

BEAM MANAGEMENT FOR SENSING SERVICES

TECHNICAL FIELD

[0001] The present disclosure relates to wireless communications, and more specifically to a user equipment (UE) for wireless communication, a network entity for wireless communication, a processor for wireless communication, methods, and a computer readable medium for beam management for sensing services.

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, among other suitable radio access technologies beyond 5G (e.g., sixth generation (6G)).

[0003] Radio information obtained during signal processing can be used to detect environmental changes caused by motion of objects and people, which is termed as radio sensing or wireless sensing, similar with radar. Some examples of ubiquitous radio sensing services are safe autonomous vehicles, environment mapping to improve positioning accuracy and enable environment related applications and real-time monitoring for intrusion detection, etc. Introducing sensing capability into cellular wireless communication system has the benefit of sharing the same spectrum and infrastructure especially on the industry with both communication and sensing, which is

one of the promising techniques in next generation radio access network (RAN), e.g., beyond 5G (B5G)/6G.

SUMMARY

[0004] The present disclosure relates to a user equipment (UE) for wireless communication, a network entity for wireless communication, a processor for wireless communication, methods, and a computer readable medium for beam management for sensing services.

[0005] In a first aspect, there is provided a UE for wireless communication. 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 a set of one or more configurations associated with a sensing service, wherein each configuration of the set of one or more configurations comprises at least one corresponding sensing occasion including at least one reference signal transmission occasion, wherein the at least one reference signal transmission occasion is associated with a corresponding beam pair comprising at least one transmission beam and at least one reception beam; determine a set of one or more resources associated with the at least one reference signal transmission occasion; and transmit a report comprising a set of one or more measurement values as sensing data associated with a set of one or more measurements on the set of one or more resources associated with the at least one reference signal transmission occasion.

[0006] In a second aspect, there is provided a network entity for wireless communication. 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 a set of one or more configurations associated with a sensing service, wherein each configuration of the set of one or more configurations comprises at least one corresponding sensing occasion including at least one reference signal transmission occasion, wherein the at least one reference signal transmission occasion is associated with a corresponding beam pair comprising at least one transmission beam and at least one reception beam; determine a set of one or more resources associated with the at least one reference signal transmission occasion; and receive a report comprising a set of one or more measurement values as sensing data associated with a set of one or more measurements on the set of one or more resources associated with the at least one reference signal transmission occasion.

[0007] In a third aspect, there is provided a processor for wireless communication. The processor comprises at least one memory; and a controller coupled with the at least one memory and configured to cause the controller to: receive a set of one or more configurations associated with a sensing service, wherein each configuration of the set of one or more configurations comprises at least one corresponding sensing occasion including at least one reference signal transmission occasion, wherein the at least one reference signal transmission occasion is associated with a corresponding beam pair comprising at least one transmission beam and at least one reception beam; determine a set of one or more resources associated with the at least one reference signal transmission occasion; and transmit a report comprising a set of one or more measurement values as sensing data associated with a set of one or more measurements on the set of one or more resources associated with the at least one reference signal transmission occasion.

[0008] In a fourth aspect, there is provided method performed by a user equipment (UE), the method comprising: receiving a set of one or more configurations associated with a sensing service, wherein each configuration of the set of one or more configurations comprises at least one corresponding sensing occasion including at least one reference signal transmission occasion, wherein the at least one reference signal transmission occasion is associated with a corresponding beam pair comprising at least one transmission beam and at least one reception beam; determining a set of one or more resources associated with the at least one reference signal transmission occasion; and transmitting a report comprising a set of one or more measurement values as sensing data associated with a set of one or more measurements on the set of one or more resources associated with the at least one reference signal transmission occasion.

[0009] In a fifth aspect, there is provided method performed by a network entity, the method comprising: transmitting a set of one or more configurations associated with a sensing service, wherein each configuration of the set of one or more configurations comprises at least one corresponding sensing occasion including at least one reference signal transmission occasion, wherein the at least one reference signal transmission occasion is associated with a corresponding beam pair comprising at least one transmission beam and at least one reception beam; determining a set of one or more resources associated with the at least one reference signal transmission occasion; and receiving a report comprising a set of one or more measurement values as sensing data

associated with a set of one or more measurements on the set of one or more resources associated with the at least one reference signal transmission occasion.

[0010] In a sixth aspect, there is provided a computer readable medium having instructions stored thereon, the instructions, when executed by a processor of an apparatus, causing the apparatus to perform the method according to the fourth or the fifth aspect of the disclosure.

[0011] In some implementations of the methods, the UE and the network entity described herein, the UE may select at least one configuration of the set of one or more configurations associated with the sensing service based at least in part on a set of one or more reference signal measurements, wherein a set of one or more reference signal transmissions is associated with a corresponding beam pair comprising a corresponding transmission beam and a corresponding reception beam.

[0012] In some implementations of the methods, the UE and the network entity described herein, to select at least one configuration, the UE may determine, for each of the set of one or more configurations, an effective angle spread based at least in part on an effective receiving angle for the corresponding reception beam of the corresponding beam pair and the set of one or more reference signal measurements; and report the effective angle spread and an index of the configuration.

[0013] In some implementations of the methods, the UE and the network entity described herein, the at least one configuration is associated with a maximum effective angle spread.

[0014] In some implementations of the methods, the UE and the network entity described herein, to select at least one configuration, the UE may report the set of one or more reference signal measurements and corresponding beam pairs; and receive information on at least one selected beam pair from the reported beam pairs.

[0015] In some implementations of the methods, the UE and the network entity described herein, the UE may receive, via higher layer signaling, an indication of at least one configuration of the set of one or more configurations associated with the sensing service; and select the at least one configuration based at least in part on the indication.

[0016] In some implementations of the methods, the UE and the network entity described herein, each configuration of the set of one or more configurations is associated with requirements of the sensing service and comprises a set of one or more parameters comprising: a corresponding duration of a corresponding sensing occasion, a corresponding periodicity of the corresponding sensing occasion, a set of one or more corresponding resources associated with a corresponding reference signal transmission occasion in the corresponding sensing occasion, or a corresponding transmission beam for a corresponding reference signal transmission occasion, or a corresponding reception beam for the corresponding reference signal transmission occasion.

[0017] In some implementations of the methods, the UE and the network entity described herein, the UE may update the set of one or more of the parameters based at least in part on higher layer signaling.

[0018] In some implementations of the methods, the UE and the network entity described herein, the UE may receive higher layer signaling that indicates to switch to at least one second corresponding configuration of the set of one or more configurations; and switch to the at least one second corresponding configuration for sensing based at least in part on the received higher layer signaling.

