METHODS AND APPARATUSES FOR A-IOT DEVICE ID REPORTING

TECHNICAL FIELD

[0001] The present disclosure relates to wireless communications, and more specifically to methods and apparatuses for ambient internet of things (A-IOT) device identifier (ID) reporting.

BACKGROUND

[0002] A wireless communications system may include one or multiple network communication devices, such as base stations (BSs), which 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, or the like). 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)).

SUMMARY

[0003] 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.

[0004] Some implementations of the methods and apparatuses described herein may include a network equipment (NE) for wireless communication. The NE may include: at least one memory; and at least one processor coupled with the at least one memory and configured to cause the NE to: receive, from a CN entity, information associated with A-IOT device ID reporting for an inventory task; and transmit at least one A-IOT device ID to the CN entity based on the information associated with A-IOT device ID reporting.

[0005] In some implementations of the NE described herein, the information associated with A-IOT device ID reporting includes one or more of a time duration associated with the inventory task, a number of A-IOT devices associated with the inventory task, or a value associated with a slot counter associated with the inventory task.

[0006] In some implementations of the NE described herein, the information associated with A-IOT device ID reporting includes the time duration associated with the inventory task, and the at least one processor is configured to cause the NE to: store an A-IOT device ID that is received during a random access procedure associated with the inventory task until the time duration elapses; and transmit all stored A-IOT device IDs together to the CN entity, wherein the stored A-IOT device IDs are the at least one A-IOT device ID.

[0007] In some implementations of the NE described herein, the information associated with A-IOT device ID reporting includes the number of A-IOT devices associated with the inventory task, and the at least one processor is configured to cause the NE to: store an A-IOT device ID that is received during a random access procedure associated with the inventory task until a number of the stored A-IOT device IDs is equal to the number of A-IOT devices associated with the inventory task; and transmit all stored A-IOT device IDs together to the CN entity, wherein the stored A-IOT device IDs are the at least one A-IOT device ID.

[0008] In some implementations of the NE described herein, the information associated with A-IOT device ID reporting includes the value associated with a slot counter associated with the inventory task, and the at least one processor is configured to cause the NE to: store an A-IOT device ID that is received during a random access procedure associated with the inventory task

until the slot counter associated with the inventory task is zero; and transmit all stored A-IOT device IDs together to the CN entity, wherein the stored A-IOT device IDs are the at least one A-IOT device ID.

[0009] In some implementations of the NE described herein, the information associated with A-IOT device ID reporting includes at least one rule for verifying A-IOT device ID.

[0010] In some implementations of the NE described herein, the at least one processor is configured to cause the NE to: receive an A-IOT device ID from a UE during a random access procedure associated with the inventory task; and verify whether the A-IOT device ID is valid based on the at least one rule.

[0011] In some implementations of the NE described herein, in response to that the A-IOT device ID is valid, the at least one processor is configured to cause the NE to: transmit, to the UE, a message indicating an acknowledgment that the A-IOT device ID is successfully identified; and transmit the A-IOT device ID to the CN entity.

[0012] In some implementations of the NE described herein, in response to that the A-IOT device ID is invalid, the at least one processor is configured to cause the NE to: transmit, to the UE, a message requesting a retransmission of the A-IOT device ID.

[0013] In some implementations of the NE described herein, the information associated with A-IOT device ID reporting further includes one or more of a time duration associated with the inventory task, a number of A-IOT devices associated with the inventory task, or a value associated with a slot counter associated with the inventory task.

[0014] In some implementations of the NE described herein, the information associated with A-IOT device ID reporting includes the time duration associated with the inventory task, and the at least one processor is configured to cause the NE to: store an A-IOT device ID which is verified to be valid until the time duration elapses; and transmit all stored A-IOT device IDs together to the CN entity, wherein the stored A-IOT device IDs are the at least one A-IOT device ID.

[0015] In some implementations of the NE described herein, the information associated with A-IOT device ID reporting includes the number of A-IOT devices associated with the inventory

task, and the at least one processor is configured to cause the NE to: store an A-IOT device ID which is verified to be valid until a number of stored A-IOT device IDs is equal to the number of A-IOT devices associated with the inventory task; and transmit all stored A-IOT device IDs together to the CN entity, wherein the stored A-IOT device IDs are the at least one A-IOT device ID.

[0016] In some implementations of the NE described herein, the information associated with A-IOT device ID reporting includes the value associated with a slot counter associated with the inventory task, and the at least one processor is configured to cause the NE to: store a A-IOT device ID which is verified to be valid until the slot counter associated with the inventory task is zero; and transmit all stored A-IOT device IDs together to the CN entity, wherein the stored A-IOT device IDs are the at least one A-IOT device ID.

[0017] Some implementations of the methods and apparatuses described herein may include a core network (CN) entity. The CN entity may include: at least one memory; and at least one processor coupled with the at least one memory and configured to cause the CN entity to: transmit, to a NE, information associated with A-IOT device ID reporting for an inventory task; and receive at least one A-IOT device ID from the NE based on the information associated with A-IOT device ID reporting.

[0018] In some implementations of the CN entity described herein, the information associated with A-IOT device ID reporting includes one or more of a time duration associated with the inventory task, a number of A-IOT devices associated with the inventory task, or a value associated with a slot counter associated with the inventory task.

[0019] In some implementations of the CN entity described herein, the information associated with A-IOT device ID reporting includes at least one rule for verifying A-IOT device ID.

[0020] In some implementations of the CN entity described herein, the received at least one A-IOT device ID is verified to be valid based on the at least one rule.

[0021] In some implementations of the CN entity described herein, the information associated with A-IOT device ID reporting further includes one or more of a time duration

associated with the inventory task, a number of A-IOT devices associated with the inventory task, or a value of associated with slot counter associated with the inventory task.

[0022] Some implementations of the methods and apparatuses described herein may include a processor for wireless communication. The processor may include: at least one controller coupled with at least one memory and configured to cause the processor to: receive, from a CN entity, information associated with A-IOT device ID reporting for an inventory task; and transmit at least one A-IOT device ID to the CN entity based on the information associated with A-IOT device ID reporting.

[0023] Some implementations of the methods and apparatuses described herein may include a processor. The processor may include: at least one controller coupled with at least one memory and configured to cause the processor to: transmit, to a NE, information associated with A-IOT device ID reporting for an inventory task; and receive at least one A-IOT device ID from the NE based on the information associated with A-IOT device ID reporting.

[0024] Some implementations of the methods and apparatuses described herein may include a method performed by a NE. The method may include: receiving, from a CN entity, information associated with A-IOT device ID reporting for an inventory task; and transmitting at least one A-IOT device ID to the CN entity based on the information associated with A-IOT device ID reporting.

[0025] Some implementations of the methods and apparatuses described herein may include a method performed by a CN entity. The method may include: transmitting, to a NE, information associated with A-IOT device ID reporting for an inventory task; and receiving at least one A-IOT device ID to the CN entity based on the information associated with A-IOT device ID reporting.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] In order to describe the manner in which advantages and features of the application can be obtained, a description of the application is rendered by reference to specific embodiments thereof, which are illustrated in the appended drawings. These drawings depict only example embodiments of the application and are not therefore to be considered limiting of its scope.

