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(54) **Title:** DETERMINATION FOR INTERMEDIATE NODE

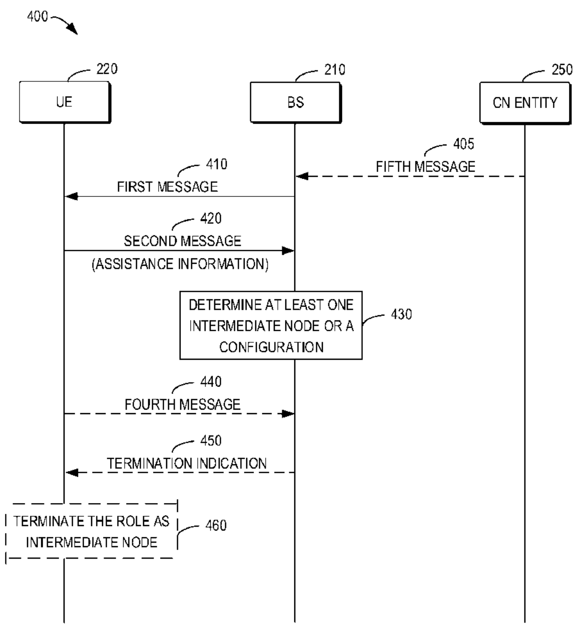

FIG. 4

(57) **Abstract:** Example embodiments of the present disclosure relate to user equipment, a base station, methods, apparatuses, and computer readable medium for determination of intermediate node. In the solution, a UE may receive a first message associated with a service for one or more A-IoT devices from a BS, and may transmit a second message comprising assistance information for determining at least one intermediate node or determining a configuration of at least one intermediate node for the one or more A-IoT devices. As such, one or more UEs may be determined to serve as at least one intermediate node which can communicate with A-IoT device (s) directly. In this way, a communication for A-IoT devices, e.g. in deployment scenario 2 with topology 2, can be enabled and guaranteed.

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DETERMINATION FOR INTERMEDIATE NODE

TECHNICAL FIELD

[0001] The present disclosure relates to wireless communications, and more specifically to a user equipment (UE), a base station (BS), methods, apparatuses, and computer readable medium for determination for intermediate node.

BACKGROUND

[0002] A wireless communications system may include one or multiple network communication devices, such as base stations, which may be otherwise known as an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. Each network communication devices, such as a base station may support wireless communications for one or multiple user communication devices, which may be otherwise known as user equipment (UE), or other suitable terminology. The wireless communications system may support wireless communications with one or multiple user communication devices by utilizing resources of the wireless communication system (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers). Additionally, the wireless communications system may support wireless communications across various radio access technologies including third generation (3G) radio access technology, fourth generation (4G) radio access technology, fifth generation (5G) radio access technology, among other suitable radio access technologies beyond 5G (e.g., sixth generation (6G)).

[0003] A study item on ambient internet of things (ambient-IoT or A-IoT) has been started in new radio (NR) release 18 (Rel-18 or R18), and will be further discussed in release 19 (Rel-19 or R19). The A-IoT devices can communicate bidirectionally with an intermediate node between the device and base station in some cases, however, some issues related to the intermediate node selection or intermediate node configuration still need to be studied.

SUMMARY

[0004] The present disclosure relates to a UE, a BS, methods, apparatuses, processors, and computer readable medium for determination of intermediate node. According to embodiments in the present disclosure, the BS can determine one or more UEs to serve as at least one intermediate node which can communicate with A-IoT device(s) directly.

[0005] In some implementations, there is provided a UE. The UE comprises at least one memory; and at least one processor coupled with the at least one memory and configured to cause the UE to: receive, from a base station, a first message associated with a service for one or more A-IoT devices; and transmit, to the base station, a second message comprising assistance information for determining at least one intermediate node or determining a configuration of at least one intermediate node for the one or more A-IoT devices.

[0006] In some implementations, there is provided a base station. The base station comprises at least one memory; and at least one processor coupled with the at least one memory and configured to cause the base station to: in accordance with a determination that a procedure of intermediate node selection is to be performed, transmit, to one or more UEs, a first message associated with a service for one or more A-IoT devices; receive, from the one or more UEs, one or more second messages each comprising assistance information for determining at least one intermediate node or determining a configuration of at least one intermediate node for the one or more A-IoT devices; and determine, based on the assistance information, one of: at least one UE from the one or more UEs, wherein the at least one UE is used as at least one intermediate node for the one or more A-IoT devices, or the configuration of at least one intermediate node for the one or more A-IoT device.

[0007] In some implementations, there is provided a device, such as a UE or a BS. The device comprises at least one memory; and at least one processor coupled with the at least one memory and configured to cause the device to: transmit an indication for requesting at least one backscattered signal from at least one A-IoT device in proximity to the device; receive the at least one backscattered signal from the at least one A-IoT device in proximity to the device; and determine existence information of the at least one A-IoT device in proximity to the device.

[0008] In some implementations, there is provided a method performed by the UE. The method comprises: receiving, from a base station, a first message associated with a service for one or more A-IoT devices; and transmitting, to the base station, a second message comprising assistance information for determining at least one intermediate node or determining a configuration of at least one intermediate node for the one or more A-IoT devices.

[0009] In some implementations, there is provided a method performed by the base station. The method comprises: in accordance with a determination that a procedure of intermediate node selection is to be performed, transmitting, to one or more UEs, a first message associated with a service for one or more A-IoT devices; receiving, from the one or more UEs, one or more second messages each comprising assistance information for determining at least one intermediate node or determining a configuration of at least one intermediate node for the one or more A-IoT devices; and determining, based on the assistance information, one of: at least one UE from the one or more UEs, wherein the at least one UE is used as at least one intermediate node for the one or more A-IoT devices, or the configuration of at least one intermediate node for the one or more A-IoT device.

[0010] In some implementations, there is provided a method performed by the device. The method comprises: transmitting an indication for requesting at least one backscattered signal from at least one A-IoT device in proximity to the device; receiving the at least one backscattered signal from the at least one A-IoT device in proximity to the device; and determining existence information of the at least one A-IoT device in proximity to the device.

[0011] In some implementations, there is provided a processor for wireless communication. The processor comprises at least one controller coupled with at least one memory and configured to cause the processor to: receive, from a base station, a first message associated with a service for one or more A-IoT devices; and transmit, to the base station, a second message comprising assistance information for determining at least one intermediate node or determining a configuration of at least one intermediate node for the one or more A-IoT devices.

[0012] In some implementations, there is provided a processor for wireless communication. The processor comprises at least one controller coupled with at least one memory and configured to cause the processor to: in accordance with a determination that a procedure of intermediate node selection is to be performed, transmit, to one or more UEs, a first message associated with a service for one or more A-IoT devices; receive, from the one or more UEs, one or more second messages each comprising assistance information for determining at least one intermediate node or determining a configuration of at least one intermediate node for the one or more A-IoT devices; and determine, based on the assistance information, one of: at least one UE from the one or more UEs, wherein the at least one UE is used as at least one intermediate node for the one or more A-IoT devices, or the configuration of at least one intermediate node for the one or more A-IoT device.

[0013] In some implementations, there is provided a processor for wireless communication.

The processor comprises at least one controller coupled with at least one memory and configured to cause the processor to: transmit an indication for requesting at least one backscattered signal from at least one A-IoT device in proximity to the device; receive the at least one backscattered signal from the at least one A-IoT device in proximity to the device; and determine existence information of the at least one A-IoT device in proximity to the device.

[0014] In some implementations of the methods and the UE described herein, further comprising: transmitting an indication for requesting at least one backscattered signal from at least one A-IoT device in proximity to the UE; receiving the at least one backscattered signal from the at least one A-IoT device in proximity to the UE; and determining the existence information of the at least one A-IoT device in proximity to the UE.

[0015] In some implementations of the methods and the UE described herein, further comprising: performing energy detection on the at least one backscattered signal, to generate the existence information.

[0016] In some implementations of the methods and the UE described herein, further comprising: receiving, from the base station, a third message comprising a configuration of an intermediate node, wherein the UE is determined as one of the at least one intermediate node; and performing communication with at least one A-IoT device based on the configuration.

[0017] In some implementations of the methods and the UE described herein, further comprising: in accordance with a determination that a stop condition is met, transmitting, to the base station, a fourth message for indicating that a role of the UE as an intermediate node is to be terminated or for requesting to terminate the role of the UE as an intermediate node.

[0018] In some implementations of the methods and the UE described herein, further comprising: receiving, from the base station, a termination indication indicating to the UE to terminate a role as an intermediate node.

[0019] In some implementations of the methods and the UE described herein, further comprising: in accordance with a determination that a stop condition is met, terminating the role as an intermediate node.

[0020] In some implementations of the methods and the BS described herein, further comprising: receiving, from a core network entity, a fifth message. The fifth message indicates one of: an indication for selecting the at least one intermediate node for the one or more A-IoT devices, a criterion or conditions for determining the at least one intermediate node for one or more A-IoT devices, a time duration for the intermediate node operation, or information about one or more preferred or suggested intermediate nodes for the one or more A-IoT devices.

[0021] In some implementations of the methods and the BS described herein, further comprising: determining that the procedure of intermediate node selection is needed based on existence information of at least one A-IoT device in proximity to the base station.

[0022] In some implementations of the methods and the BS described herein, further comprising: transmitting an indication for requesting at least one backscattered signal from at least one A-IoT device in proximity to the base station; receiving the at least one backscattered signal from the at least one A-IoT device in proximity to the base station; and determining the existence information of the at least one A-IoT device in proximity to the base station.

[0023] In some implementations of the methods and the BS described herein, further comprising: performing energy detection on the at least one backscattered signal, to generate the existence information.

[0024] In some implementations of the methods and the BS described herein, further comprising: receiving, from a first UE, a fourth message for indicating that a role of the first UE as an intermediate node is to be terminated or for requesting to terminate the role of the first UE as an intermediate node.

[0025] In some implementations of the methods and the BS described herein, further comprising: in accordance with a determination that a termination condition is met, transmitting, to a second UE, a termination indication indicating to the second UE to terminate a role as an intermediate node.

[0026] In some implementations of the methods, the UE, and the BS described herein, the first message comprises condition information, and the second message is transmitted in case the condition information is met at the UE.

[0027] In some implementations of the methods, the UE, and the BS described herein, the first message comprises a request for condition information of the UE, and the second message comprises the condition information of the UE.

[0028] In some implementations of the methods, the UE, and the BS described herein, the condition information comprises one of: UE capability information, UE status information, UE measurement information, or existence information of at least one A-IoT device in proximity to the UE.

[0029] In some implementations of the methods, the UE, and the BS described herein, the UE capability information indicates one of: the UE has a capability of supporting a function of intermediate node or a carrier wave node, or the UE has a capability of supporting a role of serving as an intermediate node or a carrier wave node.

[0030] In some implementations of the methods, the UE, and the BS described herein, the UE status information indicates one of: a UE location, a UE mobility status, a radio resource control (RRC) state of the UE, or a UE type.

[0031] In some implementations of the methods, the UE, and the BS described herein, the UE measurement information indicates one of: a measurement result for a target reference signal between the UE and the base station meets a measurement condition, or a measurement result for a target reference signal of the UE.

[0032] In some implementations of the methods, the UE, and the BS described herein, the fourth message indicates one of: the role of the UE as an intermediate node is to be terminated in a time period, the role of the UE as an intermediate node has been terminated at a time of transmitting the fourth message, or updated information of the stop condition that the UE meets.

[0033] In some implementations of the methods, the UE, and the BS described herein, the termination indication further indicates timing information for terminating the role as an intermediate node.

[0034] In some implementations of the methods, the UE, and the BS described herein, the stop condition comprises one of: the UE is to be moved out of coverage of the base station, the UE is to be handed over to a further base station, a moving distance at a specific direction of the UE exceeds a distance threshold, a measurement result of the UE is out of a specific range, or a number of the at least one A-IoT device in proximity to the UE is lower than a number threshold.

[0035] In some implementations of the methods, the UE, and the BS described herein, the termination condition comprises one of: a further termination indication associated with the second UE is received from a core network entity, a measurement result of the second UE is out of a specific range, the second UE is to be handed over to a further base station, or a direct communication between the base station and a specific A-IoT device is enabled, wherein the second UE was an intermediate node for the specific A-IoT device.

[0036] In some implementations of the methods, and the device (such as the UE or the BS) described herein, the indication is transmitted with a single carrier wave or by multiple carrier waves.

[0037] In some implementations of the methods, and the device (such as the UE or the BS) described herein, the multiple carrier waves are transmitted with a plurality of resources.

[0038] In some implementations of the methods, and the device (such as the UE or the BS) described herein, the at least one backscattered signal comprises a plurality of backscattered signals which are transmitted by using the plurality of resources.

[0039] In some implementations of the methods, and the device (such as the UE or the BS) described herein, the existence information indicates one of: there is the at least one A-IoT device in proximity to the device, a range of a number of the at least one A-IoT device in proximity to the device, a signal strength of the at least one backscattered signal, or a plurality of signal strengths for a plurality of resources of the at least one backscattered signal.

BRIEF DESCRIPTION OF THE DRAWINGS

[0040] FIG. 1 illustrates an example of a wireless communications system in which some embodiments of the present disclosure can be implemented;

[0041] FIG. 2A illustrates an example schematic of deployment scenario 1 with topology 1 for an A-IoT device;

[0042] FIG. 2B illustrates an example schematic of deployment scenario 2 with topology 2 for an A-IoT device;

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

[0044] FIG. 3 illustrates a signalling chart illustrating communication process in accordance with some example embodiments of the present disclosure;

[0045] FIG. 4 illustrates a signalling chart illustrating communication process in accordance with some example embodiments of the present disclosure;

[0046] FIG. 5 illustrates an example of a device that is suitable for implementing embodiments of the present disclosure;

[0047] FIG. 6 illustrates an example of a processor that is suitable for implementing some embodiments of the present disclosure;

[0048] FIG. 7 illustrates a flowchart of an example method implemented at a UE in accordance with aspects of the present disclosure;

[0049] FIG. 8 illustrates a flowchart of an example method implemented at a BS in accordance with aspects of the present disclosure; and

[0050] FIG. 9 illustrates a flowchart of an example method implemented at a device in accordance with aspects of the present disclosure.