[0019] In some implementations of the methods, the UE and the network entity described herein, the set of one or more measurement values as sensing data may comprise a group of channel coefficients associated the at least one corresponding sensing occasion.

[0020] In some implementations of the methods, the UE and the network entity described herein, the group of channel coefficients may comprise one or more of quantized amplitudes and phases or quantization levels of the quantized amplitudes and phases.

[0021] In some implementations of the methods, the UE and the network entity described herein, the set of one or more measurement values as sensing data may correspond to a confidence level, wherein the confidence level may be based at least in part on state information of the UE, and wherein the report may comprise an indication of the confidence level.

[0022] In some implementations of the methods, the UE and the network entity described herein, the state information of the UE may comprise at least one or more of a velocity of the UE, a pose of the UE, or a signal quality indication associated with the wireless communication of the UE.

[0023] In some implementations of the methods, the UE and the network entity described herein, the UE may select at least one beam-pair for at least one data transmission based at least in part on at least one configuration of the set of one or more configurations associated with the sensing service.

[0024] In some implementations of the methods, the UE and the network entity described herein, the UE may determine an overlap between the at least one reference signal transmission occasion and at least one channel state information-reference signal (CSI-RS) occasion; and drop the set of one or more resources associated with the at least one reference signal transmission occasion.

[0025] In some implementations of the methods, the UE and the network entity described herein, the network entity may select at least one configuration of the set of one or more configurations associated with the sensing service based at least in part on a set of one or more reference signal measurements, wherein a set of one or more reference signal transmissions is associated with a corresponding beam pair comprising a corresponding transmission beam and a corresponding reception beam.

[0026] In some implementations of the methods, the UE and the network entity described herein, to select the at least one configuration, the network entity may receive, for each of the set of one or more configurations, a corresponding effective angle spread and a corresponding index of the configuration; and select the at least one configuration based at least in part on the corresponding effective angle spread.

[0027] In some implementations of the methods, the UE and the network entity described herein, the network entity may receive the set of one or more reference signal measurements and corresponding beam pairs; and transmit information on at least one selected beam pair from the received beam pairs.

[0028] In some implementations of the methods, the UE and the network entity described herein, the network entity may transmit, via higher layer signaling, an

indication of at least one configuration of the set of one or more configurations associated with the sensing service.

[0029] In some implementations of the methods, the UE and the network entity described herein, the network entity may transmit higher layer signaling that indicates to update the set of one or more of the parameters.

[0030] In some implementations of the methods, the UE and the network entity described herein, the network entity may transmit higher layer signaling that indicates to switch to at least one second corresponding configuration of the set of one or more configurations.

[0031] In some implementations of the methods, the UE and the network entity described herein, the network entity may select at least one beam-pair for at least one data transmission based at least in part on at least one configuration of the set of one or more configurations associated with the sensing service.

BRIEF DESCRIPTION OF THE DRAWINGS

[0032] FIG. 1 illustrates an example of a wireless communications system in which some embodiments of the present disclosure can be implemented.

[0033] FIG. 2A illustrates alternatives to enable wireless sensing.

[0034] FIG. 2B illustrates an example of optimal beam pair for communication link.

[0035] FIG. 2C illustrates examples of use cases of beamforming for sensing.

[0036] FIG. 2D illustrates an example of detecting intrusion via the variance of channel state information.

[0037] FIG. 3 illustrates an example of a process flow of beam management for sensing in accordance with some example embodiments of the present disclosure.

[0038] FIG. 4 illustrates a schematic diagram of a beam-group pattern (BGP) for sensing in accordance with some example embodiments of the present disclosure.

[0039] FIG. 5 illustrates a schematic diagram of a BGP management framework in accordance with some example embodiments of the present disclosure.

[0040] FIG. 6 illustrates a schematic diagram of optimization criteria via CSI measurement reporting in accordance with some example embodiments of the present disclosure.

[0041] FIG. 7 illustrates a schematic diagram of another optimization criteria via BGP-based measurement and reporting in accordance with some example embodiments of the present disclosure.

[0042] FIG. 8 illustrates a schematic diagram of a BGP-based measurement and reporting for sensing in accordance with some example embodiments of the present disclosure.

[0043] FIG. 9 illustrates an example of BGP updating with adjusted beams in accordance with some example embodiments of the present disclosure.

[0044] FIG. 10 illustrates an example of beams for sensing and data communication in accordance with some example embodiments of the present disclosure.

[0045] FIG. 11 illustrates an example of a device that is suitable for implementing some embodiments of the present disclosure.

[0046] FIG. 12 illustrates an example of a processor that is suitable for implementing some embodiments of the present disclosure.

[0047] FIG. 13 illustrates a flowchart of a method that performed by a user equipment in accordance with aspects of the present disclosure.

[0048] FIG. 14 illustrates a flowchart of a method that performed by a network entity in accordance with aspects of the present disclosure.

[0049] Throughout the drawings, the same or similar reference numerals represent the same or similar elements.

DETAILED DESCRIPTION

[0050] Principles of the present disclosure will now be 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 below. In the following 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.

[0051] 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.

[0052] 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.

[0053] 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.

[0054] Aspects of the present disclosure are described in the context of a wireless communications system. 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 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 an 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 an 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.

[0055] 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. In a 3GPP non-terrestrial network (NTN), a network entity 102 in form of a satellite can

directly communicate to UE 104 using NR/LTE Uu interface. The satellite may be a transparent satellite or a regenerative satellite. For NTN with a transparent satellite, a base station on earth may communicate with a UE via the satellite. For NTN with a regenerative satellite, the base station may be on board and directly communicate with the UE.

[0056] 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, messaging, 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.

[0057] 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.

[0058] 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 core network 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.

[0059] 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. For example, a UE 104 may support wireless communication directly with another UE 104 over a PC5 interface.

[0060] A network entity 102 may support communications with the core network 106, or with another network entity 102, or both. For example, a network entity 102 may interface with the core network 106 through one or more backhaul links 116 (e.g., via an S1, N2, N2, 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 core network 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).

[0061] 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.

[0062] 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)).

[0063] 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 adaptation 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 160.

[0064] 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).

[0065] 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.

[0066] The core network 106 may support user authentication, access authorization, tracking, connectivity, and other access, routing, or mobility functions. The core network 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 core network 106.

[0067] The core network 106 may communicate with the packet data network 108 over one or more backhaul links 116 (e.g., via an S1, N2, N2, 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 core network 106 via a network entity 102. The core network 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 core network 106 (e.g., one or more network functions of the core network 106).

[0068] 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.