[0027] Figure 1 illustrates an example of a wireless communications system in accordance with aspects of the present disclosure.

[0028] Figure 2 illustrates an exemplary query procedure defined in RFID specification.

[0029] Figure 3 illustrates an exemplary random access procedure for an A-IOT device in accordance with aspects of the present disclosure.

[0030] Figure 4 illustrates an exemplary procedure for A-IOT device ID reporting in accordance with aspects of the present disclosure.

[0031] Figure 5 illustrates another exemplary procedure for A-IOT device ID reporting in accordance with aspects of the present disclosure.

[0032] Figure 6 illustrates a flowchart of an exemplary method performed by a NE in accordance with aspects of the present disclosure.

[0033] Figure 7 illustrates a flowchart of an exemplary method performed by a CN entity in accordance with aspects of the present disclosure.

[0034] Figure 8 illustrates an example of a NE in accordance with aspects of the present disclosure.

[0035] Figure 9 illustrates an example of a CN entity in accordance with aspects of the present disclosure.

[0036] Figure 10 illustrates an example of a processor in accordance with aspects of the present disclosure.

DETAILED DESCRIPTION

[0037] The detailed description of the appended drawings is intended as a description of preferred embodiments of the present application and is not intended to represent the only form in which the present application may be practiced. It should be understood that the same or equivalent functions may be accomplished by different embodiments that are intended to be encompassed within the spirit and scope of the present application.

[0038] While operations are depicted in the drawings in a particular order, persons skilled in the art will readily recognize that such operations need not be performed in the particular order as shown or in a sequential order, or that all illustrated operations need be performed, to achieve desirable results; sometimes one or more operations can be skipped. Further, the drawings can schematically depict one or more example processes in the form of a flow diagram. However, other operations that are not depicted can be incorporated in the example processes that are schematically illustrated. For example, one or more additional operations can be performed before, after, simultaneously, or between any of the illustrated operations. In certain circumstances, multitasking and parallel processing can be advantageous.

[0039] Reference will now be made in detail to some embodiments of the present disclosure, examples of which are illustrated in the accompanying drawings. To facilitate understanding, embodiments are provided under specific network architecture and new service scenarios, such as 3rd generation partnership project (3GPP) long-term evolution (LTE) and LTE advanced, 3GPP 5G new radio (NR), 5G-Advanced, 6G, and so on. It is contemplated that along with developments of network architectures and new service scenarios, all embodiments in the present disclosure are also applicable to similar technical problems; and moreover, the terminologies recited in the present disclosure may change, which should not affect the principle of the present disclosure.

[0040] Aspects of the present disclosure are described in the context of a wireless communications system.

[0041] Figure 1 illustrates an example of a wireless communications system 100 in accordance with aspects of the present disclosure. The wireless communications system 100 may include one or more NEs (e.g., BSs) 102, one or more UEs 104, and a CN 106. The wireless communications system 100 may support various radio access technologies. In some implementations, the wireless communications system 100 may be a 4G network, such as an LTE network or an LTE-Advanced (LTE-A) network. In some other implementations, the wireless communications system 100 may be an NR network, such as a 5G network, a 5G-Advanced (5G-A) network, or a 5G ultrawideband (5G-UWB) 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, for example, 6G. 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.

[0042] The one or more NEs 102 may be dispersed throughout a geographic region to form the wireless communications system 100. One or more of the NEs 102 described herein may be or include or may be referred to as a network node, a base station, a network element, a network function, a network entity, a radio access network (RAN), a NodeB, an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. An NE 102 and a UE 104 may communicate via a communication link, which may be a wireless or wired connection. For example, an NE 102 and a UE 104 may perform wireless communication (e.g., receive signaling, transmit signaling) over a Uu interface.

[0043] An NE 102 may provide a geographic coverage area for which the NE 102 may support services for one or more UEs 104 within the geographic coverage area. For example, an NE 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, an NE 102 may be moveable, for example, a satellite associated with a non-terrestrial network (NTN). In some implementations, different geographic coverage areas associated with the same or different radio access technologies may overlap, but the different geographic coverage areas may be associated with different NEs 102.

[0044] 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 remote unit, a mobile device, a wireless device, a remote device, a subscriber device, a transmitter device, a receiver 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.

[0045] A UE 104 may be able to support wireless communication directly with other UEs 104 over a communication link. 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 may be referred to as a sidelink. For example, a UE 104 may support wireless communication directly with another UE 104 over a PC5 interface.

[0046] An NE 102 may support communications with the CN 106, or with another NE 102, or both. For example, an NE 102 may interface with other NE 102 or the CN 106 through one or more backhaul links (e.g., S1, N2, N2, or network interface). In some implementations, the NEs 102 may communicate with each other directly. In some other implementations, the NEs 102 may communicate with each other indirectly (e.g., via the CN 106). In some implementations, one or more NEs 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 radio heads, smart radio heads, or transmission-reception points (TRPs).

[0047] 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 function (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 NEs 102 associated with the CN 106.

[0048] The CN 106 may communicate with a packet data network over one or more backhaul links (e.g., via an S1, N2, N2, or another network interface). The packet data network may include an application server. In some implementations, one or more UEs 104 may

communicate with the application server. A UE 104 may establish a session (e.g., a protocol data unit (PDU) session, or the like) with the CN 106 via an NE 102. The CN 106 may route traffic (e.g., control information, data, and the like) between the UE 104 and the application server 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).

[0049] In the wireless communications system 100, the NEs 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 NEs 102 and the UEs 104 may support different resource structures. For example, the NEs 102 and the UEs 104 may support different frame structures. In some implementations, such as in 4G, the NEs 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 NEs 102 and the UEs 104 may support various frame structures (e.g., multiple frame structures). The NEs 102 and the UEs 104 may support various frame structures based on one or more numerologies.

[0050] 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.

[0051] 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.

[0052] 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 (e.g., μ=0, μ=1, μ=2, μ=3, μ=4) associated with respective subcarrier spacings of 15 kHz, 30 kHz, 60 kHz, 120 kHz, and 240 kHz may utilize a single slot per subframe, two slots per subframe, four slots per subframe, eight slots per subframe, and 16 slots per subframe, respectively. Each slot may include a number (e.g., quantity) of symbols (e.g., OFDM symbols). In some implementations, the number (e.g., quantity) of slots for a subframe may depend on a numerology. For a normal cyclic prefix, a slot may include 14 symbols. For an extended cyclic prefix (e.g., applicable for 60 kHz subcarrier spacing), a slot may include 12 symbols. The relationship between the number of symbols per slot, the number of slots per subframe, and the number of slots per frame for a normal cyclic prefix and an extended cyclic prefix may depend on a numerology. It should be understood that reference to a first numerology (e.g., μ=0) associated with a first subcarrier spacing (e.g., 15 kHz) may be used interchangeably between subframes and slots.

[0053] 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 NEs 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 NEs 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 NEs

102 and the UEs 104, among other equipment or devices for short-range, high data rate capabilities.

[0054] 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.

[0055] Internet of Things (IOT) has attracted much attention in wireless communication world, where the IOT devices usually have smaller size, lower complexity, lower power consumption and huger number (e.g., tens or even hundreds of billion IOT devices) than the existing UEs.

