

DEVICES AND METHODS OF COMMUNICATION

TECHNICAL FIELD

[0001] The present disclosure relates to wireless communications, and more specifically to devices and methods of communication for ambient Internet of things (A-IoT).

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-IoT is an Internet of things (IoT) technology of supporting battery-less devices with no energy storage capability or devices with energy storage that do not need to be replaced or recharged manually. Recently, it is proposed to design a compact protocol stack and corresponding procedures for A-IoT, e.g., paging, random access, data transmission, etc.

SUMMARY

[0004] The present disclosure relates to methods, devices, and systems that support a communication with an A-IoT device. By considering a success and/or failure of a paging for one or more A-IoT devices, a communication with an A-IoT device may be enhanced.

[0005] In one aspect, some implementations of the method and devices described herein may comprise: receiving, at a first device and from a second device, a message for paging a set of first devices comprising the first device; determining that the message indicates a first operation requiring a response from the first device; and in accordance with a determination that the message fulfills a condition of skipping the response, making no response to the message.

[0006] Some implementations of the method and devices described herein may further comprise at least one of the following: in accordance with a determination the message does not fulfill the condition, initiating a random access to the second device; or in accordance with a determination that the message indicates a second operation requiring no response from the first device, performing the second operation.

[0007] In some implementations of the method and devices described herein, the condition may comprise at least one of the following: the message is the same a further message that has been responded to; an indication of ending the response is received; a status of the first device indicates that the first operation has been performed; identity information of the second device is the same as identity information of a further second device transmitting the further message; the second device is in a list of responded second devices; the message is not firstly received from the second device; the message is not a firstly responded message; or an ongoing service or task is unfinished.

[0008] In some implementations of the method and devices described herein, the indication of ending the response may be associated with at least one of the following: identity information of the first device indicated in the message, a cause indicated in the message, the identity information of the second device, or identity information of a service or task indicated in the message.

[0009] In some implementations of the method and devices described herein, the identity information of the first device may comprise at least one of the following: a device identity of the first device; a tag identity of the first device; an electronic product code (EPC) identity of the first device; a group identity of the first device; an area identity of the first device; or at least a part of data buffered in the first device.

[0010] In some implementations of the method and devices described herein, validity of the indication of ending the response may be associated with at least one of

the following: a time duration, number of paging for the first device, or energy of the first device.

[0011] Some implementations of the method and devices described herein may further comprise: receiving, from the second device, a command for changing the status of the first device; or in accordance with a determination that the first operation is successfully performed, changing the status of the first device to indicate that the first operation is successfully performed.

[0012] In some implementations of the method and devices described herein, the list of responded second devices may be comprised in the message.

[0013] In another aspect, some implementations of the method and devices described herein may comprise: transmitting, at a second device, a message for paging a set of first devices; receiving a response from a first device in the set of first devices; and transmitting information of the first device to at least one of a further second device or a third device.

[0014] Some implementations of the method and devices described herein may further comprise: receiving, from the third device, a further message for paging a further set of first devices, the further message comprising a list of responded second devices.

[0015] In some implementations of the method and devices described herein, the information of the first device may comprise at least one of the following: identity information of the first device, a status of the first device, or identity information of the second device receiving the response from the first device.

[0016] In another aspect, some implementations of the method and devices described herein may comprise: transmitting, at a second device, a message for paging a set of first devices; determining that a failure occurs in the paging; and performing an operation comprising at least one of the following: changing a transmission of a set of energy carriers for the set of first devices, changing a retransmission of the message, transmitting information of the failure to a third device, or updating the message.

[0017] In some implementations of the method and devices described herein, determining that the failure occurs may comprise: determining that the failure occurs based on at least one of the following: no response from the set of first devices is received during a first time window; no response from the set of first devices is received

at a resource; number of responded first devices is smaller than or equal to a number threshold in a second time window; a ratio of responded first devices in the set of first devices is smaller than or equal to a ratio threshold in a third time window; or response from a subset of first devices in the set of first devices is missing.

[0018] In some implementations of the method and devices described herein, changing the transmission of the energy carrier may comprise: transmitting the energy carrier with increased power or time; or causing an energy source to transmit the energy carrier with increased power or time.

[0019] In some implementations of the method and devices described herein, changing the retransmission of the message may comprise: retransmitting the message with an increased repetition number.