[0069] 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., $\mu=0$) 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., $\mu=0$) associated with the first subcarrier spacing (e.g., 15 kHz) may utilize one slot per subframe. A second numerology (e.g., $\mu=1$) may be associated with a second subcarrier spacing (e.g., 30 kHz) and a normal cyclic prefix. A third numerology (e.g., $\mu=2$) 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., $\mu=3$) may be associated with a fourth subcarrier spacing (e.g., 120 kHz) and a normal cyclic prefix. A fifth numerology (e.g., $\mu=4$) may be associated with a fifth subcarrier spacing (e.g., 240 kHz) and a normal cyclic prefix.

[0070] 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.

[0071] 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., $\mu=0$, $\mu=1$, $\mu=2$, $\mu=3$, $\mu=4$) 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.

[0072] 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.

[0073] 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.

[0074] The radio information obtained during signal processing can be used to detect environmental changes caused by motion of objects and people, which is termed as radio sensing or wireless sensing, similar with Radar. Some examples of ubiquitous radio sensing services are safe autonomous vehicles/unmanned aerial vehicle (UAV), environment mapping to improve positioning accuracy and enable environment related applications and real-time monitoring for intrusion detection, etc. Introducing sensing capability into cellular wireless communication system has the benefit of sharing the same spectrum and infrastructure especially on the industry with both communication and sensing, which is one of the promising techniques in next generation RAN, e.g., beyond 5G (B5G)/6G.

[0075] To support wireless sensing in RAN, there are several alternatives as shown in FIG. 2A, including network (e.g. gNB) only, UE only and joint gNB and UE. In each alternative, there are further two options, considering the role selection on either sensing signal transmitter or receiver. In general, as shown in FIG. 2A, Alt.1-A and Alt.3-A are more or less about implementation issues. For Alt.1-B, Alt.3-B and Alt.2, there should be some enhancements on the air interface, i.e., Uu or PC5 interface. The present disclosure focuses on Alt.2, i.e. to enhance air interface to support sensing.

[0076] On the other hand, in RAN, the beamforming technique is deployed to improve link quality and network performance in a multiple antenna system. The beam management is designed to establish and retain a suitable beam or beam pair, that is, a transmitter-side beam direction and a corresponding receiver-side beam direction that jointly provides good connectivity. As illustrated in FIG. 2B, a transmission (Tx) beam, e.g., Tx beam #3, and a receiving (Rx) beam, Rx beam #1, are paired for the data transmission to improve the link quality.

[0077] A beamforming framework has been well defined in NR to support the acquisition on the optimal beam pair for data transmission. However, it is different for sensing because there is no signalling interaction directly from the sensing target and/or sensing area as illustrated in FIG. 2C, which indicates that to monitor the intrusion, e.g., UAV, or track an objective, e.g., car, in an area, another beam pair needs to be set up to improve the sensing performance, in addition to the communication link performance.

[0078] Furthermore, there are also some issues when joint considering sensing and data communication, such as the acquisition on the optimal beam or beam pairs for sensing, beam (pair) switching and the joint optimization for both sensing and communication links. Therefore, there is a need to design or enhance the current beamforming framework to support the beamforming for sensing, and also the integrated sensing and communication (ISAC) system.

[0079] Currently, use cases are identified and covers a wide range of applications, including: object and intruder detection for smart home, on a highway, for railways, for factory, for predefined secure areas around critical infrastructure; collision avoidance and trajectory tracking of UAVs, vehicles, AGVs; public safety search and rescue; automotive manoeuvring and navigation; rainfall monitoring and flooding; health and sports monitoring; object detection and tracking; environment monitoring; motion monitoring, and others. Some of the use cases are further grouped into three scenarios with some short service description as highlighted in the following Table 1. For different use cases, there are different requirements on the resolution, accuracy, miss/false detection rate and confidence levels within different scenarios and sensing modes.

Table 1: The grouped use cases of Integrated Sensing and Communication

Scenario	Sensing service category	Sensing service description in a target sensing service area
Object detection and tracking	1	Indoor/outdoor (e.g., detection of human, UAV)
	2	Outdoor (e.g., detection of human, UAV)
	3	Indoor/outdoor (e.g., detection and tracking of human, animal, UAV)
	4	Indoor/outdoor (e.g., detection and tracking of human, animal, UAV, AGV, vehicle) requiring higher performance than category 3
Environment monitoring	5	Nature of environments monitored by sensing (e.g. rainfall, flooding monitoring)

Motion monitoring	6	Human motions and activities obtained by sensing
	7	Human hand gestures obtained by sensing

[0080] Compared with the beamforming techniques used in communication networks, where the beams are selected to improve the data link quality, there are some issues or requirements when integrating sensing function into the network.

[0081] Beams generation for environment monitoring needs to be studied. To monitor an area, e.g., any UAV intrusion in an area as illustrated in FIG. 2C, the beams need to be generated to cover the area to potentially detect any object intrusion. The observations on the CSI in the use case of intrusion to an empty room are illustrated in FIG. 2D, where the intrusion into an empty room is expected to be detected by sensing. In the example shown in FIG. 2D, the CSI estimated by the receiver, i.e., the laptop on the table, is monitored during a time window. Without intrusion, the CSI would be stable for the fixed multiple paths due to the environment. If any intrusion happens, the changed propagation environment would correspondently change the CSI. Thus, an intrusion to the room can be well detected.

[0082] Beams selection and tracking for object detection and tracking also needs to be studied. In some use cases, it is necessary to detect the velocity and/or position of an object in an area by sensing, where the object doesn't have the transceiver to transmit and receive the communication signals, e.g., the car in an area as illustrated in FIG. 2C. Then the sensing beams from gNB or the beam pairs between gNB and UE for such object is needed to have good enough sensing results.

[0083] Furthermore, beamforming schemes to support both sensing and data communication needs to be studied. In an Integrated Sensing and Communication (ISAC) system, there are always sensing and communication tasks, which both have requirements on beamforming but with different requirements on one hand. On the other hand, the selected UE to assist sensing could move to challenge the sensing result derivation, since the variance of the channel state is not only due to the sensing target moving. Thus, there is a need to design a beam management framework to jointly consider the requirements on sensing and communications.

[0084] In view of above, in this disclosure, a beam management framework based on the CSI report framework defined in NR is proposed to satisfy the special

requirements on the beam operations in an ISAC system, taking the new requirements on sensing services into account.

[0085] FIG. 3 illustrates an example of a process flow of beam management for sensing in accordance with some example embodiments of the present disclosure. The process flow 300 may involve a UE 301 and a network entity (e.g. a base station, such as gNB) 302. The process flow 300 may be applied to the wireless communications system 100 with reference to FIG. 1, for example, the UE 301 may be any of UEs 104, and the network entity 302 may be any of the network entities 102. It would be appreciated that the process flow 300 may be applied to other communication scenarios.