[0056] The IOT 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, for which the energy may be provided through the harvesting of radio waves, light, motion, heat, or any other power sources that are suitable for providing energy for the devices. For simplicity, such kind of IOT devices may be referred to as A-IOT devices. In other words, an A-IOT device may be an IOT device with limited energy storage capability and powered by energy harvesting.

[0057] In RAN1#116 meeting, it is agreed that a slotted ALOHA-based protocol may be as the baseline for designing a random access procedure for A-IOT devices.

[0058] As an application of the slotted ALOHA-based protocol, a query procedure defined in radio frequency identification (RFID) specification may be used by an RFID reader (or RFID interrogator) to obtain dedicated tag information for the subsequent unicast communication. For example, the tag information may include at least one of: protocol control/eXtended protocol control (PC/XPC), electronic product code (EPC), or packet cyclic redundancy check (CRC).

[0059] Figure 2 illustrates an exemplary query procedure defined in RFID specification.

[0060] Referring to Figure 2, at the beginning, an interrogator may transmit a Select command to a set of tags (e.g., via a multicast manner or groupcast manner) to enable the interrogator to select a desired subset of tags to perform the query.

[0061] Then, the interrogator may transmit a Query command to the subset of tags (e.g., via a multicast manner or groupcast manner). The Query command may include a value (e.g., denoted as "Q"). For example, Q may be an integer in the range (0, 15). Once receiving the Query command, each tag in the subset of tags may randomly select a slot number (e.g., denoted as j) between 0 and 2^{Q-1} and preload it in its slot counter.

[0062] For any tag, if j=0, the tag may transmit (e.g., backscatter) a 16-bit random number (e.g., denoted as RN16) to the interrogator; otherwise, the tag may not perform an UL transmission. The Tag may subtract j by one every time it receives a QueryRep command, and transmit an RN16 to the interrogator when j reaches 0.

[0063] In the examples of Figure 2, in the case of a short range coverage, if a single tag replies the RN16 in a given round of query procedure, the interrogator may successfully decode the RN16 and respond "ACK" to the tag to trigger the tag information report. However, in the case of high-density use case, multiple tags may select the same slot for transmitting RN16, which may result in collision and detection failure at the interrogator. If the collision happens, a tag may wait for the next round of query procedure to report its dedicated tag information.

[0064] Referring to Figure 2, in response to the Query command, a single tag may randomly select a slot number equal to 0, then the tag may transmit an RN16 to the interrogator. The interrogator may successfully decode the RN16 and respond "ACK" to the tag to trigger the tag information report. For example, the tag information may include at least one of: PC/XPC, EPC, or packet CRC. The procedure from transmitting the Query command to receive the tag information may be referred to as a single tag reply.

[0065] In some cases, the EPC for the tag may be valid (e.g., the EPC for the tag may be successfully identified), and then the interrogator may transmit a QueryRep command to trigger a next round of query procedure or transmit other commands for the tag. A command is defined as communication with identified tag to perform an operation of the tag, such as reading (read

data from the tag), writing (write data to the tag), or disabling (disable the tag temporarily or permanently).

[0066] In some cases, the EPC for the tag may be invalid (e.g., the EPC for the tag cannot be successfully identified), and then the interrogator may respond "NAK (i.e., NACK)" to the tag.

[0067] According to some embodiments of the present disclosure, a random access procedure for an A-IOT device may be designed based on the query procedure defined in RFID specification.

[0068] Figure 3 illustrates an exemplary random access procedure for an A-IOT device in accordance with aspects of the present disclosure.

[0069] Referring to Figure 3, the random access procedure for an A-IOT device may start from a step 300. Step 300 may include step 300-1 and step 300-2.

[0070] In step 300-1, a reader (e.g., a NE) may transmit a SELECT command to a set of A-IOT devices to enable the reader to select a desired subset of A-IOT devices to perform the access. The SELECT may include a value (e.g., denoted as "Q"). For example, Q may be an integer in the range (0, 15).

[0071] In response to receiving the SELECT command, each A-IOT device of the subset of A-IOT devices may randomly select a slot number (e.g., denoted as j) between 0 and N (wherein N=fun.(Q)). For example, $N=2^{Q-1}$.

[0072] In step 300-2, the reader may transmit a downlink (DL) signal to trigger the subset of A-IOT devices to perform the access. For example, the DL signal may be similar to a Query command or a QueryRep command in RFID specification. In some examples, the DL signal may also include scheduling information that indicates the corresponding UL transmission parameters. For example, the corresponding UL transmission parameters may include at least one of: time and/or frequency resources, modulation schemes, coding rate and/or payload size, etc. In some examples, considering that the A-IOT device is capable of uplink (UL) amplification, the scheduling information may also indicate the power control-related parameters.

[0073] In response to receiving the DL signal, each A-IOT device of the subset of A-IOT devices may subtract j by one.

[0074] In some cases, for a specific A-IOT device, if j=0, the A-IOT device may perform an UL transmission based on the scheduling information indicated by the reader in step 300-2. The UL transmission may at least include a random number, e.g., RN16.

[0075] In some other cases, for a specific A-IOT device, if j≠0, the A-IOT device may transmit nothing and waits for the next DL signal. The A-IOT device may subtract j by one every time it receives a DL signal, and transmit a random number, e.g., RN16, when j reaches 0.

[0076] Referring to Figure 3, for an A-IOT device in the subset of A-IOT devices, j=0. Then, in step 301, the an A-IOT device may transmit, to the reader, an UL transmission based on the scheduling information indicated by the reader in step 300-2, wherein the UL transmission may at least include a random number, e.g., RN16. In following steps, RN16 is used as an example of the random number for illustration.

[0077] In response to receiving the RN16 transmitted by the A-IOT device, in step 302, the reader may transmit an ACK message to the A-IOT device to acknowledge the successful reception of the UL transmission in step 301. The ACK message may include the same RN16 as that included in step 301 and scheduling information for transmitting a next UL transmission.

[0078] In response to receiving the ACK message, in step 303, the A-IOT device may transmit an A-IOT device ID (e.g., at least one of PC/XPC, EPC, or packet CRC) of the A-IOT device to the reader based on the scheduling information in step 302.

[0079] In response to receiving the A-IOT device ID, in step 304, the reader may transmit an ACK message to the A-IOT device to acknowledge the successful reception of the A-IOT device ID. The ACK message herein may at least include the same RN16 as that included in step 301, which implies that the successful reception of the A-IOT device ID.

[0080] In 5G system, the random access procedure may be performed between A-IOT device and reader (e.g., a NE). However, the A-IOT device ID should be verified in a CN entity (e.g., ambient internet of things function (AIOTF) or AMF). For example, the A-IOT device

ID may be carried by a NAS protocol data unit (PDU) and transmitted from the A-IOT device to the reader. In this case, the interaction between the reader and the CN entity is needed during the random access procedure. For example, the reader may forward the received A-IOT device ID to the CN entity, so that the CN entity may verify whether the A-IOT device ID is valid, and respond ACK or NACK to the reader. After that, the reader may transmit an ACK message or a NACK message to the A-IOT device. However, the interaction between the reader and the CN entity may cause much delay for the random access procedure due to a backhaul delay between the reader and the CN entity. In addition, if RN16 also needs to be verified in the CN entity, the delay will be larger.

