SERVICE FOR AMBIENT IOT DEVICES

TECHNICAL FIELD

[0001] The present disclosure relates to wireless communications, and more specifically to a base station (BS), a core network entity, an ambient internet of things (IoT) device, methods, apparatuses, and computer readable medium for a service for ambient IoT (AIoT) devices.

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] A study item on ambient internet of things (A-IoT or AIoT) has been started in new radio (NR) release 18 (Rel-18 or R18), and will be further discussed in release 19 (Rel-19 or R19). A service for an AIoT device is generally performed through a base station, in this case, the base station is expected to differentiate the AIoT device from legacy UEs, a solution of which needs to be studied.

SUMMARY

[0004] The present disclosure relates to a BS, a core network entity, an AIoT device, methods, apparatuses, processors, and computer readable medium for a service for AIoT devices. According to embodiments in the present disclosure, a type of a service may be indicated in a first message to the BS, and accordingly the BS can differentiate the AIoT

device(s).

[0005] In some implementations, there is provided a base station. The base station comprises at least one memory; and at least one processor coupled with the at least one memory and configured to cause the base station to: receive, from a core network entity, a first message indicating a type of a service for one or more AIoT devices, wherein the service is associated with at least one of an inventory request or a command request; and transmit, to the one or more AIoT devices, a second message comprising an indication of the type to initiate a procedure of the service.

[0006] In some implementations, there is provided a core network entity. The core network entity comprises at least one memory; and at least one processor coupled with the at least one memory and configured to cause the core network entity to: determine to initiate a service for one or more AIoT devices; and transmit, to a base station, a first message indicating a type of the service for the one or more AIoT devices, wherein the service is associated with at least one of an inventory request or a command request.

[0007] In some implementations, there is provided an AIoT device. The AIoT device comprises at least one memory; and at least one processor coupled with the at least one memory and configured to cause the AIoT device to: receive, from a base station, a second message comprising an indication of a type of a service to initiate a procedure of the service, wherein the service is associated with at least one of an inventory request or a command request; and enable the service for the procedure.

[0008] In some implementations, there is provided a method performed by the base station. The method comprises: receiving, from a core network entity, a first message indicating a type of a service for one or more AIoT devices, wherein the service is associated with at least one of an inventory request or a command request; and transmitting, to the one or more AIoT devices, a second message comprising an indication of the type to initiate a procedure of the service.

[0009] In some implementations, there is provided a method performed by the core network entity. The method comprises: determining to initiate a service for one or more AIoT devices; and transmitting, to a base station, a first message indicating a type of the service for the one or more AIoT devices, wherein the service is associated with at least one of an inventory request or a command request.

[0010] In some implementations, there is provided a method performed by the AIoT device.

The method comprises: receiving, from a base station, a second message comprising an indication of a type of a service to initiate a procedure of the service, wherein the service is associated with at least one of an inventory request or a command request; and enabling the service for the procedure.

[0011] In some implementations, there is provided a processor for wireless communication. The processor comprises at least one controller coupled with at least one memory and configured to cause the processor to: receive, from a core network entity, a first message indicating a type of a service for one or more AIoT devices, wherein the service is associated with at least one of an inventory request or a command request; and transmit, to the one or more AIoT devices, a second message comprising an indication of the type to initiate a procedure of the service.

[0012] In some implementations, there is provided a processor for wireless communication. The processor comprises at least one controller coupled with at least one memory and configured to cause the processor to: determine to initiate a service for one or more AIoT devices; and transmit, to a base station, a first message indicating a type of the service for the one or more AIoT devices, wherein the service is associated with at least one of an inventory request or a command request.

[0013] In some implementations, there is provided a processor for wireless communication. The processor comprises at least one controller coupled with at least one memory and configured to cause the processor to: receive, from a base station, a second message comprising an indication of a type of a service to initiate a procedure of the service, wherein the service is associated with at least one of an inventory request or a command request; and enable the service for the procedure.

[0014] In some implementations of the methods and the base station described herein, further comprising: in accordance with a determination that the assistance information indicates the complete time, starting a timer for the procedure based on the complete time.

[0015] In some implementations of the methods and the base station described herein, further comprising: determining, based on the first message, that an energy harvesting for at least one of the one or more AIoT devices is needed.

[0016] In some implementations of the methods and the base station described herein, further comprising: generating at least one radio frequency (RF) signal for energy harvesting; and transmitting, to the at least one of the one or more AIoT devices, the at least one RF

signal.

[0017] In some implementations of the methods and the base station described herein, further comprising: transmitting, to a source of energy harvesting, an indication indicating to the source to transmit at least one RF signal for energy harvesting to the at least one of the one or more AIoT devices.

[0018] In some implementations of the methods and the base station described herein, further comprising: receiving, from a first AIoT device, a third message comprising an identifier of the first AIoT device.

[0019] In some implementations of the methods and the base station described herein, further comprising: transmitting, to the first AIoT device, a fourth message indicating an acknowledgement of the third message.

[0020] receiving, from the first AIoT device, a random access ID on a carrier wave that used for transmitting the second message; and transmitting, to the first AIoT device, a random access response indicating that the random access ID is successfully received.

[0021] In some implementations of the methods and the base station described herein, further comprising: receiving, from the core network entity, an indicator indicating whether the procedure is completed.

[0022] In some implementations of the methods and the core network entity described herein, further comprising: transmitting, to the base station, an indicator indicating whether a procedure for the service is completed.

[0023] In some implementations of the methods and the AIoT device described herein, further comprising: receiving, from the base station or a source of energy harvesting, at least one RF signal for energy harvesting.

[0024] In some implementations of the methods and the AIoT device described herein, further comprising: transmitting, to the base station, a third message comprising an identifier of the AIoT device.

[0025] In some implementations of the methods and the AIoT device described herein, further comprising: receiving, from the base station, a fourth message indicating an acknowledgement of the third message.

[0026] In some implementations of the methods and the AIoT device described herein, further comprising: in accordance with a determination that the second indicator indicates

that the procedure is complete, disabling at least one operation at the AIoT device, wherein the at least one operation comprises a backscattered transmission or an uplink transmission to the base station. For example, the at least one operation further comprises a reception from the base station.

[0027] In some implementations of the methods and the AIoT device described herein, further comprising: transmitting, to the base station, a random access ID on a carrier wave that used for receiving the second message; and receiving, from the base station, a random access response indicating that the random access ID is successfully received by the base station.

[0028] In some implementations of the methods, the base station, the core network entity, and the AIoT device described herein, the type of the service comprises one of: an inventory type for identifying each of the one or more AIoT devices, a command type for performing an operation related to the one or more AIoT devices, a reading type for reading data from the one or more AIoT devices, a writing type for writing data to the one or more AIoT devices, or a disabling type for disabling the one or more AIoT devices.

[0029] In some implementations of the methods, the base station, the core network entity, and the AIoT device described herein, the first message further indicates a device type of the one or more AIoT devices.

[0030] In some implementations of the methods, the base station, the core network entity, and the AIoT device described herein, the device type comprises one of: a type of AIoT devices, a type of backscattered devices, a first type of AIoT devices with a power consumption value lower than a first threshold, a second type of AIoT devices with a power consumption value within a range from the first threshold to a second threshold and with a backscattered transmission on a carrier wave, or a third type of AIoT devices with a power consumption value within a range from the first threshold to the second threshold and with a transmission generated internally.

[0031] In some implementations of the methods, the base station, the core network entity, and the AIoT device described herein, the first message comprises assistance information for the procedure of the service.

[0032] In some implementations of the methods, the base station, the core network entity, and the AIoT device described herein, the assistance information indicates one of: an energy harvesting rate at each of the one or more AIoT devices for the procedure, a charging time

for the procedure, a power consumption value for the procedure, an energy storage size at each of the one or more AIoT devices for the procedure, a stored or available energy at each of the one or more AIoT devices during the procedure, a starting time of the procedure, a complete time of the procedure, a required latency of the procedure, or an inventory round indicator in case the procedure is associated with the inventory request.

[0033] In some implementations of the methods, the base station, the core network entity, and the AIoT device described herein, the first message comprises a first indicator indicating whether an antenna of the one or more AIoT devices is shared among an energy harvesting and communication.

[0034] In some implementations of the methods, the base station, the core network entity, and the AIoT device described herein, the second message is transmitted after a time duration, wherein the time duration comprises one of: a charging time indicated by the first message, a waiting time received from the core network entity or a further core network entity, or a waiting time configured by an operation administration and maintenance (OAM).

[0035] In some implementations of the methods, the base station, the core network entity, and the AIoT device described herein, the fourth message comprises a second indicator indicating whether the procedure is complete.