[0020] In some implementations of the method and devices described herein, the information of the failure comprising at least one of the following: a cause of the failure; identity information of a first device indicated in the message, the failure occurring in a paging for the first device; identity information of the second device in which the failure occurs; identity information of a service or task in which the failure occurs; or preferred number of a retransmission of the message.

[0021] In some implementations of the method and devices described herein, the identity information of the first device may comprise at least one of the following: a device identity of the first device; a tag identity of the first device; an EPC identity of the first device; a group identity of the first device; an area identity of the first device; or at least a part of data buffered in the first device.

[0022] In some implementations of the method and devices described herein, updating the message may comprise at least one of the following: updating the message with an increased paging area; or changing identity information of the set of first devices in the message.

[0023] In some implementations of the method and devices described herein, the first device may be an A-IoT device, the second device may be a base station or a communication node between the base station and the A-IoT device, and the third device may be a core network element.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] FIG. 1 illustrates an example of a wireless communications system that supports a communication with an A-IoT device in accordance with aspects of the present disclosure.

[0025] FIG. 2A illustrates a diagram illustrating example scenarios of a paging transmission for a service or task in accordance with aspects of the present disclosure.

[0026] FIG. 2B illustrates a diagram illustrating example scenarios of paging transmissions for different services or tasks in accordance with aspects of the present disclosure.

[0027] FIG. 3 illustrates a signaling chart of an example process that supports a communication with an A-IoT device in accordance with aspects of the present disclosure.

[0028] FIG. 4 illustrates an example of a device that supports a communication with an A-IoT device in accordance with aspects of the present disclosure.

[0029] FIG. 5 illustrates an example of a processor that supports a communication with an A-IoT device in accordance with aspects of the present disclosure.

[0030] FIG. 6 illustrates a flowchart of a method that supports a communication with an A-IoT device in accordance with aspects of the present disclosure.

[0031] FIG. 7 illustrates a flowchart of another method that supports a communication with an A-IoT device in accordance with aspects of the present disclosure.

[0032] FIG. 8 illustrates a flowchart of another method that supports a communication with an A-IoT device in accordance with aspects of the present disclosure.

DETAILED DESCRIPTION

[0033] 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 may be implemented in various manners other than the ones described below.

[0034] 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.

[0035] 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. The term ‘embodiment’ may be interchangeably used with ‘implementation’.

[0036] 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 implementations. As used herein, the term ‘and/or’ includes any and all combinations of one or more of the listed terms.

[0037] The terminology used herein is for the purpose of describing particular implementations only and is not intended to be limiting of example implementations. 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, and/or components etc., but do not preclude the presence or addition of one or more other features, elements, components and/ or combinations thereof.

[0038] In the context of the present disclosure, the term ‘a first device’ may refer to a battery-less device with no energy storage capability or a device with energy storage that do not need to be replaced or recharged manually. The term ‘a first device’ may be interchangeably used with ‘an A-IoT device’ or ‘A-IoT UE’.

[0039] In the context of the present disclosure, the term ‘a second device’ may refer to a node communicating with an A-IoT device. For example, the node may be a base station or a communication node between the base station and the A-IoT device. For example, the communication node may be a relay, integrated access and backhaul (IAB) node, UE, repeater, etc. which is capable of A-IoT associated functionalities. In some embodiments, the second device may be a node providing excitation signal or energy to the A-IoT device. In some embodiments, the second device may be a node transmitting a command to the A-IoT device to implement a selection, inventory or access (e.g., read and write) to the A-IoT device. For convenience, the term ‘a second device’ may be interchangeably used with ‘a node’.

[0040] In the context of the present disclosure, the term ‘a third device’ may refer to a core network (CN) element. In some embodiments, the CN element may be an existing CN function such as LMF, AMF, etc. In some embodiments, the CN element may be a CN function or a server newly defined for A-IoT. The term ‘a third device’ may be interchangeably used with ‘a CN element’ or ‘a CN device’ or ‘a server for A-IoT’.

[0041] In the context of the present disclosure, the term ‘paging message’ may refer to a message for paging an A-IoT device. The term ‘A-IoT’ may be interchangeably used with ‘passive IoT’.

[0042] In general, an A-IoT device may receive one or more paging messages from one or more nodes. In this case, behavior of an A-IoT device to handle the one or more paging messages may need to be defined. Furthermore, it may be not realistic that a paging is always successful for huge number of A-IoT devices. If a failure in the paging occurs, behavior of a node sending the paging may need to be defined.

