MEASUREMENT AND REPORTING CONFIGURATION FOR SENSING

TECHNICAL FIELD

[0001] The present disclosure relates to wireless communications, and more specifically to measurement and reporting for sensing.

BACKGROUND

[0002] A wireless communications system may include one or multiple network communication devices, such as base stations, which may be otherwise known as an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. Each network communication devices, such as a base station may support wireless communications for one or multiple user communication devices, which may be otherwise known as user equipment (UE), or other suitable terminology. The wireless communications system may support wireless communications with one or multiple user communication devices by utilizing resources of the wireless communication system (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers). Additionally, the wireless communications system may support wireless communications across various radio access technologies including third generation (3G) radio access technology, fourth generation (4G) radio access technology, fifth generation (5G) radio access technology, including 5G Advanced (5G-A), among other suitable radio access technologies beyond 5G (e.g., sixth generation (6G)). In some cases, the wireless communications system may support Integrated Sensing and Communication (ISAC). One or more of network communication devices or user communication devices may perform one or more sensing operations according channel state information (CSI) obtained (e.g., measured) based on one or more received signals. It may be desirable to improve on efficiently obtaining and processing CSI for ISAC.

SUMMARY

[0003] The present disclosure relates to a network entity, a UE, methods, apparatuses, processors, and computer readable medium for measurement and reporting for sensing. According to the proposed solution, enhancements for measurement and reporting for sensing are proposed.

[0004] In some implementations, there is provided a UE. The UE comprises at least one

memory; and at least one processor coupled with the at least one memory and configured to cause the UE to: receive, from a network entity being a sensing transmitter in an ISAC system, a measurement and reporting configuration for sensing, wherein the measurement and reporting configuration is associated with a set of reference signals (RS) configured for sensing one or more targets in the ISAC system; and transmit, to the network entity, a report according to the measurement and reporting configuration, wherein the report indicates a set of one or more measured values based on measuring the set of RSs.

[0005] In some implementations, there is provided a network entity. The network entity comprises at least one memory; and at least one processor coupled with the at least one memory and configured to cause the network entity to: transmit, to a user equipment, a measurement and reporting configuration for sensing, wherein the measurement and reporting configuration is associated with a set of RSs configured for sensing one or more targets in an ISAC system, wherein the network entity is a sensing transmitter in the ISAC system; and receive, from the user equipment, a report according to the measurement and reporting configuration, wherein the report indicates a set of one or more measured values based on measuring the set of RSs.

[0006] In some implementations, there is provided a method performed by the UE. The method comprises: receiving, from a network entity being a sensing transmitter in an ISAC system, a measurement and reporting configuration for sensing, wherein the measurement and reporting configuration is associated with a set of RSs configured for sensing one or more targets in the ISAC system; and transmitting, to the network entity, a report according to the measurement and reporting configuration, wherein the report indicates a set of one or more measured values based on measuring the set of RSs.

[0007] In some implementations, there is provided a method performed by the network entity. The method comprises: transmitting, to a user equipment, a measurement and reporting configuration for sensing, wherein the measurement and reporting configuration is associated with a set of RSs configured for sensing one or more targets in an ISAC system, wherein the network entity is a sensing transmitter in the ISAC system; and receiving, from the user equipment, a report according to the measurement and reporting configuration, wherein the report indicates a set of one or more measured values based on measuring the set of RSs.

[0008] In some implementations, there is provided a processor for wireless communication.

The processor comprises at least one controller coupled with at least one memory and configured to cause the processor to: receive, from a network entity being a sensing transmitter in an ISAC system, a measurement and reporting configuration for sensing, wherein the measurement and reporting configuration is associated with a set of RSs configured for sensing one or more targets in the ISAC system; and transmit, to the network entity, a report according to the measurement and reporting configuration, wherein the report indicates a set of one or more measured values based on measuring the set of RSs.

[0009] In some implementations, there is provided a processor for wireless communication. The processor comprises at least one controller coupled with at least one memory and configured to cause the processor to: transmit, to a user equipment, a measurement and reporting configuration for sensing, wherein the measurement and reporting configuration is associated with a set of RSs configured for sensing one or more targets in an ISAC system, wherein the network entity is a sensing transmitter in the ISAC system; and receive, from the user equipment, a report according to the measurement and reporting configuration, wherein the report indicates a set of one or more measured values based on measuring the set of RSs.

[0010] In some implementations of the methods and the UE described herein, further comprising: performing at least one of wireless communication and sensing according to the measurement and reporting configuration. In some implementations, the report comprises a CSI report.

[0011] In some implementations of the methods and the UE described herein, further comprising: performing at least one of positioning and sensing according to the measurement and reporting configuration. In some implementations, the report further comprises measurement results for positioning.

[0012] In some implementations of the methods and the UE described herein, further comprising: receiving, from the network entity, an indication comprising at least one of a purpose of the report or information needs to be included in the report; and generating the report based on the indication.

[0013] In some implementations of the methods and the network entity described herein, further comprising: transmitting, to the user equipment, an indication comprising at least one of a purpose of the report or information needs to be included in the report.

[0014] In some implementations of the methods and the network entity described herein, further comprising: receiving, from a core network entity, a sensing service request indicating

a requirement of sensing.

[0015] In some implementations of the methods, the network entity, and the UE described herein, the set of RSs comprises a set of channel state information-reference signals (CSI-RS).

[0016] In some implementations of the methods, the network entity, and the UE described herein, the set of RSs comprises a set of positioning reference signals (PRS).

[0017] In some implementations of the methods, the network entity, and the UE described herein, the purpose of the report comprises one of: communication, sensing, or hybrid communication and sensing.

[0018] In some implementations of the methods, the network entity, and the UE described herein, based on the purpose being sensing or hybrid communication and sensing, the information included in the report comprises at least one of: a first value of an angel of arrival (AoA) for sensing, a second value of an angle of department (AoD) for sensing, or a third value of a time of flight (ToF) for sensing.

[0019] In some implementations of the methods, the network entity, and the UE described herein, the indication comprises a bitmap with a set of bits, and each bit of the set of bits corresponds to a value associated with the sensing included in the report.

[0020] In some implementations of the methods, the network entity, and the UE described herein, the indication comprises at least one of a medium access control (MAC) control element (CE), or downlink control information (DCI).

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] FIG. 1 illustrates an example of a wireless communications system in which some embodiments of the present disclosure can be implemented;

[0022] FIG. 2A illustrates an example of a wireless communications network in which some embodiments of the present disclosure can be implemented;

[0023] FIG. 2B illustrates a signaling diagram for sensing in accordance with some example embodiments of the present disclosure;

[0024] FIG. 3 illustrates a signaling diagram in accordance with some example embodiments of the present disclosure;

[0025] FIG. 4A illustrates a signaling diagram for reusing CSI-RS and associated CSI report

for sensing in accordance with some example embodiments of the present disclosure;

[0026] FIG. 4B illustrates a signaling diagram for reusing PRS and associated PRS-based measurement report for sensing in accordance with some example embodiments of the present disclosure;

[0027] FIG. 5 illustrates an example of a device that is suitable for implementing embodiments of the present disclosure;

[0028] FIG. 6 illustrates an example of a processor that is suitable for implementing some embodiments of the present disclosure;

[0029] FIG. 7 illustrates a flowchart of an example method implemented at a UE in accordance with aspects of the present disclosure; and

[0030] FIG. 8 illustrates a flowchart of an example method implemented at a network entity in accordance with aspects of the present disclosure.

[0031] Throughout the drawings, the same or similar reference numerals represent the same or similar element.

DETAILED DESCRIPTION

[0032] **FIG. 1** illustrates an example of a wireless communications system 100 in which some embodiments of the present disclosure can be implemented. The wireless communications system 100 may include one or more network entities 102 (also referred to as network equipment (NE)), one or more UEs 104, a core network (CN) 106, and a packet data network 108. The wireless communications system 100 may support various radio access technologies. In some implementations, the wireless communications system 100 may be a 4G network, such as a long term evolution (LTE) network or an LTE-Advanced (LTE-A) network. In some other implementations, the wireless communications system 100 may be a 5G network, such as a new radio (NR) network. In other implementations, the wireless communications system 100 may be a combination of a 4G network and a 5G network, or other suitable radio access technology including Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20. The wireless communications system 100 may support radio access technologies beyond 5G. Additionally, the wireless communications system 100 may support technologies, such as time division multiple access (TDMA), frequency division multiple access (FDMA), or code division multiple access (CDMA), etc.