[0036] In some implementations of the methods, the base station, the core network entity, and the AIoT device described herein, the fourth message comprises a command request.

[0037] In some implementations of the methods, the base station, the core network entity, and the AIoT device described herein, the third message further comprises a random access ID.

[0038] In some implementations of the methods, the base station, the core network entity, and the AIoT device described herein, the first message comprises a next generation application (NGAP) message, and the type of the service is comprised in an information element of paging cause of the NGAP message.

[0039] In some implementations of the methods, the base station, the core network entity, and the AIoT device described herein, the first message comprises a message dedicated to AIoT or dedicated to the service.

[0040] In some implementations of the methods, the base station, the core network entity, and the AIoT device described herein, the core network entity comprises one of: an AIoT

management function (AIMF), an access and mobility management function (AMF) comprising an AIMF, or an AMF communicating with an AIMF.

BRIEF DESCRIPTION OF THE DRAWINGS

[0041] FIG. 1 illustrates an example of a wireless communications system in which some embodiments of the present disclosure can be implemented;

[0042] FIG. 2A illustrates an example structure of an AIoT device with device 1;

[0043] FIG. 2B illustrates a schematic diagram of an example communication network in which some embodiments of the present disclosure can be implemented;

[0044] FIGS. 2C-2E illustrate example schematics for a connection between a base station and a core network entity in accordance with some example embodiments of the present disclosure;

[0045] FIG. 3 illustrates a signalling chart illustrating communication process in accordance with some example embodiments of the present disclosure;

[0046] FIGS. 4A-4B illustrate signalling charts illustrating communication process associated with FIG. 2C in accordance with some example embodiments of the present disclosure;

[0047] FIG. 5 illustrates an example of a device that is suitable for implementing embodiments of the present disclosure;

[0048] FIG. 6 illustrates an example of a processor that is suitable for implementing some embodiments of the present disclosure;

[0049] FIG. 7 illustrates a flowchart of an example method implemented at a base station in accordance with aspects of the present disclosure;

[0050] FIG. 8 illustrates a flowchart of an example method implemented at a core network entity in accordance with aspects of the present disclosure; and

[0051] FIG. 9 illustrates a flowchart of an example method implemented at an AIoT device in accordance with aspects of the present disclosure.

[0052] Throughout the drawings, the same or similar reference numerals represent the same or similar element.

DETAILED DESCRIPTION

[0053] 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.

[0054] 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.

[0055] 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.

[0056] 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.

[0057] FIG. 1 illustrates an example of a wireless communications system 100 in which some embodiments of the present disclosure can be implemented. The wireless communications system 100 may include one or more network entities 102 (also referred to as network equipment (NE)), one or more UEs 104, a core network (CN) 106, and a packet data network 108. The wireless communications system 100 may support various radio access technologies. In some implementations, the wireless communications system 100 may be a 4G network, such as a long term evolution (LTE) network or an LTE-advanced (LTE-A) network. In some other implementations, the wireless communications system 100 may be a 5G network, such as a new radio (NR) network. In other implementations, the wireless communications system 100 may be a combination of a 4G network and a 5G network, or other suitable radio access technology including institute of electrical and electronics engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20. The wireless communications system 100 may support radio access technologies beyond 5G. Additionally, the wireless communications system 100 may support technologies, such as time division multiple access (TDMA), frequency division multiple access (FDMA), or code division multiple access (CDMA), etc.

[0058] 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.

[0059] A network entity 102 may provide a geographic coverage area 112 for which the network entity 102 may support services (e.g., voice, video, packet data, message, broadcast, etc.) for one or more UEs 104 within the geographic coverage area 112. For example, a network entity 102 and a UE 104 may support wireless communication of signals related to services (e.g., voice, video, packet data, messaging, broadcast, etc.) according to one or multiple radio access technologies. In some implementations, a network entity 102 may be moveable, for example, a satellite associated with a non-terrestrial network. In some implementations, different geographic coverage areas 112 associated with the same or different radio access technologies may overlap, but the different geographic coverage areas 112 may be associated with different network entities 102. Information and signals described herein may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[0060] 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.

[0061] The one or more UEs 104 may be devices in different forms or having different capabilities. Some examples of UEs 104 are illustrated in FIG. 1. A UE 104 may be capable of communicating with various types of devices, such as the network entities 102, other UEs 104, or network equipment (e.g., the CN 106, the packet data network 108, a relay device, an integrated access and backhaul (IAB) node, or another network equipment), as shown in FIG. 1. Additionally, or alternatively, a UE 104 may support communication with other network entities 102 or UEs 104, which may act as relays in the wireless communications system 100.

[0062] A UE 104 may also be able to support wireless communication directly with other UEs 104 over a communication link 114. For example, a UE 104 may support wireless communication directly with another UE 104 over a device-to-device (D2D) communication link. In some implementations, such as vehicle-to-vehicle (V2V) deployments, vehicle-to-everything (V2X) deployments, or cellular-V2X deployments, the communication link 114 may be referred to as a sidelink (SL). For example, a UE 104 may support wireless communication directly with another UE 104 over a PC5 interface.

[0063] A network entity 102 may support communications with the CN 106, or with another network entity 102, or both. For example, a network entity 102 may interface with the CN 106 through one or more backhaul links 116 (e.g., via an S1, N2, N3, or another network interface). The network entities 102 may communicate with each other over the backhaul links 116 (e.g., via an X2, Xn, or another network interface). In some implementations, the network entities 102 may communicate with each other directly (e.g., between the network entities 102). In some other implementations, the network entities 102 may communicate with each other or indirectly (e.g., via the CN 106). In some implementations, one or more network entities 102 may include subcomponents, such as an access network entity, which may be an example of an access node controller (ANC). An ANC may communicate with the one or more UEs 104 through one or more other access network transmission entities, which may be referred to as a radio heads, smart radio heads, or transmission-reception points (TRPs).

[0064] 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.

[0065] 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)).

[0066] Split of functionality between a CU, a DU, and an RU may be flexible and may support different functionalities depending upon which functions (e.g., network layer functions, protocol layer functions, baseband functions, radio frequency functions, and any combinations thereof) are performed at a CU, a DU, or an RU. For example, a functional split of a protocol stack may be employed between a CU and a DU such that the CU may support one or more layers of the protocol stack and the DU may support one or more different layers of the protocol stack. In some implementations, the CU may host upper protocol layer (e.g., a layer 3 (L3), a layer 2 (L2)) functionality and signaling (e.g., radio resource control (RRC), service data adaption protocol (SDAP), packet data convergence protocol (PDCP)). The CU may be connected to one or more DUs or RUs, and the one or more DUs or RUs may host lower protocol layers, such as a layer 1 (L1) (e.g., physical (PHY) layer) or an L2 (e.g., radio link control (RLC) layer, medium access control (MAC) layer) functionality and signaling, and may each be at least partially controlled by the CU.

[0067] 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).

[0068] 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.

[0069] The CN 106 may support user authentication, access authorization, tracking, connectivity, and other access, routing, or mobility functions. The CN 106 may be an evolved packet core (EPC), or a 5G core (5GC), which may include a control plane entity that manages access and mobility (e.g., a mobility management entity (MME), an access and mobility management functions (AMF)) and a user plane entity that routes packets or interconnects to external networks (e.g., a serving gateway (S-GW), a Packet Data Network (PDN) gateway (P-GW), or a user plane function (UPF)). In some implementations, the control plane entity may manage non-access stratum (NAS) functions, such as mobility, authentication, and bearer management (e.g., data bearers, signal bearers, etc.) for the one or more UEs 104 served by the one or more network entities 102 associated with the CN 106.

[0070] The CN 106 may communicate with the packet data network 108 over one or more backhaul links 116 (e.g., via an S1, N2, N3, or another network interface). The packet data network 108 may include an application server 118. In some implementations, one or more UEs 104 may communicate with the application server 118. A UE 104 may establish a session (e.g., a protocol data unit (PDU) session, or the like) with the CN 106 via a network entity 102. The CN 106 may route traffic (e.g., control information, data, and the like) between the UE 104 and the application server 118 using the established session (e.g., the established PDU session). The PDU session may be an example of a logical connection between the UE 104 and the CN 106 (e.g., one or more network functions of the CN 106).

[0071] 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.