[0043] In view of this, embodiments of the present disclosure provide solutions of communication with an A-IoT device. In one aspect, a first device receives, from a second device, a message for paging a set of first devices comprising the first device, and determines that the message indicates a first operation requiring a response from the first device. If the message fulfills a condition of skipping the response, the first device does not make the response to the message. In this way, an unnecessary response to a paging for an A-IoT device may be avoided, and energy consumption at the A-IoT device may be saved.

[0044] In another aspect, upon reception of a response from a first device, a second device transmits information of the first device to at least one of a further second device or a third device. In this way, a response to a paging for an A-IoT device may be managed in an efficient way.

[0045] In still another aspect, upon determination that a failure occurs in a paging for a set of first devices, a second device performs an operation comprising at least one of the following: changing a transmission of a set of energy carriers for the set of first devices; changing a retransmission of the message; transmitting information of the failure to a third device, or updating the message. In this way, a failure in a paging for an A-IoT device may be identified and handled.

[0046] Aspects of the present disclosure are described in the context of a wireless communications system.

[0047] FIG. 1 illustrates an example of a wireless communications system 100 that supports a paging for an A-IoT device in accordance with aspects of the present disclosure. The wireless communications system 100 may include one or more network entities (also referred to as network equipment (NE)). For convenience, network entities 102-1, 102-2 and 102-3 are shown and are collectively referred to as one or more network entities 102 hereinafter. The wireless communications system 100 may further include one or more A-IoT devices 101, one or more UEs 104, a 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 an LTE network or an LTE-Advanced (LTE-A) network. In some other implementations, the wireless communications system 100 may be a 5G network, such as an NR network. In other implementations, the wireless communications system 100 may be a combination of a 4G network and a 5G network, or other suitable radio access technology including Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20. The wireless communications system 100 may support radio access technologies beyond 5G. Additionally, the wireless communications system 100 may support technologies, such as time division multiple access (TDMA), frequency division multiple access (FDMA), or code division multiple access (CDMA), etc.

[0048] The one or more A-IoT devices 101 may be dispersed throughout a geographic region of the wireless communications system 100. An A-IoT device 101 may be a battery-less device with no energy storage capability or a device with energy storage that do not need to be replaced or recharged manually. The A-IoT device 101 may comprise an energy harvesting module and a backscattering module. The A-IoT device 101 may receive an energy supply signal or command via the energy harvesting module and backscatter a signal via the backscattering module.

[0049] 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.

[0050] A network entity 102 may provide a geographic coverage area 112 for which the network entity 102 may support services (e.g., voice, video, packet data, messaging, broadcast, etc.) for one or more UEs 104 within the geographic coverage area 112. For example, a network entity 102 and a UE 104 may support wireless communication of signals related to services (e.g., voice, video, packet data, messaging, broadcast, etc.) according to one or multiple radio access technologies. In some implementations, a network entity 102 may be moveable, for example, a satellite associated with a non-terrestrial network. In some implementations, different geographic coverage areas 112 associated with the same or different radio access technologies may overlap, but the different geographic coverage areas 112 may be associated with different network entities 102. Information and signals described herein may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[0051] 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.

[0052] The one or more UEs 104 may be devices in different forms or having different capabilities. Some examples of UEs 104 are illustrated in FIG. 1. A UE 104 may be capable of communicating with various types of devices, such as the network entities 102, other UEs 104, or network equipment (e.g., the core network 106, the packet data network 108, a relay device, an 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.

[0053] A UE 104 may also be able to support wireless communication directly with other UEs 104 over a communication link 114. For example, a UE 104 may support wireless communication directly with another UE 104 over a device-to-device (D2D) communication link. In some implementations, such as vehicle-to-vehicle (V2V) deployments, vehicle-to-everything (V2X) deployments, or cellular-V2X deployments, the communication link 114 may be referred to as a sidelink. For example, a UE 104 may support wireless communication directly with another UE 104 over a PC5 interface.