[0051] Throughout the drawings, the same or similar reference numerals represent the same or similar element.

DETAILED DESCRIPTION

[0052] Principles of the present disclosure will now be described with reference to some embodiments. It is to be understood that these embodiments are described only for the purpose of illustration and help those skilled in the art to understand and implement the present disclosure, without suggesting any limitation as to the scope of the disclosure. The disclosure described herein can be implemented in various manners other than the ones described below. In the following description and claims, unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skills in the art to which this disclosure belongs.

[0053] References in the present disclosure to "one embodiment," "an example embodiment," "an embodiment," "some embodiments," and the like indicate that the embodiment(s) described may include a particular feature, structure, or characteristic, but it is not necessary that every embodiment includes the particular feature, structure, or characteristic. Moreover, such phrases do not necessarily refer to the same embodiment(s). Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

[0054] It shall be understood that although the terms "first" and "second" or the like may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another element. For example, a first element could also be termed as a second element, and similarly, a second element could also be termed as a first element, without departing from the scope of embodiments. As used herein, the term “and/or” includes any and all combinations of one or more of the listed terms. In some examples, values, procedures, or apparatuses are referred to as “best,” “lowest,” “highest,” “minimum,” “maximum,” or the like. It will be appreciated that such descriptions are intended to indicate that a selection among many used functional alternatives can be made, and such selections need not be better, smaller, higher, or otherwise preferable to other selections.

[0055] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of embodiments. As used herein, the singular forms “a,” “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises,” “comprising,” “has,” “having,” “includes” and/or “including,” when used herein, specify the presence of stated features, elements, components and/or the like, but do not preclude the presence or addition of one or more other features, elements, components and/or combinations thereof. For example, the term “includes” and its variants are to be read as open terms that mean “includes, but is not limited to.” The term “based on” is to be read as “based at least in part on.” The term “one embodiment” and “an embodiment” are to be read as “at least one embodiment.” The term “another embodiment” is to be read as “at least one other embodiment.” The use of an expression such as “A and/or B” can mean either “only A” or “only B” or “both A and B.” Other definitions, explicit and implicit, may be included below.

[0056] FIG. 1 illustrates an example of a wireless communications system 100 in which some embodiments of the present disclosure can be implemented. The wireless communications system 100 may include one or more network entities 102 (also referred to as network equipment (NE)), one or more UEs 104, a core network (CN) 106, and a packet data network 108. The wireless communications system 100 may support various radio access technologies. In some implementations, the wireless communications system 100 may be a 4G network, such as a long term evolution (LTE) network or an LTE-Advanced (LTE-A) network. In some other implementations, the wireless communications system 100 may be a 5G network, such as a new radio (NR) network. In other implementations, the wireless communications system 100 may be a combination of a 4G network and a 5G network, or other suitable radio access technology including Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20. The wireless communications system 100 may support radio access technologies beyond 5G. Additionally, the wireless communications system 100 may support technologies, such as time division multiple access (TDMA), frequency division multiple access (FDMA), or code division multiple access (CDMA), etc.

[0057] The one or more network entities 102 may be dispersed throughout a geographic region to form the wireless communications system 100. One or more of the network entities 102 described herein may be or include or may be referred to as a network node, a base station, a network element, a radio access network (RAN), a base transceiver station, an access point, a NodeB, an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. A network entity 102 and a UE 104 may communicate via a communication link 110, which may be a wireless or wired connection. For example, a network entity 102 and a UE 104 may perform wireless communication (e.g., receive signaling, transmit signaling) over a Uu interface.

[0058] A network entity 102 may provide a geographic coverage area 112 for which the network entity 102 may support services (e.g., voice, video, packet data, message, broadcast, etc.) for one or more UEs 104 within the geographic coverage area 112. For example, a network entity 102 and a UE 104 may support wireless communication of signals related to services (e.g., voice, video, packet data, messaging, broadcast, etc.) according to one or multiple radio access technologies. In some implementations, a network entity 102 may be moveable, for example, a satellite associated with a non-terrestrial network. In some implementations, different geographic coverage areas 112 associated with the same or different radio access technologies may overlap, but the different geographic coverage areas 112 may be associated with different network entities 102. Information and signals described herein may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[0059] The one or more UEs 104 may be dispersed throughout a geographic region of the wireless communications system 100. A UE 104 may include or may be referred to as a mobile device, a wireless device, a remote device, a remote unit, a handheld device, or a subscriber device, or some other suitable terminology. In some implementations, the UE 104 may be referred to as a unit, a station, a terminal, or a client, among other examples.

Additionally, or alternatively, the UE 104 may be referred to as an Internet-of-Things (IoT) device, an Internet-of-Everything (IoE) device, or machine-type communication (MTC) device, among other examples. In some implementations, a UE 104 may be stationary in the wireless communications system 100. In some other implementations, a UE 104 may be mobile in the wireless communications system 100.

[0060] The one or more UEs 104 may be devices in different forms or having different capabilities. Some examples of UEs 104 are illustrated in FIG. 1. A UE 104 may be capable of communicating with various types of devices, such as the network entities 102, other UEs 104, or network equipment (e.g., the CN 106, the packet data network 108, a relay device, an integrated access and backhaul (IAB) node, or another network equipment), as shown in FIG. 1. Additionally, or alternatively, a UE 104 may support communication with other network entities 102 or UEs 104, which may act as relays in the wireless communications system 100.

[0061] A UE 104 may also be able to support wireless communication directly with other UEs 104 over a communication link 114. For example, a UE 104 may support wireless communication directly with another UE 104 over a device-to-device (D2D) communication link. In some implementations, such as vehicle-to-vehicle (V2V) deployments, vehicle-to-everything (V2X) deployments, or cellular-V2X deployments, the communication link 114 may be referred to as a sidelink (SL). For example, a UE 104 may support wireless communication directly with another UE 104 over a PC5 interface.

[0062] A network entity 102 may support communications with the CN 106, or with another network entity 102, or both. For example, a network entity 102 may interface with the CN 106 through one or more backhaul links 116 (e.g., via an S1, N2, N3, or another network interface). The network entities 102 may communicate with each other over the backhaul links 116 (e.g., via an X2, Xn, or another network interface). In some implementations, the network entities 102 may communicate with each other directly (e.g., between the network entities 102). In some other implementations, the network entities 102 may communicate with each other or indirectly (e.g., via the CN 106). In some implementations, one or more network entities 102 may include subcomponents, such as an access network entity, which may be an example of an access node controller (ANC). An ANC may communicate with the one or more UEs 104 through one or more other access network transmission entities, which may be referred to as a radio heads, smart radio heads, or transmission-reception points (TRPs).

[0063] In some implementations, a network entity 102 may be configured in a disaggregated architecture, which may be configured to utilize a protocol stack physically or logically distributed among two or more network entities 102, such as an integrated access backhaul (IAB) network, an open RAN (O-RAN) (e.g., a network configuration sponsored by the O-RAN Alliance), or a virtualized RAN (vRAN) (e.g., a cloud RAN (C-RAN)). For example, a network entity 102 may include one or more of a central unit (CU), a distributed unit (DU), a radio unit (RU), a RAN Intelligent Controller (RIC) (e.g., a Near-Real Time RIC (Near-RT RIC), a Non-Real Time RIC (Non-RT RIC)), a Service Management and Orchestration (SMO) system, or any combination thereof.

[0064] An RU may also be referred to as a radio head, a smart radio head, a remote radio head (RRH), a remote radio unit (RRU), or a transmission reception point (TRP). One or more components of the network entities 102 in a disaggregated RAN architecture may be co-located, or one or more components of the network entities 102 may be located in distributed locations (e.g., separate physical locations). In some implementations, one or more network entities 102 of a disaggregated RAN architecture may be implemented as virtual units (e.g., a virtual CU (VCU), a virtual DU (VDU), a virtual RU (VRU)).

[0065] Split of functionality between a CU, a DU, and an RU may be flexible and may support different functionalities depending upon which functions (e.g., network layer functions, protocol layer functions, baseband functions, radio frequency functions, and any combinations thereof) are performed at a CU, a DU, or an RU. For example, a functional split of a protocol stack may be employed between a CU and a DU such that the CU may support one or more layers of the protocol stack and the DU may support one or more different layers of the protocol stack. In some implementations, the CU may host upper protocol layer (e.g., a layer 3 (L3), a layer 2 (L2)) functionality and signaling (e.g., Radio Resource Control (RRC), service data adaption protocol (SDAP), Packet Data Convergence Protocol (PDCP)). The CU may be connected to one or more DUs or RUs, and the one or more DUs or RUs may host lower protocol layers, such as a layer 1 (L1) (e.g., physical (PHY) layer) or an L2 (e.g., radio link control (RLC) layer, medium access control (MAC) layer) functionality and signaling, and may each be at least partially controlled by the CU.

[0066] Additionally, or alternatively, a functional split of the protocol stack may be employed between a DU and an RU such that the DU may support one or more layers of the protocol stack and the RU may support one or more different layers of the protocol stack. The DU may support one or multiple different cells (e.g., via one or more RUs). In some implementations, a functional split between a CU and a DU, or between a DU and an RU may be within a protocol layer (e.g., some functions for a protocol layer may be performed by one of a CU, a DU, or an RU, while other functions of the protocol layer are performed by a different one of the CU, the DU, or the RU).

[0067] A CU may be functionally split further into CU control plane (CU-CP) and CU user plane (CU-UP) functions. A CU may be connected to one or more DUs via a midhaul communication link (e.g., F1, F1-C, F1-U), and a DU may be connected to one or more RUs via a fronthaul communication link (e.g., open fronthaul (FH) interface). In some implementations, a midhaul communication link or a fronthaul communication link may be implemented in accordance with an interface (e.g., a channel) between layers of a protocol stack supported by respective network entities 102 that are in communication via such communication links.

[0068] The CN 106 may support user authentication, access authorization, tracking, connectivity, and other access, routing, or mobility functions. The CN 106 may be an evolved packet core (EPC), or a 5G core (5GC), which may include a control plane entity that manages access and mobility (e.g., a mobility management entity (MME), an access and mobility management functions (AMF)) and a user plane entity that routes packets or interconnects to external networks (e.g., a serving gateway (S-GW), a Packet Data Network (PDN) gateway (P-GW), or a user plane function (UPF)). In some implementations, the control plane entity may manage non-access stratum (NAS) functions, such as mobility, authentication, and bearer management (e.g., data bearers, signal bearers, etc.) for the one or more UEs 104 served by the one or more network entities 102 associated with the CN 106.

[0069] The CN 106 may communicate with the packet data network 108 over one or more backhaul links 116 (e.g., via an S1, N2, N3, or another network interface). The packet data network 108 may include an application server 118. In some implementations, one or more UEs 104 may communicate with the application server 118. A UE 104 may establish a session (e.g., a protocol data unit (PDU) session, or the like) with the CN 106 via a network entity 102. The CN 106 may route traffic (e.g., control information, data, and the like) between the UE 104 and the application server 118 using the established session (e.g., the established PDU session). The PDU session may be an example of a logical connection between the UE 104 and the CN 106 (e.g., one or more network functions of the CN 106).

[0070] In the wireless communications system 100, the network entities 102 and the UEs

104 may use resources of the wireless communications system 100 (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers)) to perform various operations (e.g., wireless communications). In some implementations, the network entities 102 and the UEs 104 may support different resource structures. For example, the network entities 102 and the UEs 104 may support different frame structures. In some implementations, such as in 4G, the network entities 102 and the UEs 104 may support a single frame structure. In some other implementations, such as in 5G and among other suitable radio access technologies, the network entities 102 and the UEs 104 may support various frame structures (i.e., multiple frame structures). The network entities 102 and the UEs 104 may support various frame structures based on one or more numerologies.

[0071] 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.

[0072] 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.

[0073] 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.

[0074] In the wireless communications system 100, an electromagnetic (EM) spectrum may be split, based on frequency or wavelength, into various classes, frequency bands, frequency channels, etc. By way of example, the wireless communications system 100 may support one or multiple operating frequency bands, such as frequency range designations FR1 (410 MHz – 7.125 GHz), FR2 (24.25 GHz – 52.6 GHz), FR3 (7.125 GHz – 24.25 GHz), FR4 (52.6 GHz – 114.25 GHz), FR4a or FR4-1 (52.6 GHz – 71 GHz), and FR5 (114.25 GHz – 300 GHz). In some implementations, the network entities 102 and the UEs 104 may perform wireless communications over one or more of the operating frequency bands. In some implementations, FR1 may be used by the network entities 102 and the UEs 104, among other equipment or devices for cellular communications traffic (e.g., control information, data). In some implementations, FR2 may be used by the network entities 102 and the UEs 104, among other equipment or devices for short-range, high data rate capabilities.

[0075] 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.

[0076] A study item on Ambient IoT in Rel-18 provides a terminological and scoping framework for further discussions of Ambient IoT. It has defined representative use cases, deployment scenarios, connectivity topologies, Ambient IoT devices, design targets, and required functionalities; it also conducted a preliminary feasibility assessment and gave recommendations for down-selection in setting the scope of Rel-19 RAN WG level study. The third generation partner project (3GPP) Rel-19 A-IoT study targets a further assessment at RAN WG-level of Ambient IoT, a new 3GPP IoT technology, suitable for deployment in a 3GPP system, which relies on ultra-low complexity devices with ultra-low power consumption for the very-low end IoT applications.

