APPARATUS AND METHOD FOR AMBIENT INTERNET OF THINGS COMMUNICATION IN A WIRELESS COMMUNICATION SYSTEM

TECHNICAL FIELD

[0001] The present disclosure relates to wireless communications, and more specifically to ambient internet of things (AIoT) communication in a wireless communication system.

BACKGROUND

[0002] A wireless communications system may include one or multiple network communication devices, such as base stations, 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] Various aspects of the present disclosure relate to wireless communications, including improved methods and apparatuses that support AIoT communication in a wireless communication system. A UE may transmit a request to register with a communication network as an intermediate node for AIoT data transmissions. The UE may also receive a response indicating that the UE is registered as the intermediate node for the AIoT data transmissions.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] Figure 1 illustrates an example of a wireless communications system in accordance with aspects of the present disclosure.

[0006] Figure 2 illustrates an example of a first topology of a wireless network in accordance with aspects of the present disclosure.

[0007] Figure 3 illustrates an example of a second topology of a wireless network in accordance with aspects of the present disclosure.

[0008] Figure 4 illustrates an example of a block diagram of an ambient internet of things (AIoT) system in accordance with aspects of the present disclosure.

[0009] Figure 5 illustrates an example of a procedure in an AIoT system in accordance with aspects of the present disclosure.

[0010] Figure 6 illustrates a control plane connection configuration in accordance with aspects of the present disclosure.

[0011] Figure 7 illustrates another example of a procedure in an AIoT system in accordance with aspects of the present disclosure.

[0012] Figure 8 illustrates an example of a UE in accordance with aspects of the present disclosure.

[0013] Figure 9 illustrates an example of a processor in accordance with aspects of the present disclosure.

[0014] Figure 10 illustrates an example of a network equipment (NE) in accordance with aspects of the present disclosure.

[0015] Figure 11 illustrates a flowchart of a method performed by a UE in accordance with aspects of the present disclosure.

[0016] Figure 12 illustrates a flowchart of a method performed by a NE in accordance with aspects of the present disclosure.

DETAILED DESCRIPTION

[0017] Various aspects of the present disclosure relate to AIoT communications in a wireless communication system. The AIoT communications may be supported by a UE functioning (e.g., operating) as an AIoT reader. The AIoT communications may occur over a control plane. A wireless device, such as UE may output (e.g., transmit) a request to register with the wireless communication system based at least in part on the wireless device seeking to be an intermediate node for the AIoT communications (e.g., AIoT data transmission). However, in some cases, the wireless device may be incompatible and/or incapable of functioning as an intermediate node and thereby signaling associated with the request may result in wasted time, communication resources, and power consumption (e.g., battery life). To address these shortcomings, the wireless device, which is capable of AIoT communication, may be configured (e.g., enabled) with policy information when and how to receive and transmit data or signaling from the network to the AIoT devices in the downlink and to receive and transmit data or signaling from the AIoT devices to the network in the uplink. Assistance information with the request may provide for improvements to transmission efficiency, fewer use of communication resources, and time may be used efficiently.

[0018] Aspects of the present disclosure are described in the context of a wireless communications system.

[0019] 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 NE 102, one or more UE 104, and a core network (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 a new radio (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.

[0020] The one or more NE 102 may be dispersed throughout a geographic region to form the wireless communications system 100. One or more of the NE 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.

[0021] 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 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 NE 102.

[0022] The one or more UE 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.

[0023] 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 UE-to-UE interface (PC5 interface).

[0024] 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, N3, or network interface). In some implementations, the NE 102 may communicate with each other directly. In some other implementations, the NE 102 may communicate with each other indirectly (e.g., via the CN 106). In some implementations, one or more NE 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).

[0025] 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 NE 102 associated with the CN 106.

[0026] The CN 106 may communicate with a packet data network over one or more backhaul links (e.g., via an S1, N2, N3, 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).

[0027] 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 (i.e., multiple frame structures). The NEs 102 and the UEs 104 may support various frame structures based on one or more numerologies.

[0028] 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.

[0029] 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.

[0030] 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.

[0031] 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.

[0032] 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.

[0033] In one wireless communication system (also referred to as a wireless network), for example, a 5G system (5GS), cellular IoT services may be provided to devices with reduced capabilities. The system may include simplified devices referred to as ambient IoT (AIoT) devices. These AIoT devices may be a new class of IoT devices that are powered by harvesting energy from various sources such as radio frequency (RF) energy, solar energy, wind energy, and so forth. Distinct from traditional IoT devices, AIoT devices may not rely on batteries and may have limited energy storage capabilities, often using an internal capacitor for energy storage. RF energy may be harvested from transmissions made by the network itself.

[0034] RF energy harvesting may enable ambient IoT devices to harvest energy from RF signals available in their environment, such as RF signals transmitted from mobile networks or from nearby Wi-Fi networks. The RF energy harvesting may be a technology that enables self-sustainable wireless IoT networks and analyzes the energy harvesting performance of a Wi-Fi-based IoT network.

[0035] For an ambient IoT device to transmit data, it may first receive an RF signal that provides sufficient energy to power the device. This RF signal may commonly be referred to as a trigger signal or trigger message. The trigger message may be transmitted by a base station (BS) or a UE acting as AIoT reader as an intermediate node (UE-AIoT-I). Both the BS and the UE-AIoT-I may be assumed to be in close proximity to the AIoT device.

[0036] Several connectivity topologies may be used to enable an AIoT device to communicate with a mobility network (e.g., 5GS). Connectivity topologies for AIoT networks and devices shown in Figures 2 and 3 may be used in 3GPP. In such examples, the AIoT device may be provided with a carrier wave from other nodes either inside or outside the topology. The links in each topology may be bidirectional or unidirectional.

[0037] Figure 2 illustrates an example of a first topology 200 of a wireless network in accordance with aspects of the present disclosure. The first topology 200 includes a BS 202 communicating directly with an AIoT device 204 over a link 206 (e.g., BS 202 ↔ AIoT

device 204). The communication between the BS 202 and the AIoT device 204 includes AIoT data and/or signaling 208.