[0054] A network entity 102 may support communications with the core network 106, or with another network entity 102, or both. For example, a network entity 102 may interface with the core network 106 through one or more backhaul links 116 (e.g., via an S1, N2, N2, or another network interface). The network entities 102 may communicate with each other over the backhaul links 116 (e.g., via an X2, Xn, or another network interface). In some implementations, the network entities 102 may

communicate with each other directly (e.g., between the network entities 102). In some other implementations, the network entities 102 may communicate with each other or indirectly (e.g., via the core network 106). In some implementations, one or more network entities 102 may include subcomponents, such as an access network entity, which may be an example of an access node controller (ANC). An ANC may communicate with the one or more UEs 104 through one or more other access network transmission entities, which may be referred to as a radio heads, smart radio heads, or transmission-reception points (TRPs).

[0055] 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 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.

[0056] 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)).

[0057] Split of functionality between a CU, a DU, and an RU may be flexible and may support different functionalities depending upon which functions (e.g., network layer functions, protocol layer functions, baseband functions, radio frequency functions, and any combinations thereof) are performed at a CU, a DU, or an RU. For example, a functional split of a protocol stack may be employed between a CU and a DU such that the CU may support one or more layers of the protocol stack and the DU may support one or more different layers of the protocol stack. In some implementations, the CU

may host upper protocol layer (e.g., a layer 3 (L3), a layer 2 (L2)) functionality and signaling (e.g., Radio Resource Control (RRC), service data adaptation protocol (SDAP), Packet Data Convergence Protocol (PDCP)). The CU may be connected to one or more DUs or RUs, and the one or more DUs or RUs may host lower protocol layers, such as a layer 1 (L1) (e.g., physical (PHY) layer) or an L2 (e.g., radio link control (RLC) layer, medium access control (MAC) layer) functionality and signaling, and may each be at least partially controlled by the CU 160.

[0058] 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).

[0059] 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.

[0060] The core network 106 may support user authentication, access authorization, tracking, connectivity, and other access, routing, or mobility functions. The core network 106 may be an evolved packet core, or a 5G core (5GC), which may include one or more core network elements 103. A core network element 103 may be a control plane entity that manages access and mobility (e.g., a mobility management entity (MME), an access and mobility management functions (AMF)) or a user plane entity that routes packets or interconnects to external networks (e.g., a serving gateway (S-GW), a Packet Data Network (PDN) gateway (P-GW), or a user plane function (UPF)). In some implementations, the control plane entity may manage non-access stratum

(NAS) functions, such as mobility, authentication, and bearer management (e.g., data bearers, signal bearers, etc.) for the one or more UEs 104 served by the one or more network entities 102 associated with the core network 106.

[0061] The core network 106 may communicate with the packet data network 108 over one or more backhaul links 116 (e.g., via an S1, N2, N2, or another network interface). The packet data network 108 may include an application server 118. In some implementations, one or more UEs 104 may communicate with the application server 118. A UE 104 may establish a session (e.g., a protocol data unit (PDU) session, or the like) with the core network 106 via a network entity 102. The core network 106 may route traffic (e.g., control information, data, and the like) between the UE 104 and the application server 118 using the established session (e.g., the established PDU session). The PDU session may be an example of a logical connection between the UE 104 and the core network 106 (e.g., one or more network functions of the core network 106).

[0062] 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.

[0063] One or more numerologies may be supported in the wireless communications system 100, and a numerology may include a subcarrier spacing and a cyclic prefix. A first numerology (e.g., $\mu=0$) may be associated with a first subcarrier spacing (e.g., 15 kHz) and a normal cyclic prefix. In some implementations, the first numerology (e.g., $\mu=0$) associated with the first subcarrier spacing (e.g., 15 kHz) may utilize one slot per subframe. A second numerology (e.g., $\mu=1$) may be associated with a second subcarrier spacing (e.g., 30 kHz) and a normal cyclic prefix. A third

numerology (e.g., $\mu=2$) may be associated with a third subcarrier spacing (e.g., 60 kHz) and a normal cyclic prefix or an extended cyclic prefix. A fourth numerology (e.g., $\mu=3$) may be associated with a fourth subcarrier spacing (e.g., 120 kHz) and a normal cyclic prefix. A fifth numerology (e.g., $\mu=4$) may be associated with a fifth subcarrier spacing (e.g., 240 kHz) and a normal cyclic prefix.

[0064] 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.