[0033] The one or more network entities 102 may be dispersed throughout a geographic region to form the wireless communications system 100. One or more of the network entities 102 described herein may be or include or may be referred to as a network node, a base station, a network element, a radio access network (RAN), a base transceiver station, an access point, a NodeB, an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. A network entity 102 and a UE 104 may communicate via a communication link 110, which may be a wireless or wired connection. For example, a network entity 102 and a UE 104 may perform wireless communication (e.g., receive signaling, transmit signaling) over a Uu interface.

[0034] A network entity 102 may provide a geographic coverage area 112 for which the network entity 102 may support services (e.g., voice, video, packet data, message, broadcast, etc.) for one or more UEs 104 within the geographic coverage area 112. For example, a network entity 102 and a UE 104 may support wireless communication of signals related to services (e.g., voice, video, packet data, messaging, broadcast, etc.) according to one or multiple radio access technologies. In some implementations, a network entity 102 may be moveable, for example, a satellite associated with a non-terrestrial network. In some implementations, different geographic coverage areas 112 associated with the same or different radio access technologies may overlap, but the different geographic coverage areas 112 may be associated with different network entities 102. Information and signals described herein may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[0035] The one or more UEs 104 may be dispersed throughout a geographic region of the wireless communications system 100. A UE 104 may include or may be referred to as a mobile device, a wireless device, a remote device, a remote unit, a handheld device, or a subscriber device, or some other suitable terminology. In some implementations, the UE 104 may be referred to as a unit, a station, a terminal, or a client, among other examples. Additionally, or alternatively, the UE 104 may be referred to as an Internet-of-Things (IoT) device, an Internet-of-Everything (IoE) device, or machine-type communication (MTC) device, among other examples. In some implementations, a UE 104 may be stationary in the wireless communications system 100. In some other implementations, a UE 104 may

be mobile in the wireless communications system 100.

[0036] The one or more UEs 104 may be devices in different forms or having different capabilities. Some examples of UEs 104 are illustrated in FIG. 1. A UE 104 may be capable of communicating with various types of devices, such as the network entities 102, other UEs 104, or network equipment (e.g., the CN 106, the packet data network 108, a relay device, an integrated access and backhaul (IAB) node, or another network equipment), as shown in FIG. 1. Additionally, or alternatively, a UE 104 may support communication with other network entities 102 or UEs 104, which may act as relays in the wireless communications system 100.

[0037] A UE 104 may also be able to support wireless communication directly with other UEs 104 over a communication link 114. For example, a UE 104 may support wireless communication directly with another UE 104 over a device-to-device (D2D) communication link. In some implementations, such as vehicle-to-vehicle (V2V) deployments, vehicle-to-everything (V2X) deployments, or cellular-V2X deployments, the communication link 114 may be referred to as a sidelink (SL). For example, a UE 104 may support wireless communication directly with another UE 104 over a PC5 interface.

[0038] A network entity 102 may support communications with the CN 106, or with another network entity 102, or both. For example, a network entity 102 may interface with the CN 106 through one or more backhaul links 116 (e.g., via an S1, N2, N3, or another network interface). The network entities 102 may communicate with each other over the backhaul links 116 (e.g., via an X2, Xn, or another network interface). In some implementations, the network entities 102 may communicate with each other directly (e.g., between the network entities 102). In some other implementations, the network entities 102 may communicate with each other or indirectly (e.g., via the CN 106). In some implementations, one or more network entities 102 may include subcomponents, such as an access network entity, which may be an example of an access node controller (ANC). An ANC may communicate with the one or more UEs 104 through one or more other access network transmission entities, which may be referred to as a radio heads, smart radio heads, or transmission-reception points (TRPs).

[0039] In some implementations, a network entity 102 may be configured in a disaggregated architecture, which may be configured to utilize a protocol stack physically or logically distributed among two or more network entities 102, such as an integrated access

backhaul (IAB) network, an open RAN (O-RAN) (e.g., a network configuration sponsored by the O-RAN Alliance), or a virtualized RAN (vRAN) (e.g., a cloud RAN (C-RAN)). For example, a network entity 102 may include one or more of a central unit (CU), a distributed unit (DU), a radio unit (RU), a RAN Intelligent Controller (RIC) (e.g., a Near-Real Time RIC (Near-RT RIC), a Non-Real Time RIC (Non-RT RIC)), a Service Management and Orchestration (SMO) system, or any combination thereof.

[0040] An RU may also be referred to as a radio head, a smart radio head, a remote radio head (RRH), a remote radio unit (RRU), or a transmission reception point (TRP). One or more components of the network entities 102 in a disaggregated RAN architecture may be co-located, or one or more components of the network entities 102 may be located in distributed locations (e.g., separate physical locations). In some implementations, one or more network entities 102 of a disaggregated RAN architecture may be implemented as virtual units (e.g., a virtual CU (VCU), a virtual DU (VDU), a virtual RU (VRU)).

[0041] Split of functionality between a CU, a DU, and an RU may be flexible and may support different functionalities depending upon which functions (e.g., network layer functions, protocol layer functions, baseband functions, radio frequency functions, and any combinations thereof) are performed at a CU, a DU, or an RU. For example, a functional split of a protocol stack may be employed between a CU and a DU such that the CU may support one or more layers of the protocol stack and the DU may support one or more different layers of the protocol stack. In some implementations, the CU may host upper protocol layer (e.g., a layer 3 (L3), a layer 2 (L2)) functionality and signaling (e.g., Radio Resource Control (RRC), service data adaption protocol (SDAP), Packet Data Convergence Protocol (PDCP)). The CU may be connected to one or more DUs or RUs, and the one or more DUs or RUs may host lower protocol layers, such as a layer 1 (L1) (e.g., physical (PHY) layer) or an L2 (e.g., radio link control (RLC) layer, medium access control (MAC) layer) functionality and signaling, and may each be at least partially controlled by the CU.

[0042] Additionally, or alternatively, a functional split of the protocol stack may be employed between a DU and an RU such that the DU may support one or more layers of the protocol stack and the RU may support one or more different layers of the protocol stack. The DU may support one or multiple different cells (e.g., via one or more RUs). In some implementations, a functional split between a CU and a DU, or between a DU and an RU may be within a protocol layer (e.g., some functions for a protocol layer may be performed by one of a CU, a DU, or an RU, while other functions of the protocol layer are performed

by a different one of the CU, the DU, or the RU).

[0043] A CU may be functionally split further into CU control plane (CU-CP) and CU user plane (CU-UP) functions. A CU may be connected to one or more DUs via a midhaul communication link (e.g., F1, F1-C, F1-U), and a DU may be connected to one or more RUs via a fronthaul communication link (e.g., open fronthaul (FH) interface). In some implementations, a midhaul communication link or a fronthaul communication link may be implemented in accordance with an interface (e.g., a channel) between layers of a protocol stack supported by respective network entities 102 that are in communication via such communication links.

[0044] The CN 106 may support user authentication, access authorization, tracking, connectivity, and other access, routing, or mobility functions. The CN 106 may be an evolved packet core (EPC), or a 5G core (5GC), which may include a control plane entity that manages access and mobility (e.g., a mobility management entity (MME), an access and mobility management functions (AMF)) and a user plane entity that routes packets or interconnects to external networks (e.g., a serving gateway (S-GW), a Packet Data Network (PDN) gateway (P-GW), or a user plane function (UPF)). In some implementations, the control plane entity may manage non-access stratum (NAS) functions, such as mobility, authentication, and bearer management (e.g., data bearers, signal bearers, etc.) for the one or more UEs 104 served by the one or more network entities 102 associated with the CN 106.

[0045] The CN 106 may communicate with the packet data network 108 over one or more backhaul links 116 (e.g., via an S1, N2, N3, or another network interface). The packet data network 108 may include an application server 118. In some implementations, one or more UEs 104 may communicate with the application server 118. A UE 104 may establish a session (e.g., a protocol data unit (PDU) session, or the like) with the CN 106 via a network entity 102. The CN 106 may route traffic (e.g., control information, data, and the like) between the UE 104 and the application server 118 using the established session (e.g., the established PDU session). The PDU session may be an example of a logical connection between the UE 104 and the CN 106 (e.g., one or more network functions of the CN 106).