[0077] Ambient IoT devices are characterized according to their energy storage capacity, and capability of generating RF signals for their transmissions. The A-IoT device has either: no energy storage at all, or limited energy storage. Relying on these storage capacities, the Ambient IoT devices can be categorized to:

- Device A: No energy storage, no independent signal generation/amplification, i.e. backscattering transmission.
- Device B: Has energy storage, no independent signal generation, i.e. backscattering transmission. Use of stored energy can include amplification for reflected signals.
- Device C: Has energy storage, has independent signal generation, i.e., active RF components for transmission.

[0078] A limited energy storage can be different among implementations within Device B or implementations within Device C, and different between Device B and Device C. Such storage is expected to be order(s) of magnitude smaller than an NB-IoT device would typically include. Relying on the power peak power consumption and DL/UL amplification in the device, Device B and device C can be further categorized to:

- Device 1: ~1 μW peak power consumption, has energy storage, initial sampling frequency offset (SFO) up to 10^{X} ppm, neither DL nor UL amplification in the device. The device's UL transmission is backscattered on a carrier wave provided externally.
- Device 2a: ≤ a few hundred μW peak power consumption, has energy storage, initial sampling frequency offset (SFO) up to 10^{X} ppm, both DL and/or UL amplification in the device. The device's UL transmission is backscattered on a carrier wave provided externally.
- Device 2b: ≤ a few hundred μW peak power consumption, has energy storage, initial

sampling frequency offset (SFO) up to 10^X ppm, both DL and/or UL amplification in the device. The device's UL transmission is generated internally by the device.

[0079] Device A, B, and C are able to demodulate control, data, etc. from the relevant entity in RAN according to connectivity topology.

[0080] The following connectivity topologies for Ambient IoT networks and devices are defined for the purposes of the study. In all these topologies, the Ambient IoT device may be provided with a carrier wave from other node(s) either inside or outside the topology. The links in each topology may be bidirectional or unidirectional. BS, UE, assisting node, or intermediate node could be multiple BSs or UEs, respectively. The mixture of indoor and outdoor placement of such nodes is regarded as a network implementation choice. Account would need to be taken of potential impact on device or node complexity. In the connectivity topologies, this does not imply the existence of multi-hop assisting or intermediate nodes.

[0081] FIG. 2A illustrates an example schematic of deployment scenario 1 with topology 1 for an A-IoT device. In Topology 1, the ambient IoT device directly and bidirectionally communicates with a base station. The BS serves as the Reader for the ambient IoT device and performs operation (e.g., inventory, read, write, etc.) to the ambient IoT device. The communication between the base station and the ambient IoT device includes Ambient IoT data and/or signalling. This topology includes the possibility that the BS transmitting to the Ambient IoT device is a different from the BS receiving from the Ambient IoT device. In topology 1, the base station and coexistence characteristics may include Micro-cell, so-site, etc.

[0082] FIG. 2B illustrates an example schematic of deployment scenario 2 with topology 2 for an A-IoT device. In Topology 2, the Ambient IoT device communicates bidirectionally with an intermediate node between the device and the base station. The intermediate node serves as the Reader for the ambient IoT device and performs operation (e.g., inventory, read, write, etc.) to the ambient IoT device. In this topology, the intermediate node can be a relay, IAB node, UE, repeater, etc. which is capable of Ambient IoT. The intermediate node transfers Ambient IoT data and/or signalling between the base station and the Ambient IoT device.

[0083] In deployment scenario 2 with topology 2 as shown in FIG. 2B, the Ambient IoT device communicates bidirectionally with an intermediate node between the device and base station. In this topology, the intermediate node can be a relay, IAB node, UE, repeater, etc. which is capable of Ambient IoT. The intermediate node transfers Ambient IoT data and/or signalling between BS and the Ambient IoT and controlled by the network.

[0084] It is understandable that there may be multiple UEs within network coverage, in this case, which of them can serve as the intermediate nodes should be determined.

[0085] Embodiments of the present disclosure provide a solution for determination of an intermediate node for A-IoT device. In the solution, a UE may provide assistance information to the base station based on a first message from the base station, and the assistance information may be used for determining at least one intermediate node or a configuration thereof for A-IoT device(s). As such, a suitable intermediate node and associated configuration for the intermediate node may be determined and used for an A-IoT device, e.g. in deployment scenario 2 with topology 2, and thus a communication between the base station and the A-IoT device can be guaranteed. Principles and implementations of the present disclosure will be described in detail below with reference to the figures.

[0086] FIG. 2C illustrates a schematic diagram of an example communication network 200 in which some embodiments of the present disclosure can be implemented. As shown in FIG. 2C, the communication network 200 may include a BS 210, multiple UEs 220-1 to 220-N (may be collectively or separately referred to as a UE 220), and multiple A-IoT devices 230. With reference to FIG. 1, the BS 210 may be the network entity 102, and the UE 220 may be the UE 104.

[0087] A core network (CN) entity 250 is also shown in FIG. 2C, which may be a network function (NF) in CN, such as a 5GC or a 6G core network. For example, the core network entity 250 may be implemented as an A-IoT function (AIF) or an Access and Mobility Management Function (AMF) of a 5GC.

[0088] The multiple UEs 220 may be within coverage of the BS 210, for example each UE 220 can communicate with the BS 210. In some cases, a location of the BS 210 may be outdoor or indoor, a location of the UE 220 may be indoor, and a location of the A-IoT device 230 is indoor. In some cases, the network 200 may be used in use cases such as inventory.

[0089] It is to be understood that the numbers of UEs or A-IoT devices shown in FIG. 2C are only for the purpose of illustration only. The communication network 200 may include any suitable numbers of devices.

[0090] In the present disclosure, the BS 210 and the UE 220 may communicate with one or multiple A-IoT devices, from A-IoT device side, there may be no difference in physical layer design, that is, the A-IoT device directly and bidirectionally communicates with a device (e.g. the BS 210 or the UE 220).

[0091] FIG. 3 illustrates a signalling chart illustrating communication process 300 in accordance with some example embodiments of the present disclosure. The process 300 may involve a device 305 which may be the BS 210 or the UE 220 as discussed with reference to FIG. 2C. It would be appreciated that the process 300 may be applied to other communication scenarios, which will not be described in detail. The process 300 may be regarded as a procedure that used by the device 305 (e.g. the BS 210 or the UE 220) to detect and determine A-IoT device(s) in proximity to the device 305.

[0092] In the process 300, the device 305 transmits an indication for requesting at least one backscattered signal at 310. In some example embodiments, the indication for requesting at least one backscattered signal may be transmitted in a broadcast manner, e.g., so that a plurality of A-IoT devices can receive the indication. In some example embodiments, the indication for requesting at least one backscattered signal may be transmitted in a control signalling, or in any forms of scheduling data by using the Reader to Device (R2D) channel or other downlink channels from the reader to the A-IoT device.

[0093] In some implementations, the indication is transmitted with a single carrier wave or multiple carrier waves, which can be performed periodically or by implementation. In some example embodiments, the indication may further indicate to the A-IoT device(s) to respond for specific carrier wave. In the present disclosure, the term "carrier wave" may also be called as an energy carrier, an energy carrier wave, or the like.

[0094] In some examples, a single carrier wave may be transmitted by using a corresponding resource. In some examples, the multiple carrier waves are transmitted using multiple resources. For example, different resources may be used for different carrier waves. For example, the resources may be beam-specific resources that can be detected by the A-IoT devices from different directions.

[0095] At the other side of communication, for an A-IoT device, it may receive the indication from the device 305. In addition, the A-IoT device may perform a transmission of a backscattered signal on the received carrier wave.

[0096] In some examples, if a single carrier wave is transmitted by the device 305, the A-IoT device may transmit the backscattered signal in the same resource.

[0097] In some examples, if multiple carrier waves are transmitted by the device 305 using different resources, the A-IoT device may receive a specific carrier wave (e.g., using a resource associated with a direction of the A-IoT device), then the A-IoT device may transmit the backscattered signal in the specific carrier wave. It is to be understood that different A-IoT devices may locate at different directions and receive different carrier waves, in this case, they may respond with different resources.

[0098] Accordingly, the device 305 receives at least one backscattered signal at 320. In addition, the device 305 determines existence information of the at least one A-IoT device in proximity to the device 305 at 330, based on the received at least one backscattered signal. In some implementations, the device 305 may perform energy detection on the received at least one backscattered signal to generate the existence information of the at least one A-IoT device in proximity to the device 305.

[0099] In some examples, if a single carrier wave is transmitted by the device 305, the device 305 may measure a signal strength of the received at least one backscattered signal, and determine the existence information of the at least one A-IoT device in proximity to the device 305. For example, a quantity of A-IoT devices in proximity to the device 305 may be estimated, e.g. in a range of [x1, x2]. For example, statistically information may be pre-stored in the device 305, and the statistically information may be used for determining the quantity of A-IoT devices in proximity to the device 305.

[00100] In some examples, if multiple carrier waves are transmitted by the device 305, the device 305 may measure a signal strength of received backscattered signals per resource (or per carrier wave). For example, the device 305 may determine a first signal strength of backscattered signals received in a first resource and determine a second signal strength of backscattered signals received in a second resource, if the first signal strength is stronger than the second signal strength, the device 305 may determine that there are more A-IoT devices in a first direction associated with the first resource, or the device 305 may determine that the A-IoT devices in the first direction are at a relatively close distance.

[00101] For example, a quantity of A-IoT devices in proximity to the device 305 may be estimated for each resource (e.g., each carrier wave). For example, a total number or a distribution of the A-IoT devices in proximity to the device 305 may be determined by the device 305.

[00102] As such, the device 305 (e.g., the BS 210 or the UE 220) can detect and determine A-IoT device(s) in proximity to the device 305 by sending an indication with a single or multiple carrier waves and performing energy detection on the received backscattered signals. Therefore, a use case of inventory can be enabled in some cases.

[00103] It is to be noted that although the single or multiple carrier waves are used in the process 300, the present disclosure does not limit for this aspect. In some other embodiments, the device 305 (which is a BS 210) may transmit downlink control information (DCI) or other control signalling.

[00104] Reference is further made to FIG. 4, which illustrates a signalling chart illustrating communication process 400 in accordance with some example embodiments of the present disclosure. The process 400 may involve a BS 210, a UE 220, and a CN entity 250 as discussed with reference to FIG. 2C. It would be appreciated that the process 400 may be applied to other communication scenarios, which will not be described in detail.

[00105] The process 400 may include a procedure for determining at least one intermediate node or a configuration thereof for A-IoT devices. As mentioned above, intermediate node is introduced for deployment scenario 2 with topology 2, where A-IoT device is indoor and the base station is outdoor, the intermediate node transfers Ambient IoT data and/or signalling between the base station and the A-IoT devices.

[00106] The procedure for determining at least one intermediate node (e.g., intermediate node selection) or a configuration thereof (configuration determination) for A-IoT devices may be initiated or triggered at network side.

[00107] In some implementations, the BS 210 may receive a fifth message from the CN entity 250 at 405. For example, the procedure is triggered by the CN entity 250, based on service consideration. In some embodiments, is a service related to the A-IoT device(s) needs to be initiated, the CN entity 250 may transmit the fifth message. In some embodiments, the fifth message may indicate to the BS 210 to determine at least one intermediate node, or to determine a configuration of at least one intermediate node.

[00108] In some examples, the fifth message may include an indication that indicates to the BS 210 to perform the intermediate node selection. For example, the fifth message may include a criterion (or guideline) or a condition for determining at least one intermediate node. For example, the fifth message may include a time duration for an operation of the at least one intermediate node to be determined. For example, the fifth message may include a UE type which indicates a type that the at least one intermediate node to be determined should be with. For example, the fifth message may indicate a plurality of UEs (e.g. a plurality of UE identifications may be included), so that the BS 210 needs to select the at least one intermediate node from the plurality of UEs. For example, the BS 210 has information about one or more preferred intermediate nodes, e.g. configured by OAM (operations, administration, and maintenance).

[00109] In some other examples, the fifth message may include information about one or more preferred or suggested intermediate nodes. For example, the fifth message may indicate to the BS 210 to determine a configuration of the one or more preferred or suggested intermediate nodes. For example, detailed information of one or more UEs may be included and the one or more UEs should be used as the at least one intermediate node. For example, the detailed information of the one or more UEs may include one or more UE identifications. As a specific example, the BS 210 is outdoor and the A-IoT devices are indoor, and the intermediate node selection may be unable to make by the BS 210.

[00110] In some other implementations, the BS 210 may determine that the procedure is needed. For example, the BS 210 may determine to initiate the procedure of intermediate node selection or configuration determination.

[00111] In some examples, the BS 210 may determine whether a criterion or a condition is met. In some examples, the BS 210 may determine to initiate the procedure if the criterion or condition is met. In some instances, the criterion or condition may be configured or indicated by the CN entity 250, for example, the fifth message at 405 may indicate the criterion or condition. In some other instances, the criterion or condition may be determined by the BS 210, e.g. based on detection results at the BS 210.

[00112] For example, the BS 210 may determine existence information of A-IoT devices in proximity to the BS 210, e.g. by the process 300. For example, the BS 210 may determine that the criterion or condition is met based on the existence information of A-IoT devices in proximity to the BS 210.

[00113] For instance, if the signal strength of backscattered signals exceeds a first threshold, the BS 210 may determine that there are enough A-IoT devices surrounding, and determine that the procedure of intermediate node selection is not needed. For instance, if the signal strength of backscattered signals is lower than a second threshold, the BS 210 may determine that there are not enough A-IoT devices surrounding, and determine that the procedure of intermediate node selection is needed. For example, the first threshold and the second threshold may be configured or indicated by the CN entity 250. For example, the second threshold may equal to or be less than the first threshold.