[0081] Given this, how to reduce the latency for a random access procedure for inventory considering A-IOT device ID verification needs to be solved. The inventory is used for identifying individual A-IOT devices.

[0082] Embodiments of the present disclosure provide solutions for A-IOT device ID reporting, which can reduce the latency for a random access procedure for inventory. More details will be described in the following text in combination with the appended drawings.

[0083] Figure 4 illustrates an exemplary procedure for A-IOT device ID reporting in accordance with aspects of the present disclosure.

[0084] The method in the example of Figure 4 may be performed by a CN entity (e.g., AIOTF or AMF), a NE (e.g., a BS), and a plurality of UEs (e.g., including UE#1 and UE#2). Each of the plurality of UEs may be an A-IOT device or is a device having similar characteristics as an A-IOT device.

[0085] Although two UEs are depicted in Figure 4 for illustrative purpose, it is contemplated that any number of UEs may be involved in the procedure illustrated in Figure 4. In addition, although the method is illustrated in a system level by a CN entity, a NE, and two UEs, persons skilled in the art can understand that the operations implemented in the CN entity, the NE, and the two UEs can be separately implemented and incorporated by other apparatus with the like functions.

[0086] In the example of Figure 4, the CN entity may trigger an A-IOT communication task. The A-IOT communication task may be for inventory, and can also be referred to as an inventory task. The inventory task may be used for identifying individual A-IOT devices.

[0087] In step 400, the CN entity may transmit, to the NE, information associated with A-IOT device ID reporting for an inventory task. Consequently, in step 401, the NE may receive, from the CN entity, the information associated with A-IOT device ID reporting for an inventory task.

[0088] The information associated with A-IOT device ID reporting may include one or more of a time duration associated with the inventory task, a number of A-IOT devices associated with the inventory task, or a value (e.g., denoted as Q) associated with a slot counter associated with the inventory task. For example, Q may be an integer in the range (0, 15).

[0089] In some examples, the information associated with A-IOT device ID reporting may be included in a paging message used for the inventory task.

[0090] In step 401, the NE may transmit a SELECT command to a set of UEs to select a desired subset of UEs (e.g., including UE#1 and UE#2) to perform the access. In some examples, the SELECT command may be included in the paging message for the inventory task. In some examples, the SELECT command may include the value Q which is included in the information associated with A-IOT device ID reporting.

[0091] In response to receiving the SELECT command, each UE of the subset of UE may randomly select a slot number (e.g., denoted as j) between 0 and N (wherein N=fun.(Q)). For example, $N=2^{Q-1}$.

[0092] The NE may perform an inventory procedure by triggering random access procedures for the subset of UEs.

[0093] For example, in step 402, the NE may transmit a DL signal to trigger the subset of UEs (e.g., including UE#1 and UE#2) to perform the access. For example, the DL signal may be similar to a Query command or a QueryRep command in RFID specification.

[0094] In some examples, the DL signal may also include scheduling information that indicates the corresponding UL transmission parameters. For example, the corresponding UL

transmission parameters may include at least one of: time and/or frequency resources, modulation schemes, coding rate and/or payload size, etc. In some examples, the scheduling information may also indicate the power control-related parameters.

[0095] In response to receiving the DL signal, each UE of the subset of UE may subtract j by one.

[0096] In some cases, if j=0, the UE may perform an UL transmission based on the scheduling information. The UL transmission may at least include a random number, e.g., RN16.

[0097] In some other cases, if j≠0, the UE may transmit nothing and waits for the next DL signal. The UE may subtract j by one every time it receives a DL signal, and transmit a random number, e.g., RN16, when j reaches 0.

[0098] In the embodiments of Figure 4, after subtracting j by one, the value j of UE#1 may reach 0. In step 403, UE#1 may transmit an UL transmission based on the scheduling information in step 402 due to j=0. The UL transmission may at least include a random number, e.g., RN16. The UL transmission in step 403 may also be referred to as Msg. 1 in a random access procedure associated with the inventory task for UE#1. In the following steps, RN16 is used as an example of the random number for illustration.

[0099] In response to receiving the RN16 transmitted by UE#1 in step 403, in step 404, the NE may transmit a message (e.g., an ACK message) to UE#1 to acknowledge the successful reception of the UL transmission in step 403. The message may include the same RN16 as that included in step 403 and scheduling information for transmitting a next UL transmission. The message in step 404 may also be referred to as Msg. 2 in the random access procedure associated with the inventory task for UE#1.

[0100] In response to receiving the message, in step 405, UE#1 may transmit an A-IOT device ID of UE#1 to the NE based on the scheduling information in step 404. For example, an A-IOT device ID may include at least one of PC/XPC, EPC, or CRC. As another example, an A-IOT device ID may include at least one of: information that can be used for identifying a UE and verification information (e.g., CRC) of the information for identifying a UE. The message in step 405 may also be referred to as Msg. 3 in the random access procedure associated with the inventory task for UE#1.

[0101] In response to receiving the A-IOT device ID, in step 406, the NE may transmit a message (e.g., ACK message) to UE#1 to acknowledge the successful reception of the A-IOT device ID. The message herein may at least include the same RN16 as that included in step 403, which implies that the successful reception of the A-IOT device ID. The message in step 406 may also be referred to as Msg. 4 in the random access procedure associated with the inventory task for UE#1. In some examples, step 406 may not occur.

[0102] In step 407, the NE may store the A-IOT device ID of UE#1 that is received during the random access procedure associated with the inventory task for UE#1.

[0103] Then, the NE may trigger a random access procedure associated with the inventory task for another UE.

[0104] For example, in step 408, the NE may transmit a DL signal to the subset of UEs (e.g., including UE#1 and UE#2) to trigger a random access procedure for another UE. The DL signal in step 408 may be the same as or similar to that in step 402.

[0105] In response to receiving the DL signal, except for UE#1, each UE of the subset of UE may subtract j by one. After subtracting j by one, the value j of UE#2 may reach 0. Accordingly, in step 409, the UE#2 may perform an UL transmission based on the scheduling information in step 408. The UL transmission may at least include a random number, e.g., RN16. In the following steps, RN16 is used as an example of the random number for illustration.

[0106] The UL transmission in step 409 may also be referred to as Msg. 1 in the random access procedure associated with the inventory task for UE#2.

[0107] In response to receiving the RN16 transmitted by UE#2 in step 409, in step 410, the NE may transmit a message (e.g., an ACK message) to UE#2 to acknowledge the successful reception of the UL transmission in step 409. The message may include the same RN16 as that included in step 409 and scheduling information for transmitting a next UL transmission. The message in step 410 may also be referred to as Msg. 2 in the random access procedure associated with the inventory task for UE#2.

[0108] In response to receiving the message, in step 411, UE#2 may transmit an A-IOT device ID of UE#2 to the NE based on the scheduling information in step 410. The message in

step 411 may also be referred to as Msg. 3 in in the random access procedure associated with the inventory task for UE#2.