[0086] At 310, the network entity 302 may transmit, to the UE 201, a set of one or more configurations 315 associated with a sensing service. Accordingly, at 320, the UE 301 may receive the set of one or more configurations 315 associated with the sensing service. In some embodiments, each configuration of the set of one or more configurations may comprise at least one corresponding sensing occasion including at least one reference signal transmission occasion, and each of the at least one reference signal transmission occasion may be associated with a corresponding beam pair comprising at least one transmission beam and at least one reception beam.

[0087] At 330, the UE 301 may determine a set of one or more resources associated with the at least one reference signal transmission occasion. At 330, the network entity 302 may also determine a set of one or more resources associated with the at least one reference signal transmission occasion. By doing this, the resources for sensing are aligned between the UE 301 and the network entity 302.

[0088] At 340, the UE 301 may transmit a report 345 comprising a set of one or more measurement values as sensing data associated with a set of one or more measurements on the set of one or more resources associated with the at least one reference signal transmission occasion. Accordingly, at 350, the network entity 302 may receive the report 345 comprising measurement values as sensing data. With the sensing data, the network 302 may perform sensing tasks, e.g., object detection and tracking, environment monitoring, or motion monitoring, depending on implementations.

[0089] In this disclosure, the configuration(s) 315 associated with sensing service(s) transmitted from network entity 302 to the UE 301 may also be referred as a Beam-

Group Pattern (BGP), which includes a set of associated parameters, for example, duration, transmission occasions, transmission (Tx) beams and reception (Rx) beams, configured for relevant sensing service(s). In some embodiments, a group of beams or beam-pairs on some transmission occasions in a duration may be defined as BGP, which are used by the cooperative nodes (e.g., UE 301 and network entity 302) to derive the measurement results for sensing.

[0090] FIG. 4 illustrates a schematic diagram of a BGP for sensing in accordance with some example embodiments of the present disclosure. As shown in FIG. 4, a BGP may be defined by a set of dedicated reference signals transmitted in a window duration as one sensing occasion with corresponding beams in this occasion, including a window duration of a sensing occasion, relevant reference signal occasions in the duration, Tx beams and Rx beams.

[0091] For more details, the set of parameters in each configuration 315 or a BGP may be associated with requirements of the sensing service and comprises a window duration of a sensing occasion, periodicity of the corresponding sensing occasion, a set of resources associated with reference signal transmission occasion(s) in the sensing occasion; or a set of beam pairs. Each beam pair may comprise a transmission beam and a reception beam for a corresponding reference signal transmission occasion.

[0092] The window duration for one sensing occasion is time duration for the transmitter (e.g., the network entity 302) to cover a sensing area with a number of beam or beam pairs for one sensing occasion to collect the sensing data or measurement data. For example, the window duration may correspond to the periodicity of a periodic reference signal (RS) set for sensing. In some embodiments, multiple sensing occasions may be needed to derive the sensing results via analyzing the variance among them, e.g., amplitude, power, angle and phase.

[0093] The window duration may include one or more RS transmission occasions. The RS transmission occasions may be associated with resources used for sensing in the sensing occasion, including the dedicated reference signals for sensing, time/frequency locations of the signals, for example, the symbols and the resource element (RE) locations for each of the RS transmission in a RS resource set (i.e., a sensing occasion). The resources in one window duration may need to be enough to sweep enough multiple

beams/beam-pairs to cover a sensing area, considering the reasonable beams switching gap.

[0094] Regarding the transmission beams (Tx) used in the occasion, the Tx beam of each RS transmission in the occasion may be indicated by beam ID or dedicated RS (e.g., port) in a BGP. Note that the receiver may assume that the Tx beam of each RS resource within a set transmitted in different windows are not changed for a determined and configured BGP.

[0095] Regarding the reception (Rx) beams used in the occasion, the Rx beam of each RS transmission in the occasion may be provided by indicating a quasi-colocation (QCL)-TypeD RS, e.g., a Synchronization Signal and PBCH Block (SSB) index, for each of the RS resources in the resource set. Note that different with that in NR, the receiver for sensing may use the same Rx spatial filter parameters for the reception of the RS resource in the configured BGP.

[0096] In some embodiments, a BGP with a set of configurations on above parameters may be indicated by a higher layer signaling, e.g., a new radio resource control (RRC) information element (IE) after a determination procedure. One or more BGP may be associated with a measurement report configuration for the UE 301 to determine the resources for measurement to obtain the sensing results.

[0097] The ‘*CSI resource set*’ in NR may be reused for definition of the BGP. In some embodiments, the beams or beam pairs of the BGP may be indicated by CSI resource indicator (CRI) or SSB resource indicator (SSBRI). The occasions and Tx beams indication may be achieved by a non-zero power (NZP) CSI-RS resource set comprising CSI-RS resources. For example, all the CSI-RS resources in the set are transmitted in a same slot or adjacent slots. The main difference from the ‘*CSI resource set*’ in NR is that the related configurations of a BGP are associated for indication together with the requirements on the Rx beam indication, since the set of parameters needs to be aligned in all sensing occasion during a whole sensing session. In addition, for sensing service, measurements to derive sensing results may be based on a selected BGP.

[0098] FIG. 5 illustrates a schematic diagram of a BGP management framework in accordance with some example embodiments of the present disclosure. The BGP

management framework in FIG. 5 may be an example implementation to support the process flow 300 as shown in FIG. 3.

[0099] As shown in FIG. 5, the BGP management framework may include BGP determination, BGP-based measurement and report, and BGP updating and switching modules as shown. In general, a dedicated BGP may be determined according to the sensing service requirement, radio resource management schemes and other issues. Then, the measurement results based on the BGP can be collected and reported to derive the sensing results. If the sensing object moves, the BGP may need to be updated and switched with some sensing performance monitoring scheme.

[0100] A proper BGP may be determined for a sensing service according to requirements of the sensing service, including parameters such as the window duration per sensing occasion, a number of RS transmission occasions per sensing occasion, and beams used in each RS transmission occasion. The network entity may select a UE in the sensing area to assist sensing, and the beams between network entity and UE need to be selected and fixed for the sensing service with the determined BGP.

[0101] In some embodiments, the configured BGP may be selected based at least in part on a set of one or more reference signal measurements, where a set of one or more reference signal transmissions is associated with a corresponding beam pair comprising a corresponding transmission beam and a corresponding reception beam. For example, to cover the sensing area, instead of improving the communication link, the configured BGP, e.g., the beams or beam-pairs per occasion may be selected based on different optimization criteria.

[0102] In some embodiments, the UE may report the set of one or more reference signal measurements and corresponding beam pair to the network entity. The network entity may select at least one selected beam pair from the received beam pairs and transmit information on selected beam pair to the UE.