[00114] For instance, the BS 210 may determine that a number of A-IoT devices in proximity to the BS 210 is in a number range. For instance, if a lower limit or a middle number of the range exceeds a first quantity threshold, the BS 210 may determine that there are enough A-IoT devices surrounding, and determine that the procedure of intermediate node selection is not needed. For instance, if an upper limit or a middle number of the range is less than a second quantity threshold, the BS 210 may determine that there are not enough A-IoT devices surrounding, and determine that the procedure of intermediate node selection is needed. For example, the second quantity threshold may equal to or be less than the first quantity threshold. For example, the first quantity threshold and the second quantity threshold may be configured or indicated by the CN entity 250. For example, the first quantity threshold and the second quantity threshold may be determined by the BS 210, e.g. based on prior knowledge. The prior knowledge may be associated with one of: a total number of A-IoT devices to be inventoried, historical information of the A-IoT devices to be inventoried, or a predefined ratio value.

[00115] In the process 400, the BS 210 transmits a first message to the UE 220 at 410. In some implementations, the BS 210 may be indicated by the CN entity 250 to perform intermediate node selection or the BS 210 determines to perform intermediate node selection by itself, the first message may be transmitted in a broadcast manner. In some other implementations, the fifth message from the CN entity 250 may indicate one or more preferred or suggested intermediate nodes, in this case, the first message may be transmitted to the one or more preferred or suggested intermediate nodes, for example, the first message may request assistance information of the one or more preferred or suggested intermediate nodes.

[00116] In some implementations, the first message may include condition information, in this case, the BS 210 may expect that UEs meeting the condition information should respond the first message. In some example embodiments, the condition information may include one or more of: UE capability information, UE status information, UE measurement information, or existence information of at least one A-IoT device in proximity to the UE.

[00117] For example, UE capability information in the first message may indicate one or more of: the UE has a capability of supporting a function of intermediate node or a carrier wave node, or the UE has a capability of supporting a role of serving as an intermediate node or a carrier wave node.

[00118] For example, UE status information in the first message may indicate one or more of: a UE location, a UE mobility status, an RRC state of the UE, or a UE type. For instance, the UE location may be one of: three-dimensional coordinate information, a distance and an orientation, or the like. For instance, the UE mobility status may indicate one or more of: whether the UE is moving or fixed, a moving direction, a moving velocity, a moving trajectory over time. For instance, the RRC state may indicate an RRC connected state, an RRC inactive state, or an RRC idle state. For instance, the UE type may indicate one of: location available, location unavailable, global navigation satellite system (GNSS) capable, etc.

[00119] For example, UE measurement information in the first message may indicate that a measurement result for a target reference signal between the UE and the BS 210 meets a measurement condition. For instance, it may indicate that a measurement result should exceeds a threshold. For instance, it may indicate that a measurement result should be within a predefined range, e.g. with a minimum threshold and a maximum threshold. For instance, the measurement result may be a link quality associated with a reference signal received quality (RSRQ) or reference signal received power (RSRP) of a downlink reference signal.

[00120] For example, the existence information in the first message may indicate that a signal strength of backscattered signals from A-IoT devices in proximity to the UE should exceeds a quality threshold. For example, the existence information in the first message may indicate that a number of A-IoT devices in proximity to the UE should exceeds a number threshold.

[00121] For ease of description, it is assumed that the condition information indicates three types of conditions: condition 1, condition 2, and condition 3. Condition 1 may include UE capability information and/or UE status information. Condition 2 may include UE measurement information. Condition 3 may include existence information of at least one A-IoT device in proximity to the UE.

[00122] In some implementations, the first message may include condition 1, and the first message may indicate that a potential intermediate node (e.g. a UE meets condition 1) should report information related to condition 2 and/or information related to condition 3. In some implementations, the first message may include condition 2, and the first message may indicate that a potential intermediate node (e.g. a UE meets condition 2) should report information related to condition 1 and/or information related to condition 3. In some implementations, the first message may include condition 1 and condition 2, and the first message may indicate that a potential intermediate node (e.g. a UE meets condition 1 and condition 2) should report information related to condition 3.

[00123] On the other side of communication, the UE 220 receives the first message from the BS 210. In some implementations, the first message includes condition information and the UE 220 may determine whether the condition information is met.

[00124] In the process 400, the UE 220 transmits a second message to the BS 210 at 420. In some implementations, the second message is a response to the first message, and the second message may include assistance information, which may be used by the BS 210 for the intermediate node selection or configuration determination.

[00125] In some example embodiments, the first message may include condition 1, and the UE 220 does not meet condition 1, if the UE 220 intends to be an intermediate node, the UE 220 may respond with the second message which include capability information and/or status information of the UE 220. In some example embodiments, the first message may not include condition 1, and the UE 220 may respond with the second message which include capability information and/or status information of the UE 220.

[00126] In some example embodiments, the first message may include condition 2, and the UE 220 does not meet condition 2, if the UE 220 intends to be an intermediate node, the UE 220 may respond with the second message which include measurement information the UE 220, e.g. a measurement result for a target reference signal. In some example embodiments, the first message may not include condition 2, and the UE 220 may respond with the second message which include measurement information the UE 220, e.g. a measurement result for a target reference signal.

[00127] In some example embodiments, the second message may include existence information of at least one A-IoT device in proximity to the UE 220, e.g., if the first message indicates to report information related to condition 3. For example, the second message may indicate one of: a signal strength of backscattered signals from A-IoT devices in proximity to the UE 220, or a number of A-IoT devices in proximity to the UE 220 (which may be a number range). For example, the second message may indicate an existence of at least one A-IoT devices in proximity to the UE 220.

[00128] In some embodiments, the UE 220 may perform the process 300 to generate or determine the existence information of at least one A-IoT device in proximity to the UE 220.

[00129] In the process 400, the BS 210 determines at least one intermediate node or a configuration of the at least one intermediate node at 430, based on the second message.

[00130] In some implementations, one or multiple UEs may respond the BS 210, and the BS 210 may determine the at least one intermediate node by considering response messages from the one or multiple UEs. In some examples, the at least one intermediate node may be selected from the one or multiple UEs.

[00131] For example, in case the second message from the UE 220 includes existence information of at least one A-IoT device in proximity to the UE 220, the BS 210 may determine that the at least one intermediate node includes the UE 220 (that is the UE 220 is selected as one intermediate node) if a signal strength of backscattered signals from A-IoT devices in proximity to the UE 220 exceeds a quality threshold or a number of A-IoT devices in proximity to the UE 220 exceeds a number threshold.

[00132] In some implementations, the BS 210 may determine at least one configuration for the at least one intermediate node. In some examples, configurations for different intermediate nodes may be the same (i.e. common) or be different.

[00133] In some examples, the BS 210 may further transmit a report to the CN entity 250, for example, the report may include information about the at least one intermediate node, such as ID information of the at least one intermediate node, information related to condition 1, information related to condition 2, and/or information related to condition 3. In some examples, the CN entity 250 may determine a configuration of the at least one intermediate node based on the report, and in addition the CN entity 250 may transmit the configuration of the at least one intermediate node to the BS 210.

[00134] In addition or alternatively, the BS 210 may transmit a configuration to a corresponding intermediate node. In some examples, if the UE 220 is determined (or selected) as an intermediate node, the BS 210 may transmit a third message to the UE 220, and the third message may include a configuration of an intermediate node. For example, the configuration may include information related to paging, random access channel (RACH), data transmission, etc. and corresponding resources. In addition, the UE 220, with a role of intermediate node, may further perform a communication with at least one A-IoT device for a service associated with the at least one A-IoT device, based on the configuration. For example, the UE 220 may transfer A-IoT data and/or signalling between the BS 210 and at least one A-IoT device.

[00135] As such, a solution of intermediate node selection/configuration is provided in the present disclosure. In the solution, the BS 210 can determine one or more UEs to serve as at least one intermediate node which can communicate with A-IoT device(s) directly.

[00136] As discussed above, the UE 220 needs to meet some specific condition for acting as an intermediate node. It is understood that the certain condition may change, in this case, an operation of intermediate node may need to be terminated or stopped. The process 400 may further include a procedure for terminating (or stopping) the intermediate node operation. In some implementations, the termination procedure may be initiated or triggered by the UE 220 or by network.

[00137] In some implementations, the UE 220 may transmit a fourth message to the BS 210 at 440. In some example embodiments, the fourth message may request to terminate or stop a role as an intermediate node, for example, the fourth message may include a termination request. In some other example embodiments, the fourth message may notify that a role as an intermediate node is to be or has been terminated or stopped, for example, the fourth message may include a termination notification.

[00138] In some example embodiments, the UE 220 may determine whether a stop condition is met, and may further transmit the fourth message if the stop condition is met. In some examples, the stop condition may be associated with information related to condition 1, condition 2, and/or condition 3 discussed above.

[00139] For example, the stop condition may include: the UE 220 has or is to be moved out of coverage of the BS 210. For instance, some or all of the following can be used for determining whether the UE 220 is in coverage: a moving speed, a moving direction, a moving trajectory, a measurement result of a link quality between the UE 220 and the BS 210, etc. As one example, if the measurement result (such as RSRQ, RSRP) between the UE 220 and the BS 210 is out of a specific range (e.g., lower than a specific threshold) for a time window, the UE 220 may determine that it is to be out of coverage. As another example, if a moving distance along a direction within a time window exceeds a specific threshold, the UE 220 may determine that it is to be out of coverage.

[00140] For example, the stop condition may include: the UE 220 is to be handed over to another base station. For instance, the UE 220 has received a handover command, and will switch to another base station.

[00141] For example, the stop condition may include: existence information indicates that a number of A-IoT devices in proximity to the UE is lower than a number threshold. For instance, there is no A-IoT device surrounding any more. For example, a signal strength of backscattered signal is lower than a minimum limit, or no backscattered signal can be measured.

[00142] In some example embodiments, the fourth message may include a termination request, which may be a stop intention indication. In some examples, the fourth message may further include updated information of the stop condition that the UE 220 meets. In this case, the BS 210 may be aware of the state of the UE 220, and the BS 210 may determine whether to termination the intermediate node operation at the UE 220. In some examples, the BS 210 may transmit, to the UE 220, a termination indication which is determined based on the fourth message, and in addition, the UE 220 may terminate the intermediate node operation accordingly.

[00143] In some other example embodiments, the fourth message may include a termination notification. In some examples, the termination notification may indicate that the intermediate node operation is terminated, e.g. immediately. In some examples, the fourth message may further indicate a time period, and the intermediate node operation will be terminated after the time period.

[00144] In some other implementations, the termination may be triggered by the network. In some example embodiments, the CN entity 250 may determine to terminate the intermediate node operation at the UE 220, and optionally to reselect the new intermediate node. In some examples, the CN entity 250 may transmit a termination indication to the BS 210, and then the BS 210 may transmit the termination indication to the UE 220 e.g. at 450. In some other example, the CN entity 250 may transmit the termination indication to the UE 220, i.e. transparent to the BS 210, which is not shown in FIG. 4. In some other example embodiments, the BS 210 may determine to terminate the intermediate node operation at the UE 220 and may further transmit the termination indication to the UE 220 e.g. at 450. In some examples, the termination indication may indicate to the UE 220 to terminate the intermediate node operation, e.g. to stop a role as an intermediate node. In some examples, the termination indication to the UE 220, e.g. at 450 means the BS 210 may need to reselect a new intermediate node to perform the operation instead of the UE 220.

[00145] For example, the BS 210 may determine whether a termination condition is met, and may further transmit the termination indication if the condition is met. For example, the termination condition may be associated with: information from the UE 220 and /or one or more different intermediate nodes, information related to A-IoT devices in proximity to the BS 210.

[00146] For instance, the UE 220 may report updated information to the BS 210, which may include information related to condition 1, information related to condition 2, or information related to condition 3 as discussed above. The BS 210 may determine that the UE 220 is no longer suitable for acting as an intermediate node based on the information from the UE 220. In some examples, the BS 210 may determine to select a new UE for acting as the intermediate node instead of the UE 220.

[00147] For instance, the BS 210 may receive information from a further UE, and may determine that the further UE is more suitable to be an intermediate node than the UE 220. For instance, the BS 210 may determine updated existence information of A-IoT devices in proximity to the BS 210, for example, the signal strength exceeds a first threshold, or the number of A-IoT devices surrounding exceeds a first quantity threshold. For instance, the BS 210 may determine updated existence information of A-IoT devices in proximity to the BS 210 and also receive a report from the UE 220 which indicates updated existence information of A-IoT devices in proximity to the UE 220, if they are the same or with a difference lower than an error, the BS 210 may determine that topology 1 may be applied.

[00148] In some examples, the termination indication to the UE 220 may further indicate a termination time or a time period, which may indicate to the UE 220 to terminate the intermediate node operation at the termination time or after the time period.

[00149] In addition or alternatively, the UE 220 terminates its role as an intermediate node at 460, that is the intermediate node operation will be stopped.

[00150] According to some embodiments discussed above, a solution for intermediate node selection/configuration is provided. In the solution, the BS 210 can determine one or more UEs to serve as at least one intermediate node which can communicate with A-IoT device(s) directly. A stop condition at the UE side and/or a termination condition at the network side is defined, accordingly an intermediate node operation may be terminated. In this way, a communication for A-IoT devices, e.g. in deployment scenario 2 with topology 2, can be enabled and guaranteed.