[0046] In the wireless communications system 100, the network entities 102 and the UEs 104 may use resources of the wireless communications system 100 (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers)) to perform various operations (e.g., wireless communications). In some

implementations, the network entities 102 and the UEs 104 may support different resource structures. For example, the network entities 102 and the UEs 104 may support different frame structures. In some implementations, such as in 4G, the network entities 102 and the UEs 104 may support a single frame structure. In some other implementations, such as in 5G and among other suitable radio access technologies, the network entities 102 and the UEs 104 may support various frame structures (i.e., multiple frame structures). The network entities 102 and the UEs 104 may support various frame structures based on one or more numerologies.

[0047] One or more numerologies may be supported in the wireless communications system 100, and a numerology may include a subcarrier spacing and a cyclic prefix. A first numerology (e.g., μ=0) may be associated with a first subcarrier spacing (e.g., 15 kHz) and a normal cyclic prefix. In some implementations, the first numerology (e.g., μ=0) associated with the first subcarrier spacing (e.g., 15 kHz) may utilize one slot per subframe. A second numerology (e.g., μ=1) may be associated with a second subcarrier spacing (e.g., 30 kHz) and a normal cyclic prefix. A third numerology (e.g., μ=2) may be associated with a third subcarrier spacing (e.g., 60 kHz) and a normal cyclic prefix or an extended cyclic prefix. A fourth numerology (e.g., μ=3) may be associated with a fourth subcarrier spacing (e.g., 120 kHz) and a normal cyclic prefix. A fifth numerology (e.g., μ=4) may be associated with a fifth subcarrier spacing (e.g., 240 kHz) and a normal cyclic prefix.

[0048] A time interval of a resource (e.g., a communication resource) may be organized according to frames (also referred to as radio frames). Each frame may have a duration, for example, a 10 millisecond (*ms*) duration. In some implementations, each frame may include multiple subframes. For example, each frame may include 10 subframes, and each subframe may have a duration, for example, a 1 *ms* duration. In some implementations, each frame may have the same duration. In some implementations, each subframe of a frame may have the same duration.

[0049] Additionally or alternatively, a time interval of a resource (e.g., a communication resource) may be organized according to slots. For example, a subframe may include a number (e.g., quantity) of slots. The number of slots in each subframe may also depend on the one or more numerologies supported in the wireless communications system 100. For instance, the first, second, third, fourth, and fifth numerologies (i.e., μ=0, μ=1, μ=2, μ=3, μ=4) associated with respective subcarrier spacings of 15 kHz, 30 kHz, 60 kHz, 120 kHz, and 240 kHz may utilize a single slot per subframe, two slots per subframe, four slots per subframe,

eight slots per subframe, and 16 slots per subframe, respectively. Each slot may include a number (e.g., quantity) of symbols (e.g., OFDM symbols). In some implementations, the number (e.g., quantity) of slots for a subframe may depend on a numerology. For a normal cyclic prefix, a slot may include 14 symbols. For an extended cyclic prefix (e.g., applicable for 60 kHz subcarrier spacing), a slot may include 12 symbols. The relationship between the number of symbols per slot, the number of slots per subframe, and the number of slots per frame for a normal cyclic prefix and an extended cyclic prefix may depend on a numerology. It should be understood that reference to a first numerology (e.g., $\mu=0$) associated with a first subcarrier spacing (e.g., 15 kHz) may be used interchangeably between subframes and slots.

[0050] In the wireless communications system 100, an electromagnetic (EM) spectrum may be split, based on frequency or wavelength, into various classes, frequency bands, frequency channels, etc. By way of example, the wireless communications system 100 may support one or multiple operating frequency bands, such as frequency range designations FR1 (410 MHz – 7.125 GHz), FR2 (24.25 GHz – 52.6 GHz), FR3 (7.125 GHz – 24.25 GHz), FR4 (52.6 GHz – 114.25 GHz), FR4a or FR4-1 (52.6 GHz – 71 GHz), and FR5 (114.25 GHz – 300 GHz). In some implementations, the network entities 102 and the UEs 104 may perform wireless communications over one or more of the operating frequency bands. In some implementations, FR1 may be used by the network entities 102 and the UEs 104, among other equipment or devices for cellular communications traffic (e.g., control information, data). In some implementations, FR2 may be used by the network entities 102 and the UEs 104, among other equipment or devices for short-range, high data rate capabilities.

[0051] FR1 may be associated with one or multiple numerologies (e.g., at least three numerologies). For example, FR1 may be associated with a first numerology (e.g., $\mu=0$), which includes 15 kHz subcarrier spacing; a second numerology (e.g., $\mu=1$), which includes 30 kHz subcarrier spacing; and a third numerology (e.g., $\mu=2$), which includes 60 kHz subcarrier spacing. FR2 may be associated with one or multiple numerologies (e.g., at least 2 numerologies). For example, FR2 may be associated with a third numerology (e.g., $\mu=2$), which includes 60 kHz subcarrier spacing; and a fourth numerology (e.g., $\mu=3$), which includes 120 kHz subcarrier spacing.

[0052] As the metaverse continues to evolve, there is an increasing demand from industries for enhanced sensing services, including higher accuracy and broader sensing range. The improvement of sensing services imposes greater requirements on hardware platforms and

bandwidth. Therefore, it can be foreseen that future wireless networks, such as beyond 5G (B5G) and 6G, will integrate sensing functionalities on top of existing high-quality communication capabilities, thereby reducing hardware and bandwidth overheads.

[0053] Considering that the sensing functionalities will be used in variety scenarios, it is desirable to define a solution for enabling the sensing operations, e.g. in a wireless communication network comprising a network entity 102 and a UE 104. In the present disclosure, a solution for sensing is provided. In the solution, the network entity 102 can determine and transmits a measurement and reporting configuration for sensing to the UE 104, and the measurement and reporting configuration is associated with one or more reference signals for sensing. As such, the UE 104 can receive and measure the one or more reference signals for sensing, and in addition generate and transmit a report according to the associated measurement and reporting configuration. Therefore, the sensing can be enabled in the wireless communication network, and accordingly the sensing functionalities on top of the high-quality communication capabilities can be guaranteed.

[0054] ISAC is currently supported in the wireless communication network, and the research on the topic of ISAC is rapidly increasing due to the desire on sensing.

[0055] In certain scenarios, such as frequency division duplex (FDD) systems, where channel reciprocity is not present, CSI can be obtained through feedback. In detail, the transmitter transmits pilot signals, the receiver estimates CSI, and the transmitter obtains CSI information through feedback from the receiver. However, directly feeding back the whole CSI would incur high overhead and lower communication efficiency. Thus, existing communication systems compress the CSI using some ways. The compression design of CSI varies slightly between Wi-Fi and cellular scenarios.

[0056] In the ISAC system, the measured CSI from the received signal can be utilized for sensing because the signal undergoes reflections, refractions, and diffractions as it propagates through the physical environment, carrying information about the surrounding objects. Therefore, efficiently obtaining and processing CSI has become a key issue in ISAC.

[0057] In the Wi-Fi system, the feedback scheme based on singular value decomposition (SVD) is widely used. Specifically, the receiver estimates CSI and then performs SVD on the CSI matrix to obtain the feedback matrix. Subsequently, the feedback matrix is further compressed by utilizing Givens rotations to transform the feedback matrix into a series of angles and selecting appropriate quantization bits for quantization. Finally, the receiver

feeds back the quantized information to the transmitter, which then reconstructs the feedback matrix.

[0058] In cellular networks, the steps for compressing CSI are similar, and some compression algorithms based on sparsity, differential compression, etc., need to be chosen based on specific requirements.

[0059] However, sensing services may have different feedback requirements than that for communication. In this event, the feedback mechanism for CSI report for communication cannot be directly applied in the ISAC systems.

[0060] Example embodiments of the present disclosure provide a solution for measurement and reporting configuration for sensing. In the solution, a UE may be provided with a measurement and reporting configuration for sensing which is associated with a set of reference signals configured for sensing, such as a set of CSI-RSs. In addition, the UE may perform the sensing based on received reference signals and transmit a report based on the measurement and reporting configuration. As such, a measurement and reporting configuration for both communication and sensing in the ISAC system can be provided to the UE in some embodiments. Therefore, a sensing service can be guaranteed without affecting the communication. Principles and implementations of the present disclosure will be described in detail below with reference to the figures.