[0103] FIG. 6 illustrates a schematic diagram of optimization criteria via CSI measurement reporting in accordance with some example embodiments of the present disclosure. A CSI report procedure may be reused to derive the L1-RSRP/L1-SINR per beam or beam-pair with some interaction as illustrated in FIG. 6, which assumes 4 Tx beams (indicated by {#0, #1, #2, #3}) and 2 Rx beams (indicated by {#a, #b}). The

configurations on the procedure for beam group determination is firstly transmitted to UE, which are used to indicate the used RS, transmission occasions and assumptions on the beams. In each RS transmission occasion, one Tx beam is repeated twice to support 2 different Rx beams. After four occasions, the UE can derive all the results (e.g., L1-RSRP/L1-SINR) of these beam pairs, which are reported to gNB.

[0104] With the reported L1-RSRP/L1-SINR values, a group of beam pairs with some optimal value can be selected. For example, the group of beams with maximum effective angle spread can be selected as

$$AS_{eff} = \frac{\sum_{k=0}^{(K-1)} L1RSRP_k \times \theta_k}{\sum_{k=0}^{(K-1)} L1RSRP_k} \quad (1)$$

where K is the number of RS transmission occasions in a BGP and θ_k is the effective departure angle of the k th Tx beam. Then, the K beam pairs are selected to have the maximum the angle spread to cover the sensing area.

[0105] FIG. 7 illustrates a schematic diagram of another optimization criteria via BGP-based measurement and reporting in accordance with some example embodiments of the present disclosure. In this embodiment, the UE and the network entity may determine the beam group with new dedicated values reported for sensing, where a new value reported and the corresponding CSI report type for sensing is designed. The reported value may be derived from a group of beams, i.e., a BGP, for a sensing service, e.g., the effective angle spread as formula (1), where the θ_k is the effective arrival angle of the k^{th} Rx beam for the UE. For example, a new quantity may be newly defined in higher layer parameter *reportQuantity*, e.g., ‘cri-group-RSRP-Average’, which can be reported together with a dedicated BGP index and the new values for sensing, e.g., the averaged effective angle spread.

[0106] For each configured BPG, the UE may determine an effective angle spread based at least in part on an effective receiving angle for the corresponding reception beam of the corresponding beam pair and the set of one or more reference signal measurements. The UE may report the effective angle spread and an index of the configured BGP, as shown in Table 2 below.

Table 2: An illustration of group-based report for sensing

Field	Bit width
BGP index	$\lceil \log_2(K^{BGP}) \rceil$
Effective AS	7
Differential effective AS	5

The bit width of the BGP index and the effective AS to be reported are illustrated in Table 2, where K^{BGP} is the number of BGP to be measured on one sensing occasion and indicated by the higher layer signaling. Differential effective AS may be calculated with the reference of the 7-bits effective AS in a CSI report. This alternative may be applied to select the Rx beams on the UE side. The selected BGP may be associated with a maximum effective angle spread among the configured BGPs.

[0107] After the determination procedure, the configurations of the selected BGP needs to be indicated to the UE for the following sensing procedure, which can be realized via higher layer signaling, i.e., RRC signaling. Accordingly, the UE receives an indication of at least one selected BGP via the higher layer signaling, and selects the BGP as indicated. Note that the BGP can be identified with an ID for different sensing areas and/or services as illustrated in Table 3 as below. In Table 3, BGP #1 is a set of configurations to detect intrusion in an indoor environment, so the sensing area would be a door of the room. For BGP #3, the parameters are configured to detection and track a car in a lane to derive the velocity.

Table 3: Illustration on application of BGP with different identities

BGP ID	Sensing area	Sensing services
1	A door of the room	Intrusion detection, e.g., indoor
2	An air space	Intrusion detection, e.g., UAV
3	A lane of a road	Object detection and tracking, e.g., velocity of a car in lane
...	...	...

[0108] After the BGP determination, the BGP-based measurement and report is enabled for the requested sensing service. FIG. 8 illustrates a schematic diagram of a BGP-based measurement and reporting for sensing in accordance with some example embodiments of the present disclosure.

[0109] As illustrated in FIG. 8, there are N periodical sensing occasions with the configured BGP, which includes four RS transmission occasions with (#Tx, #Rx) beam

pairs of $\{(\#0, \#a), (\#1, \#a), (\#2, \#b), (\#3, \#b)\}$. The UE would report the measurement results per sensing occasion according to the report configuration.

[0110] To derive the sensing results, the channel coefficients on each RS transmission occasion are always used as the sensing data. Thus, the UE may need to report the channel coefficients directly to the gNB with some quantization on the amplitude and phase. As illustrated in FIG. 8, the set of channel coefficients, $\{\mathbf{h}_0^{(n)}, \mathbf{h}_1^{(n)}, \mathbf{h}_2^{(n)}, \mathbf{h}_3^{(n)}\}$, of the n th sensing occasion (SO) is reported after configured quantization on the amplitude and phase. The quantization level of the amplitude and phase may be pre-configured via higher layer signalling. Once receiving the reported CSIs from all occasions, the sensing results may be derived via some algorithm, such as parameter estimation algorithm from the variance of the channel or some artificial intelligence (AI) method.

[0111] In some embodiments, for sensing, the event-triggered CSI report may be considered. For example, if the UE observed that the RSRP or the probability distribution function (PDF) of the same set of Tx-Rx beam pairs over a time duration has changed over a certain threshold or matched with a certain PDF pattern, the UE may trigger a CSI report to report such event and correspondent channel coefficients.

[0112] In some embodiments, if the CSIs of some occasions are observed to be varying a lot in the environment monitoring sensing service, there could be a target appears in those beam direction. To acquire more accurate sensing results as the object tracking, it is beneficial to schedule more resources in those direction. That is, there is a need to update the current BGP, for example, to change the beam pairs for sensing.

[0113] FIG. 9 illustrates an example of BGP updating with adjusted beams in accordance with some example embodiments of the present disclosure. In FIG. 9, more beams on the direction, e.g., beam pair $(\#1, \#a)$ are needed. Thus, it is beneficial to update the BGP, via changing the beam pair $(\#2, \#b)$ on the 3rd occasion into beam pair $(\#1, \#a)$. It is also beneficial to update the parameters in a BGP with more or less resources and/or beam tuning. There are two options to update the deployed BGP, one is to update the parameters in the identified and under-used BGP, and the other is to switch to another identified BGP.

[0114] In one option, the UE and the network may update the configuration in an identified BGP. With this option, the dedicated signals need to be defined for an identified BGP. For example, a RRC signaling, *updateRSresourceBGP*, is used to update the parameter of RS transmission resources in a sensing occasion of a BGP, so as for the other parameters. Note that the BGP ID should be involved in this kind of signals to indicate which BGP needs to be updated. MAC CE based parameters updating for a BGP may be applicable as well.