[0109] In response to receiving the A-IOT device ID, in step 412, the NE may transmit a message (e.g., an ACK message) to UE#2 to acknowledge the successful reception of the A-IOT device ID. The message herein may at least include the same RN16 as that included in step 409, which implies that the successful reception of the A-IOT device ID of UE#2. The message in step 412 may also be referred to as Msg. 4 in the random access procedure associated with the inventory task for UE#2. In some examples, step 412 may not occur.

[0110] In step 413, the NE may store the A-IOT device ID of UE#2 that is received during the random access procedure associated with the inventory task for UE#2.

[0111] The NE may continue to trigger random access procedure(s) similar to the random access procedure for UE#2 for other UEs in the subset of UEs, and store the A-IOT device ID(s) that is(are) received during the random access procedure(s). The NE may transmit the stored A-IOT device ID(s) to the CN entity based on the information associated with A-IOT device ID reporting received from the CN. For example, the UE may store the A-IOT device ID(s) that is(are) received during the random access procedure(s)until the condition based on the information associated with A-IOT device ID reporting is satisfied.

[0112] For example, the information associated with A-IOT device ID reporting may include the time duration associated with the inventory task. Then, the NE may store A-IOT device ID that is received during a random access procedure associated with the inventory task until the time duration elapses. Then, in step 414, the NE may transmit all stored A-IOT device IDs together to the CN entity, wherein the stored A-IOT device IDs may include at least one A-IOT device ID.

[0113] Alternatively or additionally, the information associated with A-IOT device ID reporting may include the number of A-IOT devices associated with the inventory task. Then, the NE may store the A-IOT device ID that is received during a random access procedure associated with the inventory task until the number of the stored A-IOT device IDs is equal to the number of A-IOT devices associated with the inventory task. Then, in step 414, the NE may

transmit all stored A-IOT device IDs together to the CN entity, wherein the stored A-IOT device IDs may include at least one A-IOT device ID.

[0114] Alternatively or additionally, the information associated with A-IOT device ID reporting may include the value Q associated with the slot counter N (e.g., which is denoted as N=fun.(Q). Once receiving an A-IOT device ID of a UE, the NE may subtract the slot counter N by 1. The NE may store an A-IOT device ID that is a received during a random access procedure associated with the inventory task until the slot counter associated with the inventory task is zero. Then, in step 414, the NE may transmit all stored A-IOT device IDs together to the CN entity, wherein the stored A-IOT device IDs may include at least one A-IOT device ID.

[0115] In some embodiments of Figure 4, each A-IOT device ID may be encapsulated in a NAS PDU and transmitted from a UE to the NE.

[0116] In some embodiments of Figure 4, the NE may transmit the at least one A-IOT device ID to the CN entity in a non-UE associated next generation application protocol (NGAP) message to the CN entity. In some examples, the NGAP message may also include an ID for the A-IOT communication task.

[0117] After receiving the at least one A-IOT device ID, the CN entity may verify whether the at least one A-IOT device ID is valid or not.

[0118] Figure 5 illustrates another exemplary procedure for A-IOT device ID reporting in accordance with aspects of the present disclosure.

[0119] The method in the example of Figure 5 may be performed by a CN entity (e.g., AIOTF or AMF), a NE (e.g., a BS), and a plurality of UEs (e.g., including UE#1 and UE#2). Each of the plurality of UEs may be an A-IOT device or is a device having similar characteristics as an A-IOT device.

[0120] Although two UEs are depicted in Figure 5 for illustrative purpose, it is contemplated that any number of UEs may be involved in the procedure illustrated in Figure 5. Although the method is illustrated in a system level by a CN entity, a NE, and two UEs, persons skilled in the art can understand that the operations implemented in the CN entity, the NE, and the two UEs can be separately implemented and incorporated by other apparatus with the like functions.

[0121] The difference between Figure 5 and Figure 4 is that: in Figure 4, the NE reports all stored A-IOT device IDs to the CN entity, and the CN entity verifies the A-IOT device IDs reported by the NE; whereas in Figure 5, the NE performs A-IOT device verification during a random access procedure based on the information associated with A-IOT device ID reporting from the CN entity. The specific procedure illustrated in Figure 5 is as follows.

[0122] At the beginning, the CN entity may trigger an inventory task.

[0123] In step 500, the CN entity may transmit, to the NE, information associated with A-IOT device ID reporting for the inventory task. Consequently, in step 500, the NE may receive, from the CN entity, the information associated with A-IOT device ID reporting for the inventory task.

[0124] The information associated with A-IOT device ID reporting may include at least one rule for verifying A-IOT device ID. In some examples, the assistance information for A-IOT device ID reporting may be included in a paging message used for inventory.

[0125] Then, the NE and UE#1 may perform steps 502-505. The steps 502-505 may be the same as steps 402-405 in Figure 4, respectively.

[0126] In response to receiving the A-IOT device ID of UE#1 in step 505, the NE may verify whether the A-IOT device ID is valid based on the at least one rule.

[0127] In response to that the A-IOT device ID is successfully identified (e.g., the A-IOT device ID is valid), in step 507, the NE may transmit a message (e.g., an ACK message) indicating an acknowledgment that the A-IOT device ID is successfully identified (i.e., indicating that the A-IOT device ID is valid). In step 508, the NE may also transmit the A-IOT device ID to the CN entity. Step 507 may occur before, after or simultaneously with step 508.

[0128] In response to that the A-IOT device ID is not successfully identified (e.g., the A-IOT device ID is invalid), in step 507, the NE may transmit a message requesting a retransmission of the A-IOT device ID to UE#1. For example, the message may be a Query command, a QueryRep command, or a Query command/QueryRep command liked indication. In such cases, step 508 may not occur. In response to receiving the message requesting the retransmission, UE#1 may retransmit the A-IOT device ID of UE#1 to the NE.

[0129] After performing the random access procedure for UE#1, the NE may trigger a random access procedure for another UE. For example, UE may perform steps 509-512, wherein steps 509-512 are the same as steps 408-411 in Figure 4, respectively.

[0130] In response to receiving the A-IOT device ID of UE#2 in step 512, the NE may verify whether the A-IOT device ID of UE#2 is valid based on the at least one rule.

[0131] In response to that the A-IOT device ID is successfully identified (i.e., the A-IOT device ID is valid), in step 514, the NE may transmit a message (e.g., an ACK message) indicating an acknowledgment that the A-IOT device ID is successfully identified (e.g., indicating that the A-IOT device ID is valid). In step 515, the NE may also transmit the A-IOT device ID to the CN entity. Step 514 may occur before, after or simultaneously with step 515.

[0132] In response to that the A-IOT device ID is not successfully identified (e.g., the A-IOT device ID is invalid), in step 514, the NE may transmit a message requesting a retransmission of the A-IOT device ID to UE#2. For example, the message may be a Query command, a QueryRep command, or a Query command/QueryRep command liked indication. In such cases, step 515 may not occur. In response to receiving the message requesting the retransmission, UE#2 may retransmit the A-IOT device ID of UE#2 to the NE.

[0133] The NE may continue to trigger random access procedure(s) similar to the random access procedure for UE#2 for other UEs in the subset of UEs.

[0134] In some examples of Figure 5, the NE may not immediately transmit an A-IOT device ID to the CN entity once the A-IOT device ID is verified to be valid, but store an A-IOT device ID which is verified to be valid, and report all stored A-IOT device IDs based on the information associated with A-IOT device ID reporting from the CN entity.