[0072] One or more numerologies may be supported in the wireless communications system 100, and a numerology may include a subcarrier spacing and a cyclic prefix. A first

numerology (e.g., μ=0) may be associated with a first subcarrier spacing (e.g., 15 kHz) and a normal cyclic prefix. In some implementations, the first numerology (e.g., μ=0) associated with the first subcarrier spacing (e.g., 15 kHz) may utilize one slot per subframe. A second numerology (e.g., μ=1) may be associated with a second subcarrier spacing (e.g., 30 kHz) and a normal cyclic prefix. A third numerology (e.g., μ=2) may be associated with a third subcarrier spacing (e.g., 60 kHz) and a normal cyclic prefix or an extended cyclic prefix. A fourth numerology (e.g., μ=3) may be associated with a fourth subcarrier spacing (e.g., 120 kHz) and a normal cyclic prefix. A fifth numerology (e.g., μ=4) may be associated with a fifth subcarrier spacing (e.g., 240 kHz) and a normal cyclic prefix.

[0073] 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.

[0074] Additionally or alternatively, a time interval of a resource (e.g., a communication resource) may be organized according to slots. For example, a subframe may include a number (e.g., quantity) of slots. The number of slots in each subframe may also depend on the one or more numerologies supported in the wireless communications system 100. For instance, the first, second, third, fourth, and fifth numerologies (i.e., μ=0, μ=1, μ=2, μ=3, μ=4) associated with respective subcarrier spacings of 15 kHz, 30 kHz, 60 kHz, 120 kHz, and 240 kHz may utilize a single slot per subframe, two slots per subframe, four slots per subframe, eight slots per subframe, and 16 slots per subframe, respectively. Each slot may include a number (e.g., quantity) of symbols (e.g., orthogonal frequency-division multiplexing (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., μ=0) associated with a first subcarrier spacing (e.g., 15 kHz) may be used interchangeably between subframes and slots.

[0075] 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.

[0076] 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., μ=0), which includes 15 kHz subcarrier spacing; a second numerology (e.g., μ=1), which includes 30 kHz subcarrier spacing; and a third numerology (e.g., μ=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., μ=2), which includes 60 kHz subcarrier spacing; and a fourth numerology (e.g., μ=3), which includes 120 kHz subcarrier spacing.

[0077] Ambient IoT devices, which are a type of devices with no or limited energy storage capability, have attracted much attention in the wireless communication world. AIoT devices have a smaller size, lower complexity, lower power consumption, and a huger number (e.g. tens or even hundreds of billion) than existing UEs. Considering the capability, the AIoT devices may include:

- Device 1: ~1 μW peak power consumption, has energy storage, initial sampling frequency offset (SFO) up to 10^X ppm, neither DL nor UL amplification in the device. The device's UL transmission is backscattered on a carrier wave provided externally.

- Device 2a: $\leq$ a few hundred μW peak power consumption, has energy storage, initial sampling frequency offset (SFO) up to 10^X ppm, both DL and/or UL amplification in the device. The device's UL transmission is backscattered on a carrier wave provided externally.

- Device 2b: ≤ a few hundred μW peak power consumption, has energy storage, initial sampling frequency offset (SFO) up to 10^X ppm, both DL and/or UL amplification in the device. The device's UL transmission is generated internally by the device.

[0078] FIG. 2A illustrates an example structure of an AIoT device with Device 1. For example, the following blocks are studied for Device 1 architecture.

[0079] Antenna could be either shared or separate for RF energy harvester and receiver/transmitter. Matching network is to match impedance between antenna and other components (including RF energy harvester and receiver related blocks). RF energy harvester can include rectifier performing RF signal (AC) to DC conversion. Energy storage (e.g., capacitor) stores harvested energy from RF energy harvester. Power management unit (PMU) manages storing energy to energy storage from energy harvester and suppling power to active component blocks which needs power supply. Digital BB logic includes functional blocks like encoder, decoder, controller, etc. Memory can include two types of memory: 1) non-volatile memory (NVM) such as EEPROM for permanently storing device ID, etc., and 2) registers for temporarily keeping any information required for its operation only while energy is available in energy storage. Clock generator provides required clock signal(s). Reception related blocks: RF BPF for improving selectivity, depending on implementation, it may not exist, RAN4 RF requirement (if any, e.g., ACS) and peak power consumption target also need to be considered; RF Envelope Detector converts RF signal to baseband; BB LPF can filter out harmonics and high frequency components to improve input signal quality to comparator, depending on implementation, it may not exist, presence of BB LPF is assumed for the study; Comparator determines high/low of input signal. Transmission related blocks: Backscatter modulator switches impedance to modulate backscattered signal with tx signal from BB logics. Waveform/Modulation type is to be studied.

[0080] The AIoT devices are typically battery less devices with no energy storage capability, or devices with energy storage that do not need to be replaced or recharged manually, where the energy is provided through the harvesting of radio waves, light, motion, heat, or any other power source that could be seen suitable. An AIoT service may be triggered by NW, such as a core network entity. The AIoT service generally is performed through a base station, in this case, a solution that the base station differentiates the AIoT devices should be addressed.

[0081] Embodiments of the present disclosure provide a solution for a service for AIoT devices. In the solution, a base station may receive a first message from a core network entity, and the first message may indicate a type of a service for one or more AIoT devices. Accordingly, the base station may identify that the first message is for AIoT service, and in addition, the base station may transmit a second message to the one or more AIoT devices to initiate a procedure of the service. As such, the base station can differentiate a service of AIoT from legacy UEs, and the service for AIoT devices can be guaranteed. Principles and implementations of the present disclosure will be described in detail below with reference to the figures.

[0082] FIG. 2B illustrates a schematic diagram of an example communication network 200 in which some embodiments of the present disclosure can be implemented. As shown in FIG. 2B, the communication network 200 may include a BS 210, multiple AIoT devices 230, and a core network entity 250. With reference to FIG. 1, the BS 210 may be the network entity 102. The core network (CN) entity 250 may be a network function (NF) in CN, such as a 5GC or a 6G core network.

[0083] For example, the core network entity 250 may include an AIoT management function (AIMF) 251 and/or an Access and Mobility Management Function (AMF) 252 of a 5GC. Some examples related to the AIMF 251 and the AMF 252 are illustrated in FIGS. 2C-2E.

[0084] As illustrated in FIG. 2C, the AIMF 251 is a logical entity in the CN different from the AMF 252, and the base station 210 communicates with the AIMF 251 directly. As illustrated in FIG. 2D, the AIMF 251 is a logical entity in the CN different from the AMF 252, and the base station 210 communicates with the AIMF 251 through the AMF 252. As illustrated in FIG. 2E, the AIMF 251 is a function (i.e. an internal function) in the AMF 252, that is the AMF 252 includes the AIMF 251.

[0085] In the present disclosure, the AIMF 251 may include some or all functionalities listed below:

- AIoT device data processing, e.g., gathering the raw data of the AIoT device, filtering and cleaning the raw data, and putting the raw data in a usable format for processing.
- Device management, e.g., monitoring, managing, control and coordination of the AIoT devices and/or AIoT readers (e.g., base station), where the AIoT reader is a device that reads and writes data to AIoT devices using radio frequency waves. For example,

- Inventory: identifying individual AIoT devices.
- Command: communication with an identified AIoT device to perform an operation of the AIoT device, such as reading (read data from the AIoT device), writing (write data to the AIoT device), or disabling (disable the AIoT device temporarily or permanently).
- AIoT reader configuration, such as the configuration of the radio frequency receiver sensitivity, or radio frequency transmit power.

- Service management, e.g., receiving queries from the external entities, and filtering the results from the data retrieved from the AIoT devices and/or AIoT readers.

[0086] FIG. 3 illustrates a signalling chart illustrating communication process 300 in accordance with some example embodiments of the present disclosure. The process 300 may involve the base station 210, the AIoT device 230, and the core network entity 250 as discussed with reference to FIG. 2B. It would be appreciated that the process 300 may be applied to other communication scenarios, which will not be described in detail.

[0087] In the process 300, the core network entity 250 transmits a first message to the base station 210 at 310. The first message indicates a type of a service for the AIoT device 230. In some implementations, the service may be associated with an inventory request, a command request, or a request for both inventory and command (i.e., both inventory request and command request). In some implementations, the type of the service may also be called as a service operation type, and the present disclosure does not limit for this aspect.

[0088] In some implementations, the type (e.g. the service operation type) may include at least one of: an inventory type for identifying each of the one or more AIoT devices, a command type for performing an operation related to the one or more AIoT devices, a reading type for reading data from the one or more AIoT devices, a writing type for writing data to the one or more AIoT devices, or a disabling type for disabling the one or more AIoT devices (e.g. temporarily or permanently). In some embodiments, the inventory may be used to identify individual AIoT device, and the command may be used to perform an operation of the AIoT device. In some examples, the type may be inventory type and/or command. For example, the type may be both inventory and command (which may be regarded as a full type or full service), indicating to perform operation(s) after identifying individual AIoT device. In some examples, the type may be one or more of: inventory, reading, writing, or disabling.

