds of sensing there needs to be a function that handles requests from different applications. The function could be split into two logical, or physical, entities – control and processing.

3) Sensing data processing

This function interprets sensing measurements and converts them into a format meaningful to an external receiver. Further processing may involve, e.g., creation of maps. Available local data is handled by this function, e.g., base station ID and observations.

4) Sensing service availability

A requesting application needs to understand what sensing services are available in the requested area and period. The API may include additional information regarding the sensing potential and availability of resources, e.g., active sensing might be limited in an area with high load. Further, the API should provide assurance for critical application coverage.

5) Authorization and data disclosure

The access to sensing data needs to be limited to satisfy privacy and security requirements. The access control applies to produced data and both internally and externally. Therefore, a sensing request must be verified, i.e., is the requester authorized for the service and to receive the specific sensing data.

6) Privacy preserving mechanisms

A privacy check should be performed with every sensing request and prior to the sensing result disclosure. A configurable privacy policy should be exposed to relevant actors, including a consent API for observed targets. Also, fallback mechanisms are needed, e.g., data anonymization, aggregation, de-identification, hashing, etc.

7) Sensing service trustworthiness

Data use and retention assurance mechanisms and policies should extend to 3rd parties. Impact should apply to combinations of data, e.g., although the sensing result does not reveal anything by itself, if combined with other data it may have an impact on a person’s privacy. Data integrity and authenticity is core for critical applications and should be considered for both internal and external data as well as for raw measurements, semi-processed data and sensing results. Legally there will also be a need for data traceability; this is also useful to remediate accidental or intentional data leaks.

8) Application support

Sensing will support future applications. For example, with programmability new services can be created on top, and with applications controlling processing tasks there may be performance benefits, e.g., the application provides an AI model that is used by the network to detect desired conditions, or allowing an enterprise application determine data access control rules, etc.

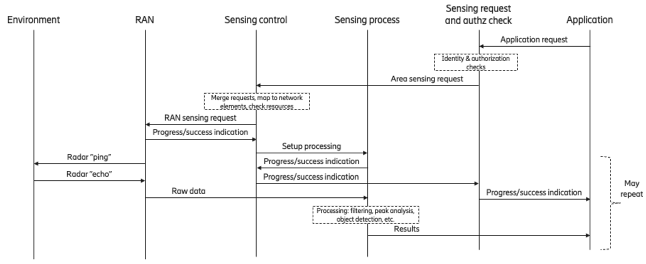

Figure 1 Sequence diagram: base functional architecture

IV. SUMMARY

Important new functions include data exposure, sensing request handling and processing, authorization, and privacy. Privacy is one of the most important functions to be able to provide new services that users can trust. In the poster presentation we will present these functions in more detail and the architecture in which these functions are integrated from the inception.

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