[0065] Additionally or alternatively, a time interval of a resource (e.g., a communication resource) may be organized according to slots. For example, a subframe may include a number (e.g., quantity) of slots. The number of slots in each subframe may also depend on the one or more numerologies supported in the wireless communications system 100. For instance, the first, second, third, fourth, and fifth numerologies (i.e., $\mu=0$, $\mu=1$, $\mu=2$, $\mu=3$, $\mu=4$) associated with respective subcarrier spacings of 15 kHz, 30 kHz, 60 kHz, 120 kHz, and 240 kHz may utilize a single slot per subframe, two slots per subframe, four slots per subframe, eight slots per subframe, and 16 slots per subframe, respectively. Each slot may include a number (e.g., quantity) of symbols (e.g., OFDM symbols). In some implementations, the number (e.g., quantity) of slots for a subframe may depend on a numerology. For a normal cyclic prefix, a slot may include 14 symbols. For an extended cyclic prefix (e.g., applicable for 60 kHz subcarrier spacing), a slot may include 12 symbols. The relationship between the number of symbols per slot, the number of slots per subframe, and the number of slots per frame for a normal cyclic prefix and an extended cyclic prefix may depend on a numerology. It should be understood that reference to a first numerology (e.g., $\mu=0$) associated with a first subcarrier spacing (e.g., 15 kHz) may be used interchangeably between subframes and slots.

[0066] 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.

[0067] FR1 may be associated with one or multiple numerologies (e.g., at least three numerologies). For example, FR1 may be associated with a first numerology (e.g., $\mu=0$), which includes 15 kHz subcarrier spacing; a second numerology (e.g., $\mu=1$), which includes 30 kHz subcarrier spacing; and a third numerology (e.g., $\mu=2$), which includes 60 kHz subcarrier spacing. FR2 may be associated with one or multiple numerologies (e.g., at least 2 numerologies). For example, FR2 may be associated with a third numerology (e.g., $\mu=2$), which includes 60 kHz subcarrier spacing; and a fourth numerology (e.g., $\mu=3$), which includes 120 kHz subcarrier spacing.

[0068] In some scenarios, the A-IoT device 101 may directly and bidirectionally communicate with the network entity 102. The communication between the A-IoT device 101 and the network entity 102 includes A-IoT data and/or signaling. These scenarios may be called as Topology 1.

[0069] In some scenarios, the A-IoT device 101 may communicate bidirectionally with an intermediate node between the A-IoT device 101 and the network entity 102. The intermediate node may be the UE 104, a relay, a IAB node, a repeater, etc. which is capable of A-IoT. The intermediate node may transfer A-IoT data and/or signaling between the A-IoT device 101 and the network entity 102. These scenarios may be called as Topology 2.

[0070] In some scenarios, the A-IoT device 101 may transmit data/signaling to the network entity 102, and receive data/signaling from an assisting node; or the A-IoT device 101 may receive data/signaling from the network entity 102, and transmit

data/signaling to the assisting node. The assisting node may be the UE 104, a relay, an IAB node, a repeater, etc. which is capable of A-IoT. These scenarios may be called as Topology 3.

[0071] In some scenarios, the A-IoT device 101 may communicate bidirectionally with the UE 104. The communication between the A-IoT device 101 and the UE 104 includes A-IoT data and/or signaling. These scenarios may be called as Topology 4.

[0072] In some scenarios for a service or task, the CN 106 may trigger one or more nodes (e.g., the network entities 102-1, 102-2, the UE 104, etc.) to send one or more paging messages to search a set of A-IoT devices (i.e., one or more A-IoT devices). FIG. 2A illustrates a diagram 200A illustrating example scenarios of a paging transmission for a service or task in accordance with aspects of the present disclosure.

[0073] In a scenario 210 of FIG. 2A, one node (Node 1) may transmit one paging message for the service or task. In some embodiments, the node may transmit the same paging message with repetition numbers, i.e., paging message retransmissions.

[0074] In a scenario 211 of FIG. 2A, one node (Node 1) may transmit multiple paging messages (Paging message #1, #2, ..., #N) for the service or task, some or all of contents of the paging messages may be the same (if all the contents of the paging messages are the same, this scenario is a paging retransmission as described in the scenario 210 of FIG. 2A). For example, a paging cause may be the same for an inventory use case. Since after one inventory cycle, not all target A-IoT devices complete an inventory procedure, the node may send multiple paging messages to complete the inventory procedure for all target A-IoT devices.