[00151] FIG. 5 illustrates an example of a device 500 that is suitable for implementing embodiments of the present disclosure. The device 500 may be an example of a UE or a BS as described herein. The device 500 may support wireless communication with a BS 210, a UE 220, or any combination thereof. The device 500 may include components for bi-directional communications including components for transmitting and receiving communications, such as a processor 502, a memory 504, a transceiver 506, and, optionally, an I/O controller 508. These components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

[00152] The processor 502, the memory 504, the transceiver 506, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. For example, the processor 502, the memory 504, the transceiver 506, or various combinations or components thereof may support a method for performing one or more of the operations described herein.

[00153] In some implementations, the processor 502, the memory 504, the transceiver 506, or various combinations or components thereof may be implemented in hardware (e.g., in communications management circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), a field-programmable gate array (FPGA) or other programmable logic device, a discrete gate or transistor logic, discrete hardware components, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure. In some implementations, the processor 502 and the memory 504 coupled with the processor 502 may be configured to perform one or more of the functions described herein (e.g., executing, by the processor 502, instructions stored in the memory 504).

[00154] For example, the processor 502 may support wireless communication at the device 500 in accordance with examples as disclosed herein. The processor 502 may be configured to operable to support a means for operations discussed above.

[00155] The processor 502 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, a microcontroller, an ASIC, an FPGA, a programmable logic device, a discrete gate or transistor logic component, a discrete hardware component, or any combination thereof). In some implementations, the processor 502 may be configured to operate a memory array using a memory controller. In some other implementations, a memory controller may be integrated into the processor 502. The processor 502 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 504) to cause the device 500 to perform various functions of the present disclosure.

[00156] The memory 504 may include random access memory (RAM) and read-only memory (ROM). The memory 504 may store computer-readable, computer-executable code including instructions that, when executed by the processor 502 cause the device 500 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. In some implementations, the code may not be directly executable by the processor 502 but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some implementations, the memory 504 may include, among other things, a basic I/O system (BIOS) which may control basic hardware or software operation such as the interaction with peripheral components or devices.

[00157] The I/O controller 508 may manage input and output signals for the device 500. The I/O controller 508 may also manage peripherals not integrated into the device 500. In some implementations, the I/O controller 508 may represent a physical connection or port to an external peripheral. In some implementations, the I/O controller 508 may utilize an operating system such as iOS®, ANDROID®, MS-WINDOWS®, OS/2®, UNIX®, LINUX®, or another known operating system. In some implementations, the I/O controller 508 may be implemented as part of a processor, such as the processor 502. In some implementations, a user may interact with the device 500 via the I/O controller 508 or via hardware components controlled by the I/O controller 508.

[00158] In some implementations, the device 500 may include a single antenna 510. However, in some other implementations, the device 500 may have more than one antenna 510 (i.e., multiple antennas), including multiple antenna panels or antenna arrays, which may be capable of concurrently transmitting or receiving multiple wireless transmissions. The transceiver 506 may communicate bi-directionally, via the one or more antennas 510, wired, or wireless links as described herein. For example, the transceiver 506 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 506 may also include a modem to modulate the packets, to provide the modulated packets to one or more antennas 510 for transmission, and to demodulate packets received from the one or more antennas 510. The transceiver 506 may include one or more transmit chains, one or more receive chains, or a combination thereof.

[00159] A transmit chain may be configured to generate and transmit signals (e.g., control information, data, packets). The transmit chain may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature amplitude modulation (QAM). The transmit chain may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmit chain may also include one or more antennas 510 for transmitting the amplified signal into the air or wireless medium.

[00160] A receive chain may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receive chain may include one or more antennas 510 for receive the signal over the air or wireless medium. The receive chain may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receive chain may include at least one demodulator configured to demodulate the receive signal and obtain the transmitted data by reversing the modulation technique applied during transmission of the signal. The receive chain may include at least one decoder for decoding the processing the demodulated signal to receive the transmitted data.

[00161] FIG. 6 illustrates an example of a processor 600 that is suitable for implementing some embodiments of the present disclosure. The processor 600 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 600 may include a controller 602 configured to perform various operations in accordance with examples as described herein. The processor 600 may optionally include at least one memory 604, such as L1/L2/L3 cache. Additionally, or alternatively, the processor 600 may optionally include one or more arithmetic-logic units (ALUs) 606. One or more of these components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

[00162] The processor 600 may be a processor chipset and include a protocol stack (e.g., a software stack) executed by the processor chipset to perform various operations (e.g., receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) in accordance with examples as described herein. The processor chipset may include one or more cores, one or more caches (e.g., memory local to or included in the processor chipset (e.g., the processor 600) or other memory (e.g., random access memory (RAM), read-only memory (ROM), dynamic RAM (DRAM), synchronous dynamic RAM (SDRAM), static RAM (SRAM), ferroelectric RAM (FeRAM), magnetic RAM (MRAM), resistive RAM (RRAM), flash memory, phase change memory (PCM), and others).

[00163] The controller 602 may be configured to manage and coordinate various operations (e.g., signaling, receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) of the processor 600 to cause the processor 600 to support various operations in accordance with examples as described herein. For example, the controller 602 may operate as a control unit of the processor 600, generating control signals that manage the operation of various components of the processor 600. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[00164] The controller 602 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 604 and determine subsequent instruction(s) to be executed to cause the processor 600 to support various operations in accordance with examples as described herein. The controller 602 may be configured to track memory address of instructions associated with the memory 604. The controller 602 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 602 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 600 to cause the processor 600 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 602 may be configured to manage flow of data within the processor 600. The controller 602 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 600.

[00165] The memory 604 may include one or more caches (e.g., memory local to or included in the processor 600 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementations, the memory 604 may reside within or on a processor chipset (e.g., local to the processor 600). In some other implementations, the memory 604 may reside external to the processor chipset (e.g., remote to the processor 600).

[00166] The memory 604 may store computer-readable, computer-executable code including instructions that, when executed by the processor 600, cause the processor 600 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. The controller 602 and/or the processor 600 may be configured to execute computer-readable instructions stored in the memory 604 to cause the processor 600 to perform various functions. For example, the processor 600 and/or the controller 602 may be coupled with or to the memory 604, the processor 600, the controller 602, and the memory 604 may be configured to perform various functions described herein. In some examples, the processor 600 may include multiple processors and the memory 604 may include multiple memories. One or more of the multiple processors may be coupled with one or more of the multiple memories, which may, individually or collectively, be configured to perform various functions herein.

[00167] The one or more ALUs 606 may be configured to support various operations in accordance with examples as described herein. In some implementations, the one or more ALUs 606 may reside within or on a processor chipset (e.g., the processor 600). In some other implementations, the one or more ALUs 606 may reside external to the processor chipset (e.g., the processor 600). One or more ALUs 606 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 606 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 606 be configured with a variety of logical and arithmetic circuits, including adders, subtractors, shifters, and logic gates, to process and manipulate the data according to the operation. Additionally, or alternatively, the one or more ALUs 606 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 606 to handle conditional operations, comparisons, and bitwise operations.

[00168] The processor 600 may support wireless communication in accordance with examples as disclosed herein. The processor 600 may be configured to or operable to support a means for operations described in some embodiments of the present disclosure.

[00169] FIG. 7 illustrates a flowchart of a method 700 performed by a UE in accordance with aspects of the present disclosure. The operations of the method 700 may be implemented by a device or its components as described herein. For example, the operations of the method 700 may be performed by the UE 220 in FIG. 2C. In some implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or alternatively, the device may perform aspects of the described functions using special-purpose hardware.

[00170] At 710, the method may include receiving, from a base station, a first message associated with a service for one or more A-IoT devices. The operations of 710 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 710 may be performed by the UE 220 as described with reference to FIG. 2C.

[00171] At 720, the method may include transmitting, to the base station, a second message comprising assistance information for determining at least one intermediate node or determining a configuration of at least one intermediate node for the one or more A-IoT devices. The operations of 720 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 720 may be performed by the UE 220 as described with reference to FIG. 2C.

[00172] FIG. 8 illustrates a flowchart of a method 800 performed by a base station in accordance with aspects of the present disclosure. The operations of the method 800 may be implemented by a device or its components as described herein. For example, the operations of the method 800 may be performed by the BS 210 in FIG. 2C. In some implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or alternatively, the device may perform aspects of the described functions using special-purpose hardware.

[00173] At 810, the method may include in accordance with a determination that a procedure of intermediate node selection is to be performed, transmitting, to one or more UEs, a first message associated with a service for one or more A-IoT devices. The operations of 810 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 810 may be performed by the BS 210 as described with reference to FIG. 2C.

[00174] At 820, the method may include determining, based on the assistance information, one of: at least one UE from the one or more UEs, wherein the at least one UE is used as at least one intermediate node for the one or more A-IoT devices, or the configuration of at least one intermediate node for the one or more A-IoT device. The operations of 820 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 820 may be performed by the BS 210 as described with reference to FIG. 2C.

[00175] At 830, the method may include determining a UL phase offset based on at least one SRS resource from the UE and an SRS resource from the UE to the second base station. The operations of 830 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 830 may be performed by the BS 210 as described with reference to FIG. 2C.

[00176] At 840, the method may include determining a reciprocity calibration factor based on the DL phase offset and the UL phase offset. The operations of 840 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 840 may be performed by the BS 210 as described with reference to FIG. 2C.

[00177] FIG. 9 illustrates a flowchart of a method 900 performed by a device in accordance with aspects of the present disclosure. The operations of the method 900 may be implemented by a device or its components as described herein. For example, the operations of the method 900 may be performed by the BS 210 or the UE 220 in FIG. 2C. In some implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or alternatively, the device may perform aspects of the described functions using special-purpose hardware.

[00178] At 910, the method may include transmitting an indication for requesting at least one backscattered signal from at least one A-IoT device in proximity to the device. The operations of 910 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 910 may be performed by the BS 210 or the UE 220 as described with reference to FIG. 2C.

[00179] At 920, the method may include receiving the at least one backscattered signal from the at least one A-IoT device in proximity to the device. The operations of 920 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 920 may be performed by the BS 210 or the UE 220 as described with reference to FIG. 2C.

[00180] At 930, the method may include determining existence information of the at least one A-IoT device in proximity to the device. The operations of 930 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 930 may be performed by the BS 210 or the UE 220 as described with reference to FIG. 2C.

[00181] It should be noted that the methods described herein describes possible implementations, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible. Further, aspects from two or more of the methods may be combined.

[00182] The various illustrative blocks and components described in connection with the disclosure herein may be implemented or performed with a general-purpose processor, a DSP, an ASIC, a CPU, an FPGA or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but in the alternative, the processor may be any processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices (e.g., a combination of a DSP and a microprocessor, multiple microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

[00183] The functions described herein may be implemented in hardware, software executed by a processor, firmware, or any combination thereof. If implemented in software executed by a processor, the functions may be stored on or transmitted over as one or more instructions or code on a computer-readable medium. Other examples and implementations are within the scope of the disclosure and appended claims. For example, due to the nature of software, functions described herein may be implemented using software executed by a processor, hardware, firmware, hardwiring, or combinations of any of these. Features implementing functions may also be physically located at various positions, including being distributed such that portions of functions are implemented at different physical locations.

[00184] Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage medium may be any available medium that may be accessed by a general-purpose or special-purpose computer. By way of example, non-transitory computer-readable media may include RAM, ROM, electrically erasable programmable ROM (EEPROM), flash memory, compact disk (CD) ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other non-transitory medium that may be used to carry or store desired program code means in the form of instructions or data structures and that may be accessed by a general-purpose or special-purpose computer, or a general-purpose or special-purpose processor.

[00185] As used herein, including in the claims, an article “a” before an element is unrestricted and understood to refer to “at least one” of those elements or “one or more” of those elements. The terms “a,” “at least one,” “one or more,” and “at least one of one or more” may be interchangeable. As used herein, including in the claims, “or” as used in a list of items (e.g., a list of items prefaced by a phrase such as “at least one of” or “one or more of” or “one or both of”) indicates an inclusive list such that, for example, a list of at least one of A, B, or C means A or B or C or AB or AC or BC or ABC (i.e., A and B and C). Also, as used herein, the phrase “based on” shall not be construed as a reference to a closed set of conditions. For example, an example step that is described as “based on condition A” may be based on both a condition A and a condition B without departing from the scope of the present disclosure. In other words, as used herein, the phrase “based on” shall be construed in the same manner as the phrase “based at least in part on. Further, as used herein, including in the claims, a “set” may include one or more elements.

[00186] The description herein is provided to enable a person having ordinary skill in the art to make or use the disclosure. Various modifications to the disclosure will be apparent to a person having ordinary skill in the art, and the generic principles defined herein may be applied to other variations without departing from the scope of the disclosure. Thus, the disclosure is not limited to the examples and designs described herein but is to be accorded the broadest scope consistent with the principles and novel features disclosed herein.

CLAIMS

What is claimed is:

1. A user equipment (UE) comprising:

at least one memory; and

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

receive, from a base station, a first message associated with a service for one or more ambient internet of things (A-IoT) devices; and

transmit, to the base station, a second message comprising assistance information for determining at least one intermediate node or determining a configuration of at least one intermediate node for the one or more A-IoT devices.

2. The UE of claim 1, wherein the first message comprises condition information, and the second message is transmitted in case the condition information is met at the UE,

or wherein the first message comprises a request for condition information of the UE, and the second message comprises the condition information of the UE.

3. The UE of claim 2, wherein the condition information comprises one of:

UE capability information,

UE status information,

UE measurement information, or

existence information of at least one A-IoT device in proximity to the UE.

4. The UE of claim 3, wherein the at least one processor is further configured to cause the UE to:

transmit an indication for requesting at least one backscattered signal from at least one A-IoT device in proximity to the UE;

receive the at least one backscattered signal from the at least one A-IoT device in proximity to the UE; and

determine the existence information of the at least one A-IoT device in proximity to the UE.