[0038] Figure 3 illustrates an example of a second topology 300 of a wireless network in accordance with aspects of the present disclosure. The second topology 300 includes a BS 302 communicating bidirectionally with an intermediate node 304 (e.g., UE) between the BS 302 and an AIoT device 306 using communication links 308 and 310. This is denoted as "BS ↔ intermediate node ↔ AIoT device." The intermediate node 304 may be a special UE capable of transmitting and receiving data and/or signaling 312 with the AIoT device 306. The intermediate node 304 as a UE may be denoted for short as "UE-AIoT-I" for a UE capable of AIoT communication as the intermediate node 304. AIoT communication may mean transmitting and/or receiving data and/or signaling to and/or from the AIoT device 306 (e.g., from the network, BS, and/or intermediate node associated with the AIoT device 306). The intermediate node 304 (e.g., AIoT intermediate node) may be a UE, or another device capable of communicating (e.g., making transmissions) with the AIoT device 306.

[0039] Figure 4 illustrates an example of a block diagram of an AIoT system 400 in accordance with aspects of the present disclosure. The AIoT system 400 may be for an AIoT service for an automated warehouse inventory. The inventory may use a request-response operation. Another example of an AIoT service may use sensor monitoring where the network may need to read and write data to the AIoT device. At 402, the truck is unloaded and the goods with embedded AIoT devices pass through an AIoT device reader into the warehouse. The AIoT device reader is shown at 404 as a gate. According to the first topology 200, the AIoT device reader may be a BS. According to the second topology 300, the AIoT device reader may be a UE-AIoT-I. At 406, the goods with embedded AIoT devices are stored in the warehouse. During this time the goods with embedded AIoT devices may be reached by a BS. At 408, the goods with embedded AIoT devices pass through an AIoT device reader out of the warehouse. At 410, the goods with embedded AIoT devices pass through an AIoT device reader and are loaded into a truck.

[0040] At 404, 406, and 408 the AIoT devices may be empowered and the network (to which the AIoT reader is connected) may communicate with the devices and read the AIoT device identifier (ID). Thus, the network may determine the location of the AIoT device and the corresponding good and/or stock.

[0041] Certain examples herein my use a connectivity topology where an AIoT reader (or gate as in Figure 4 at 404 and 408) is implemented as a UE capable of AIoT communication as an intermediate node (e.g., UE-AIoT-I) (e.g., the second topology 300 wherein the intermediate node is denoted as UE-AIoT-I). For this purpose, the UE-AIoT-I node may be registered with the network and the AIoT data and/or signaling may pass through the UE-AIoT-I node.

[0042] In some examples, the UE-AIoT-I node is a subscriber to the communication network (e.g., a public land mobile network (PLMN) or standalone non-public network (SNPN)), but it may be owned by an AIoT service provider. In other words, the AIoT service provider (AIoT-SP) may have an AIoT application server (AIoT-AS) and may want to directly control the AIoT data and/or signaling transmission via the UE-AIoT-I node.

[0043] In various examples, to allow a UE-AIoT-I node to communicate with AIoT devices and with the network (e.g., via a Uu interface) the following may be determined: how the UE-AIoT-I node receives and transmits AIoT data and/or signaling via the communication network (e.g., PLMN or SNPN implementing over the Uu interface) to and/or from the AIoT-AS, and how the data connection between the UE-AIoT-I and the 5GC is configured to allow AIoT data and/or signaling with efficient transmission.

[0044] Figure 5 illustrates an example of a procedure 500 in an AIoT system in accordance with aspects of the present disclosure. In some implementations, the procedure 500 may implement, or be implemented by, aspects of the wireless communications system 100 as described with reference to Figure 1. The procedure 500 may include a AIoT device 502 (or multiple AIoT devices), an AIoT device reader 503 (including a UE-AIoT-I 504 and a radio access network (RAN) 506), a CN 507 (including an AIoT-GW, access and mobility management function (AMF), session management function (SMF), user plane functions (UPFs) 508, a unified data repository (UDR)/unified data management (UDM) 510, and a charging function (CHF) 512), an operations, administration, and management (OAM) 514, and an AIoT application function (AF) and/or application server (AS) 516. In the following description of the procedure 500, the operations may be transmitted in a different order than the example order shown, or the operations may be performed in different orders or at different times. Some operations may also be omitted from the procedure 500, and other operations may be added to the procedure 500. The AIoT device 502 communicates with the AIoT device reader 503.

[0045] Specifically, Figure 5 illustrates an overview of deployment and configuration of an AIoT service in a communication network. The Figure 5 shows steps (or phases) for the deployment of the AIoT service including the configuration of the network entities and AIoT transmitters and the communication service for the transmission of the AIoT data and/or signaling.

[0046] In Figure 5, CN control plane (CP) (or user plane) NFs may be used for the purposes of the AIoT service in the 3GPP network. Such NFs may be referred to as an AIoT gateway 508 (AIoT-GW) or AIoT NF. The AIoT-GW 508 may: store the AIoT service parameters and configure UE-AIoT-I 504, RAN 506 and/or BS or CP NFs for the AIoT service, receive and transmit AIoT data and/or signaling from and/or to the AIoT AF/AS 516, receive and transmit AIoT data and/or signaling from and/or to the AIoT reader (e.g. RAN 506 and/or BS or UE-AIoT-I 504), perform store-and-forward functionality for the AIoT data and/or signaling, create charging data for the AIoT data and/or signaling and transmit the data to the CHF 512, and/or verify the identity of the AIoT device 502.

[0047] During a service provisioning phase 517, at 518, the AIoT AF and/or AS 516 is configured with at least one of the following information: a list of AIoT device IDs (to which data and/or signaling has to be transmitted or inventory action is to be performed), a service ID (which may identify the AIoT service) and credentials for the service and the AIoT devices. The AIoT devices may be identified with a Group ID.