[0089] In some embodiments, the first message may be an NGAP message. In some embodiments, the NGAP message includes a paging cause information element (IE), and the IE of paging cause may include the type of the service.

[0090] In some other embodiments, the first message may be a message dedicated to AIoT or dedicated to the service. In some examples, the first message may be an AIoT request message, an AIoT inventory message, an AIoT command message, or the like.

[0091] In some examples, the first message may be a message dedicated to AIoT, e.g., an AIoT request message. In some cases, the type may be included in the AIoT request message, and the type may be at least one of: inventory, command, reading, write, or disable. In some other cases, the type may be not included (e.g., absent) in the AIoT request message, and a default type may be pre-configured or predefined associated with the AIoT request message, for example, the default type may be inventory, however, it is understood that the present disclosure does not limit for this aspect.

[0092] In some examples, the first message may be a message dedicated to the service, e.g. an AIoT inventory message. In some instances, the AIoT inventory message may include detailed inventory request information. In some instances, the AIoT inventory message may indicate the type inventory, and there may be not an explicit IE or field including the type.

[0093] In some examples, the first message may be a message dedicated to the service, e.g. an AIoT command message. In some instances, the AIoT command message may include detailed command request information. In some instances, the AIoT command message may indicate the type command, and there may be no explicit IE or field including the type.

[0094] In some implementations, the first message may indicate a device type. In some example embodiments, one or more AIoT devices with the device type may be determined and be used for the service. In some implementations, the device type may be one or more of: AIoT device, AIoT device 1, AIoT device 2a, AIoT device 2b, or backscattered device. In this case, the base station 210 may be aware of the first message being for AIoT service but not for legacy UEs.

[0095] In some examples, the device type may be AIoT device, for example, a device with limited energy storage capability and is powered by energy harvesting. In some examples, the device type may be a first type of AIoT devices, i.e. device 1 as provided above. In some examples, the device type may be a second type of AIoT devices, i.e. device 2a as

provided above. In some examples, the device type may be a third type of AIoT devices, i.e. device 2b as provided above. In some examples, the device type may be backscattered device, for example, a device with a UL transmission being backscattered on a carrier wave provided externally.

[0096] In some implementations, the first message may include assistance information for a procedure of the service. In some implementations, the assistance information may include part or all of the following: an energy harvesting rate at each of the one or more AIoT devices for the procedure, a charging time for the procedure, a power consumption value for the procedure, an energy storage size at each of the one or more AIoT devices for the procedure, a stored or available energy at each of the one or more AIoT devices during the procedure, a starting time of the procedure, a complete time of the procedure, a required latency of the procedure, or an inventory round indicator in case the procedure is associated with the inventory request.

[0097] In some examples, the assistance information may include an energy harvesting rate, which may indicate a rate for energy harvesting, e.g., a rate for the conversion of ambient energy present in the RF signal into electronic energy for use in powering the AIoT device.

[0098] In some examples, the assistance information may include a charging time, which may indicate a time length or a time duration for charging the AIoT device.

[0099] In some examples, the assistance information may include a power consumption value, which may indicate a power consumption for one inventory round, or power consumption for transmitting or receiving a message.

[00100] In some examples, the assistance information may include an energy storage size, which may indicate the energy amount that an AIoT device could store.

[00101] In some examples, the assistance information may include a stored or available energy, which may indicate an amount of available energy of the AIoT device. For example, the CN entity 250 may determine (e.g. calculate) the stored/available energy by using an energy storage size minus the power consumption value.

[00102] In some examples, the assistance information may include a time requirement for the procedure of the service. In some instances, the time requirement may include a starting time and/or a complete time. For example, the starting time may indicate when to start the inventory procedure or the command procedure. For example, the completer time may indicate an ending time or a time length for the procedure, e.g., how long the base station 210

needs to complete the inventory procedure or the command procedure for multiple AIoT devices. In some instances, the time requirement may include a latency, which may indicate a required latency for the inventory procedure or the command procedure.

[00103] In some examples, the assistance information may include an inventory round indicator, which may indicate a time duration for one inventory round. For example, the time duration may be represented as multiple time units (such as slots, symbols, frames, seconds, etc.), and the inventory round indicator may indicate a total number of the multiple time units.

[00104] In some implementations, the first message may include a first indicator, and the first indicator may indicate whether an antenna of the AIoT device is shared among an energy harvesting and communication. For example, the first indicator may indicate that an RF energy harvester and communication (e.g., receiver/transmitter) should or should not share a same antenna.

[00105] In some example embodiments, the first message may be an NGAP paging message, in this case, the type of the service (i.e. service operation type) may be included in the paging cause, while the device type, the assistance information, and the first indicator may be included in AIoT device capability or assistance data for paging of the first message.

[00106] In some example embodiments, the information indicated by the first message, such as the device type, assistance information, and/or a first indicator may be determined by the CN entity 250, e.g. based on a device capability. For example, the device capability may be obtained from an AIoT device (e.g., by a capability report) during a registration procedure.

[00107] From the BS perspective, it may receive the first message from the CN entity 250. In some implementations, the BS 210 may determine the one or more AIoT devices 230 for the service, for example, the device type indicated by the first message may be considered.

[00108] In addition, the BS 210 may determine whether an energy harvesting is needed. In some examples, the BS 210 may determine that an RF signal for energy harvesting needs to be sent to at least one AIoT device. In some embodiments, the BS 210 may determine that the energy harvesting is needed, if (1) a device type indicated by the first message is: AIoT device, AIoT device 1, AIoT device 2a, AIoT device 2b, or backscattered device, (2) the first message is a message dedicated to AIoT or dedicated to inventory/command, (3) a first indicator in the first message indicates an antenna of the AIoT device is shared for RF energy harvester and communication, and/or (4) the assistance information in the first message

indicates that the stored/available energy is less than the power consumption value. In other words, the BS 210 may determine that an RF signal for energy harvesting should be sent to at least one AIoT device 230.

[00109] In some embodiments, the BS 210 may determine a time duration of the RF signal for energy harvesting, e.g., based on the first message. In some examples, the assistance information in the first message may include the charging time, and the BS 210 may determine the time duration for the RF signal for energy harvesting based on the charging time. In some other examples, the assistance information in the first message may include one or more of: the energy harvesting rate, the power consumption value, the energy storage size, the stored/available energy, and the BS 210 may determine the time duration for the RF signal for energy harvesting based on one or more of: the energy harvesting rate (e.g. represented as R_{rate}), the power consumption value (e.g. represented as $E_{consumption}$), the energy storage size, the stored/available energy (e.g. represented as E_{stored}). As one non-limited example, the time duration of the RF signal for energy harvesting may be represented as:

$$T_{duration} = \frac{E_{consumption} - E_{stored}}{R_{rate}} \quad (1)$$

[00110] In some examples, the BS 210 may determine a source of the RF signal for energy harvesting.

[00111] In some implementations, the BS 210 may transmit an indication to the source (which may be another BS or a UE), and the indication may indicate to the source to transmit an RF signal to at least one AIoT device for energy harvesting. In some examples, the indication to the source may include the time duration of the RF signal for energy harvesting. Accordingly, the source may transmit the RF signal for energy harvesting based on the indication from the BS 210.

[00112] In some other implementations, as shown in FIG. 3, the BS 210 may determine the RF signal for energy harvesting at 322 and further transmits the RF signal at 324. In some examples, the BS 210 may determine to charge the at least one AIoT device by itself, that is, the source is the BS 210. In some examples, the BS 210 may generate the RF signal and transmits it to the at least one AIoT device for energy harvesting.

[00113] It is to be appreciated that the above description about the RF signal for energy harvesting is only for illustration without any limitation. In some examples, the BS 210

may be configured with to defined with a default behavior upon receiving the first message from the CN entity 250. For example, the default behavior may include: not providing an RF signal to the AIoT device. For example, the default behavior may include: transmitting the second message after a charging time or a waiting time, details on the transmission of the second message may refer to the step 330 below. For example, the default behavior may include: transmitting (or providing) that RF signal to the AIoT device with a waiting time. For instance, the waiting time may be preconfigured by OAM. For instance, the waiting time may be indicated by the CN entity 250 using a different message. For instance, the waiting time may be indicated by another different CN entity.

[00114] In the process 300, the BS 210 transmits a second message to the one or more AIoT devices 230 at 330. In some implementations, the second message may be a triggering message to initiate a procedure of the service. In some examples, the one or more AIoT devices 230 may be determined based on the first message, e.g. the device type.