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

UE to:

perform energy detection on the at least one backscattered signal, to generate the existence information.

6. The UE of claim 4, wherein the existence information indicates one of:

there is the at least one A-IoT device in proximity to the UE,

a range of a number of the at least one A-IoT device in proximity to the UE,

a signal strength of the at least one backscattered signal, or

a plurality of signal strengths for a plurality of resources of the at least one backscattered signal.

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

receive, from the base station, a third message comprising a configuration of an intermediate node, wherein the UE is determined as one of the at least one intermediate node; and

perform communication with at least one A-IoT device based on the configuration.

8. The UE of claim 7, wherein the at least one processor is further configured to cause the UE to:

in accordance with a determination that a stop condition is met, transmit, to the base station, a fourth message for indicating that a role of the UE as an intermediate node is to be terminated or for requesting to terminate the role of the UE as an intermediate node.

9. The UE of claim 8, wherein the fourth message indicates one of:

the role of the UE as an intermediate node is to be terminated in a time period,

the role of the UE as an intermediate node has been terminated at a time of transmitting the fourth message, or

updated information of the stop condition that the UE meets.

10. The UE of claim 7, wherein the at least one processor is further configured to cause the UE to:

receive, from the base station, a termination indication indicating to the UE to terminate a role as an intermediate node.

11. The UE of claim 8 or 9, wherein the stop condition comprises one of:

the UE is to be moved out of coverage of the base station,

the UE is to be handed over to a further base station,

a moving distance at a specific direction of the UE exceeds a distance threshold,

a measurement result of the UE is out of a specific range, or

a number of the at least one A-IoT device in proximity to the UE is lower than a number threshold.

12. A base station comprising:

at least one memory; and

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

in accordance with a determination that a procedure of intermediate node selection is to be performed, transmit, to one or more user equipment (UE), a first message associated with a service for one or more ambient internet of things (A-IoT) devices;

receive, from the one or more UEs, one or more second messages each comprising assistance information for determining at least one intermediate node or determining a configuration of at least one intermediate node for the one or more A-IoT devices; and

determine, based on the assistance information, one of:

at least one UE from the one or more UEs, wherein the at least one UE is used as at least one intermediate node for the one or more A-IoT devices, or

the configuration of at least one intermediate node for the one or more A-IoT device.

13. The base station of claim 12, wherein the at least one processor is further configured to cause the base station to:

receive, from a core network entity, a fifth message indicates one of:

an indication for selecting the at least one intermediate node for the one or more A-IoT devices,

a criterion or conditions for determining the at least one intermediate node for one or more A-IoT devices,

a time duration for the intermediate node operation, or information about one or more preferred or suggested intermediate nodes for the one or more A-IoT devices.

14. The base station of claim 12, wherein the at least one processor is further configured to cause the base station to:

determine that the procedure of intermediate node selection is needed based on existence information of at least one A-IoT device in proximity to the base station.

15. The base station of claim 14, wherein the at least one processor is further configured to cause the base station to:

transmit an indication for requesting at least one backscattered signal from at least one A-IoT device in proximity to the base station;

receive the at least one backscattered signal from the at least one A-IoT device in proximity to the base station; and

determine the existence information of the at least one A-IoT device in proximity to the base station.

16. The base station of claim 15, wherein the at least one processor is configured to cause the base station to:

perform energy detection on the at least one backscattered signal, to generate the existence information.

17. The base station of claim 15, wherein the existence information indicates one of:

there is the at least one A-IoT device in proximity to the base station,

a range of a number of the at least one A-IoT device in proximity to the base station,

a signal strength of the at least one backscattered signal, or

a plurality of signal strengths for a plurality of resources of the at least one backscattered signal.

18. The base station of claim 12, wherein the at least one processor is further configured to cause the base station to:

in accordance with a determination that a termination condition is met, transmit, to a second UE, a termination indication indicating to the second UE to terminate a role as an intermediate node.

19. The base station of claim 18, wherein the termination condition comprises one of:

a further termination indication associated with the second UE is received from a core network entity,

a measurement result of the second UE is out of a specific range,

the second UE is to be handed over to a further base station, or

a direct communication between the base station and a specific A-IoT device is enabled, wherein the second UE was an intermediate node for the specific A-IoT device.

20. A device comprising:

at least one memory; and

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

transmit an indication for requesting at least one backscattered signal from at least one ambient internet of things (A-IoT) device in proximity to the device;

receive the at least one backscattered signal from the at least one A-IoT device in proximity to the device; and

determine existence information of the at least one A-IoT device in proximity to the device.

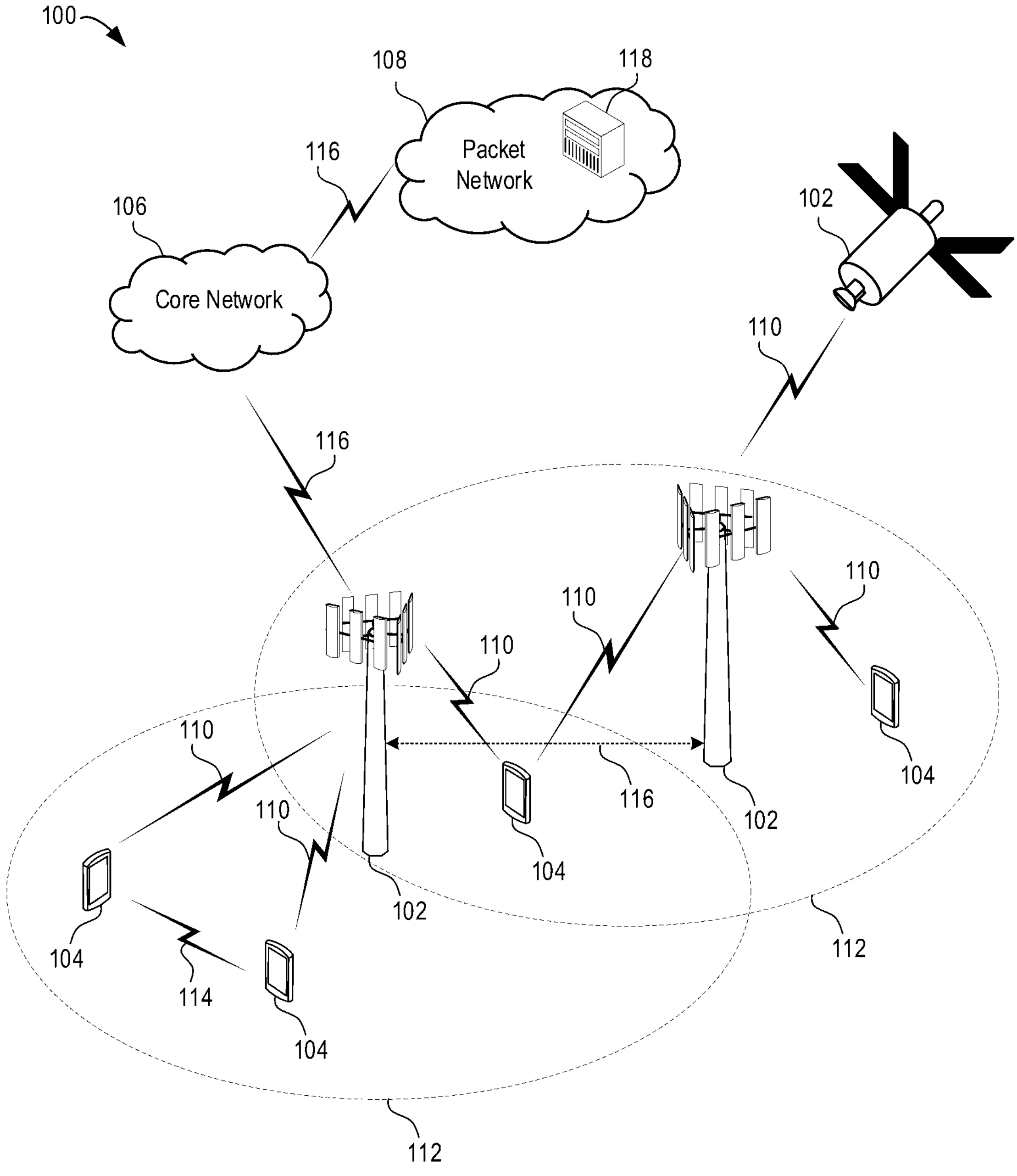
100
108
118
116
Packet
Network
102
106
Core Network
110
116
110
110
110
110
116
110
102
104
104
102
104
114
104
112
112

FIG. 1

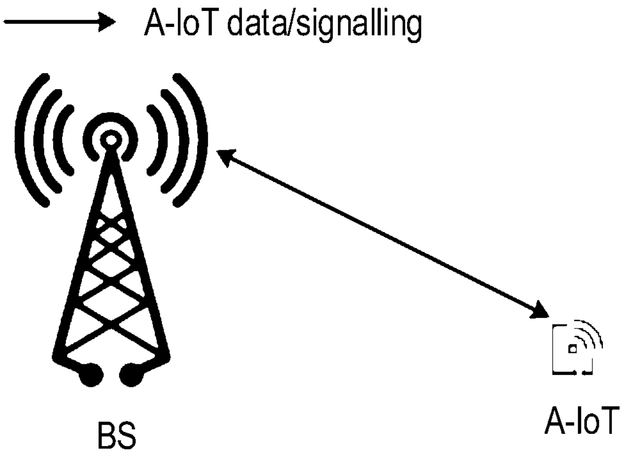
A-IoT data/signalling
BS
A-IoT

FIG. 2A

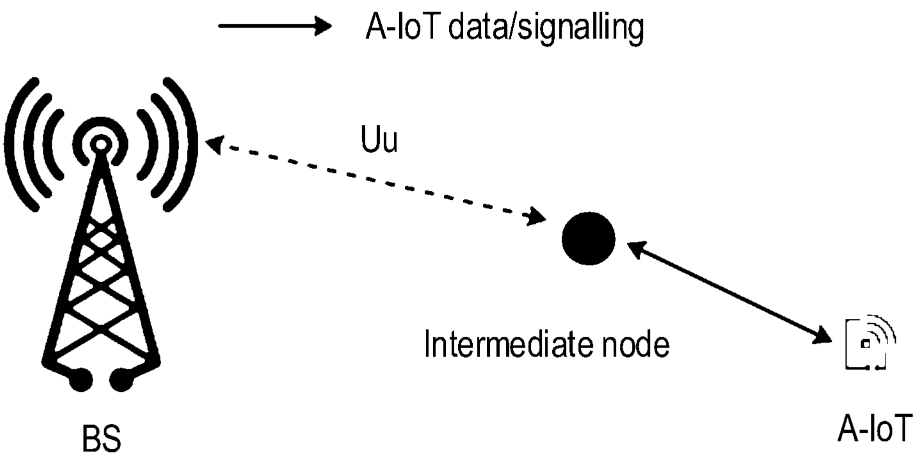
A-IoT data/signalling
Uu
Intermediate node
BS
A-IoT

FIG. 2B

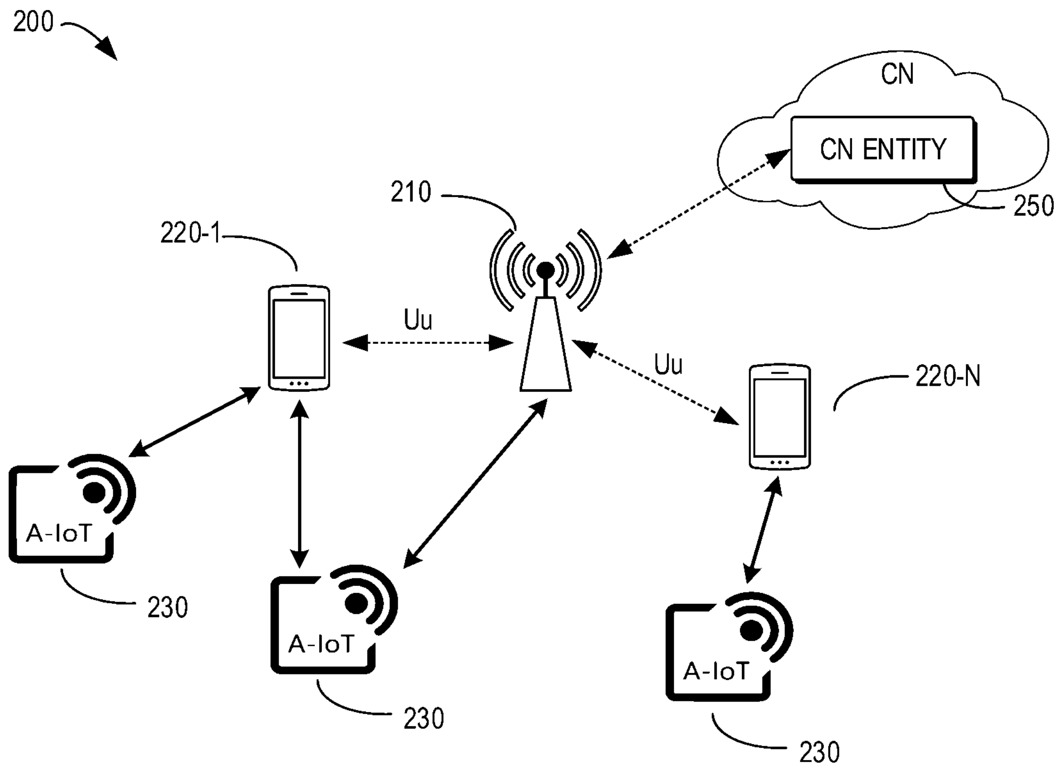
200
CN
CN ENTITY
210
250
220-1
Uu
Uu
220-N
A-IoT
230
A-IoT
230
A-IoT
230