[0135] In some examples, in addition to the at least one rule for verifying A-IOT device ID, the information associated with A-IOT device ID reporting may further include one or more of a time duration associated with the inventory task, a number of A-IOT devices associated with the inventory task, or a value (e.g., denoted as Q) associated with a slot counter associated with the inventory task. For example, Q may be an integer in the range (0, 15).

[0136] As an example, the information associated with A-IOT device ID reporting may include the time duration associated with the inventory task. Then, the NE may store an A-IOT device ID which is verified to be valid until the time duration elapses. In other words, step 508 and 515 may not occur. Then, the NE may transmit all stored A-IOT device IDs together to the CN entity, wherein the stored A-IOT device IDs may include at least one A-IOT device ID.

[0137] Alternatively or additionally, the information associated with A-IOT device ID reporting may include the number of A-IOT devices associated with the inventory task. Then, the NE may store an A-IOT device ID which is verified to be valid until a number of stored A-IOT device IDs is equal to the number of A-IOT devices associated with the inventory task. Then, the NE may transmit all stored A-IOT device IDs together to the CN entity, wherein the stored A-IOT device IDs may include at least one A-IOT device ID.

[0138] Alternatively or additionally, the information associated with A-IOT device ID reporting may include the value Q associated with the slot counter N (e.g., which is denoted as N=fun.(Q). Once an A-IOT device ID of a UE is identified to be valid, the NE may subtract the slot counter N by 1. The NE may store an A-IOT device ID which is verified to be valid until the slot counter associated with the inventory task is zero. Then, the NE may transmit all stored A-IOT device IDs together to the CN entity, wherein the stored A-IOT device IDs may include at least one A-IOT device ID.

[0139] Figure 6 illustrates a flowchart of an exemplary method in accordance with aspects of the present disclosure. The operations of the method illustrated in Figure 6 may be performed by a NE (e.g., NE 102 in Figure 1) as described herein or other apparatus with the like functions. In some implementations, the NE may execute a set of instructions to control functional elements of the NE to perform the described operations or functions.

[0140] As shown in Figure 6, in step 602, the NE may receive, from a CN entity (e.g., CN 106 in Figure 1), information associated with A-IOT device ID reporting for an inventory task.

[0141] In step 604, the NE may transmit at least one A-IOT device ID to the CN entity based on the information associated with A-IOT device ID reporting.

[0142] According to some embodiments of the present disclosure, the information associated with A-IOT device ID reporting may include one or more of a time duration

associated with the inventory task, a number of A-IOT devices associated with the inventory task, or a value associated with a slot counter associated with the inventory task.

[0143] In some embodiments, the information associated with A-IOT device ID reporting may include the time duration associated with the inventory task, and the NE may: store an A-IOT device ID that is received during a random access procedure associated with the inventory task until the time duration elapses; and transmit all stored A-IOT device IDs together to the CN entity, wherein the stored A-IOT device IDs are the at least one A-IOT device ID.

[0144] In some embodiments, the information associated with A-IOT device ID reporting may include the number of A-IOT devices associated with the inventory task, and the NE may: store an A-IOT device ID that is received during a random access procedure associated with the inventory task until a number of the stored A-IOT device IDs is equal to the number of A-IOT devices associated with the inventory task; and transmit all stored A-IOT device IDs together to the CN entity, wherein the stored A-IOT device IDs are the at least one A-IOT device ID.

[0145] In some embodiments, the information associated with A-IOT device ID reporting may include the value associated with a slot counter associated with the inventory task, and the NE may: store an A-IOT device ID that is received during a random access procedure associated with the inventory task until the slot counter associated with the inventory task is zero; and transmit all stored A-IOT device IDs together to the CN entity, wherein the stored A-IOT device IDs are the at least one A-IOT device ID.

[0146] According to some embodiments of the present disclosure, the information associated with A-IOT device ID reporting may include at least one rule for verifying A-IOT device ID.

[0147] In some embodiments, the NE may: receive an A-IOT device ID from a UE during a random access procedure associated with the inventory task; and verify whether the A-IOT device ID is valid based on the at least one rule.

[0148] In an embodiment, in response to that the A-IOT device ID is valid, the NE may: transmit, to the UE, a message indicating an acknowledgment that the A-IOT device ID is successfully identified; and transmit the A-IOT device ID to the CN entity.

[0149] In another embodiment, in response to that the A-IOT device ID is invalid, the NE may: transmit, to the UE, a message requesting a retransmission of the A-IOT device ID.

[0150] In some embodiments, the information associated with A-IOT device ID reporting further may include one or more of a time duration associated with the inventory task, a number of A-IOT devices associated with the inventory task, or a value associated with a slot counter associated with the inventory task.

[0151] In an embodiment, the information associated with A-IOT device ID reporting may include the time duration associated with the inventory task, and the NE may: store an A-IOT device ID which is verified to be valid until the time duration elapses; and transmit all stored A-IOT device IDs together to the CN entity, wherein the stored A-IOT device IDs are the at least one A-IOT device ID.

[0152] In another embodiment, the information associated with A-IOT device ID reporting may include the number of A-IOT devices associated with the inventory task, and the NE may: store an A-IOT device ID which is verified to be valid until a number of stored A-IOT device IDs is equal to the number of A-IOT devices associated with the inventory task; and transmit all stored A-IOT device IDs together to the CN entity, wherein the stored A-IOT device IDs are the at least one A-IOT device ID.

[0153] In another embodiment, the information associated with A-IOT device ID reporting may include the value associated with a slot counter associated with the inventory task, and the NE may: store a A-IOT device ID which is verified to be valid until the slot counter associated with the inventory task is zero; and transmit all stored A-IOT device IDs together to the CN entity, wherein the stored A-IOT device IDs are the at least one A-IOT device ID.

[0154] Figure 7 illustrates a flowchart of an exemplary method in accordance with aspects of the present disclosure. The operations of the method illustrated in Figure 7 may be performed by a CN entity (e.g., CN 106 in Figure 1) as described herein or other apparatus with the like functions. In some implementations, the CN entity may execute a set of instructions to control functional elements of the CN entity to perform the described operations or functions.

[0155] As shown in Figure 7, in step 702, the CN entity may transmit, to a NE (e.g., NE 102), information associated with A-IOT device ID reporting for an inventory task.

[0156] In step 704, the CN entity may receive at least one A-IOT device ID from the NE based on the information associated with A-IOT device ID reporting.

[0157] According to some embodiments of the present discloses, the information associated with A-IOT device ID reporting may include one or more of a time duration associated with the inventory task, a number of A-IOT devices associated with the inventory task, or a value associated with a slot counter associated with the inventory task.

[0158] According to some embodiments of the present discloses, the information associated with A-IOT device ID reporting may include at least one rule for verifying A-IOT device ID. In an embodiment, the received at least one A-IOT device ID is verified to be valid based on the at least one rule. In an embodiments, the information associated with A-IOT device ID reporting further may include one or more of a time duration associated with the inventory task, a number of A-IOT devices associated with the inventory task, or a value of associated with slot counter associated with the inventory task.