[00115] In some embodiments, the BS 210 may transmit the second message after a time duration upon receiving the first message, where the time duration associated with the second message may include a charging time or a waiting time. For example, the time duration may be the charging time, which is indicated by the assistance information in the first message. For example, the time duration may be the waiting time, which may be preconfigured by OAM or be indicated by the CN entity 250 or another CN entity. For example, the time duration may be a sum of the charging time and the waiting time. As such, the second message may be transmitted until a charging time or a waiting time is expired.

[00116] In some implementations, the second message may indicate a type of the service, e.g. a service operation type, as discussed above.

[00117] In some examples, the second message may include an inventory round indicator, e.g., that included in the assistance information in the first message. In some examples, the second message may include detailed inventory information and/or detailed command information, e.g. that included in the first message.

[00118] In some embodiments, the second message may be a RAN paging message. In some examples, the RAN paging message may be sued for a notification to the one or more AIoT devices. In some examples, the RAN paging message may explicitly include the type of the service, i.e. the service operation type. In some other examples, the RAN paging

message may not include the type of the service, in this case, a default type may be implicitly indicated. For example, the default type may be inventory.

[00119] In some embodiments, the second message may be a message dedicated to AIoT. In some examples, the second message may be an AIoT inventory triggering message or an AIoT command triggering message. In some examples, the second message may include the type of the service which is command (or reading, writing, disabling), which may indicate that the second message is originated due to a command service (or a reading service, a writing service, a disabling service). In some examples, the second message may not include the type, in this case, a default type may be implicitly indicated. For example, the default type may be inventory, which may indicate that the second message is originated due to an inventory service.

[00120] In addition or alternatively, the BS 210 may start a timer for the procedure. In some embodiments, the assistance information in the first message may include a complete time, and the BS 210 may start the timer which will expire at a time related to the complete time. In some examples, the assistance information in the first message may include a starting time, in this case, the BS 210 may start to transmit the second message according to the starting time.

[00121] On the other side of communication, each of the one or more AIoT device 230 may receive the second message, and in addition the procedure of the service may be performed. Take one AIoT device (such as a first AIoT device) as an example, it may access the BS 210 and activate corresponding operation(s).

[00122] In addition or alternatively, the AIoT device 230 may transmit a third message to the BS 210 at 342, the third message may include an identifier (ID) of the AIoT device 230. For example, the third message may be transmitted on a carrier wave which is used for receiving the second message.

[00123] In some implementations, a random access process may be performed, e.g. before the step 342. In some example embodiments, the AIoT device 230 may transmit a random access ID to the BS 210, where the random access ID is transmitted on a carrier wave which is used for receiving the second message. For example, the AIoT device 230 may generate and send the random access ID. For example, the generated random access ID may be in a specific range, such as $(0, 2^Q-1)$ or $(1, 2^Q)$, where Q may be an inventory round indicator that included in the second message. For example, the AIoT device 230 may load the random

access ID in a slot counter, and if the slot counter value is zero, the AIoT device 230 sends the random access ID to the BS 210. Otherwise, the AIoT device 230 may decrement the slot counter value by one when it receives another message (e.g., another triggering message) until the value reaches zero, and sends the random number to the BS 210. In some example embodiments, the BS 210 may transmit a random access ID response to the AIoT device, e.g. in response to receiving the random access ID. For example, the BS 210 may monitor and receive the random access ID on a carrier wave which is used for transmitting the second message. For example, the random access ID response may indicate that the random access ID is successfully received by the BS 210. For example, the BS 210 may not need to monitor on the carrier wave which is used for transmitting the second message, e.g. in case the AIoT device 230 is with a device type Device 2b.

[00124] In some implementations, the random access ID may be included in the third message, in this case, additional signalling for the random access ID may be not needed, and the overhead can be reduced.

[00125] In some examples, the third message may be implemented as an inventory response which includes an ID of the AIoT device, i.e. AIoT device ID. In some other examples, the third message may include the random access ID and the inventory response which includes an AIoT device ID.

[00126] For example, the AIoT device ID may be a protocol control used to control the backscattering of AIoT device data, an extended protocol control used to provide additional protocol control information, and/or an electronic product code used to identify the object to which the corresponding AIoT device is affixed. However, it is to be noted that the AIoT device ID may be implemented as another format and the present disclosure does not limit for this aspect.

[00127] In addition or alternatively, the BS 210 may transmit a fourth message to the AIoT device 230 at 344. In some examples, the fourth message may include an inventory acknowledge, e.g., when the third message is the inventory response. In some other examples, the fourth message may include a random access ID response and the inventory acknowledge, e.g., when the third message includes the random access ID and the inventory response. For example, the inventory acknowledge may indicate that the AIoT device ID is successfully received by the BS 210.

[00128] In some examples, the fourth message may include a second indicator, which may indicate whether the procedure of the service is complete. For example, the second indicator may be included in the inventory acknowledge. For instance, a value of the second indicator may be set as "YES", which indicates the procedure between the BS 210 and the AIoT device 230 is completed, in other words, there will be no further command (or data) sent to the AIoT device 230, e.g., in case the service operation type is inventory. For instance, a value of the second indicator may be set as "NO", which indicates the procedure between the BS 210 and the AIoT device 230 is not completed, in other words, there will be further command (or data) sent to the AIoT device 230, e.g., in case the service operation type is command (or reading, writing, disabling).

[00129] In some examples, the BS 210 may determine the value of the second indicator in the fourth message based on an indicator from the CN entity 250, for example the indicator from the CN entity 250 may indicate whether the procedure is completed. In some instances, the BS 210 may provide the AIoT device ID to the CN entity 250 upon receiving the AIoT device ID from the AIoT device 230 e.g. in the third message. The CN entity 250 may determine whether the procedure associated with the AIoT device ID is completed and transmit the indicator to the BS 210.

[00130] In some examples, the fourth message may include detailed command information. For example, if the second message indicates that the service operation type is command (or reading, writing, disabling), then detailed command (or reading, writing, disabling) information may be included in the fourth message. For example, the detailed command information may be included in the inventory acknowledge.

[00131] In addition or alternatively, the AIoT device 230 may determine whether to disable the operation(s) at the AIoT device 230. As an illustrative example, the AIoT device 230 disables at least one operation at 350 as shown in FIG. 3.

[00132] In some examples, the deactivation may be performed by the AIoT device 230 if the service operation type indicated by the second message is inventory. In some examples, the deactivation may be performed by the AIoT device 230 if the service operation type indicated by the second message is command (or reading, writing, disabling).

[00133] In some implementations, the AIoT device 230 may determine whether to disable (or deactivate) a physical channel which is used to receive data from the BS 210 and/or a physical channel which is used to transmit data to the BS 210.

[00134] In some examples, the downlink physical channel which is used to receive data from the BS 210 will not be deactivated until an inventory acknowledge is received.

[00135] In some embodiments, the step 350 may be performed before the step 344. In this case, an uplink physical channel which is used to transmit data to the BS 210 may be deactivated and the downlink physical channel which is used to receive data from the BS 210 is still activated.

[00136] In some embodiments, the step 350 may be performed after the step 344. In some examples, both the uplink physical channel and the downlink physical channel are deactivated, e.g. in response to receiving the fourth message which is or includes the inventory acknowledge. In some examples, the fourth message may include a second indicator, and the AIoT device 230 may determine whether to activate the physical channel(s) based on the second indicator. For example, if a value of the second indicator is "YES", the AIoT device 230 may determine to perform the deactivation. For example, if a value of the second indicator is "NO", the AIoT device 230 may determine not to perform the deactivation.

[00137] According to embodiments with reference to FIG. 3, a procedure of a service for one or more AIoT devices may be enabled via the BS 210, specifically, a first message indicating a type of the service may be transmitted from the CN entity 250 to the BS 210, as such, the BS 210 is able to determine that the service is related to AIoT. Therefore, the communication for the one or more AIoT devices will be guaranteed.

[00138] It is to be understood that the embodiments with reference to FIG. 3 are only for illustration without any limitation, for example, some step(s) in FIG. 3 may be omitted, reordered, modified, or combined, some further step(s) may be also included, the present disclosure does not limit for this aspect. As detailed examples, FIGS. 4A-4B are provided below with an assumption of a relation between the AIMF 251 and AMF 252 in FIG. 2D.

[00139] FIG. 4A illustrates a signalling chart illustrating communication process 410 which involves an AIoT device 230, a BS 210, an AMF 252, and an AIMF 251.

[00140] In the process 410, the AIMF 251 transmits a request to the AMF 252 at 411. In some examples, if the AIMF 251 would like to initiate or trigger a service for one or more AIoT devices, then the request may be generated and transmitted. In some implementations, the request may indicate one or more of: a type of a service, a device type, assistance information, or a first indicator, details of which may refer to those discussed above with reference to FIG. 3, and thus will not be repeated herein.