[0048] At 520, there may be configuration of the AIoT device 502 which includes at least one of: a device ID, a service ID, and credentials. At 522, the service provisioning or service level agreement (SLA) between the AIoT AF/AS 516 and the CN 597 of the network. Information like the list of AIoT device IDs, the service ID, the credentials, the service area, and the service operation type are provisioned to the network. Two examples of signaling may be used. In one example, the AIoT AF/AS 516 sends the AIoT provisioning data to the OAM 514 and the OAM 514 provides the data to the UDM/UDR 510. In another example, the AIoT AF/AS 516 sends the data directly to the UDM/UDR 510 (e.g., via a network exposure function (NEF)).

[0049] The service provisioning phase 517 may also include AIoT device management procedures which are used to manage the AIoT states in the network and in the AIoT AF/AS 516.

[0050] During a configuration phase 523, the AIoT device reader 503 (e.g., the RAN 506 or the UE-AIoT-I 504) is configured to act as an AIoT reader in general or for a particular AIoT service. Such configuration may also include the configuration of the CN 507 entities to serve the particular AIoT service. At 524, the RAN 506 may select and register with the CN 507 its AIoT capability and/or service area with the CN 507 responsible for AIoT communication. At 526, the UE-AIoT-I 504 may register with the CN 507 and indicate its AIoT capability and/or service area with the CN 507 entity responsible for AIoT communication. At 524 and 526, the CN 507 responsible for AIoT communication may configure or enable the AIoT device reader 503 to serve as such for a particular AIoT service. At 528, the CN 507 NFs responsible for AIoT communication may exchange information to configure or activate the parameters related to the particular AIoT service. At 530, the CN 507 NFs responsible for AIoT communication may exchange information for further service parameter configuration or update with the AIoT AF/AS 516.

[0051] During an AIoT service procedure phase 531, the AIoT data and/or signaling is transmitted between the AIoT AF/AS 516 and the AIoT device 502. For this phase, it may be assumed that the AIoT service agreement is established and network together with the AIoT devices are configured with necessary information. It may also be assumed that the procedure for the AIoT service is initiated from the network to support traffic types of device-terminated (DT) and device-originated (DO)-– device-terminated triggered (DTT). This phase may also include the authentication and/or authorization of the AIoT device 502 or the AIoT device ID. At 532, the AIoT service provider (e.g., represented as AF or AS) sends the data or signaling to be transmitted in the AIoT device 502. One or more entities in the CN 507 may store the data and/or signaling, process the data and/or signaling and prepare for transmission to the AIoT device reader 503. At 534, the CN 507 may transmit the AIoT data and/or signaling to the AIoT device reader 503. The AIoT device reader 503 may transmit the AIoT data and/or signaling to the AIoT device 502 which may backscatter or actively transmit the signal back to the AIoT device reader 503. The AIoT device reader 503 may transmit the AIoT data and/or signaling to the CN 507. At 536, the AIoT responsible CN 507 entity may collect the AIoT data and/or signaling and prepare an AIoT data report. The AIoT responsible CN 507 entity transmits the AIoT data report to the AIoT AF/AS 516. In addition, at 538, the AIoT responsible CN 507 entity may collect charging data and transmit it to the CHF 512 for charging purposes.

[0052] Different examples found herein may focus on an AIoT service procedure phase for AIoT data and/or signaling transmission, more specifically over a CP of the CN.

[0053] Figure 6 illustrates a control plane connection configuration 600 in accordance with aspects of the present disclosure. The control plane connection configuration 600 includes a UPF 602, an AMF 604, an AIoT 606, a UE-AIoT-I 608, a RAN 610, a UPF 612, an AIoT-GW 614, an NEF 616, and an AIoT AF/AS 618. Specifically, Figure 6 shows the high-level architecture for the user plane connection configuration 600 for the UE-AIoT-I 608. One communication path shows the AIoT data and/or signaling transmission between the AIoT application server (e.g., AIoT AF/AS 618) and the AIoT devices (e.g., AIoT 606) via the UE-AIoT-I 608. This AIoT data and/or signaling transmission is performed via the control plane. A UE (e.g., UE-AIoT-I 608) may implement an AIoT application client which handles the transmission to and/or from the AIoT devices (e.g., AIoT 606) and process the AIoT data to be transmitted to and/or from the AIoT-GW 614.

[0054] Another communication path (numbered 620, 622, and 624) shows the control plane signaling for the configuration of the CP transmission path (e.g., for the AIoT data and/or signaling) between the UE-AIoT-I 608 for the AIoT-GW 614. The network (e.g., PLMN or SNPN) may implement the AIoT-GW 614 (e.g., in the user plane and/or in the control plane) via which the AIoT data and/or signaling is transmitted. The reason to use the AIoT-GW 614 is to allow the network operator (e.g., PLMN or SNPN operator) to add network layer security or specific processing to the AIoT data and/or signaling from the AIoT server before the AIoT data and/or signaling is transmitted by the UE-AIoT-I 608 over the radio interface to the AIoT devices (e.g., AIoT 606). The AIoT-GW 614 may need to select an appropriate UE-AIoT node that can reach the target AIoT devices to which the AIoT data and/or signaling is finally destined to.

[0055] At 620, the registration of the UE-AIoT-I 608 with the AMF 604 may occur. At 622, the AMF 604 may retrieve the UE-AIoT-I 608 subscription data from the UDM (e.g., UPF 602) and learn which AIoT services are allowed for the UE (e.g., UE-AIoT-I 608). The AMF 604 may determine to register the with one or more AIoT-GWs and select the appropriate AIoT-GWs. At 624, the AMF 604 may send a request to register the UE-AIoT-I 608 with the AIoT-GW 614 and indicate the authorized and/or allowed AIoT services. The AIoT-GW 614 may create and store a list of UE-AIoT-I nodes and the corresponding locations or service areas and the corresponding allowed AIoT services.