[0159] Figure 8 illustrates an example of a NE 800 in accordance with aspects of the present disclosure. The NE 800 may include at least one processor 802 and at least one memory 804. Additionally, the NE 800 may also include one or more of at least one controller 806 or at least one transceiver 808. The processor 802, the memory 804, the controller 806, or the transceiver 808, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. These components may be coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces.

[0160] The processor 802, the memory 804, the controller 806, or the transceiver 808, or various combinations or components thereof may be implemented in hardware (e.g., circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), or other programmable logic device, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure.

[0161] The processor 802 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, an ASIC, an FPGA, or any combination thereof). In some

implementations, the processor 802 may be configured to operate the memory 804. In some other implementations, the memory 804 may be integrated into the processor 802. The processor 802 may be configured to execute computer-readable instructions stored in the memory 804 to cause the NE 800 to perform various functions of the present disclosure.

[0162] The memory 804 may include volatile or non-volatile memory. The memory 804 may store computer-readable, computer-executable code including instructions when executed by the processor 802 cause the NE 800 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as the memory 804 or another type of memory. 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.

[0163] In some implementations, the processor 802 and the memory 804 coupled with the processor 802 may be configured to cause the NE 800 to perform one or more of the functions described herein (e.g., executing, by the processor 802, instructions stored in the memory 804). For example, the processor 802 may support wireless communication at the NE 800 in accordance with examples as disclosed herein. The NE 800 may be configured to support a means for performing the operations of the methods described in the embodiments of the present disclosure. In an embodiment, the processor 802 may be configured to cause the NE 800 to: receive, from a CN entity, information associated with A-IOT device ID reporting for an inventory task; and transmit at least one A-IOT device ID to the CN entity based on the information associated with A-IOT device ID reporting.

[0164] The controller 806 may manage input and output signals for the NE 800. The controller 806 may also manage peripherals not integrated into the NE 800. In some implementations, the controller 806 may utilize an operating system such as iOS®, ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 806 may be implemented as part of the processor 802.

[0165] In some implementations, the NE 800 may include at least one transceiver 808. In some other implementations, the NE 800 may have more than one transceiver 808. The

transceiver 808 may represent a wireless transceiver. The transceiver 808 may include one or more receiver chains 810, one or more transmitter chains 812, or a combination thereof.

[0166] A receiver chain 810 may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receiver chain 810 may include one or more antennas for receive the signal over the air or wireless medium. The receiver chain 810 may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 810 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 receiver chain 810 may include at least one decoder for decoding the demodulated signal to receive the transmitted data.

[0167] A transmitter chain 812 may be configured to generate and transmit signals (e.g., control information, data, packets). The transmitter chain 812 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 transmitter chain 812 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 transmitter chain 812 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

[0168] Figure 9 illustrates an example of a CN entity 900 in accordance with aspects of the present disclosure. The CN entity 900 may include at least one processor 902 and at least one memory 904. Additionally, the CN entity 900 may also include one or more of at least one controller 906 or at least one transceiver 908. The processor 902, the memory 904, the controller 906, or the transceiver 908, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. These components may be coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces.

[0169] The processor 902, the memory 904, the controller 906, or the transceiver 908, or various combinations or components thereof may be implemented in hardware (e.g., circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), or other programmable logic device, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure.

[0170] The processor 902 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, an ASIC, an FPGA, or any combination thereof). In some implementations, the processor 902 may be configured to operate the memory 904. In some other implementations, the memory 904 may be integrated into the processor 902. The processor 902 may be configured to execute computer-readable instructions stored in the memory 904 to cause the CN entity 900 to perform various functions of the present disclosure.

[0171] The memory 904 may include volatile or non-volatile memory. The memory 904 may store computer-readable, computer-executable code including instructions when executed by the processor 902 cause the CN entity 900 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as the memory 904 or another type of memory. 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.

[0172] In some implementations, the processor 902 and the memory 904 coupled with the processor 902 may be configured to cause the CN entity 900 to perform one or more of the functions described herein (e.g., executing, by the processor 902, instructions stored in the memory 904). For example, the processor 902 may support wireless communication at the CN entity 900 in accordance with examples as disclosed herein. The CN entity 900 may be configured to support a means for performing the operations of the methods described in the embodiments of the present disclosure. In an embodiment, the processor 902 may be configured to cause the CN entity 900 to: transmit, to a NE, information associated with A-IOT device ID reporting for an inventory task; and receive at least one A-IOT device ID from the NE based on the information associated with A-IOT device ID reporting.

[0173] The controller 906 may manage input and output signals for the CN entity 900. The controller 906 may also manage peripherals not integrated into the CN entity 900. In some implementations, the controller 906 may utilize an operating system such as iOS®, ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 906 may be implemented as part of the processor 902.

[0174] In some implementations, the CN entity 900 may include at least one transceiver 908. In some other implementations, the CN entity 900 may have more than one transceiver 908. The transceiver 908 may represent a wireless transceiver. The transceiver 908 may include one or more receiver chains 910, one or more transmitter chains 912, or a combination thereof.

[0175] A receiver chain 910 may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receiver chain 910 may include one or more antennas for receive the signal over the air or wireless medium. The receiver chain 910 may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 910 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 receiver chain 910 may include at least one decoder for decoding the demodulated signal to receive the transmitted data.

[0176] A transmitter chain 912 may be configured to generate and transmit signals (e.g., control information, data, packets). The transmitter chain 912 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 transmitter chain 912 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 transmitter chain 912 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

[0177] Figure 10 illustrates an example of a processor 1000 in accordance with aspects of the present disclosure. The processor 1000 may be an example of a processor configured to

perform various operations in accordance with examples as described herein. The processor 1000 may include at least one controller 1002 configured to perform various operations in accordance with examples as described herein. The processor 1000 may optionally include at least one memory 1004, which may be, for example, a layer 1 (L1), layer 2 (L2), or layer 3 (L3) cache. Additionally, or alternatively, the processor 1000 may optionally include one or more arithmetic-logic units (ALUs) 1006. 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).

[0178] The processor 1000 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 1000) 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).

[0179] The controller 1002 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 1000 to cause the processor 1000 to support various operations in accordance with examples as described herein. For example, the controller 1002 may operate as a control unit of the processor 1000, generating control signals that manage the operation of various components of the processor 1000. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[0180] The controller 1002 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 1004 and determine subsequent instruction(s) to be executed to cause the processor 1000 to support various operations in accordance with examples as described herein. The controller 1002 may be configured to track memory address of instructions associated with the memory 1004. The controller 1002 may be configured to

decode instructions to determine the operation to be performed and the operands involved. For example, the controller 1002 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 1000 to cause the processor 1000 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 1002 may be configured to manage flow of data within the processor 1000. The controller 1002 may be configured to control transfer of data between registers, ALUs, and other functional units of the processor 1000.

[0181] The memory 1004 may include one or more caches (e.g., memory local to or included in the processor 1000 or other memory, such as RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc.). In some implementations, the memory 1004 may reside within or on a processor chipset (e.g., local to the processor 1000). In some other implementations, the memory 1004 may reside external to the processor chipset (e.g., remote to the processor 1000).