[0115] In the other option, the UE and the network may switch to another BGP. For example, if another sensing service and/or the sensing area have changed, the BGP used for the requested sensing may be switched. Note that with this option, the relevant BGPs need to be identified in advanced. Once adjusting the BGP, the updated BGP configuration may be informed to UE to align the indications for the following CSI report. The UE may receive higher layer signaling from the network entity that indicates to switch to a second BGP among the set of configured BGPs, and switch to the second BGP as indicated.

[0116] Next, consider the joint beamforming scheme for both sensing signals and data transmission in an ISAC system. FIG. 10 illustrates an example of beams for sensing and data communication in accordance with some example embodiments of the present disclosure. In FIG. 10, the Tx-Rx beam pair (#3, #1) is the optimal selection to have the highest quality for the communication link, and (#4, #2) is the optimal beam pair for the sensing target. The beam management framework may need to consider the optimal beam selection for the data transmission and the impact between the selected beams between these two kinds of links.

[0117] Because a UE in the network is selected to assist sensing, the optimal data transmission beams for the UE needs to consider the BGP, i.e., a group of beams, for sensing. In some embodiments, the UE and the network may re-use CSI-RS as the reference signal for sensing. In this case, the beam management scheme for communication link may need to be enhanced to support BGP-related procedures. Besides, when considering the communication link, the optimal beams or beam-pairs for data transmission may need to be selected from the beams in a determined BGP.

[0118] In some embodiments, the UE and the network may use dedicated RS and a dedicated procedure for sensing. In this case, the proposed BGP based sensing may be

triggered independently with the procedure for CSI report, and it is beneficial to avoid the collision with the CSI procedure. If collision happens, the resources for sensing may be omitted to guarantee the data transmission. For example, if the UE determines that there is an overlap between the reference signal transmission occasion for sensing and CSI-RS occasion, it may drop the resources associated with the corresponding reference signal transmission occasion for sensing.

[0119] For the object detection and tracking service with cooperative sensing, the state of the selected UE may play an important role for the sensing data analysis. The reported measurement values as sensing data may correspond to a confidence level, wherein the confidence level is based at least in part on state information of the UE, and wherein the report comprises an indication of the confidence level. The state information of the UE may comprise a velocity of the UE, a pose of the UE, or a signal quality indication associated with the wireless communication of the UE.

[0120] For example, if the selected UE is moving, it could be challenging for the network to detect and estimate the correct values, e.g., velocity and position, of the sensing target from the CSI reported from the moving UE. Thus, the confidence level of the sensing data, i.e., the channel coefficients, reported from the assisting UE is provided based on the UE's state, including the velocity, posture variance and SINR. For example, for a static UE, e.g., remote side unit (RSU) with good signal quality, the confidence level of the reported channel coefficients is high, e.g., the maximum quantizable value, 1. A moving UE, e.g., handset in pocket, could have the lower confidence level, e.g., 0.1.

[0121] FIG. 11 illustrates an example of a device that is suitable for implementing some embodiments of the present disclosure. The device 1100 may be an example of a UE 104 or network entity 102 as described herein. The device 1100 may support wireless communication with one or more network entities 102, UEs 104, or any combination thereof. The device 1100 may include components for bi-directional communications including components for transmitting and receiving communications, such as a processor 1102, a memory 1104, a transceiver 1106, and, optionally, an I/O controller 1108. 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).

[0122] The processor 1102, the memory 1104, the transceiver 1106, 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 1102, the memory 1104, the transceiver 1106, or various combinations or components thereof may support a method for performing one or more of the operations described herein.

[0123] In some implementations, the processor 1102, the memory 1104, the transceiver 1106, 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 1102 and the memory 1104 coupled with the processor 1102 may be configured to perform one or more of the functions described herein (e.g., executing, by the processor 1102, instructions stored in the memory 1104).

[0124] For example, the processor 1102 may support wireless communication at the device 1100 in accordance with examples as disclosed herein. The device 1100 may be an example of a UE 104. In this case, the processor 1102 may be configured to operable to support means for receiving a set of one or more configurations associated with a sensing service, wherein each configuration of the set of one or more configurations comprises at least one corresponding sensing occasion including at least one reference signal transmission occasion, wherein the at least one reference signal transmission occasion is associated with a corresponding beam pair comprising at least one transmission beam and at least one reception beam; means for determining a set of one or more resources associated with the at least one reference signal transmission occasion; and means for transmitting a report comprising a set of one or more measurement values as sensing data associated with a set of one or more measurements on the set of one or more resources associated with the at least one reference signal transmission occasion.

[0125] The device 1100 may be an example of a network entity 102, e.g. a network entity. In this case, the processor 1102 may be configured to operable to support means

for transmitting a set of one or more configurations associated with a sensing service, wherein each configuration of the set of one or more configurations comprises at least one corresponding sensing occasion including at least one reference signal transmission occasion, wherein the at least one reference signal transmission occasion is associated with a corresponding beam pair comprising at least one transmission beam and at least one reception beam; means for determining a set of one or more resources associated with the at least one reference signal transmission occasion; and means for receiving a report comprising a set of one or more measurement values as sensing data associated with a set of one or more measurements on the set of one or more resources associated with the at least one reference signal transmission occasion.

[0126] The processor 1102 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 1102 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 1102. The processor 1102 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 1104) to cause the device 1100 to perform various functions of the present disclosure.

[0127] The memory 1104 may include random access memory (RAM) and read-only memory (ROM). The memory 1104 may store computer-readable, computer-executable code including instructions that, when executed by the processor 1102 cause the device 1100 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 1102 but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some implementations, the memory 1104 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.

[0128] The I/O controller 1108 may manage input and output signals for the device 1100. The I/O controller 1108 may also manage peripherals not integrated into the

device 1100. In some implementations, the I/O controller 1108 may represent a physical connection or port to an external peripheral. In some implementations, the I/O controller 1108 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 1108 may be implemented as part of a processor, such as the processor 1102. In some implementations, a user may interact with the device 1100 via the I/O controller 1108 or via hardware components controlled by the I/O controller 1108.

[0129] In some implementations, the device 1100 may include a single antenna 1110. However, in some other implementations, the device 1100 may have more than one antenna 1110 (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 1106 may communicate bi-directionally, via the one or more antennas 1110, wired, or wireless links as described herein. For example, the transceiver 1106 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 1106 may also include a modem to modulate the packets, to provide the modulated packets to one or more antennas 1110 for transmission, and to demodulate packets received from the one or more antennas 1110. The transceiver 1106 may include one or more transmit chains, one or more receive chains, or a combination thereof.