[0056] In some examples described herein:

[0057] A. There may be a method for configuring a control plane connection (e.g., including the configuration of the UE-AIoT-I, AMF and AIoT-GW) to be used for AIoT data and/or signaling transmission between the UE-AIoT-I and the AIoT-GW;

[0058] B. The AMF may be enhanced to receive (e.g., from an AM PCF) and send to the SMF AIoT-specific information for a PDU session configuration. Furthermore, the AMF may: receive a registration request message indicating the UE capability to act as an AIoT intermediate node, retrieve the UE-AIoT-I subscription data from the UDM which indicates whether the UE is enabled and/or disabled to act as AIoT reader, a list of AIoT services allowed for the UE, and AIoT-GW selection information, select appropriate AIoT-GWs and transmit a request to register the UE-AIoT-I with a AIoT-GW - the request may indicate the authorized and/or allowed AIoT services, service area, and location associated with the UE-AIoT-I, transmit an indication to the UE (e.g., in a registration accept message or a UE configuration command message) that one or more AIoT services are enabled or disabled, receive and transmit AIoT data and/or signaling to and/or from the AIoT-GW, and/or receive and transmit AIoT data and/or signaling to and/or from the UE-AIoT-I via NAS transport messages.

[0059] C. An AIoT-GW may be able to perform the following: store the AIoT service parameters and configure UE-AIoT-I, RAN and/or BS or CP NFs for the AIoT service, receive and transmit AIoT data and/or signaling from and/or to the AIoT application server, receive and transmit AIoT data and/or signaling from/to the AIoT reader (e.g., RAN and/or BS or UE-AIoT-I), perform store-and-forward functionality for the AIoT data and/or signaling, create charging data for the AIoT data and/or signaling and transmit the data to the CHF, verify the identity of the AIoT devices, receive a request to register an UE-AIoT-I node as a possible UE reader for AIoT devices, wherein the request may indicate the authorized and/or allowed AIoT services, service area, land location associated with the UE-AIoT-I, store a list of one or more UE-AIoT-I nodes (or RAN nodes) (e.g., AIoT reader nodes) capable of transmitting AIoT data and/or signaling to AIoT devices, wherein each node may be associated with location information and allowed services, receive a request to transmit AIoT data to AIoT devices (e.g., associated with specific target area), select one or more appropriate AIoT reader nodes for the transmission of AIoT data and/or signaling, and/or transmit the AIoT data and/or signaling to the selected AIoT reader nodes via control

plane signaling, wherein the AIoT data and/or signaling is transmitted as an AIoT transparent container to the AMF.

[0060] Figure 7 illustrates another example of a procedure 700 in an AIoT system in accordance with aspects of the present disclosure. In some implementations, the procedure 700 may implement, or be implemented by, aspects of the wireless communications system 100 as described with reference to Figure 1. The procedure 700 may include a UE 702 (e.g., AIoT-I), a RAN 704, an AMF 706, an AIoT-GW 708, a UDR/UDM 710, an NEF 712, and an AIoT-AF 714 (and/or AIoT-AS). In the following description of the procedure 700, the operations may be transmitted in a different order than the example order shown, or the operations may be performed in different orders or at different times. Some operations may also be omitted from the procedure 700, and other operations may be added to the procedure 700. Specifically, Figure 7 shows a signaling flow for a UE-AIoT-I configuration for AIoT data and/or signaling transmission via the control plane.

[0061] There may be one or more AIoT-GWs (e.g., specific for an AIoT service for a particular AIoT customer). For this purpose, the AIoT-GW 708 may register itself with the network repository function (NRF) and indicate which AIoT service ID it is configured to serve. For example, the AIoT-GW 708 may use Nnrf_NFManagement_NFRegister service operation including AIoT service ID as an input parameter.

[0062] At 716, the UE 702 implements a capability to act as an intermediate node AIoT with transmission capability for transmissions to AIoT devices. The UE 702 may be a UE-AIoT-I. In addition, the UE 702 may store various parameters for AIoT services, denoted as AIoT service parameters, which may be stored in a mobile equipment (ME) part (e.g., in a universal integrated circuit card (UICC)). The UE 702 may implement an application client functionality which is responsible for: reception and transmission of AIoT data and/or signaling from and/or to the network (e.g., from the AIoT-GW 708), processing the data, and/or transmission and reception of AIoT data and/or signaling to and/or from the AIoT devices.

[0063] At 718, the AIoT-AF 714 may use a parameter provisioning service exposed by the NEF 712. The AIoT-AF 714 may send a request using a Nnef_ServiceParameter_Create/Update service operation and include at least one of the following parameters: AIoT application external ID or UE external ID, single network slice selection assistance information (S-NSSAI)/data network name (DNN), and include AIoT

configuration information (e.g., service or session configuration information). The AIoT configuration information may include the AIoT service ID, AIoT related service parameters (e.g., AIoT service area, transmission time or periodicity of the AIoT data/signalling, type of AIoT service to be configured in the network and so forth), and/or other parameters. The type of AIoT service refers to the service which is requested by the AIoT AF and which is configured in the network. The type of AIoT service may be one of the following:

[0064] (A) inventory service, which is used to discover what goods (e.g. boxes, containers, packages, tools) are present in a specific area. The network may transmit a request within the specific area and the AIoT devices (attached to the goods) report an identifier associated with the good, possibly supplemented with other information such as status, measurement results and/or location.

[0065] (B) sensor data collection service, which is used to transfer sensor data from AIoT device to the network. The transfer can be done periodically, when the AIoT device has enough power for transmission, or when the AIoT device is triggered by the network.

[0066] (C) asset tracking service, which is used to determine the location of goods to which AIoT device is attached. The AIoT devices attached to these goods report an identifier associated with the good and associated location information.

[0067] (D) actuator control service, which is used by the network to transfer (actuator) commands to the AIoT device. The AIoT device can store the command and act correspondingly.