FIG. 2C

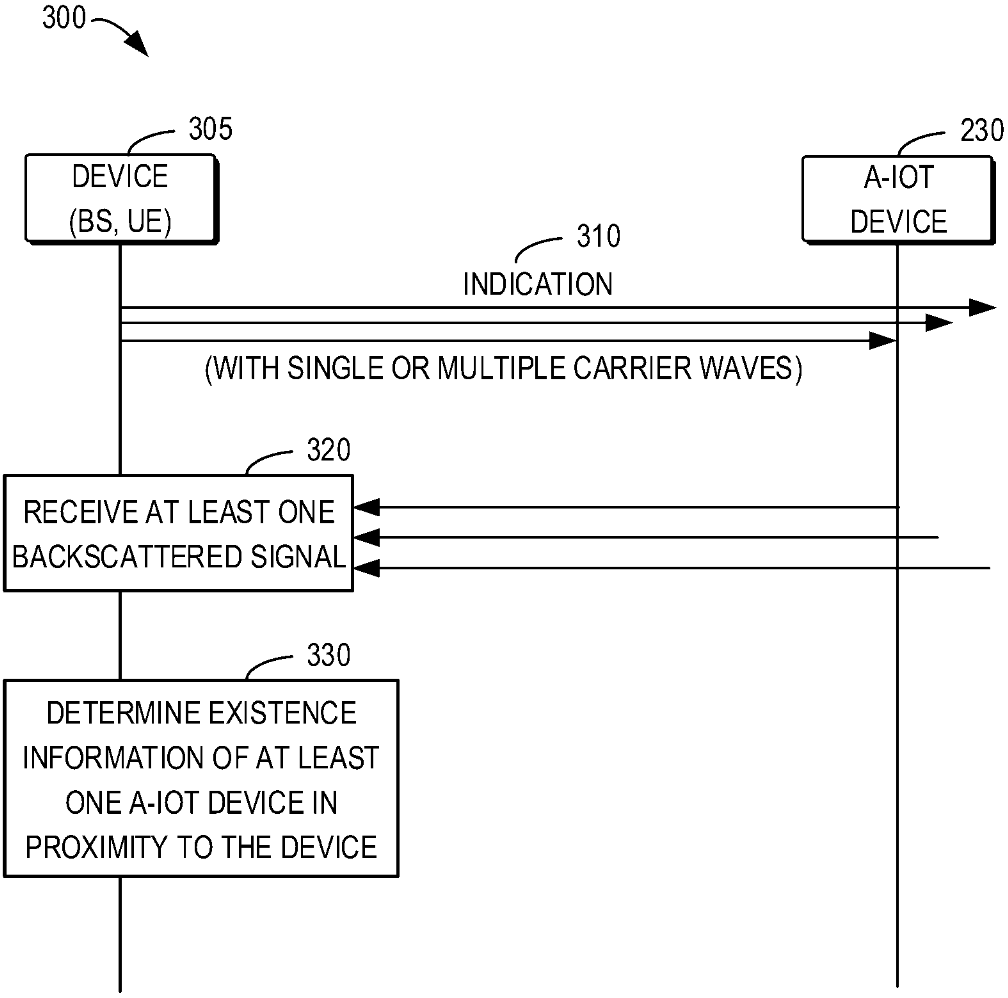
300
305
DEVICE
(BS, UE)
230
A-IOT
DEVICE
310
INDICATION
(WITH SINGLE OR MULTIPLE CARRIER WAVES)
320
RECEIVE AT LEAST ONE
BACKSCATTERED SIGNAL
330
DETERMINE EXISTENCE
INFORMATION OF AT LEAST
ONE A-IOT DEVICE IN
PROXIMITY TO THE DEVICE

FIG. 3

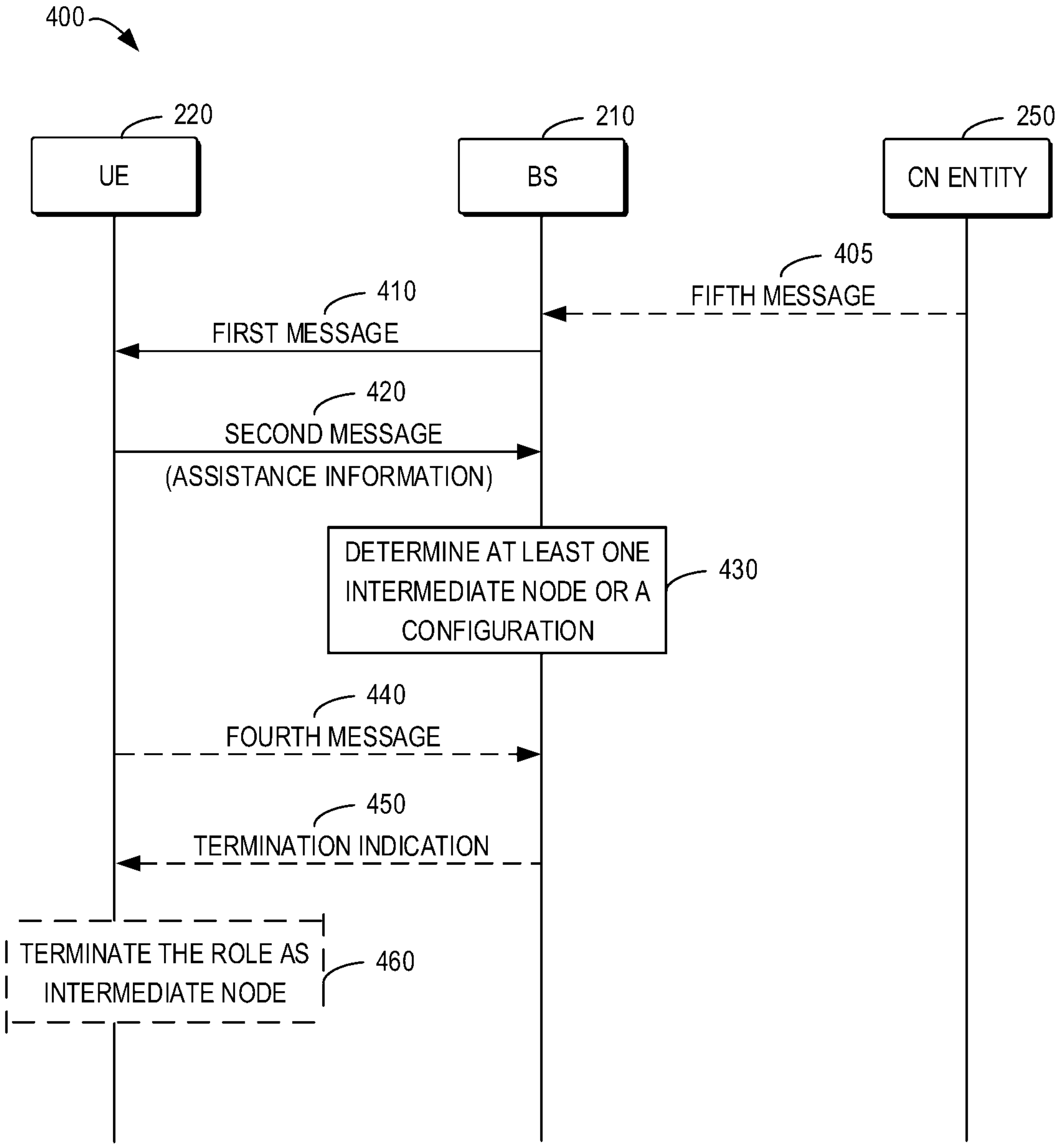
400
220
UE
210
BS
250
CN ENTITY
405
FIFTH MESSAGE
410
FIRST MESSAGE
420
SECOND MESSAGE
(ASSISTANCE INFORMATION)
DETERMINE AT LEAST ONE INTERMEDIATE NODE OR A CONFIGURATION
430
440
FOURTH MESSAGE
450
TERMINATION INDICATION
TERMINATE THE ROLE AS INTERMEDIATE NODE
460

FIG. 4

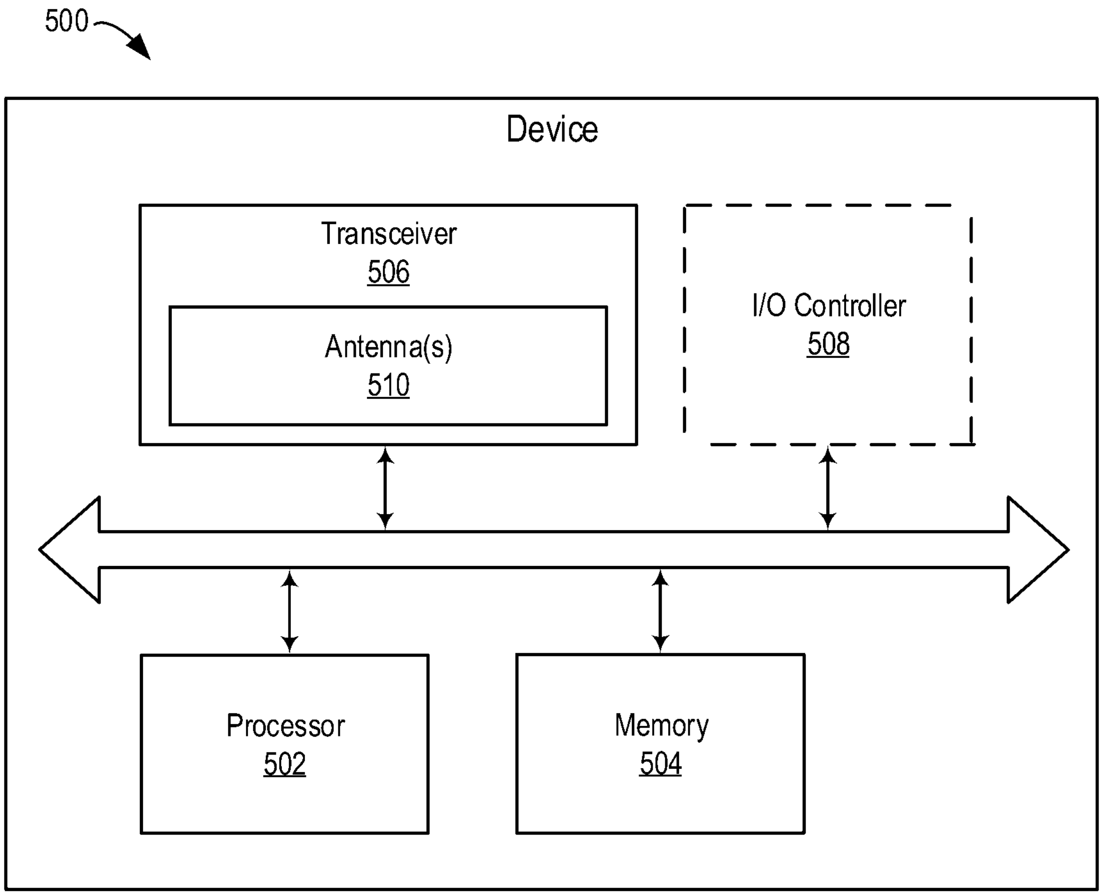
500
Device
Transceiver
506
Antenna(s)
510
I/O Controller
508
Processor
502
Memory
504