[0061] **FIG. 2A** illustrates an example of a wireless communications network 200 in which some embodiments of the present disclosure can be implemented. As shown in FIG. 2A, the wireless communications network 200 may include a network entity 102 and a UE 104, which may perform wireless communication (e.g., receive and/or transmit information) with each other. The UE 104 may be located within a geographic coverage area of the network entity 102. In the example of FIG. 2A, the network entity 102 may be a serving BS (such as a gNB) of the UE 104. In some implementations, the network entity 102 may transmit a downlink transmission to the UE 104 and receive an uplink transmission from the UE 104.

[0062] The wireless communications network 200 may include an ISAC system, for example, the wireless communications network 200 may further include one or more target entities (also referred to as targets) for sensing, such as a sensing target 230. In some implementations, the network entity 102 may be implemented as a sensing transmitter. The network entity 102 may transmit a sensing signal (e.g., a reference signal), and receive a signal reflected from one or more target entities (e.g., the sensing target 230).

[0063] As described herein, a sensing mode of UE-assisted gNB sensing may support wireless sensing in RAN. In this sensing mode, the gNB transmits sensing signal(s) and intends to determine one or more target entities (e.g., the sensing target 230), while the UE may assist the sensing of the gNB, for example, the UE may provide some information to the gNB for helping sensing. For example, the network entity 102 can transmit one or more reference signals (e.g., RSs 202) to the UE 104, and the UE 104 can transmit related information (e.g., the report 404), which may include one or more of CSI and sensing measurement results.

[0064] The wireless communications network 200 may also include a CN 106, which may include at least one CN entity 250. The CN entity 250 may include one or more network functions. For example, the CN entity 250 may include one or more of: a sensing function (SF) 251, a location management function (LMF) 252, etc.

[0065] It is to be understood that the numbers of network entities, UEs, targets, CN entities shown in FIG. 2A are for the purpose of illustration only. The wireless communications network 200 may include any suitable numbers of sensing transmitters, sensing receivers, and UEs.

[0066] **FIG. 2B** illustrates a signaling diagram 210 for sensing in accordance with some example embodiments of the present disclosure. The signaling diagram 210 may include a network entity 102 (e.g., a base station), a UE 104, and an SF 251, which may be examples of network entities 102, UEs 104, and/or SFs 251 as described herein with reference to FIGs. 1 and 2A. In the following description of the signaling diagram 210, the operations between the network entity 102, the UE 104, and/or the SF 251 may be transmitted in a different order than the example order shown, or the operations performed by the network entity 102, the UE 104, and/or the SF 251 may be performed at different orders or at different times. Some operations may also be omitted from the signaling diagram 210, and other operations may be added to the signaling diagram 210.

[0067] At 1, the SF 251 may transmit, and the network entity 102 may receive, a sensing service request.

[0068] At 2, the network entity 102 may generate one or more RAN configurations for sensing. The one or more RAN configurations may include a sensing reference signal configuration and a measurement configuration.

[0069] At 3, the network entity 102 may transmit, and the UE 104 may receive, the one or more RAN configurations including the sensing reference signal configuration and/or the measurement configuration.

[0070] At 4, the network entity 102 may transmit, and the UE 104 may receive, one or more sensing reference signal transmissions. For example, the network entity 102 may transmit, and the UE 104 may receive, one or more sensing reference signal transmissions (e.g., CSI-RSs, PRSs, etc.) based on the sensing reference signal configuration.

[0071] At 5, the UE 104 may calculate (e.g., obtain, determine, measure) sensing measurement results. For example, the UE 104 may calculate (e.g., obtain, determine, measure) sensing measurement results based on the measurement configuration.

[0072] At 6, the UE 104 may transmit, and the network entity 102 may receive, a report (also referred to as a sensing measurement results report) that indicates the sensing measurement results.

[0073] At 7, the network entity 102 may transmit (e.g., output, forward), and the SF 251 may receive, the report.

[0074] As described herein, the term "measurement and reporting configuration" may be used interchangeably with a measurement report configuration, a measurement configuration, a report configuration for measurement results, a CSI report configuration, a configuration for at least sensing report, a report configuration for at least sensing measurement results, or the like, the present disclosure does not limit for this aspect.

[0075] **FIG. 3** illustrates a signaling diagram 300 in accordance with some example embodiments of the present disclosure. The signaling diagram 300 may include a network entity 102 (e.g., a base station) and a UE 104, which may be examples of network entities 102 and UEs 104 as described herein with reference to FIGs. 1, 2A, and 2B. In the following description of the signaling diagram 300, the operations between the network entity 102 and the UE 104 may be transmitted in a different order than the example order shown, or the operations performed by the network entity 102 and the UE 104 may be performed at different orders or at different times. Some operations may also be omitted from the signaling diagram 300, and other operations may be added to the signaling diagram 300.

[0076] In the example of FIG. 3, the network entity 102 may be a sensing transmitter in an ISAC system and the UE 104 may be a sensing receiver in the ISAC system. It would be appreciated that the signaling diagram 300 may be applied to other scenarios, which will not

be described in detail.

[0077] At 310, the network entity 102 may transmit, and the UE 104 may receive, a reference signal configuration. In some examples, the reference signal configuration may be a CSI-RS configuration or a PRS configuration. The reference signal configuration may indicate a set of reference signals, for example, a reference signal resource set, such as a set of CSI-RS resources or a set of PRS resources. The set of reference signals may be configured for sensing. That is, one or more of the network entity 102 or the UE 104 may be configured to perform sensing based on the set of references signals. In some examples, there may be one or more sensing target entities in the ISAC system, and the set of reference signals may be used by one or more of the network entity 102 or the UE 104 for sensing the one or more sensing target entities in the ISAC system.

[0078] At 320, the network entity 102 may transmit, and the UE 104 may receive, a measurement and reporting configuration. In some implementations, the measurement and reporting configuration may be associated with the reference signal configuration. The measurement and reporting configuration may be associated with the set of reference signals (e.g., a set of CSI-RS resources or a set of PRS resources) indicated by the reference signal configuration. In some other examples, the reference signal configuration and the measurement and reporting configuration may be transmitted via a same message (e.g. RRC message/signaling) or different messages (e.g. two separate RRC messages).

[0079] The reference signal configuration may be a PRS configuration, and the measurement and reporting configuration may be a report configuration for both positioning and sensing. In this case, the set of reference signals may be one or more PRSs. The measurement and reporting configuration may configure the set of reference signals for one or more of: positioning, sensing, or for both positioning and sensing (joint/hybrid positioning and sensing).

[0080] The reference signal configuration may be a CSI-RS configuration, and the measurement and reporting configuration may be a CSI report configuration for both communication and sensing. In this case, the set of reference signals may be one or more CSI-RSs. The measurement and reporting configuration may configure the set of reference signals for one or more of: communication, sensing, or for both communication and sensing (joint/hybrid communication and sensing).

[0081] In some examples, three different purposes may be configured by the measurement

and reporting configuration, which include communication, sensing, and hybrid communication and sensing.

[0082] In some examples, the content (or information) needs to be included in a corresponding report may also be configured by the measurement and reporting configuration. In some examples, the content may be associated with the purpose. In some instances, the content (or information) may be configured based on various requirements of different sensing services that can be supported.

[0083] For the case of "communication" purpose, a legacy content defined in the current 3GPP NR specification (e.g. release 19) need be included in the corresponding report. For example, legacy parameters, such as channel quality indicator and compresses CSI, should be included in the corresponding report, such as a CSI report.

[0084] For the case of "sensing" purpose, multiple types of information may be considered for different requirements of different sensing services. For example, one or more values of AoA, AoD, ToF, etc. may be configured.

[0085] For the case of "hybrid communication and sensing" purpose, a combination of "communication" and "sensing" may be considered.

[0086] According to the configurations described, the report in the ISAC system can be enabled, based on the measurement and reporting configuration.

[0087] At 325, the network entity 102 may receive a sensing service request, e.g., for a specific sensing service, from a core network entity 250 (which is not illustrated in FIG. 3). For example, the core network entity 250 may be an SF 251. In some examples, the sensing service request may indicate a requirement of sensing. In some examples, the sensing service request may indicate one or more of: a type of the sensing service, information needed to the reported, etc.

[0088] In some instances, a type of the sensing service may include detecting target(s), e.g., to detect whether there are targets (such as people) in a specific area. In some instances, a type of the sensing service may include identifying specific target(s), e.g. to determine yes or no. In some instances, a type of the sensing service may include estimating, e.g., to classify something into a category.