[0182] The memory 1004 may store computer-readable, computer-executable code including instructions that, when executed by the processor 1000, cause the processor 1000 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 1002 and/or the processor 1000 may be configured to execute computer-readable instructions stored in the memory 1004 to cause the processor 1000 to perform various functions. For example, the processor 1000 and/or the controller 1002 may be coupled with or to the memory 1004, the processor 1000, the controller 1002, and the memory 1004 may be configured to perform various functions described herein. In some examples, the processor 1000 may include multiple processors and the memory 1004 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.

[0183] The one or more ALUs 1006 may be configured to support various operations in accordance with examples as described herein. In some implementations, the one or more ALUs 1006 may reside within or on a processor chipset (e.g., the processor 1000). In some other implementations, the one or more ALUs 1006 may reside external to the processor chipset (e.g., the processor 1000). One or more ALUs 1006 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs

1006 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 1006 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 1006 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 1006 to handle conditional operations, comparisons, and bitwise operations.

[0184] The processor 1000 may support wireless communication in accordance with examples as disclosed herein. The processor 1000 may be configured to or operable to support a means for performing the operations of the methods described in the embodiments of the present disclosure. In an embodiment, the controller 1002 may cause the processor 1000 to: receive, from a CN entity, information associated with A-IOT device ID reporting for an inventory task; and transmit at least one A-IOT device ID to the CN entity based on the information associated with A-IOT device ID reporting. In another embodiment, the controller 1002 may cause the processor 1000 to: transmit, to a NE, information associated with A-IOT device ID reporting for an inventory task; and receive at least one A-IOT device ID from the NE based on the information associated with A-IOT device ID reporting.

[0185] 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 network equipment (NE) for wireless communication, comprising:

at least one memory; and

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

receive, from a core network (CN) entity, information associated with ambient internet of things (A-IOT) device identifier (ID) reporting for an inventory task; and

transmit at least one A-IOT device ID to the CN entity based on the information associated with A-IOT device ID reporting.

2. The NE of Claim 1, wherein the information associated with A-IOT device ID reporting comprises one or more of a time duration associated with the inventory task, a number of A-IOT devices associated with the inventory task, or a value associated with a slot counter associated with the inventory task.

3. The NE of Claim 2, wherein the information associated with A-IOT device ID reporting comprises the time duration associated with the inventory task, and the at least one processor is configured to cause the NE to:

store an A-IOT device ID that is received during a random access procedure associated with the inventory task until the time duration elapses; and

transmit all stored A-IOT device IDs together to the CN entity, wherein the stored A-IOT device IDs are the at least one A-IOT device ID.

4. The NE of Claim 2, wherein the information associated with A-IOT device ID reporting comprises the number of A-IOT devices associated with the inventory task, and the at least one processor is configured to cause the NE to:

store an A-IOT device ID that is received during a random access procedure associated with the inventory task until a number of the stored A-

IOT device IDs is equal to the number of A-IOT devices associated with the inventory task; and

transmit all stored A-IOT device IDs together to the CN entity, wherein the stored A-IOT device IDs are the at least one A-IOT device ID.

5. The NE of Claim 2, wherein the information associated with A-IOT device ID reporting comprises the value associated with a slot counter associated with the inventory task, and the at least one processor is configured to cause the NE to:

store an A-IOT device ID that is received during a random access procedure associated with the inventory task until the slot counter associated with the inventory task is zero; and

transmit all stored A-IOT device IDs together to the CN entity, wherein the stored A-IOT device IDs are the at least one A-IOT device ID.

6. The NE of Claim 1, wherein the information associated with A-IOT device ID reporting comprises at least one rule for verifying A-IOT device ID.

7. The NE of Claim 6, wherein the at least one processor is configured to cause the NE to:

receive an A-IOT device ID from a user equipment (UE) during a random access procedure associated with the inventory task; and

verify whether the A-IOT device ID is valid based on the at least one rule.

8. The NE of Claim 7, wherein in response to that the A-IOT device ID is valid, the at least one processor is configured to cause the NE to:

transmit, to the UE, a message indicating an acknowledgment that the A-IOT device ID is successfully identified; and

transmit the A-IOT device ID to the CN entity.

9. The NE of Claim 7, wherein in response to that the A-IOT device ID is invalid, the at least one processor is configured to cause the NE to:

transmit, to the UE, a message requesting a retransmission of the A-IOT device ID.

10. The NE of Claim 7, wherein the information associated with A-IOT device ID reporting further comprises one or more of a time duration associated with the inventory task, a number of A-IOT devices associated with the inventory task, or a value associated with a slot counter associated with the inventory task.

11. The NE of Claim 10, wherein the information associated with A-IOT device ID reporting comprises the time duration associated with the inventory task, and the at least one processor is configured to cause the NE to:

store an A-IOT device ID which is verified to be valid until the time duration elapses; and

transmit all stored A-IOT device IDs together to the CN entity, wherein the stored A-IOT device IDs are the at least one A-IOT device ID.

12. The NE of Claim 10, wherein the information associated with A-IOT device ID reporting comprises the number of A-IOT devices associated with the inventory task, and the at least one processor is configured to cause the NE to:

store an A-IOT device ID which is verified to be valid until a number of stored A-IOT device IDs is equal to the number of A-IOT devices associated with the inventory task; and

transmit all stored A-IOT device IDs together to the CN entity, wherein the stored A-IOT device IDs are the at least one A-IOT device ID.

13. The NE of Claim 10, wherein the information associated with A-IOT device ID reporting comprises the value associated with a slot counter associated with the inventory task, and the at least one processor is configured to cause the NE to:

store a A-IOT device ID which is verified to be valid until the slot counter associated with the inventory task is zero; and

transmit all stored A-IOT device IDs together to the CN entity, wherein the stored A-IOT device IDs are the at least one A-IOT device ID.

14. A code network (CN) entity, comprising:

at least one memory; and

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

transmit, to a network equipment (NE), information associated with ambient internet of things (A-IOT) device identifier (ID) reporting for an inventory task; and

receive at least one A-IOT device ID from the NE based on the information associated with A-IOT device ID reporting.

15. The CN entity of Claim 14, wherein the information associated with A-IOT device ID reporting comprises one or more of a time duration associated with the inventory task, a number of A-IOT devices associated with the inventory task, or a value associated with a slot counter associated with the inventory task.

16. The CN entity of Claim 14, wherein the information associated with A-IOT device ID reporting comprises at least one rule for verifying A-IOT device ID.

17. The CN entity of Claim 16, wherein the received at least one A-IOT device ID is verified to be valid based on the at least one rule.

18. The CN entity of Claim 17, wherein the information associated with A-IOT device ID reporting further comprises one or more of a time duration associated with the inventory task, a number of A-IOT devices associated with the inventory task, or a value of associated with slot counter associated with the inventory task.

19. A processor for wireless communication, comprising:

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

receive, from a core network (CN) entity, information associated with ambient internet of things (A-IOT) device identifier (ID) reporting for an inventory task; and

transmit at least one A-IOT device ID to the CN entity based on the information associated with A-IOT device ID reporting.

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

receiving, from a core network (CN) entity, information associated with ambient internet of things (A-IOT) device identifier (ID) reporting for an inventory task; and

transmitting at least one A-IOT device ID to the CN entity based on the information associated with A-IOT device ID reporting.