[0075] In a scenario 212 of FIG. 2A, multiple nodes (Node 1, Node 2, ..., Node N) may transmit multiple paging messages (Paging message #1, #2, ..., #N) for the service or task. In this case, the transmission of the paging messages from the nodes may be scheduled by CN according to requirements of the service or task.

[0076] In some scenarios for different services or tasks, the CN 106 may trigger one or more nodes (e.g., the network entities 102-1, 102-2, the UE 104, etc.) to send multiple paging messages to search one or multiple sets of A-IoT devices. FIG. 2B illustrates a diagram 200B illustrating example scenarios of paging transmissions for different services or tasks in accordance with aspects of the present disclosure.

[0077] In a scenario 220 of FIG. 2B, after a node (Node 1) transmits a paging message #1 for a service or task #1, the node may transmit another paging message #2 for a service or task #2, and so on. That is, one node may transmit multiple paging messages for multiple services or tasks. In some cases, some contents of the paging messages may be the same, i.e., a paging cause in paging message #1 is inventory for service/task #1, a paging cause in paging message #2 is also inventory for service/task #2, and so on.

[0078] In a scenario 221 of FIG. 2B, multiple nodes (Node 1, Node 2, ..., Node N) may transmit multiple paging messages (Paging message #1, #2, ..., #N) for different services or tasks.

[0079] It can be seen that an A-IoT device may receive one or more paging messages from one or more nodes for one or more services/tasks. In this case, how to handle these paging scenarios needs to be defined. For example, after an A-IoT device receives a paging message, the behaviors of the A-IoT device on whether a paging ID in a paging record of the paging message matches an identity of the A-IoT device need to be designed. In addition, for the inventory use case, one or more nodes may send multiple paging messages to A-IoT devices since not all target A-IoT devices complete the inventory with receiving one paging message (for the aperiodic paging case) or one cycle of paging message (for the periodic paging case). In this case, those A-IoT devices that have completed the inventory procedure may not need to respond the paging message again to save power or due to capability limitation. Hence, A-IoT devices may need to determine in what case there no need to respond to the paging message. Another issue is that a paging is not always successful in fact. Thus, how to define a failure in the paging and potential behaviors of a node to handle the failure also needs to be developed.

[0080] In view of the above, embodiments of the present disclosure provide solutions of a communication with an A-IoT device. The solutions will be described in connection with FIG. 3 below.

[0081] FIG. 3 illustrates a signaling chart of an example process 300 that supports a communication with an A-IoT device in accordance with aspects of the present disclosure. For purpose of discussion, the process 300 will be described in connection with FIG. 1. The process 300 may involve a first device, a second device and a third

device. The first device may be an A-IoT device, and the second device may be a base station or a communication node between the base station and the A-IoT device, and the third device may be a core network element. For illustration, the following description will be given by assuming that the first device is the A-IoT device 101, and the second device is the network entity 102-1, and the third device is the core network element 103. It is to be understood that the steps and the order of the steps in FIG. 3 are merely for illustration, and not for limitation.

[0082] It is assumed that the A-IoT device 101 has been waken up (i.e., activated) before receiving a paging message by a separate energy carrier or an energy carrier along with a paging message.

[0083] As shown in FIG. 3, the network entity 102-1 may transmit 310 a message (i.e., a paging message) for paging a set of A-IoT devices (i.e., one or more A-IoT devices). For example, CN may indicate one or more base stations to transmit one or more paging messages to find the set of A-IoT devices for one or more service/tasks. In some embodiments, the paging message may comprise a set of paging records for the set of A-IoT devices. Paging records in the set of paging records may have different paging identities (IDs).

[0084] After the A-IoT device 101 is activated, the A-IoT device 101 may receive the paging message. It is to be understood that the A-IoT device 101 may receive multiple paging messages from different network entities. For convenience, only one paging message from one network entity is shown. In some embodiments, the A-IoT device 101 may perform backscatter transmission upon reception of the one or multiple paging messages. In some embodiments, the A-IoT device 101 may decode all the received paging messages. In some embodiments, the A-IoT device 101 may randomly select a paging message and decode the paging message.

[0085] Continuing to refer to FIG. 3, the A-IoT device 101 may determine 311 whether ID information of the set of A-IoT devices matches ID information of the A-IoT device 101. It is to be understood that the ID information may adopt any suitable forms.