[0089] In some instances, a requirement of a sensing may indicate CSI phase and amplitude. In some instances, a requirement of a sensing may indicate frequency response and delay.

In some instances, a requirement of a sensing may indicate angle, delay, and multipath effects information.

[0090] For a specific positioning service, the network entity 102 may receive a positioning request from a core network entity 250 (which is not illustrated in FIG. 3). For example, the core network entity 250 may be an LMF 252. In some examples, the positioning request may indicate one or more of: a type of positioning, an identifier of a target to be positioned, etc.

[0091] At 330, the network entity 102 may transmit, and the UE 104 may receive, reference signals. In some example embodiments, the reference signals may be transmitted based on the reference signal configuration at 310, for example, the reference signals include CSI-RSs or PRSs. At 335, the network entity 102 may transmit, and the UE 104 may receive, an indication, for example, the indication may indicate a purpose of a corresponding report and/or content need to be included in the corresponding report. In some examples, the indication may be included in a MAC CE or in a DCI. In some examples, the detailed meaning of the indication may be determined based on the measurement and reporting configuration, such as Table 1 below.

[0092] The indication may include a first indicator and/or a second indicator. The first indicator may indicate the purpose, for example, the first indicator may include 2 or more bits. The second indicator may indicate the content need to be included, for example, the second indicator may include 3 or more bits.

[0093] In some examples, the indication (e.g. the first indicator in the indication) may indicate a purpose, which is one of: communication (e.g., for communication only), sensing (e.g., for sensing only), or hybrid communication and sensing (e.g., for both communication and sensing). For example, the first indicator "00" indicates communication (e.g., for communication only), the first indicator "01" indicates sensing (e.g., for sensing only), the first indicator "10" indicates hybrid communication and sensing (e.g., for both communication and sensing), and the first indicator "11" is reserved. For another example, the first indicator "10" indicates communication (e.g., for communication only), the first indicator "01" indicates sensing (e.g., for sensing only), the first indicator "11" indicates hybrid communication and sensing (e.g., for both communication and sensing), and the first indicator "00" is reserved.

[0094] In some examples, the indication (e.g. the second indicator in the indication) may

indicate the content, in case the purpose is associated with sensing, e.g. if the purpose is sensing (e.g., for sensing only) or hybrid communication and sensing (e.g., for both communication and sensing). In some examples, the content may include one or more of: a first value of AoA for sensing, a second value of AoD for sensing, or a third value of ToF for sensing. In some examples, the second indicator may be a bitmap with a set of bits, for example, multiple bits are corresponding to multiple values for sensing respectively. For example, the second indicator "001" indicates a first value of AoA for sensing, the second indicator "010" indicates a second value of AoD for sensing, the second indicator "100" indicates a third value of ToF for sensing, the second indicator "011" indicates the first value and the second value, … etc.

[0095] Accordingly, when the purpose is "sensing" or "hybrid communication and sensing", the second indicator may be included in the indication, and the second indicator may be used for indicating the content to be included in the report. In some instances, the second indicator may be determined based on a requirement of a sensing service, e.g., a sensing service request received from an SF 251.

[0096] For ease of understanding, a detailed example is provided below in Table 1, which may be provided by the measurement and reporting configuration (CSI report configuration) at 320, e.g. via RRC signaling.

Table 1

First Indicator	Second Indicator	Reported information
00: communication	N/A	CSI for communication, e.g., PMIs with a given codebook.
01: sensing	001	Measured AoA value.
	010	Measured AoD value.
	100	Measured ToF value.
10: hybrid sensing and communication	001	CSI for communication, e.g., PMIs with a given codebook; and measured AoA value.
	010	CSI for communication, e.g., PMIs with a given codebook; and measured AoD value.
	100	CSI for communication, e.g., PMIs with a given codebook; and measured ToF value.
11: reserved	N/A	-

[0097] In some examples, the measurement and reporting configuration may provide

configurations as shown in Table 1 above, and the indication may indicate one case in the table.

[0098] As an example, the indication may be "01001", i.e. the first indicator is "01" and the second indicator is "001", which indicates that the purpose is sensing (e.g. for sensing only) and the content should include a value of AoA. As another example, the indication may be "10100", i.e. the first indicator is "10" and the second indicator is "100", which indicates that the purpose is hybrid communication and sensing (e.g. for both communication and sensing) and the content should include legacy CSI parameters and a value of ToF.

[0099] At 340, the UE 104 may generate a report based on the indication and the measurement and reporting configuration, e.g., by measuring the received reference signals.

[00100] In some implementations, the indication may indicate that the purpose is hybrid positioning and sensing (e.g. for both positioning and sensing), in this case, the report may be generated based on measurement results for positioning and measurement results for sensing. In some examples, the report may include measurement results for positioning and measurement results for sensing, for example, the measurement results for sensing may include one or more measured values for sensing.

[00101] In some implementations, the indication may indicate that the purpose is sensing (e.g. only for sensing), in this case, the report may be generated based on measurement results for sensing which may include one or more measured values for sensing.

[00102] In some implementations, the indication may indicate that the purpose is hybrid communication and sensing (e.g. for both communication and sensing), in this case, the report may be generated based on measurement results for communication and measurement results for sensing. In some examples, the report may include measurement results for communication (e.g. CSI) and measurement results for sensing (e.g., one or more measured values for sensing). With reference to FIG. 2A, the reference signals may be reflected by the sensing target 230 and measured by the UE 104.

[00103] In some example embodiments, the indication may include a first indicator and a second indicator as discussed above. As an example, if the indication is "01001", i.e. the first indicator is "01" and the second indicator is "001", then the UE 104 will generate the report including measured AoA value. As another example, if the indication is "10100", i.e. the first indicator is "10" and the second indicator is "100", then the UE 104 will generate the report including legacy CSI and measured ToF value.

[00104] At 350, the UE 104 may transmit, and the network entity 102 may receive, the report. In some implementations, if the purpose is sensing (e.g. for sensing only), the report may include measurement results for sensing, e.g., one or more measured values for sensing. In some implementations, if the purpose is hybrid positioning and sensing (e.g. for both positioning and sensing), the report may include both measurement results for positioning and measurement results for sensing. In some implementations, if the purpose is hybrid communication and sensing (e.g. for both communication and sensing), the report may include both measurement results for communication (e.g. CSI) and measurement results for sensing (e.g., one or more measured values for sensing).

[00105] In addition or alternatively, the network entity 102 may derive the measurement results for sensing (e.g., one or more measured values for sensing), and may transmit the measurement results for sensing (e.g., one or more measured values for sensing) to the core network entity 250, e.g. the SF 251.

[00106] It is to be understood that the embodiments with reference to FIG. 3 are only for illustration without any limitation, for example, some step(s) in FIG. 3 may be omitted, reordered, modified, or combined, some further step(s) may be also included, the present disclosure does not limit for this aspect. For example, the sensing service request may be received by the network entity 102, and the reference signal configuration and the measurement and reporting configuration may be generated based on the sensing service request. For example, a positioning service request may be received by the network entity 102 and a purpose for both positioning and sensing can be enabled.

[00107] As mentioned above, a set of RSs may be configured for sensing one or more targets in the ISAC system, and in some implementations, the set of RSs may be a set of CSI-RSs. For example, a set of CSI-RSs may be configured for both communication and sensing. In the present disclosure, the set of CSI-RSs may also be interchangeably used with one of: a CSI-RS resource set, a set of CSI-RS resources, one or more CSI-RSs, one or more CSI-RS resources, or the like, the present disclosure does not limit for this aspect.

[00108] **FIG. 4A** illustrates a signaling diagram 400 with a set of CSI-RSs configured for sensing in accordance with some example embodiments of the present disclosure. The signaling diagram 400 may include an SF 251, a network entity102 (e.g., a base station), and a UE 104, which may be examples of SFs 251, network entities 102 and UEs 104 as described herein with reference to FIGs. 1, 2A, and 2B. In the following description of the signaling

diagram 400, the operations between the network entity 102, the UE 104, and/or the SF 251 may be transmitted in a different order than the example order shown, or the operations performed by the network entity 102, the UE 104, and/or the SF 251 may be performed at different orders or at different times. Some operations may also be omitted from the signaling diagram 400, and other operations may be added to the signaling diagram 400.