[0068] At 720, the UDM/UDR 710 may store UE subscription data and application subscription data (e.g., AIoT). The UE subscription data may contain information related to the AIoT service (e.g., at least one of: that the UE is allowed to operate as an intermediate AIoT device, the AIoT services which are allowed for this UE, AIoT-GW selection information, control plane (CP) and/or user plane (UP) transmission allowed and/or subscribed for the allowed AIoT services, and so forth). The UE subscription data may contain information about an association between the UE 702 and the AIoT-AF ID (or AIoT application ID) or AIoT service ID.

[0069] The application subscription data may contain the AIoT configuration information received at 718. It should be noted that the use of an AIoT service may mean a communication service provided by the network to an AIoT data and/or signaling exchange

between the AIoT device and the AIoT-AF 714. The AIoT service may be identified by an AIoT service ID that may be used in the signaling between the AIoT-AF 714 and the CN of the network. It may mean that the CN of the network (e.g., UDR/UDM 710) may store an association between the AIoT service ID and the related service parameters (e.g., AIoT service area, AIoT service type, transmission time or periodicity, and so forth), the related AIoT application ID, group credentials associated for the network layer security, a list of one or more AIoT devices, and/or a list of UEs acting as intermediate readers allowed to serve this AIoT service.

[0070] At 722, the AIoT-GW 708 may receive AIoT-related service parameters from the UDR/UDM 710. For example, the AIoT-GW 708 may send a request for the AIoT-related application subscription data stored in the UDM/UDR 710. The UDM/UDR may identify the stored AIoT application subscription data and send the AIoT application subscription data to the AIoT-GW 708. The AIoT-GW 708 may also be configured with policies for the AIoT service ID. It may be possible that the AIoT-AF 714 send the AIoT configuration information to the AIoT-GW 708 directly or via the NEF 712.

[0071] At 724, the UE 702 initiates a registration procedure. A registration request message (e.g., a non-access stratum (NAS) message) may include at least one of the following AIoT-assistance indications: that the UE 702 is capable of AIoT communication and may serve as an intermediate node, whether the UE 702 may receive and transmit AIoT data from and/or to the network via CP or UP communication path, and/or AIoT capabilities (e.g., supported frequency bands, range of communication or AIoT radio coverage area or information), one or more power modes (e.g., about the mode or category of transmission energy to AIoT devices), an indication whether the UE is a mobile or stationary node, an indication whether the UE operates indoor or outdoor or both, and so forth. The indications may be implemented in the NAS protocol as a mobility management (MM) capability container sent from the UE 702 to the AMF. In one example, the indications may be transmitted as a stand-alone informational element in the NAS message.

[0072] At 726, the AMF 706 may process a registration request message and a successful UE authentication and authorization, and the AMF 706 may send a request message to retrieve the UE's subscription data from the UDM/UDR 710. The AMF 706 may use a subscription permanent identifier (SUPI) as a reference identifier.

[0073] Further, the response message from the UDM/UDR 710 may include at least one of the following indications: that the UE 702 is authorized or enabled and/or disabled to serve as an AIoT intermediate node, a list of one or more AIoT services for which the UE 702 is allowed to transmit AIoT data and/or signaling to the AIoT devices, AIoT-GW selection information, whether CP or UP transmission for each of the allowed services is preferred (or configured), and so forth.

[0074] The AIoT services may be identified by an ID or a combination of DNN and/or S-NSSAI. If there are different AIoT-GWs deployed for different AIoT services, then AIoT service identification may be required. The AIoT-GW 708 selection information may provide the AIoT-GW address which may be configured in the UDM/UDR 710 for use for the particular AIoT service.

[0075] Based on a UE capability indication at 724 and/or the subscription data indication, or based on local configuration, the AMF 706 may decide whether to configure the UE 702 for AIoT data and/or signaling transmission over the control plane or over the user plane. As used herein, the AMF 706 may decide to use a control plane transmission path.

[0076] At 728, the AMF 706 may determine to register the UE 702 (which is authorized to act as an AIoT intermediate node) with one or more AIoT-GWs for AIoT services. The AMF 706 may select an AIoT-GW 708 for each allowed AIoT service. The AMF 706 may use either a local policy for AIoT-GW 708 selection, or the AMF 706 may use NRF services, or the UDR/UDM 710 may have indicated information for AIoT-GW 708 selection as part of the UE 702 subscription data retrieved at 726.

[0077] The AIoT-GW 708 may have registered itself with the NRF. When the AMF 706 sends a request to the NRF for AIoT-GW 708 selection, the AMF 706 may include an indication about the AIoT service IDs for which the AIoT-GW 708 is sought.

[0078] At 730, the AMF 706 sends a request message to the AIoT-GW 708 to register the UE 702 (e.g., AIoT-I). The AMF 706 may use a service offered by the AIoT-GW 708 (e.g., a new service called Naiotgw_Register_AIoTreader or Naiot_IntermediateNode_Register service operation). The AMF 706 may include at least one of the parameters received from the UE at an earlier time. For example, the AMF 706 may include the following indications: the SUPI (as UE ID), an access type (e.g., NR, LTE), an indication that the UE 702 is allowed to act as intermediate node, the UE's AIoT

capabilities, a list of one or more allowed AIoT service IDs, an indication about whether the UE 702 is capable of user plane or control plane reception and transmission of AIoT data and/or signaling from the network, a location of the UE 702, the AIoT radio coverage area (or service area for AIoT) of the UE 702, an indication about whether the UE 702 is a stationary or a mobile node, and so forth. The UE 702 location information may include either the network topology information (e.g., cell ID or tracking area identity (TAI)) or geographical information (e.g., global positioning system (GPS) coordinates) where the UE 702 is currently located.

[0079] The AIoT-GW 708 may update its stored and/or context data by taking into account the information received from the AMF 706. The AIoT-GW 708 may send a response to the AMF 706 indicating the result of the request (e.g. the result may be a successful registration or a registration failure). For registration failure, the AIoT-GW 708 may indicate an appropriate reason for failure.