[0130] 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 1110 for transmitting the amplified signal into the air or wireless medium.

[0131] 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 1110 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.

[0132] FIG. 12 illustrates an example of a processor 1200 is suitable for implementing some embodiments of the present disclosure. The processor 1200 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 1200 may include a controller 1202 configured to perform various operations in accordance with examples as described herein. The processor 1200 may optionally include at least one memory 1204. Additionally, or alternatively, the processor 1200 may optionally include one or more arithmetic-logic units (ALUs) 1206. 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).

[0133] The processor 1200 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 1200) 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).

[0134] The controller 1202 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 1200 to cause the processor 1200 to support various operations in accordance with examples as described herein. For example, the controller 1202 may operate as a control unit of the processor 1200, generating control signals that manage the operation of various components of the processor 1200. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[0135] The controller 1202 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 1204 and determine subsequent instruction(s) to be executed to cause the processor 1200 to support various operations in accordance with examples as described herein. The controller 1202 may be configured to track memory address of instructions associated with the memory 1204. The controller 1202 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 1202 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 1200 to cause the processor 1200 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 1202 may be configured to manage flow of data within the processor 1200. The controller 1202 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 1200.

[0136] The memory 1204 may include one or more caches (e.g., memory local to or included in the processor 1200 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementation, the memory 1204 may reside within or on a processor chipset (e.g., local to the processor 1200). In some other implementations, the memory 1204 may reside external to the processor chipset (e.g., remote to the processor 1200).

[0137] The memory 1204 may store computer-readable, computer-executable code including instructions that, when executed by the processor 1200, cause the processor 1200 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 1202 and/or the processor 1200 may be configured to execute computer-readable instructions stored in the memory 1204 to cause the processor 1200 to perform various functions (e.g., functions or tasks supporting transmit power

prioritization). For example, the processor 1200 and/or the controller 1202 may be coupled with or to the memory 1204, the processor 1200, the controller 1202, and the memory 1204 may be configured to perform various functions described herein. In some examples, the processor 1200 may include multiple processors and the memory 1204 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.

[0138] The one or more ALUs 1206 may be configured to support various operations in accordance with examples as described herein. In some implementation, the one or more ALUs 1206 may reside within or on a processor chipset (e.g., the processor 1200). In some other implementations, the one or more ALUs 1206 may reside external to the processor chipset (e.g., the processor 1200). One or more ALUs 1206 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 1206 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 1206 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 1206 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 1206 to handle conditional operations, comparisons, and bitwise operations.

[0139] The processor 1200 may support wireless communication in accordance with examples as disclosed herein. The processor 1200 may implemented at a UE 104. In this case, the processor 1200 may be configured to operable to support means for receiving a set of one or more configurations associated with a sensing service, wherein each configuration of the set of one or more configurations comprises at least one corresponding sensing occasion including at least one reference signal transmission occasion, wherein the at least one reference signal transmission occasion is associated with a corresponding beam pair comprising at least one transmission beam and at least one reception beam; means for determining a set of one or more resources associated with the at least one reference signal transmission occasion; and means for transmitting a report comprising a set of one or more measurement values as sensing data associated

with a set of one or more measurements on the set of one or more resources associated with the at least one reference signal transmission occasion.

[0140] The processor 1200 may implemented at a network entity 102, e.g. a base station. In this case, the processor 1200 may be configured to operable to support means for transmitting a set of one or more configurations associated with a sensing service, wherein each configuration of the set of one or more configurations comprises at least one corresponding sensing occasion including at least one reference signal transmission occasion, wherein the at least one reference signal transmission occasion is associated with a corresponding beam pair comprising at least one transmission beam and at least one reception beam; means for determining a set of one or more resources associated with the at least one reference signal transmission occasion; and means for receiving a report comprising a set of one or more measurement values as sensing data associated with a set of one or more measurements on the set of one or more resources associated with the at least one reference signal transmission occasion.

[0141] FIG. 13 illustrates a flowchart of a method 1300 performed by a UE in accordance with aspects of the present disclosure. The operations of the method 1300 may be implemented by a device or its components as described herein. For example, the operations of the method 1300 may be performed by a UE 104 as described herein. 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.

[0142] At 1310, the method may include receiving a set of one or more configurations associated with a sensing service, wherein each configuration of the set of one or more configurations comprises at least one corresponding sensing occasion including at least one reference signal transmission occasion, and wherein the at least one reference signal transmission occasion is associated with a corresponding beam pair comprising at least one transmission beam and at least one reception beam. The operations of 1310 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1310 may be performed by a UE 104 as described with reference to FIG. 1.

[0143] At 1320, the method may include determining a set of one or more resources associated with the at least one reference signal transmission occasion. The operations of 1320 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1320 may be performed by a UE 104 as described with reference to FIG. 1.

[0144] At 1330, the method may include transmitting a report comprising a set of one or more measurement values as sensing data associated with a set of one or more measurements on the set of one or more resources associated with the at least one reference signal transmission occasion. The operations of 1330 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1330 may be performed by a UE 104 as described with reference to FIG. 1.

[0145] FIG. 14 illustrates a flowchart of a method 1400 performed by a network entity in accordance with aspects of the present disclosure. The operations of the method 1400 may be implemented by a device or its components as described herein. For example, the operations of the method 1400 may be performed by a network entity 102 as described herein. 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.

[0146] At 1410, the method may include transmitting a set of one or more configurations associated with a sensing service, wherein each configuration of the set of one or more configurations comprises at least one corresponding sensing occasion including at least one reference signal transmission occasion, and wherein the at least one reference signal transmission occasion is associated with a corresponding beam pair comprising at least one transmission beam and at least one reception beam. The operations of 1410 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1410 may be performed by a network entity 102 as described with reference to FIG. 1.

[0147] At 1420, the method may include determining a set of one or more resources associated with the at least one reference signal transmission occasion. The operations of 1420 may be performed in accordance with examples as described herein. In some

implementations, aspects of the operations of 1420 may be performed by a network entity 102 as described with reference to FIG. 1.

[0148] At 1430, the method may include receiving a report comprising a set of one or more measurement values as sensing data associated with a set of one or more measurements on the set of one or more resources associated with the at least one reference signal transmission occasion. The operations of 1430 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1430 may be performed by a network entity 102 as described with reference to FIG. 1.

[0149] 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.

[0150] 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).

[0151] 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.

[0152] 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.

[0153] 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.

[0154] 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

1. A user equipment (UE) for wireless communication, 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 a set of one or more configurations associated with a sensing service, wherein each configuration of the set of one or more configurations comprises at least one corresponding sensing occasion including at least one reference signal transmission occasion, and wherein the at least one reference signal transmission occasion is associated with a corresponding beam pair comprising at least one transmission beam and at least one reception beam;

determine a set of one or more resources associated with the at least one reference signal transmission occasion; and

transmit a report comprising a set of one or more measurement values as sensing data associated with a set of one or more measurements on the set of one or more resources associated with the at least one reference signal transmission occasion.