[00109] At 401, the SF 251 may transmit, and the network entity 102 may receive, a sensing service request. In some implementations, the sensing service request may indicate one or more of: a type of the sensing service, information needed to the reported, etc.

[00110] At 402, the network entity 102 may generate the RAN configuration for sensing based on the sensing service request. In some implementations, the generated RAN configuration may include a CSI-RS configuration and a CSI report configuration.

[00111] At 403, the network entity 102 may transmit, and the UE 104 may receive, the CSI-RS configuration. At 404, the network entity 102 may transmit, and the UE 104 may receive, the CSI report configuration.

[00112] In some example embodiments, the CSI-RS configuration may indicate a set of CSI-RSs, e.g., which may be configured jointly considering requirements of communication and sensing. In some examples, the CSI-RS configuration may include a periodicity of the set of CSI-RSs and a number of ports associated with the set of CSI-RSs. For example, the CSI-RS configuration may be based on an enhancement of current CSI-RS configuration for communication.

[00113] In some example embodiments, the CSI report configuration may indicate a purpose and information to be reported. In some examples, the purpose may be "hybrid communication and sensing", and the information to be reported may include one or more of AoA, AoD, or ToF which may be determined based on the sensing service request.

[00114] At 405, the network entity 102 may transmit, and the UE 104 may receive, the CSI-RS transmission. At 406, the UE 104 may calculate CSI for communication and sensing, e.g. based on the received CSI-RS transmission.

[00115] At 407, the UE 104 may transmit, and the network entity 102 may receive, a CSI report. In some implementations, the CSI report, which is based on the CSI report configuration, includes CSI for communication and measured value(s) for sensing.

[00116] At 408, the network entity 102 may derive, from the CSI report, the CSI for

communication. In addition, at 409, the network entity 102 may transmit, and the SF 251 may receive, the sensing measurement results, e.g., including the measured value(s) for sensing.

[00117] According to embodiments with reference to FIG. 4A, a solution of enhancement of CSI-RS configuration and CSI report configuration is provided for supporting both communication and sensing. The scheme can jointly consider performance of both communication and sensing, so that the feedback from the UE can include auxiliary communication information and sensing information.

[00118] As mentioned above, a set of RSs may be configured for sensing one or more targets in the ISAC system, and in some implementations, the set of RSs may be a set of PRSs. For example, a set of PRSs may be configured for both positioning and sensing. In the present disclosure, the set of PRSs may also be interchangeably used with one of: a PRS resource set, a set of PRS resources, one or more PRSs, one or more PRS resources, or the like, the present disclosure does not limit for this aspect.

[00119] **FIG. 4B** illustrates a signaling diagram 450 with a set of PRSs configured for sensing in accordance with some example embodiments of the present disclosure. The signaling diagram 450 may include an SF 251, an LMF 252, a network entity102 (e.g., a base station), and a UE 104, which may be examples of SFs 251, LMFs 252, network entities 102, and UEs 104 as described herein with reference to FIGs. 1, 2A, and 2B. In the following description of the signaling diagram 450, the operations between the network entity 102, the UE 104, the SF 251, and/or the LMF 252 may be transmitted in a different order than the example order shown, or the operations performed by the network entity 102, the UE 104, the SF 251, and/or the LMF 252 may be performed at different orders or at different times. Some operations may also be omitted from the signaling diagram 450, and other operations may be added to the signaling diagram 450.

[00120] At 451, the SF 251 may transmit, and the network entity 102 may receive, a sensing service request. At 452, the LMF 252 may transmit, and the network entity 102 may receive, a positioning request. In some implementations, the sensing service request may indicate one or more of: a type of the sensing service, information needed to the reported, etc. In some implementations, the positioning request may indicate one or more of: a type of positioning, an identifier of a target to be positioned, etc.

[00121] At 453, the network entity 102 may generate the RAN configuration for sensing,

e.g., based on the sensing service request and the positioning request. In some implementations, the generated RAN configuration may include a PRS configuration and a positioning measurement configuration.

[00122] At 454, the network entity 102 may transmit, and the UE 104 may receive, the PRS configuration. At 455, the network entity 102 may transmit, and the UE 104 may receive, the positioning measurement configuration.

[00123] In some example embodiments, the PRS configuration may indicate a set of PRSs, e.g., which may be configured jointly considering requirements of positioning and sensing. In some examples, the PRS configuration may include a periodicity of the set of PRSs and a number of ports associated with the set of PRSs. For example, the PRS configuration may be based on an enhancement of current PRS configuration for positioning.

[00124] In some example embodiments, the positioning measurement configuration may indicate a purpose and information to be reported. In some examples, the purpose may be "joint (or hybrid) positioning and sensing", and the information to be reported may include one or more of AoA, AoD, or ToF which may be determined based on the sensing service request. In some examples, the information to be reported may further include measured distance-related information, which may be determined based on the positioning request.

[00125] At 456, the network entity 102 may transmit, and the UE 104 may receive, the PRS transmission. At 457, the UE 104 may calculate measurement results for positioning and sensing, e.g., based on the received PRS transmission.

[00126] At 458, the UE 104 may transmit, and the network entity 102 may receive, a report including the measurement results. In some implementations, the report, which is based on the positioning measurement configuration, includes measurement results for positioning and measurement results, e.g., measured value(s), for sensing.

[00127] The network entity 102 may derive, from the report, the measurement results for positioning. At 459, the network entity 102 may transmit, and the LMF 252 may receive, the measurement results for positioning.

[00128] The network entity 102 may derive, from the report, the measurement results for sensing, e.g., including the measured value(s) for sensing. At 460, the network entity 102 may transmit, and the SF 251 may receive, the measurement results for sensing, e.g., including the measured value(s) for sensing.

[00129] According to embodiments with reference to FIG. 4B, a solution of enhancement of PRS configuration and positioning measurement configuration is provided for supporting both positioning and sensing.

[00130] According to embodiments with reference to FIGs. 2A-4B, a solution for measurement and reporting for sensing is provided. In the solution, the UE may be configured with a set of reference signals which are configured for sensing one or more targets in the ISAC system, and may also be configured with a measurement and reporting configuration associated with the set of reference signals. As such, the UE can transmit, to the network entity, a report according to the measurement and reporting configuration based on measuring the set of reference signals configured for sensing. Therefore, the report may be used by the network entity for sensing one or more targets in the ISAC system.

[00131] It is to be noted that some embodiments have been discussed above with examples of CSI-RSs or PRSs, in some other examples, the reference signals for sensing may be other types, such as synchronization signal blocks (SSB) or the like, the present disclosure does not limit for this aspect.

[00132] **FIG. 5** illustrates an example of a device 500 that is suitable for implementing embodiments of the present disclosure. The device 500 may be an example of a UE or a BS as described herein. The device 500 may support wireless communication with a network entity 102, a UE 104, or any combination thereof. The device 500 may include components for bi-directional communications including components for transmitting and receiving communications, such as a processor 502, a memory 504, a transceiver 506, and, optionally, an I/O controller 508. These components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

[00133] The processor 502, the memory 504, the transceiver 506, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. For example, the processor 502, the memory 504, the transceiver 506, or various combinations or components thereof may support a method for performing one or more of the operations described herein.

[00134] In some implementations, the processor 502, the memory 504, the transceiver 506, or various combinations or components thereof may be implemented in hardware (e.g., in communications management circuitry). The hardware may include a processor, a digital

signal processor (DSP), an application-specific integrated circuit (ASIC), a field-programmable gate array (FPGA) or other programmable logic device, a discrete gate or transistor logic, discrete hardware components, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure. In some implementations, the processor 502 and the memory 504 coupled with the processor 502 may be configured to perform one or more of the functions described herein (e.g., executing, by the processor 502, instructions stored in the memory 504).

[00135] For example, the processor 502 may support wireless communication at the device 500 in accordance with examples as disclosed herein. The processor 502 may be configured to operable to support a means for operations discussed above.

[00136] The processor 502 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, a microcontroller, an ASIC, an FPGA, a programmable logic device, a discrete gate or transistor logic component, a discrete hardware component, or any combination thereof). In some implementations, the processor 502 may be configured to operate a memory array using a memory controller. In some other implementations, a memory controller may be integrated into the processor 502. The processor 502 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 504) to cause the device 500 to perform various functions of the present disclosure.