[00141] In some embodiments, the AIMF 251 may determine, based on some information about one or more AIoT devices which the AIMF 252 already knows, some further information. For example, some information already known by the AIMF 252 may include a device type, and/or a device capability. For example, some information determined by the AIMF 252 may include the device type, the assistance information, and/or the first indicator.

[00142] In the process 410, the AMF 251 transmits a first message to the BS 210 at 412. Details of the first message may refer to those discussed with reference to FIG. 3, and thus will not be repeated herein. For example, the first message may be an NGAP message or another newly defined message.

[00143] In some examples, the information included in the first message may be the same as that included in the request from the AIMF 252. In some examples, the information included in the first message may be more than that included in the request from the AIMF 252. For example, the AMF 251 may perform some additional operations such as calculation to determine more information. For example, the device capability may be used by the AMF 251 to determine more information.

[00144] In the process 410, the BS 210 determines that the RF signal for energy harvesting is needed at 413, which is similar as the step 342 in FIG. 3. As shown in FIG. 4A, the BS 210 transmits the RF signal for energy harvesting to AIoT device 230 at 414. However, it should be understood that the source of the RF signal for energy harvesting may be another device, such as another BS or a UE, which is not shown in FIG. 4A.

[00145] In the process 410, the BS 210 transmits a second message (e.g. triggering message) to the AIoT device 230 at 415. Details of the second message may refer to those discussed above with reference to FIG. 3, and thus will not be repeated herein. In some embodiments, the BS 210 may start a timer which is associated with a complete time of the procedure.

[00146] In some embodiments, after the step 415, option 1 or option 2 or step 414 may be performed. In some embodiments, step 414 may be performed after option 1 or option 2.

[00147] Option 1 may include steps 416-420. At step 416, the AIoT device 230 transmits a random access ID to the BS 210. For example, the random access ID may be transmitted on a carrier wave on which the triggering message is received.

[00148] At step 417, the BS 210 may transmit an access ID response to the AIoT device 230, e.g. based on a reception of the random access ID from the AIoT device 230. For example, the access ID response may include the received random access ID. In some instances, if

the device type is one of: AIoT device, AIoT device 1, AIoT device 2a, or backscattered device, the BS 210 may monitor and receive the random access ID on the same carrier wave that was used to send the triggering message. In some instances, if the device type is AIoT device 2b, the BS 210 do not need to monitor the same carrier wave. For example, a different carrier wave may be used by the AIoT device 230 to transmit the random access ID.

[00149] At step 418, the AIoT device 230 transmits an inventory response to the BS 210. The inventory response includes the AIoT device ID of the AIoT device 230.

[00150] At step 419, the AIoT device 230 determines whether to deactivate (or disable) the downlink physical channel and/or the uplink physical channel. For example, a default behavior of the AIoT device 230 at 419 may deactivate the uplink physical channel while keeping the downlink physical channel activated (i.e. not be deactivated).

[00151] In some examples, the downlink physical channel may not be deactivated, i.e. is activated, and in addition at step 420, the BS 210 transmits an inventory acknowledge to the AIoT device 230. For example, the inventory acknowledge is transmitted in response to receiving an AIoT device ID, e.g. included in the inventory response. In some instances, if the service operation type is command (or reading, writing, or disabling), then detailed command information may be included in the inventory acknowledge.

[00152] It is to be noted that although the step 420 is shown after the step 419, it may be performed before the step 419 in an actual scenario.

[00153] Option 2 may include steps 421-423. At step 421, the AIoT device 230 transmits a third message including a random access ID and an inventory response (which includes an AIoT device ID) to the BS 210.

[00154] In some instances, if the device type is one of: AIoT device, AIoT device 1, AIoT device 2a, or backscattered device, the third message may be transmitted on a carrier wave that is used to receive the triggering message. In some instances, if the device type is AIoT device 2b, the third message may be transmitted on a carrier wave that is used to receive the triggering message, or may be on a different carrier wave.

[00155] At step 422, the AIoT device 230 determines whether to deactivate (or disable) the downlink physical channel and/or the uplink physical channel. For example, a default behavior of the AIoT device 230 at 422 may deactivate the uplink physical channel while keeping the downlink physical channel activated (i.e. not be deactivated).

[00156] In some examples, the downlink physical channel may not be deactivated, i.e. is activated, and in addition at step 423, the BS 210 transmits a fourth message including an access ID response and an inventory acknowledge to the AIoT device 230. For example, the access ID response may indicate that the random access ID is received successfully, and the inventory acknowledge may indicate that the AIoT device ID is received successfully. For example, the access ID response may include the random access ID which is received at step 421. In some instances, if the service operation type is command (or reading, writing, or disabling), then detailed command information may be included in the inventory acknowledge.

[00157] It is to be noted that although the step 423 is shown after the step 422, it may be performed before the step 422 in an actual scenario.

[00158] At step 424, the AIoT device 230 may transmit a command acknowledge to the BS 210. In some embodiments, if detailed command information is received, e.g. at step 415, 420, or 423, the AIoT device 230 may determine to transmit the command acknowledge. For example, the command acknowledge may be transmitted on a carrier wave that is used for receiving the detailed command information, e.g. at step 415, 420, or 423.

[00159] At step 425, the BS 210 transmits an AIoT service response to the AIMF 251 via the AMF 252. In some examples, if an AIoT device ID is received from an AIoT device, such as AIoT device 230, the BS 210 may transmit the AIoT service response to the AMF 252 at 425a, and accordingly the AMF 252 may forward it to the AIMF 251 at 425b. In some other examples, the AIoT service response is transmitted if an AIoT device ID from each of the one or more AIoT devices is received and the complete time is expired. In some other examples, the AIoT service response is transmitted is a latency is expired.

[00160] It is to be appreciated that the process 410 in FIG. 4A is only for illustration without any limitation. In some examples, the steps 416-420 in option 1 are performed and the steps 421-423 in option 2 are not performed. In some examples, the steps 421-423 in option 2 are performed and the steps 416-420 in option 1 are not performed. In some examples, neither option 1 nor option 2 is performed, and step 424 is performed after step 415. In some examples, the steps 418-420 in option 1 may be omitted, for example, steps 416-417 in option 1 are performed, and step 424 is performed after the step 417. In some examples, the step 424 may be omitted while the command acknowledge may be combined into some other message. For example, the third message at 421 may include a random access ID and

a command acknowledge. It is to be understood that some further embodiments may be obtained and are still in the protection scope of the present disclosure.

[00161] FIG. 4B illustrates a signalling chart illustrating communication process 450 which involves an AIoT device 230, a BS 210, an AMF 252, and an AIMF 251.

[00162] The steps 411, 412, 413, 414, 415, 416, 417, 418, and 421 shown in FIG. 4B may refer to those discussed in FIG. 4A, detailed of which will not be repeated herein.

[00163] At step 429, the BS 210 transmits an inventory acknowledge to the AIoT device 230.

[00164] In some examples, the inventory acknowledge at step 429 may include a second indicator, which may indicate whether the procedure of the service is complete. For example, the second indicator may be included in the inventory acknowledge. For instance, a value of the second indicator may be set as "YES", which indicates the procedure between the BS 210 and the AIoT device 230 is completed, in other words, there will be no further command (or data) sent to the AIoT device 230, e.g., in case the service operation type is inventory. For instance, a value of the second indicator may be set as "NO", which indicates the procedure between the BS 210 and the AIoT device 230 is not completed, in other words, there will be further command (or data) sent to the AIoT device 230, e.g., in case the service operation type is command (or reading, writing, disabling) or both inventory and command (or reading, writing, disabling).

[00165] In some examples, the BS 210 may determine the value of the second indicator based on an indicator from the CN entity 250, for example the indicator from the CN entity 250 may indicate whether the procedure is completed. In some instances, the BS 210 may provide the AIoT device ID to the CN entity 250 upon receiving the AIoT device ID from the AIoT device 230 e.g. at step 418. The CN entity 250 may determine whether the procedure associated with the AIoT device ID is completed and transmit the indicator to the BS 210.

[00166] At step 430, the AIoT device 230 determines whether to deactivate (or disable) the downlink physical channel and/or the uplink physical channel.

[00167] In some examples, if the inventory acknowledge at 429 includes a second indicator with a value "YES", the AIoT device 230 may determine to deactivate the downlink physical channel, alternatively, the AIoT device 230 may further deactivate or not deactivate (keep it active) the uplink physical channel. In some other examples, if the inventory acknowledge at 429 includes a second indicator with a value "NO", the AIoT device 230 may determine not to deactivate ((keep it active)) the downlink physical channel, alternatively, the AIoT

device 230 may further deactivate or not deactivate (keep it active) the uplink physical channel.