[0080] At 732, the AIoT-GW 708 may process the request and create a context for the UE 702 acting as an AIoT intermediate node. The AIoT-GW 708 may determine to update the UE 702 configuration for the AIoT data and/or signaling transmission operation. The AIoT-GW 708 may send configuration information to the UE 702. For example, the AIoT-GW 708 may use the existing AMF 706 service Namf_Communication_N1N2MessageTransfer or similar service. The AIoT-GW 708 may include the AIoT configuration information in an N1 AIoT container which is to be transferred transparently to the UE 702 via the AMF 706.

[0081] At 734, the AMF 706 may send a registration accept message (or in various scenarios a UE configuration update (UCU) command) which may include one or more indications about whether the operation as the AIoT intermediate node is allowed (or disallowed) and which AIoT services are allowed to be served. If the AIoT-GW 708 has included an N1 AIoT container at 732, the AMF 706 may also include the N1 AIoT container in the message. The AMF 706 may further indicate: whether the network supports CP or UP transmission for AIoT data and/or signaling, that the network prefers (or has selected) UP and/or CP transmission for AIoT data and/or signaling, and the service area where the AIoT data and/or signaling is allowed to be transmitted. In general, the transmission of the N1 AIoT container may be independent of the registration procedure. If the N1 AIoT container is to be transmitted after the registration procedure, the AMF 706 may use a NAS DL transport message to carry the N1 AIoT container.

[0082] At 736, the AIoT-GW 708 may determine to keep the UE-AIoT-I context up-to-date. For example, the AIoT-GW 708 may subscribe with the AMF 706 for location or service area updates. One trigger for the UE-AIoT-I location update may be the need to transmit AIoT data and/or signaling to AIoT devices.

[0083] At 738, the AIoT-GW 708 may subscribe with the AMF 706 to be informed of the UE-AIoT-I location and/or UE-AIoT-I reachability status and/or may subscribe for an area of interest (AoI). The AoI may be derived from the AIoT service area for which the AIoT-GW 708 is interested to reach the AIoT devices.

[0084] At 740, the AIoT-AF 714 may send, to the AIoT-GW 708, AIoT data and/or signaling to be transmitted to the AIoT devices. The request message may include: an AIoT service ID, a target transmission area, AIoT data and/or signaling, a list of AIoT device IDs or group ID, type of AIoT service and so forth. The AIoT-GW 708 may determine AIoT readers are available (e.g., UE-AIoT-I nodes) in the area where the AIoT data is to be transmitted. For this purpose, the AIoT-GW 708 may need to perform 742 and 744.

[0085] At 742, the AIoT-GW 708 may send a request to the AMF 706 for a current UE 702 status (e.g., whether the UE 702 is reachable and the UE 702 location). The AMF 706 may respond to the request including the UE 702 status and location.

[0086] At 744, the AIoT-GW 708 may send a request for the UE 702 location to a positioning functionality in the network (e.g., to a gateway mobile location center (GMLC) and/or location management function (LMF) 746). The GMLC/LMF 746 may reply to the AIoT-GW 708 with the UE 702 location information.

[0087] At 748, the AIoT-GW 708 may perform a selection of one or more UEs acting as AIoT intermediate nodes or RAN nodes for the transmission of the AIoT data and/or signaling. The AIoT-GW 708 may take into account the following information when determining which nodes will be acting as AIoT reader nodes:

[0088] A. UE AIoT capabilities and the UE configuration of how to transmit AIoT data and/or signaling to AIoT device and over Uu (e.g., the communication parameters for the AIoT device);

[0089] B. A current location and current service area of the stored contexts for registered UE-AIoT-I nodes - this may include the UE current RAT, the public land mobile networks (PLMNs) in which the UE 702 is authorized to perform AIoT communication, and/or an

indication of whether the UE 702 is allowed to perform AIoT communication when the UE 702 is not served by evolved universal terrestrial radio access (E-UTRA) and not served by NR; and/or

[0090] C. A UE current availability (e.g., whether the UE 702 is in a CM-Connected state or a CM-Idle state).

[0091] At 750, 752, 754, and 756, the UE 702 may be configured for the transmission of the AIoT data and/or signaling for a specific AIoT service or AIoT application. This may function as a session establishment between the UE 702 and the AIoT-GW 708, wherein the session may be used for one or more AIoT data exchanges in the downlink (DL) (e.g., device terminated data transmissions) or in the uplink (UL) (e.g., device originated data transmissions). Moreover, the UE 702 and the AIoT-GW 708 may exchange a session identifier (e.g., AIoT service ID, application ID, UL port ID, DL port ID, and so forth) which are used for the correct routing of the AIoT data and/or signaling in the UE 702 and the AIoT-GW 708.

[0092] Specifically, at 750, the AIoT-GW 708 may decide to configure the UE 702 for the transmission of the AIoT data and/or signaling before the actual communication. The AIoT-GW 708 may create an AIoT service configuration information for the selected UE 702. The AIoT-GW 708 may use an N1 AIoT container to include: a session ID (e.g., AIoT service ID) and/or the AIoT service configuration information. The AIoT-GW 708 may use an existing service provided by the AMF 706 to transmit the N1 AIoT container. For example, the AIoT-GW 708 may use a Namf_Communication_N1N2MessageTransfer service. The N1 AIoT container may include, in addition to AIoT service configuration information (e.g., including in parts the service parameters received and processed as per steps 722, 740 and 748), a AIoT-GW 708 address or an AIoT-AS 714 address (e.g., in the user plane like an internet protocol (IP) address and/or a fully qualified domain name (FQDN)), request to report an exact location and an AIoT service area.

[0093] At 752, the AMF 706 receives the N1 AIoT container and transmits it to the UE 702. The AMF 706 may use an NAS DL transport message which may include: an AIoT service ID and/or an N1 AIoT container (e.g., including AIoT configuration data).