[00137] The memory 504 may include random access memory (RAM) and read-only memory (ROM). The memory 504 may store computer-readable, computer-executable code including instructions that, when executed by the processor 502 cause the device 500 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. In some implementations, the code may not be directly executable by the processor 502 but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some implementations, the memory 504 may include, among other things, a basic I/O system (BIOS) which may control basic hardware or software operation such as the interaction with peripheral components or devices.

[00138] The I/O controller 508 may manage input and output signals for the device 500. The I/O controller 508 may also manage peripherals not integrated into the device 500. In some implementations, the I/O controller 508 may represent a physical connection or port to

an external peripheral. In some implementations, the I/O controller 508 may utilize an operating system such as iOS®, ANDROID®, MS-WINDOWS®, OS/2®, UNIX®, LINUX®, or another known operating system. In some implementations, the I/O controller 508 may be implemented as part of a processor, such as the processor 502. In some implementations, a user may interact with the device 500 via the I/O controller 508 or via hardware components controlled by the I/O controller 508.

[00139] In some implementations, the device 500 may include a single antenna 510. However, in some other implementations, the device 500 may have more than one antenna 510 (i.e., multiple antennas), including multiple antenna panels or antenna arrays, which may be capable of concurrently transmitting or receiving multiple wireless transmissions. The transceiver 506 may communicate bi-directionally, via the one or more antennas 510, wired, or wireless links as described herein. For example, the transceiver 506 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 506 may also include a modem to modulate the packets, to provide the modulated packets to one or more antennas 510 for transmission, and to demodulate packets received from the one or more antennas 510. The transceiver 506 may include one or more transmit chains, one or more receive chains, or a combination thereof.

[00140] A transmit chain may be configured to generate and transmit signals (e.g., control information, data, packets). The transmit chain may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature amplitude modulation (QAM). The transmit chain may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmit chain may also include one or more antennas 510 for transmitting the amplified signal into the air or wireless medium.

[00141] A receive chain may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receive chain may include one or more antennas 510 for receive the signal over the air or wireless medium. The receive chain may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receive chain may include at least one demodulator configured to demodulate the receive signal and obtain the transmitted data by reversing the modulation

technique applied during transmission of the signal. The receive chain may include at least one decoder for decoding the processing the demodulated signal to receive the transmitted data.

[00142] FIG. 6 illustrates an example of a processor 600 that is suitable for implementing some embodiments of the present disclosure. The processor 600 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 600 may include a controller 602 configured to perform various operations in accordance with examples as described herein. The processor 600 may optionally include at least one memory 604, such as L1/L2/L3 cache. Additionally, or alternatively, the processor 600 may optionally include one or more arithmetic-logic units (ALUs) 606. One or more of these components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

[00143] The processor 600 may be a processor chipset and include a protocol stack (e.g., a software stack) executed by the processor chipset to perform various operations (e.g., receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) in accordance with examples as described herein. The processor chipset may include one or more cores, one or more caches (e.g., memory local to or included in the processor chipset (e.g., the processor 600) or other memory (e.g., random access memory (RAM), read-only memory (ROM), dynamic RAM (DRAM), synchronous dynamic RAM (SDRAM), static RAM (SRAM), ferroelectric RAM (FeRAM), magnetic RAM (MRAM), resistive RAM (RRAM), flash memory, phase change memory (PCM), and others).

[00144] The controller 602 may be configured to manage and coordinate various operations (e.g., signaling, receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) of the processor 600 to cause the processor 600 to support various operations in accordance with examples as described herein. For example, the controller 602 may operate as a control unit of the processor 600, generating control signals that manage the operation of various components of the processor 600. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[00145] The controller 602 may be configured to fetch (e.g., obtain, retrieve, receive)

instructions from the memory 604 and determine subsequent instruction(s) to be executed to cause the processor 600 to support various operations in accordance with examples as described herein. The controller 602 may be configured to track memory address of instructions associated with the memory 604. The controller 602 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 602 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 600 to cause the processor 600 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 602 may be configured to manage flow of data within the processor 600. The controller 602 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 600.

[00146] The memory 604 may include one or more caches (e.g., memory local to or included in the processor 600 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementations, the memory 604 may reside within or on a processor chipset (e.g., local to the processor 600). In some other implementations, the memory 604 may reside external to the processor chipset (e.g., remote to the processor 600).

[00147] The memory 604 may store computer-readable, computer-executable code including instructions that, when executed by the processor 600, cause the processor 600 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. The controller 602 and/or the processor 600 may be configured to execute computer-readable instructions stored in the memory 604 to cause the processor 600 to perform various functions. For example, the processor 600 and/or the controller 602 may be coupled with or to the memory 604, the processor 600, the controller 602, and the memory 604 may be configured to perform various functions described herein. In some examples, the processor 600 may include multiple processors and the memory 604 may include multiple memories. One or more of the multiple processors may be coupled with one or more of the multiple memories, which may, individually or collectively, be configured to perform various functions herein.

[00148] The one or more ALUs 606 may be configured to support various operations in accordance with examples as described herein. In some implementations, the one or more ALUs 606 may reside within or on a processor chipset (e.g., the processor 600). In some other implementations, the one or more ALUs 606 may reside external to the processor

chipset (e.g., the processor 600). One or more ALUs 606 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 606 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 606 be configured with a variety of logical and arithmetic circuits, including adders, subtractors, shifters, and logic gates, to process and manipulate the data according to the operation. Additionally, or alternatively, the one or more ALUs 606 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 606 to handle conditional operations, comparisons, and bitwise operations.

[00149] The processor 600 may support wireless communication in accordance with examples as disclosed herein. The processor 600 may be configured to or operable to support a means for operations described in some embodiments of the present disclosure.

[00150] FIG. 7 illustrates a flowchart of a method 700 performed by a UE in accordance with aspects of the present disclosure. The operations of the method 700 may be implemented by a device or its components as described herein. For example, the operations of the method 700 may be performed by the UE 104 in FIG. 2A. In some implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or alternatively, the device may perform aspects of the described functions using special-purpose hardware.

[00151] At 710, the method may include receiving, from a network entity being a sensing transmitter in an ISAC system, a measurement and reporting configuration for sensing, wherein the measurement and reporting configuration is associated with a set of RSs configured for sensing one or more targets in the ISAC system. The operations of 710 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 710 may be performed by the UE 104 as described with reference to FIG. 2A.

[00152] At 720, the method may include transmitting, to the network entity, a report according to the measurement and reporting configuration, wherein the report indicates a set of one or more measured values based on measuring the set of RSs. The operations of 720 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 720 may be performed by the UE 104 as described with reference to FIG. 2A.

[00153] FIG. 8 illustrates a flowchart of a method 800 performed by a network entity in accordance with aspects of the present disclosure. The operations of the method 800 may be implemented by a device or its components as described herein. For example, the operations of the method 800 may be performed by the network entity 102 in FIG. 2A. In some implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or alternatively, the device may perform aspects of the described functions using special-purpose hardware.

[00154] At 810, the method may include transmitting, to a user equipment, a measurement and reporting configuration for sensing, wherein the measurement and reporting configuration is associated with a set of RSs configured for sensing one or more targets in an ISAC system, wherein the network entity is a sensing transmitter in the ISAC system. The operations of 810 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 810 may be performed by the network entity 102 as described with reference to FIG. 2A.

[00155] At 820, the method may include receiving, from the user equipment, a report according to the measurement and reporting configuration, wherein the report indicates a set of one or more measured values based on measuring the set of RSs. The operations of 820 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 820 may be performed by the network entity 102 as described with reference to FIG. 2A.

[00156] It should be noted that the methods described herein describes possible implementations, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible. Further, aspects from two or more of the methods may be combined.

[00157] The various illustrative blocks and components described in connection with the disclosure herein may be implemented or performed with a general-purpose processor, a DSP, an ASIC, a CPU, an FPGA or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but in the alternative, the processor may be any processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices (e.g., a combination of a DSP and a microprocessor, multiple microprocessors, one or more

microprocessors in conjunction with a DSP core, or any other such configuration.

[00158] The functions described herein may be implemented in hardware, software executed by a processor, firmware, or any combination thereof. If implemented in software executed by a processor, the functions may be stored on or transmitted over as one or more instructions or code on a computer-readable medium. Other examples and implementations are within the scope of the disclosure and appended claims. For example, due to the nature of software, functions described herein may be implemented using software executed by a processor, hardware, firmware, hardwiring, or combinations of any of these. Features implementing functions may also be physically located at various positions, including being distributed such that portions of functions are implemented at different physical locations.