[00168] At step 432, the BS 210 transmits a fourth message including an access ID response and an inventory acknowledge to the AIoT device 230.

[00169] In some examples, the fourth message may include a second indicator, for example, the second indicator may be included in the inventory acknowledge. Details on the second indicator may refer to those discussed above, and thus will not be repeated herein.

[00170] At step 433, the AIoT device 230 determines whether to deactivate (or disable) the downlink physical channel and/or the uplink physical channel, which is similar with the step 430 in option 1.

[00171] At step 434, the BS 210 transmits an AIoT inventory response to the AIMF 251 via the AMF 252, where the AIoT inventory response may include the AIoT device ID.

[00172] At step 435, the AIMF 251 transmits an AIoT command to the AIoT device 230 via the AMF 252 and the BS 210. In some examples, the AIoT device 230 may perform operation(s) based on the AIoT command.

[00173] At step 436, the AIoT device 230 transmits a command acknowledge to the AIMF 251 via the BS 210 and the AMF 252.

[00174] It is to be appreciated that the process 450 in FIG. 4B is only for illustration without any limitation. In some examples, the steps 416-418 and 429-430 in option 1 are performed and the steps 421 and 432-433 in option 2 are not performed. In some examples, the steps 421 and 432-433 in option 2 are performed and the steps 416-418 and 429-430 in option 1 are not performed. In some examples, the triggering message at 415 in process 450 may not include detailed command information, which may be provided at step 435. In some examples, the triggering message at 415 in process 450 may be an NGAP message or a message dedicated to inventory service. In some examples, the steps 434, 435a and 435b are performed before the step 429, and the step 435c is included in the step 429, in option 1. In some example, the steps 434, 435a and 435b are performed before the step 432, and the step 435c is included in the step 432, in option 2.

[00175] According to some embodiments discussed above, a solution for supporting AIoT services is provided. A type of the service and/or a device type may be indicated, and thus the BS 210 can differentiate AIoT devices from legacy UEs. Behaviors at the BS are

defined e.g. according to the type of the service, i.e. service operation type. For the inventory service, the BS initiates the inventory procedure towards the AIoT device. The BS may forward the service operation type to the AIoT device. In other options, the BS may send an indicator to the AIoT device indicating the procedure is complete, after receiving the AIoT device ID from the AIoT device, or after receiving the complete indication from the CN entity. For the command service, the BS may initiate the inventory procedure towards the AIoT device. After receiving the AIoT device ID by the inventory procedure, the BS forwards the detailed command message (e.g., in the NAS message) to the AIoT device. In other options, the BS may forward the command message to the AIoT device without initiating the inventory procedure. Behaviors at the AIoT are defined e.g. according to the received type of the service, i.e. service operation type. For the command service, the AIoT device should keep alive (e.g., activate the physical channel transmission to receive or send data from/to the BS) after the inventory procedure. In other options, the AIoT device may deactivate the physical channel transmission to receive/send data from/to the BS, after providing the command acknowledge to the BS. For the inventory service, the AIoT device may deactivate the physical channel transmission to receive/send data from/to the BS, after providing the AIoT device ID to the BS. For the full service, the AIoT device should keep alive (e.g., activate the physical channel transmission to receive or send data from/to the BS) after the inventory procedure. Alternatively, the default behavior is to deactivate the physical channel transmission to receive/send data from/to the BS, after providing the AIoT device ID to the BS.

[00176] FIG. 5 illustrates an example of a device 500 that is suitable for implementing embodiments of the present disclosure. The device 500 may be an example of a UE or a BS as described herein. The device 500 may support wireless communication with a BS 210, an AIoT device 230, a CN entity 250, or any combination thereof. The device 500 may include components for bi-directional communications including components for transmitting and receiving communications, such as a processor 502, a memory 504, a transceiver 506, and, optionally, an I/O controller 508. These components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

[00177] The processor 502, the memory 504, the transceiver 506, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. For example, the processor 502, the

memory 504, the transceiver 506, or various combinations or components thereof may support a method for performing one or more of the operations described herein.

[00178] In some implementations, the processor 502, the memory 504, the transceiver 506, or various combinations or components thereof may be implemented in hardware (e.g., in communications management circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), a field-programmable gate array (FPGA) or other programmable logic device, a discrete gate or transistor logic, discrete hardware components, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure. In some implementations, the processor 502 and the memory 504 coupled with the processor 502 may be configured to perform one or more of the functions described herein (e.g., executing, by the processor 502, instructions stored in the memory 504).

[00179] For example, the processor 502 may support wireless communication at the device 500 in accordance with examples as disclosed herein. The processor 502 may be configured to operable to support a means for operations discussed above.

[00180] The processor 502 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, a microcontroller, an ASIC, an FPGA, a programmable logic device, a discrete gate or transistor logic component, a discrete hardware component, or any combination thereof). In some implementations, the processor 502 may be configured to operate a memory array using a memory controller. In some other implementations, a memory controller may be integrated into the processor 502. The processor 502 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 504) to cause the device 500 to perform various functions of the present disclosure.

[00181] The memory 504 may include random access memory (RAM) and read-only memory (ROM). The memory 504 may store computer-readable, computer-executable code including instructions that, when executed by the processor 502 cause the device 500 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. In some implementations, the code may not be directly executable by the processor 502 but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some implementations, the memory 504 may include, among other things, a basic I/O system

(BIOS) which may control basic hardware or software operation such as the interaction with peripheral components or devices.

[00182] The I/O controller 508 may manage input and output signals for the device 500. The I/O controller 508 may also manage peripherals not integrated into the device 500. In some implementations, the I/O controller 508 may represent a physical connection or port to an external peripheral. In some implementations, the I/O controller 508 may utilize an operating system such as iOS®, ANDROID®, MS-WINDOWS®, OS/2®, UNIX®, LINUX®, or another known operating system. In some implementations, the I/O controller 508 may be implemented as part of a processor, such as the processor 502. In some implementations, a user may interact with the device 500 via the I/O controller 508 or via hardware components controlled by the I/O controller 508.

[00183] In some implementations, the device 500 may include a single antenna 510. However, in some other implementations, the device 500 may have more than one antenna 510 (i.e., multiple antennas), including multiple antenna panels or antenna arrays, which may be capable of concurrently transmitting or receiving multiple wireless transmissions. The transceiver 506 may communicate bi-directionally, via the one or more antennas 510, wired, or wireless links as described herein. For example, the transceiver 506 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 506 may also include a modem to modulate the packets, to provide the modulated packets to one or more antennas 510 for transmission, and to demodulate packets received from the one or more antennas 510. The transceiver 506 may include one or more transmit chains, one or more receive chains, or a combination thereof.

[00184] A transmit chain may be configured to generate and transmit signals (e.g., control information, data, packets). The transmit chain may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature amplitude modulation (QAM). The transmit chain may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmit chain may also include one or more antennas 510 for transmitting the amplified signal into the air or wireless medium.

[00185] A receive chain may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receive chain may include one or more antennas 510 for receive the signal over the air or wireless medium. The receive chain may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receive chain may include at least one demodulator configured to demodulate the receive signal and obtain the transmitted data by reversing the modulation technique applied during transmission of the signal. The receive chain may include at least one decoder for decoding the processing the demodulated signal to receive the transmitted data.

[00186] FIG. 6 illustrates an example of a processor 600 that is suitable for implementing some embodiments of the present disclosure. The processor 600 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 600 may include a controller 602 configured to perform various operations in accordance with examples as described herein. The processor 600 may optionally include at least one memory 604, such as L1/L2/L3 cache. Additionally, or alternatively, the processor 600 may optionally include one or more arithmetic-logic units (ALUs) 606. One or more of these components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

[00187] The processor 600 may be a processor chipset and include a protocol stack (e.g., a software stack) executed by the processor chipset to perform various operations (e.g., receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) in accordance with examples as described herein. The processor chipset may include one or more cores, one or more caches (e.g., memory local to or included in the processor chipset (e.g., the processor 600) or other memory (e.g., random access memory (RAM), read-only memory (ROM), dynamic RAM (DRAM), synchronous dynamic RAM (SDRAM), static RAM (SRAM), ferroelectric RAM (FeRAM), magnetic RAM (MRAM), resistive RAM (RRAM), flash memory, phase change memory (PCM), and others).

[00188] The controller 602 may be configured to manage and coordinate various operations (e.g., signaling, receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) of the processor 600 to cause the processor 600 to support various operations in accordance with examples as described herein.