[0094] At 754, the UE 702 may receive and process the N1 AIoT container containing the AIoT service configuration information. The UE 702 may reply to the AIoT-GW 708 by creating an N1 AIoT container. The UE 702 may use an NAS UL transport message

transmitted to the AMF 706 and including: the AIoT service ID and/or the AIoT container (e.g., including AIoT configuration data). In one example, the UE 702 may include its current location and current AIoT service area in the N1 AIoT container sent to the AIoT-GW 708.

[0095] At 756, the AMF 706 forwards the received N1 AIoT container to the target AIoT-GW 708. The AMF 706 may determine the target AIoT-GW 708 based on the AIoT service ID. The AMF 706 may use the Namf_Communication_N1N2MessageTransfer service and include the N1 AIoT container as a payload.

[0096] At 758, the AIoT-GW 708 may include the AIoT data and/or signaling and associated parameters in an N1 AIoT container. The AIoT-GW 708 may send the N1 AIoT container to the AMF 706 serving the selected UE 702. The AIoT-GW 708 may use the existing service Namf_Communication_N1N2MessageTransfer service offered by the AMF 706 for transparent signaling transmission.

[0097] At 760, the AMF 706 may receive the N1 AIoT container from the AIoT-GW 708. The AMF 706 prepares and sends a NAS DL transport message to the UE 702 which includes: the N1 AIoT container and information for the UE 702 to route the container to the correct AIoT application client in the UE 702. The information for the UE 702 to route the container to the correct AIoT application client in the UE 702 may be a AIoT service ID, an AIoT application ID, and/or a port ID.

[0098] At 762, the UE 702 may receive or acquire information from the AIoT devices. The UE 702 (or application client in the UE 702) may prepare uplink AIoT data and/or signaling to be transmitted to the AIoT-GW 708. The UE 702 may use an NAS UL transport message which includes: the N1 AIoT container and/or information for the AMF 706 to route the container to the correct AIoT-GW 708. The information for the AMF 706 to route the container to the correct AIoT-GW 708 may include an AIoT-GW ID and/or AIoT service ID.

[0099] At 764, the AMF 706 may forward the received N1 AIoT container to the AIoT-GW 708. The AMF 706 may use the Namf_Communication_N1N2MessageTransfer service. The AMF 706 may include in the message sent to the AIoT-GW 708: an AIoT service ID and/or an N1 AIoT container.

[0100] At 766, the AIoT-GW 708 may receive the N1 AIoT container and may extract the AIoT data and/or signaling. If needed, the AIoT-GW 708 may process the received AIoT

data and/or signaling (e.g., for security or verification purposes of the AIoT device or AIoT data integrity). For example, the AIoT-GW 708 may verify whether the right or false AIoT device has sent the data, wherein this verification may be based on the AIoT device ID included in the AIoT data and/or signaling. The AIoT-GW 708 may send an AIoT message report (or response if there was a request) to the AIoT-AF 714. The message may contain: the AIoT data and/or signaling received and/or information about sourcing AIoT devices (e.g., device IDs), an AIoT service ID, and so forth.

[0101] At 768, the AIoT-GW 708 may create a charging record for the transmitted AIoT data and/or signaling in both UL and DL. The AIoT-GW 708 may transmit the charging record to a CHF. It should be noted that the process 700 of Figure 7 may be applied to public networks (e.g., PLMN), or for private network (e.g., non-public network (NPN) or SNPN.

[0102] One benefit of the method of Figure 7 may be that it uses a specific network entity (e.g., the AIoT-GW 708) which allows store-and-forward transmission of AIoT data and/or signaling between the AIoT-AF 714 and the AIoT devices. The AIoT-GW 708 may store the availability information of the UEs acting as intermediate nodes and may select the most appropriate UE for a current transmission of AIoT data and/or signaling.

[0103] Figure 8 illustrates an example of a UE 800 in accordance with aspects of the present disclosure. The UE 800 may include a processor 802, a memory 804, a controller 806, and a 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.

[0104] 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.

[0105] The processor 802 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, an ASIC, a field programmable gate array (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 UE 800 to perform various functions of the present disclosure.

[0106] 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 UE 800 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such 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.

[0107] In some implementations, the processor 802 and the memory 804 coupled with the processor 802 may be configured to cause the UE 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 UE 800 in accordance with examples as disclosed herein. For example, the processor 802 coupled with the memory 804 may be configured to cause the UE 800 to transmit a request to register with a communication network as an intermediate node for AIoT data transmissions. The UE 800 may also receive a response indicating that the UE is registered as the intermediate node for the AIoT data transmissions.

[0108] The controller 806 may manage input and output signals for the UE 800. The controller 806 may also manage peripherals not integrated into the UE 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.

[0109] In some implementations, the UE 800 may include at least one transceiver 808. In some other implementations, the UE 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.

[0110] 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 receiving 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 received 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 and processing the demodulated signal to receive the transmitted data.

[0111] 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.

[0112] Figure 9 illustrates an example of a processor 900 in accordance with aspects of the present disclosure. The processor 900 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 900 may include a controller 902 configured to perform various operations in accordance with examples as described herein. The processor 900 may optionally include at least one memory 904, which may be, for example, an L1/L2/L3 cache. Additionally, or alternatively, the processor 900 may optionally include one or more arithmetic-logic units (ALUs) 906. 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).

[0113] The processor 900 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 900) 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).

[0114] The controller 902 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 900 to cause the processor 900 to support various operations in accordance with examples as described herein. For example, the controller 902 may operate as a control unit of the processor 900, generating control signals that manage the operation of various components of the processor 900. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[0115] The controller 902 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 904 and determine subsequent instruction(s) to be executed to cause the processor 900 to support various operations in accordance with examples as described herein. The controller 902 may be configured to track memory address of instructions associated with the memory 904. The controller 902 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 902 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 900 to cause the processor 900 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 902 may be configured to manage flow of data within the processor 900. The controller 902 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 900.