FIG. 5

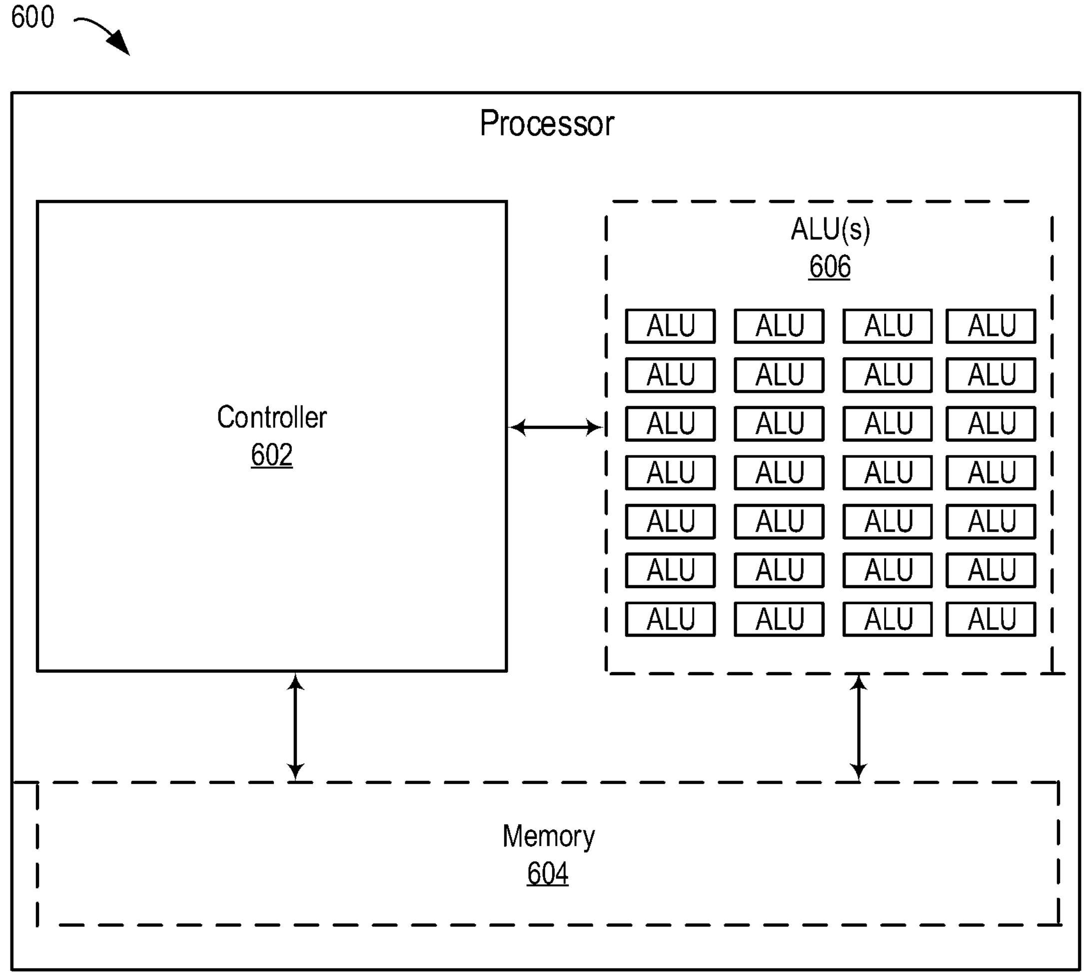

FIG. 6

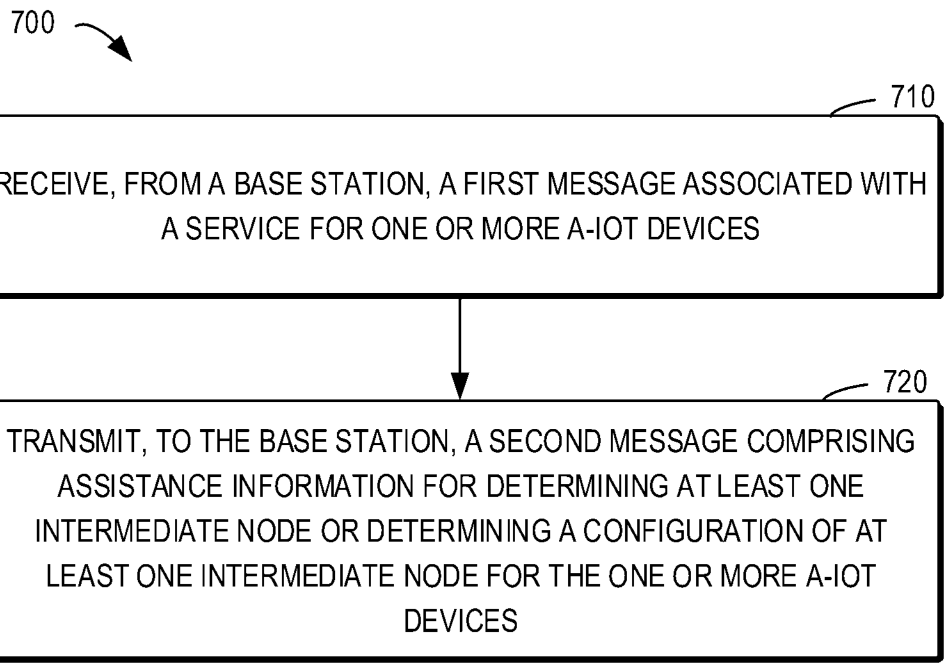
700
710
RECEIVE, FROM A BASE STATION, A FIRST MESSAGE ASSOCIATED WITH A SERVICE FOR ONE OR MORE A-IOT DEVICES
720
TRANSMIT, TO THE BASE STATION, A SECOND MESSAGE COMPRISING ASSISTANCE INFORMATION FOR DETERMINING AT LEAST ONE INTERMEDIATE NODE OR DETERMINING A CONFIGURATION OF AT LEAST ONE INTERMEDIATE NODE FOR THE ONE OR MORE A-IOT DEVICES

FIG. 7

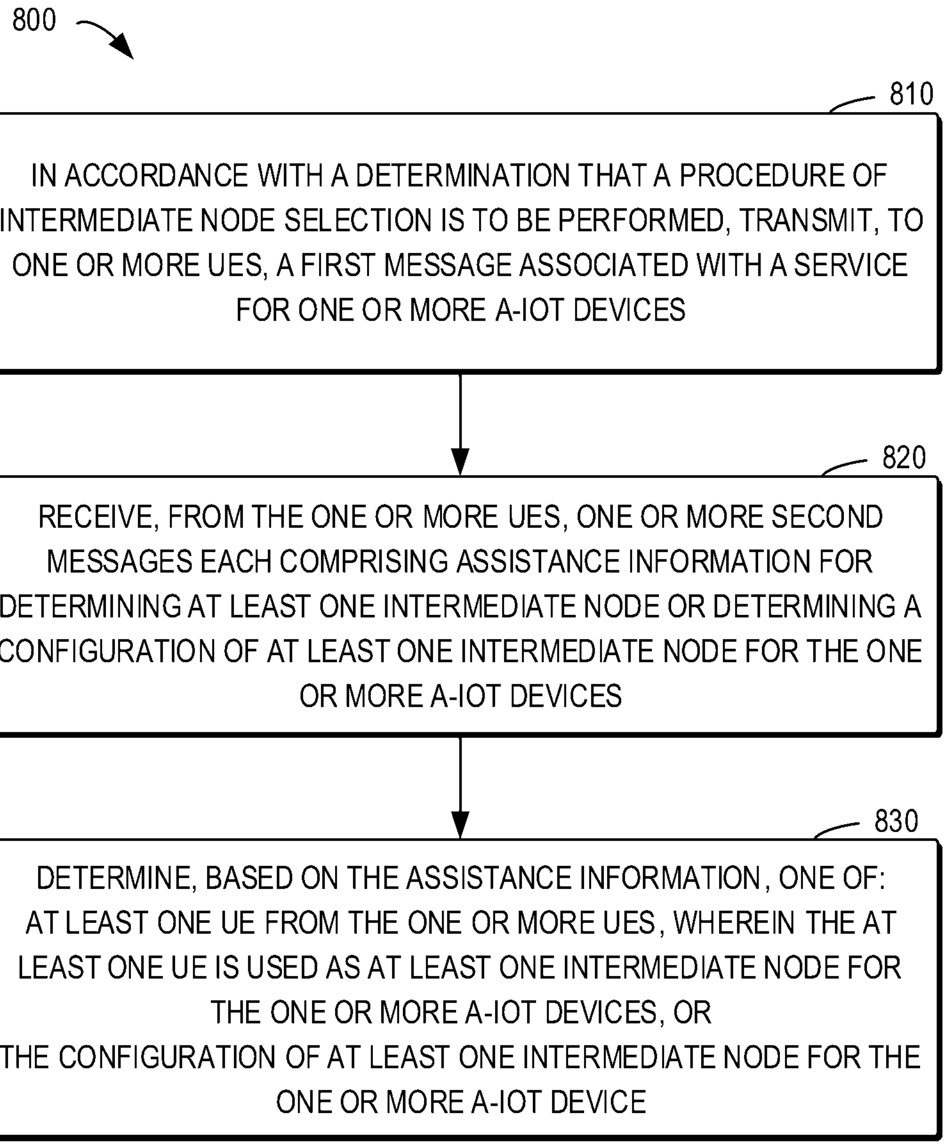
800
810
IN ACCORDANCE WITH A DETERMINATION THAT A PROCEDURE OF INTERMEDIATE NODE SELECTION IS TO BE PERFORMED, TRANSMIT, TO ONE OR MORE UES, A FIRST MESSAGE ASSOCIATED WITH A SERVICE FOR ONE OR MORE A-IOT DEVICES
820
RECEIVE, FROM THE ONE OR MORE UES, ONE OR MORE SECOND MESSAGES EACH COMPRISING ASSISTANCE INFORMATION FOR DETERMINING AT LEAST ONE INTERMEDIATE NODE OR DETERMINING A CONFIGURATION OF AT LEAST ONE INTERMEDIATE NODE FOR THE ONE OR MORE A-IOT DEVICES
830
DETERMINE, BASED ON THE ASSISTANCE INFORMATION, ONE OF:
AT LEAST ONE UE FROM THE ONE OR MORE UES, WHEREIN THE AT LEAST ONE UE IS USED AS AT LEAST ONE INTERMEDIATE NODE FOR THE ONE OR MORE A-IOT DEVICES, OR
THE CONFIGURATION OF AT LEAST ONE INTERMEDIATE NODE FOR THE ONE OR MORE A-IOT DEVICE

FIG. 8

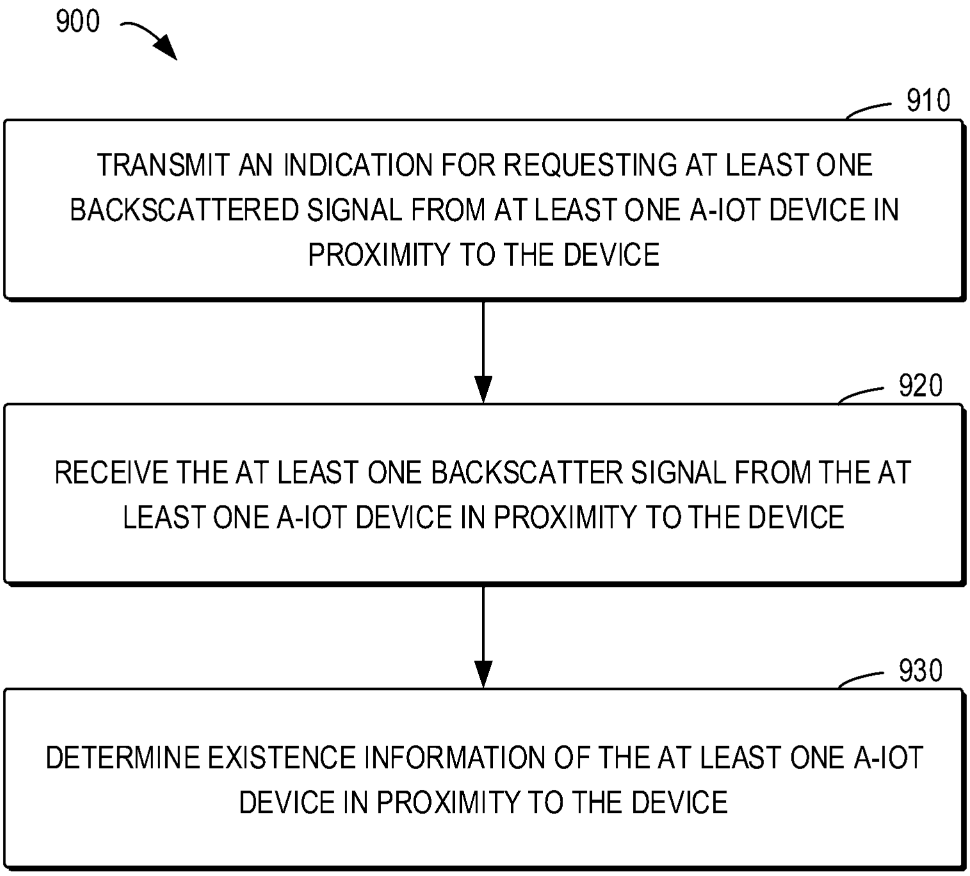
900
910
TRANSMIT AN INDICATION FOR REQUESTING AT LEAST ONE BACKSCATTERED SIGNAL FROM AT LEAST ONE A-IOT DEVICE IN PROXIMITY TO THE DEVICE
920
RECEIVE THE AT LEAST ONE BACKSCATTER SIGNAL FROM THE AT LEAST ONE A-IOT DEVICE IN PROXIMITY TO THE DEVICE
930
DETERMINE EXISTENCE INFORMATION OF THE AT LEAST ONE A-IOT DEVICE IN PROXIMITY TO THE DEVICE

FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2024/085360

A. CLASSIFICATION OF SUBJECT MATTER

H04W 4/70(2018.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC:H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

3GPP,CNKI,IEEE,CNTXT,DWPI,ENTXT,ENTXTC,VEN:ambient,ambient-IOT,AIOT,A-IOT,P-IOT,IOT,passive,PIOT, passive-iot,IN-UE,IN UE,UE,intermediat+,intermediate node?,as,auxiliary,reader,config+,assist+,service?,determin+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	LENOVO. "Discussion on downlink and uplink channel/signal aspects for ambient IoT" *3GPP TSG RAN WG1 #116 R1-2400201,* 01 March 2024 (2024-03-01), pages 8-10	1-19
A	CN 117729541 A (TECHNOLOGY INNOVATION CENT CHINA TELECOM CORPORATION LIMITED et al.) 19 March 2024 (2024-03-19) the whole document	1-19
A	CN 117676763 A (TECHNOLOGY INNOVATION CENT CHINA TELECOM CORPORATION LIMITED et al.) 08 March 2024 (2024-03-08) the whole document	1-19
A	WO 2022095435 A1 (SHENZHEN BBAI INFORMATION TECHNOLOGY CO., LTD.) 12 May 2022 (2022-05-12) the whole document	1-19
A	US 2023189269 A1 (QUALCOMM INCORPORATED) 15 June 2023 (2023-06-15) the whole document	1-19

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 December 2024	**23 December 2024**

Name and mailing address of the ISA/CN	Authorized officer
CHINA NATIONAL INTELLECTUAL PROPERTY ADMINISTRATION **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China**	**TONG,Lu** Telephone No. **(+86) 010-53960612**

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

The first invention relates to claims (1, 12); the second invention relates to claim 20.The same or corresponding technical features of the two inventions are: comprising at least one memory; and at least one processor coupled with the at least one memory and configured to implement method.The above features are well-known in the art. Therefore, they do not have the same or corresponding special technical feature. The first invention of claims (1,12) and the second invention of claim 20 are not so linked as to form a single general inventive concept, and do not satisfy the criteria set out in PCT Rule13.1, 13.2.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☑ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: **1-19**

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2024/085360

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	117729541	A	19 March 2024	None			
CN	117676763	A	08 March 2024	None			
WO	2022095435	A1	12 May 2022	CN	112235416	A	15 January 2021
US	2023189269	A1	15 June 2023	WO	2023114576	A1	22 June 2023