For example, the controller 602 may operate as a control unit of the processor 600, generating control signals that manage the operation of various components of the processor 600. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[00189] The controller 602 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 604 and determine subsequent instruction(s) to be executed to cause the processor 600 to support various operations in accordance with examples as described herein. The controller 602 may be configured to track memory address of instructions associated with the memory 604. The controller 602 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 602 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 600 to cause the processor 600 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 602 may be configured to manage flow of data within the processor 600. The controller 602 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 600.

[00190] The memory 604 may include one or more caches (e.g., memory local to or included in the processor 600 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementations, the memory 604 may reside within or on a processor chipset (e.g., local to the processor 600). In some other implementations, the memory 604 may reside external to the processor chipset (e.g., remote to the processor 600).

[00191] The memory 604 may store computer-readable, computer-executable code including instructions that, when executed by the processor 600, cause the processor 600 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. The controller 602 and/or the processor 600 may be configured to execute computer-readable instructions stored in the memory 604 to cause the processor 600 to perform various functions. For example, the processor 600 and/or the controller 602 may be coupled with or to the memory 604, the processor 600, the controller 602, and the memory 604 may be configured to perform various functions described herein. In some examples, the processor 600 may include multiple processors and the memory 604 may include multiple memories. One or more of the multiple processors may be coupled with one or more of the multiple memories, which may,

individually or collectively, be configured to perform various functions herein.

[00192] The one or more ALUs 606 may be configured to support various operations in accordance with examples as described herein. In some implementations, the one or more ALUs 606 may reside within or on a processor chipset (e.g., the processor 600). In some other implementations, the one or more ALUs 606 may reside external to the processor chipset (e.g., the processor 600). One or more ALUs 606 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 606 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 606 be configured with a variety of logical and arithmetic circuits, including adders, subtractors, shifters, and logic gates, to process and manipulate the data according to the operation. Additionally, or alternatively, the one or more ALUs 606 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 606 to handle conditional operations, comparisons, and bitwise operations.

[00193] The processor 600 may support wireless communication in accordance with examples as disclosed herein. The processor 600 may be configured to or operable to support a means for operations described in some embodiments of the present disclosure.

[00194] FIG. 7 illustrates a flowchart of a method 700 performed by a base station in accordance with aspects of the present disclosure. The operations of the method 700 may be implemented by a device or its components as described herein. For example, the operations of the method 700 may be performed by the BS 210 in FIG. 2B. 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.

[00195] At 710, the method may include receiving, from a core network entity, a first message indicating a type of a service for one or more AIoT devices, wherein the service is associated with at least one of an inventory request or a command request. The operations of 710 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 710 may be performed by the BS 210 as described with reference to FIG. 2B.

[00196] At 720, the method may include transmitting, to the one or more AIoT devices, a second message comprising an indication of the type to initiate a procedure of the service.

The operations of 720 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 720 may be performed by the BS 210 as described with reference to FIG. 2B.

[00197] FIG. 8 illustrates a flowchart of a method 800 performed by a core network entity in accordance with aspects of the present disclosure. The operations of the method 800 may be implemented by a device or its components as described herein. For example, the operations of the method 800 may be performed by the CN entity 250 in FIG. 2B. 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.

[00198] At 810, the method may include determining to initiate a service for one or more AIoT devices. The operations of 810 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 810 may be performed by the CN entity 250 as described with reference to FIG. 2B.

[00199] At 820, the method may include transmitting, to a base station, a first message indicating a type of the service for the one or more AIoT devices, wherein the service is associated with at least one of an inventory request or a command request. The operations of 820 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 820 may be performed by the CN entity 250 as described with reference to FIG. 2B.

[00200] FIG. 9 illustrates a flowchart of a method 900 performed by an AIoT device in accordance with aspects of the present disclosure. The operations of the method 900 may be implemented by a device or its components as described herein. For example, the operations of the method 900 may be performed by the AIoT device 230 in FIG. 2B. 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.

[00201] At 910, the method may include receiving, from a base station, a second message comprising an indication of a type of a service to initiate a procedure of the service, wherein the service is associated with at least one of an inventory request or a command request. The operations of 910 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 910 may be performed by the AIoT

device 230 as described with reference to FIG. 2B.

[00202] At 920, the method may include enabling the service for the procedure. The operations of 920 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 920 may be performed by the AIoT device 230 as described with reference to FIG. 2B.

[00203] 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.

[00204] 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.

[00205] 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.

[00206] 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.

[00207] 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.

[00208] The description herein is provided to enable a person having ordinary skill in the art to make or use the disclosure. Various modifications to the disclosure will be apparent to a person having ordinary skill in the art, and the generic principles defined herein may be applied to other variations without departing from the scope of the disclosure. Thus, the disclosure is not limited to the examples and designs described herein but is to be accorded the broadest scope consistent with the principles and novel features disclosed herein.

CLAIMS

What is claimed is:

1. A base station comprising:

at least one memory; and

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

receive, from a core network entity, a first message indicating a type of a service for one or more ambient internet of things (AIoT) devices, wherein the service is associated with at least one of an inventory request or a command request; and

transmit, to the one or more AIoT devices, a second message comprising an indication of the type to initiate a procedure of the service.

2. The base station of claim 1, wherein the type comprises one of:

an inventory type for identifying each of the one or more AIoT devices,

a command type for performing an operation related to the one or more AIoT devices,

a reading type for reading data from the one or more AIoT devices,

a writing type for writing data to the one or more AIoT devices, or

a disabling type for disabling the one or more AIoT devices.

3. The base station of claim 1, wherein the first message further indicates a device type of the one or more AIoT devices.

4. The base station of claim 3, wherein the device type comprises one of:

a type of AIoT devices,

a type of backscattered devices,

a first type of AIoT devices with a power consumption value lower than a first threshold,

a second type of AIoT devices with a power consumption value within a range from the first threshold to a second threshold and with a backscattered transmission on a carrier wave, or

a third type of AIoT devices with a power consumption value within a range from the first threshold to the second threshold and with a transmission generated internally.

5. The base station of claim 1, wherein the first message comprises assistance information for the procedure of the service.

6. The base station of claim 5, wherein the assistance information indicates one of:

an energy harvesting rate at each of the one or more AIoT devices for the procedure,

a charging time for the procedure,

a power consumption value for the procedure,

an energy storage size at each of the one or more AIoT devices for the procedure,

a stored or available energy at each of the one or more AIoT devices during the procedure,

a starting time of the procedure,

a complete time of the procedure,

a required latency of the procedure, or

an inventory round indicator in case the procedure is associated with the inventory request.

7. The base station of claim 6, wherein the at least one processor is further configured to cause the base station to:

in accordance with a determination that the assistance information indicates the complete time, start a timer for the procedure based on the complete time.

8. The base station of claim 1, wherein the first message comprises a first indicator indicating whether an antenna of the one or more AIoT devices is shared among an energy harvesting and communication.

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

determine, based on the first message, that an energy harvesting for at least one of the one or more AIoT devices is needed.

10. The base station of claim 9, wherein the at least one processor is further configured to cause the base station to:

generate at least one radio frequency (RF) signal for energy harvesting; and

transmit, to the at least one of the one or more AIoT devices, the at least one RF signal.

11. The base station of claim 1, wherein the at least one processor is further configured to cause the base station to:

transmit, to a source of energy harvesting, an indication indicating to the source to transmit at least one RF signal for energy harvesting to the at least one of the one or more AIoT devices.

12. The base station of claim 1, wherein the second message is transmitted after a time duration, wherein the time duration comprises one of:

a charging time indicated by the first message,

a waiting time received from the core network entity or a further core network entity, or

a waiting time configured by an operation administration and maintenance (OAM).

13. The base station of claim 1, wherein the at least one processor is further configured to cause the base station to:

receive, from the core network entity, an indicator indicating whether the procedure is completed.

14. A core network entity comprising:

at least one memory; and

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

determine to initiate a service for one or more ambient internet of things (AIoT) devices; and

transmit, to a base station, a first message indicating a type of the service for the one or more AIoT devices, wherein the service is associated with at least one of an inventory request or a command request.

15. A ambient internet of things (AIoT) device comprising:

at least one memory; and

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

receive, from a base station, a second message comprising an indication of a

type of a service to initiate a procedure of the service, wherein the service is associated with at least one of an inventory request or a command request; and

enable the service for the procedure.

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

receive, from the base station or a source of energy harvesting, at least one radio frequency (RF) signal for energy harvesting.

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

transmit, to the base station, a third message comprising an identifier of the AIoT device.

18. The AIoT device of claim 17, wherein the at least one processor is further configured to cause the AIoT device to:

receive, from the base station, a fourth message indicating an acknowledgement of the third message.

19. The AIoT device of claim 18, wherein the fourth message comprises a second indicator indicating whether the procedure is complete.

20. The AIoT device of claim 18, wherein the fourth message comprises a command request.