[0116] The memory 904 may include one or more caches (e.g., memory local to or included in the processor 900 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementations, the memory 904 may reside within or on a processor chipset (e.g., local to the processor 900). In some other implementations, the memory 904 may reside external to the processor chipset (e.g., remote to the processor 900).

[0117] The memory 904 may store computer-readable, computer-executable code including instructions that, when executed by the processor 900, cause the processor 900 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 902 and/or the processor 900 may be configured to execute computer-readable instructions stored in the memory 904 to cause the processor 900 to perform various functions. For example, the processor 900 and/or the controller 902 may be coupled with or to the memory 904, the processor 900, the controller 902, and the memory 904 may be configured to perform various functions described herein. In some examples, the processor 900 may include multiple processors and the memory 904 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.

[0118] The one or more ALUs 906 may be configured to support various operations in accordance with examples as described herein. In some implementations, the one or more ALUs 906 may reside within or on a processor chipset (e.g., the processor 900). In some other implementations, the one or more ALUs 906 may reside external to the processor chipset (e.g., the processor 900). One or more ALUs 906 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 906 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 906 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 906 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 906 to handle conditional operations, comparisons, and bitwise operations.

[0119] The processor 900 may support wireless communication in accordance with examples as disclosed herein. The processor 900 may be configured to or operable to support a means for: transmitting a request to register with a communication network as an intermediate node for AIoT data transmissions, and receiving a response indicating that the UE is registered as the intermediate node for the AIoT data transmissions.

[0120] Figure 10 illustrates an example of a NE 1000 in accordance with aspects of the present disclosure. The NE 1000 may include a processor 1002, a memory 1004, a controller

1006, and a transceiver 1008. The processor 1002, the memory 1004, the controller 1006, or the transceiver 1008, 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.

[0121] The processor 1002, the memory 1004, the controller 1006, or the transceiver 1008, 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.

[0122] The processor 1002 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 1002 may be configured to operate the memory 1004. In some other implementations, the memory 1004 may be integrated into the processor 1002. The processor 1002 may be configured to execute computer-readable instructions stored in the memory 1004 to cause the NE 1000 to perform various functions of the present disclosure. For example, the processor 1002 coupled with the memory 1004 may be configured to cause the NE 1000 to: receive a request to register a UE as an intermediate node for AIoT data transmissions, wherein the request comprises AIoT assistance information, store a list of a set of AIoT radio nodes capable of making AIoT data transmissions to AIoT devices, receive a request to transmit AIoT data to the AIoT devices, and select at least one AIoT radio node of the set of AIoT radio nodes to transmit the AIoT data.

[0123] The memory 1004 may include volatile or non-volatile memory. The memory 1004 may store computer-readable, computer-executable code including instructions when executed by the processor 1002 cause the NE 1000 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such the memory 1004 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.

[0124] In some implementations, the processor 1002 and the memory 1004 coupled with the processor 1002 may be configured to cause the NE 1000 to perform one or more of the functions described herein (e.g., executing, by the processor 1002, instructions stored in the memory 1004). For example, the processor 1002 may support wireless communication at the NE 1000 in accordance with examples as disclosed herein.

[0125] The controller 1006 may manage input and output signals for the NE 1000. The controller 1006 may also manage peripherals not integrated into the NE 1000. In some implementations, the controller 1006 may utilize an operating system such as iOS®, ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 1006 may be implemented as part of the processor 1002.

[0126] In some implementations, the NE 1000 may include at least one transceiver 1008. In some other implementations, the NE 1000 may have more than one transceiver 1008. The transceiver 1008 may represent a wireless transceiver. The transceiver 1008 may include one or more receiver chains 1010, one or more transmitter chains 1012, or a combination thereof.

[0127] A receiver chain 1010 may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receiver chain 1010 may include one or more antennas for receive the signal over the air or wireless medium. The receiver chain 1010 may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 1010 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 1010 may include at least one decoder for decoding and/or processing the demodulated signal to receive the transmitted data.

[0128] A transmitter chain 1012 may be configured to generate and transmit signals (e.g., control information, data, packets). The transmitter chain 1012 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 1012 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 1012 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

[0129] Figure 11 illustrates a flowchart of a method 1100 in accordance with aspects of the present disclosure. The operations of the method 1100 may be implemented by a first apparatus (e.g., UE) as described herein. In some implementations, a UE may execute a set of instructions to control the function elements of a processor to perform the described functions.

[0130] At 1102, the method may include transmitting a request to register with a communication network as an intermediate node for AIoT data transmissions. The operations of 1102 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1102 may be performed by a UE as described with reference to Figure 8.

[0131] At 1104, the method may include receiving a response indicating that the UE is registered as the intermediate node for the AIoT data transmissions. The operations of 1104 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1104 may be performed by a UE as described with reference to Figure 8.

[0132] Figure 12 illustrates a flowchart of another method 1200 in accordance with aspects of the present disclosure. The operations of the method 1200 may be implemented by a second apparatus (e.g., NE) as described herein. In some implementations, a NE 1000 may execute a set of instructions to control the function elements of a processor to perform the described functions.

[0133] At 1202, the method may include receiving a request to register a UE as an intermediate node for AIoT data transmissions, wherein the request comprises AIoT assistance information. The operations of 1202 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1202 may be performed by a NE as described with reference to Figure 10.

[0134] At 1204, the method may include storing a list of a set of AIoT radio nodes capable of making AIoT data transmissions to AIoT devices. The operations of 1204 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1204 may be performed by a NE as described with reference to Figure 10.

[0135] At 1206, the method may include receiving a request to transmit AIoT data to the AIoT devices. The operations of 1206 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1206 may be performed by a NE as described with reference to Figure 10.

[0136] At 1208, the method may include selecting at least one AIoT radio node of the set of AIoT radio nodes to transmit the AIoT data. The operations of 1208 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1208 may be performed by a NE as described with reference to Figure 10.

[0137] It should be noted that the methods described herein describe possible implementations, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible.

[0138] 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.