2. The UE of claim 1, wherein the at least one processor is further configured to cause the UE to:

select at least one configuration of the set of one or more configurations associated with the sensing service based at least in part on a set of one or more reference signal measurements,

wherein a set of one or more reference signal transmissions is associated with a corresponding beam pair comprising a corresponding transmission beam and a corresponding reception beam.

3. The UE of claims 2, wherein, to select the at least one configuration, the at least one processor is further configured to cause the UE to:

for each of the set of one or more configurations,

determine, an effective angle spread based at least in part on an effective receiving angle for the corresponding reception beam of the corresponding beam pair and the set of one or more reference signal measurements; and

report the effective angle spread and an index of the configuration.

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

report the set of one or more reference signal measurements and corresponding beam pairs; and

receive information on at least one selected beam pair from the reported beam pairs.

5. The UE of claim 1, wherein each configuration of the set of one or more configurations is associated with requirements of the sensing service and comprises a set of one or more parameters comprising:

a corresponding duration of a corresponding sensing occasion,

a corresponding periodicity of the corresponding sensing occasion,

a set of one or more corresponding resources associated with a corresponding reference signal transmission occasion in the corresponding sensing occasion,

a corresponding transmission beam for a corresponding reference signal transmission occasion, or

a corresponding reception beam for the corresponding reference signal transmission occasion.

6. The UE of claim 5, wherein the at least one processor is further configured to cause the UE to:

receive higher layer signaling that indicates to switch to at least one second corresponding configuration of the set of one or more configurations; and

switch to the at least one second corresponding configuration for sensing based at least in part on the received higher layer signaling.

7. The UE of claim 1, wherein the set of one or more measurement values as sensing data comprises a group of channel coefficients associated the at least one corresponding sensing occasion.

8. The UE of claim 1, wherein the set of one or more measurement values as

sensing data correspond to a confidence level, wherein the confidence level is based at least in part on state information of the UE, and wherein the report comprises an indication of the confidence level.

9. The UE of claim 1, wherein the at least one processor is further configured to cause the UE to:

determine an overlap between the at least one reference signal transmission occasion and at least one channel state information-reference signal (CSI-RS) occasion; and

drop the set of one or more resources associated with the at least one reference signal transmission occasion.

10. A network entity for wireless communication, 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 a set of one or more configurations associated with a sensing service, wherein each configuration of the set of one or more configurations comprises at least one corresponding sensing occasion including at least one reference signal transmission occasion, and wherein the at least one reference signal transmission occasion is associated with a corresponding beam pair comprising at least one transmission beam and at least one reception beam;

determine a set of one or more resources associated with the at least one reference signal transmission occasion; and

receive a report comprising a set of one or more measurement values as sensing data associated with a set of one or more measurements on the set of one or more resources associated with the at least one reference signal transmission occasion.

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

select at least one configuration of the set of one or more configurations associated with the sensing service based at least in part on a set of one or more reference signal measurements,

wherein a set of one or more reference signal transmissions is associated with a corresponding beam pair comprising a corresponding transmission beam and a corresponding reception beam.

12. The network entity of claims 11, wherein, to select the at least one configuration, the at least one processor is further configured to cause the network entity to:

receive, for each of the set of one or more configurations, a corresponding effective angle spread and a corresponding index of the configuration; and

select the at least one configuration based at least in part on the corresponding effective angle spread.

13. The network entity of claim 11, wherein, to select at least one configuration, the at least one processor is configured to cause the network entity to:

receive the set of one or more reference signal measurements and corresponding beam pairs; and

transmit information on at least one selected beam pair from the received beam pairs.

14. The network entity of claim 11, wherein the at least one processor is further configured to cause the network entity to:

transmit, via higher layer signaling, an indication of at least one configuration of the set of one or more configurations associated with the sensing service.

15. The network entity of claim 10, wherein each configuration of the set of one or more configurations is associated with requirements of the sensing service and comprises a set of one or more parameters comprising:

a corresponding duration of a corresponding sensing occasion,

a corresponding periodicity of the corresponding sensing occasion,

a set of one or more corresponding resources associated with a corresponding reference signal transmission occasion in the corresponding sensing occasion,

a corresponding transmission beam for a corresponding reference signal transmission occasion, or

a corresponding reception beam for the corresponding reference signal transmission occasion.

16. The network entity of claim 15, wherein the at least one processor is further configured to cause the network entity to:

transmit higher layer signaling that indicates to update the set of one or more of the parameters.

17. The network entity of claim 15, wherein the at least one processor is further configured to cause the network entity to:

transmit higher layer signaling that indicates to switch to at least one second corresponding configuration of the set of one or more configurations.

18. A processor for wireless communication, comprising:

at least one memory; and

a controller coupled with the at least one memory and configured to cause the controller to:

receive a set of one or more configurations associated with a sensing service, wherein each configuration of the set of one or more configurations comprises at least one corresponding sensing occasion including at least one reference signal transmission occasion, and wherein the at least one reference signal transmission occasion is associated with a corresponding beam pair comprising at least one transmission beam and at least one reception beam;

determine a set of one or more resources associated with the at least one reference signal transmission occasion; and

transmit a report comprising a set of one or more measurement values as sensing data associated with a set of one or more measurements on the set of one or more resources associated with the at least one reference signal transmission occasion.

19. A method performed by a user equipment (UE), the method comprising:

receiving a set of one or more configurations associated with a sensing service, wherein each configuration of the set of one or more configurations comprises at least one corresponding sensing occasion including at least one reference signal transmission

occasion, and wherein the at least one reference signal transmission occasion is associated with a corresponding beam pair comprising at least one transmission beam and at least one reception beam;

determining a set of one or more resources associated with the at least one reference signal transmission occasion; and

transmitting a report comprising a set of one or more measurement values as sensing data associated with a set of one or more measurements on the set of one or more resources associated with the at least one reference signal transmission occasion.

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

transmitting a set of one or more configurations associated with a sensing service, wherein each configuration of the set of one or more configurations comprises at least one corresponding sensing occasion including at least one reference signal transmission occasion, and wherein the at least one reference signal transmission occasion is associated with a corresponding beam pair comprising at least one transmission beam and at least one reception beam;

determining a set of one or more resources associated with the at least one reference signal transmission occasion; and

receiving a report comprising a set of one or more measurement values as sensing data associated with a set of one or more measurements on the set of one or more resources associated with the at least one reference signal transmission occasion.