[00159] Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage medium may be any available medium that may be accessed by a general-purpose or special-purpose computer. By way of example, non-transitory computer-readable media may include RAM, ROM, electrically erasable programmable ROM (EEPROM), flash memory, compact disk (CD) ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other non-transitory medium that may be used to carry or store desired program code means in the form of instructions or data structures and that may be accessed by a general-purpose or special-purpose computer, or a general-purpose or special-purpose processor.

[00160] Principles of the present disclosure have been described with reference to some embodiments. It is to be understood that these embodiments are described only for the purpose of illustration and help those skilled in the art to understand and implement the present disclosure, without suggesting any limitation as to the scope of the disclosure. The disclosure described herein can be implemented in various manners other than the ones described above. In the description and claims, unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skills in the art to which this disclosure belongs.

[00161] References in the present disclosure to "one embodiment," "an example embodiment," "an embodiment," "some embodiments," and the like indicate that the embodiment(s) described may include a particular feature, structure, or characteristic, but it is not necessary that every embodiment includes the particular feature, structure, or

characteristic. Moreover, such phrases do not necessarily refer to the same embodiment(s). Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

[00162] It shall be understood that although the terms "first" and "second" or the like may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another element. For example, a first element could also be termed as a second element, and similarly, a second element could also be termed as a first element, without departing from the scope of embodiments. As used herein, the term "and/or" includes any and all combinations of one or more of the listed terms. In some examples, values, procedures, or apparatuses are referred to as "best," "lowest," "highest," "minimum," "maximum," or the like. It will be appreciated that such descriptions are intended to indicate that a selection among many used functional alternatives can be made, and such selections need not be better, smaller, higher, or otherwise preferable to other selections.

[00163] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of embodiments. As used herein, the singular forms "a," "an", and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises," "comprising," "has," "having," "includes", and/or "including," when used herein, specify the presence of stated features, elements, components and/or the like, but do not preclude the presence or addition of one or more other features, elements, components and/or combinations thereof. For example, the term "includes" and its variants are to be read as open terms that mean "includes, but is not limited to." The term "based on" is to be read as "based at least in part on." The term "one embodiment" and "an embodiment" are to be read as "at least one embodiment." The term "another embodiment" is to be read as "at least one other embodiment." The use of an expression such as "A and/or B" can mean either "only A" or "only B" or "both A and B." Other definitions, explicit and implicit, may be included below.

[00164] As used herein, including in the claims, an article "a" before an element is unrestricted and understood to refer to "at least one" of those elements or "one or more" of those elements. The terms "a," "at least one," "one or more," and "at least one of one or more" may be interchangeable. As used herein, including in the claims, "or" as used in a

list of items (e.g., a list of items prefaced by a phrase such as "at least one of" or "one or more of" or "one or both of") indicates an inclusive list such that, for example, a list of at least one of A, B, or C means A or B or C or AB or AC or BC or ABC (i.e., A and B and C). Also, as used herein, the phrase "based on" shall not be construed as a reference to a closed set of conditions. For example, an example step that is described as "based on condition A" may be based on both a condition A and a condition B without departing from the scope of the present disclosure. In other words, as used herein, the phrase "based on" shall be construed in the same manner as the phrase "based at least in part on. Further, as used herein, including in the claims, a "set" may include one or more elements.

[00165] The description herein is provided to enable a person having ordinary skill in the art to make or use the disclosure. Various modifications to the disclosure will be apparent to a person having ordinary skill in the art, and the generic principles defined herein may be applied to other variations without departing from the scope of the disclosure. Thus, the disclosure is not limited to the examples and designs described herein but is to be accorded the broadest scope consistent with the principles and novel features disclosed herein.

CLAIMS

What is claimed is:

1. A user equipment (UE), comprising:

at least one memory; and

at least one processor coupled with the at least one memory and configured to cause the UE to:

receive, from a network entity being a sensing transmitter in an integrated sensing and communication (ISAC) system, a measurement and reporting configuration for sensing, wherein the measurement and reporting configuration is associated with a set of reference signals (RS) configured for sensing one or more targets in the ISAC system; and

transmit, to the network entity, a report according to the measurement and reporting configuration, wherein the report indicates a set of one or more measured values based on measuring the set of RSs.

2. The UE of claim 1, wherein the at least one processor is further configured to cause the UE to perform at least one of wireless communication and sensing according to the measurement and reporting configuration, and wherein the set of RSs comprises a set of channel state information-reference signals (CSI-RS).

3. The UE of claim 1, wherein the at least one processor is further configured to cause the UE to perform at least one of positioning and sensing according to the measurement and reporting configuration, and wherein the set of RSs comprises a set of positioning reference signals (PRS).

4. The UE of claim 2, wherein the at least one processor is further configured to cause the UE to:

receive, from the network entity, an indication comprising at least one of a purpose of the report or information needs to be included in the report; and

generate the report based on the indication, wherein the report comprises a CSI report.

5. The UE of claim 4, wherein the purpose of the report comprises one of: communication, sensing, or hybrid communication and sensing.

6. The UE of claim 4, wherein, based on the purpose being sensing or hybrid communication and sensing, the information included in the report comprises at least one of:

a first value of an angel of arrival (AoA) for sensing,

a second value of an angle of department (AoD) for sensing, or

a third value of a time of flight (ToF) for sensing.

7. The UE of claim 6, wherein the indication comprises a bitmap with a set of bits, and each bit of the set of bits corresponds to a value associated with the sensing included in the report.

8. The UE of claim 4, wherein the indication comprises at least one of a medium access control (MAC) control element (CE), or downlink control information (DCI).

9. A network entity comprising:

at least one memory; and

at least one processor coupled with the at least one memory and configured to cause the network entity to:

transmit, to a user equipment, a measurement and reporting configuration for sensing, wherein the measurement and reporting configuration is associated with a set of reference signals (RS) configured for sensing one or more targets in an integrated sensing and communication (ISAC) system, wherein the network entity is a sensing transmitter in the ISAC system; and

receive, from the user equipment, a report according to the measurement and reporting configuration, wherein the report indicates a set of one or more measured values based on measuring the set of RSs.

10. The network entity of claim 9, wherein the set of RSs comprises a set of channel state information-reference signals (CSI-RS).

11. The network entity of claim 9, wherein the set of RSs comprises a set of positioning reference signals (PRS).

12. The network entity of claim 11, wherein the report further comprises measurement results for positioning.

13. The network entity of claim 10, wherein the at least one processor is further configured to cause the network entity to:

transmit, to the user equipment, an indication comprising at least one of a purpose of the report or information needs to be included in the report.

14. The network entity of claim 13, wherein the purpose of the report comprises one of: communication, sensing, or hybrid communication and sensing.

15. The network entity of claim 13, wherein, based on the purpose being sensing or hybrid communication and sensing, the information included in the report comprises at least one of:

a first value of an angel of arrival (AoA) for sensing,

a second value of an angle of department (AoD) for sensing, or

a third value of a time of flight (ToF) for sensing.

16. The network entity of claim 15, wherein the indication comprises a bitmap with a set of bits, and each bit of the set of bits corresponds to a value associated with the sensing included in the report.

17. The network entity of claim 13, wherein the indication comprises at least one of a medium access control (MAC) control element (CE), or downlink control information (DCI).

18. The network entity of claim 9, wherein the at least one processor is further configured to cause the network entity to:

receive, from a core network entity, a sensing service request indicating a requirement of sensing.

19. A method performed by a user equipment, comprising:

receiving, from a network entity being a sensing transmitter in an integrated sensing and communication (ISAC) system, a measurement and reporting configuration for sensing, wherein the measurement and reporting configuration is associated with a set of reference signals (RS) configured for sensing one or more targets in the ISAC system; and

transmitting, to the network entity, a report according to the measurement and reporting configuration, wherein the report indicates a set of one or more measured values based on measuring the set of RSs.

20. A method performed by a network entity, comprising:

transmitting, to a user equipment, a measurement and reporting configuration for sensing, wherein the measurement and reporting configuration is associated with a set of reference signals (RS) configured for sensing one or more targets in an integrated sensing and communication (ISAC) system, wherein the network entity is a sensing transmitter in the ISAC system; and

receiving, from the user equipment, a report according to the measurement and reporting configuration, wherein the report indicates a set of one or more measured values based on measuring the set of RSs.