[0086] In some embodiments, the set of A-IoT devices may comprise the A-IoT device 101. In this case, the ID information of the A-IoT device 101 may match one of

the ID information of the set of A-IoT devices. For example, an ID of the A-IoT device 101 may match a paging ID of a paging record in the paging message.

[0087] In some embodiments, the set of A-IoT devices may not comprise the A-IoT device 101. In this case, the ID information of the A-IoT device 101 may mismatch any of the ID information of the set of A-IoT devices. For example, an ID of the A-IoT device 101 may not match any paging IDs of any paging records in the paging message.

[0088] With reference to FIG. 3, if the ID information of the set of A-IoT devices does not match the ID information of the A-IoT device 101, the A-IoT device 101 may not perform 312 any operations or actions. In this case, the A-IoT device 101 may go to sleep when the energy carrier is not enough.

[0089] With reference to FIG. 3, if the ID information of the set of A-IoT devices matches the ID information of the A-IoT device 101, the A-IoT device 101 may determine 313 whether the paging message indicates an operation (for convenience, also referred to as a first operation herein) requiring a response from the A-IoT device 101 or an operation (for convenience, also referred to as a second operation herein) requiring no response from the A-IoT device 101.

[0090] In some embodiments, the first operation may be an inventory operation. In some embodiments, the first operation may be a downlink command that needs a response. It is to be understood that any other suitable operations requiring a response are also feasible.

[0091] In some embodiments, the second operation may be a request to change a status of a specific service or task. In another example, the second operation may be a downlink command without response, including online modification of medical instruments status, device activation and deactivation, elderly health care, device permanent deactivation, electronic shelf label, etc. It is to be understood that any other suitable operations requiring no response are also feasible.

[0092] As shown in FIG. 3, if the paging message indicates the second operation without any response from the A-IoT device 101, the A-IoT device 101 may perform 314 the second operation. In other words, the A-IoT device 101 may perform a requested action if the paging message does not require a response from the A-IoT device 101.

[0093] Continuing to refer to FIG. 3, if the paging message indicates the first operation requiring a response from the A-IoT device 101, the A-IoT device 101 may determine 315 whether the paging message fulfills a condition of skipping the response. For example, for the case that an A-IoT device receives multiple paging messages from one or more nodes for the same service/task, e.g., inventory, an A-IoT device that have responded to the node may not need to respond to the paging message with the same service/task again to save power. Thus, an A-IoT device may need to determine in what case there is no need to respond to the matched paging message.

[0094] With reference to FIG. 3, if the paging message fulfills the condition of skipping the response, the A-IoT device 101 may not respond 316 to the paging message. For illustration, some example embodiments will be described below.

[0095] In some embodiments, the condition of skipping the response may comprise that the paging message is the same as a further paging message that has been responded to. In some embodiments, if a paging record in the paging message is the same as a last responded paging message, i.e., paging message retransmission, the A-IoT device 101 may not respond to the paging message. In other words, the A-IoT device 101 may only respond to one paging message for the paging message retransmission case. The A-IoT device 101 may have no action or response when receiving the same paging message again, and the network entity 102-1 may not need to indicate number of retransmissions to the A-IoT device 101.

[0096] In some embodiments, the condition of skipping the response may comprise that an indication (also referred to as 'END' indication herein) of ending the response is received. In some embodiments, if the 'END' indication is received or valid, the A-IoT device 101 may not respond to the paging message.

[0097] In some embodiments, the A-IoT device 101 may receive the 'END' indication from a node that has received a response from an A-IoT device directly or has received response information from other nodes for a service/task. In some embodiments, the 'END' indication may be effective for a newly received paging message. In some embodiments, multiple 'END' indications for different services or tasks may be received and maintained for an A-IoT device at the same time.

[0098] In some embodiments, the 'END' indication may be associated with ID information of an A-IoT device indicated in the paging message (i.e., paging ID). In

some embodiments, the ID information of the A-IoT device may comprise at least one of the following: a device ID, a tag ID, an EPC ID, a group ID, an area ID, or at least a part of data buffered in the A-IoT device. For example, the 'END' indication may be indicated per paging ID. If the current paging message has the same paging ID with the last responded paging message, the A-IoT device 101 may not respond to the current paging message again. For example, the 'END' indication may be indicated per area ID/group ID/EPC/tag ID. If the current paging message has the same area ID/group ID/EPC/tag ID with the last responded paging message, the A-IoT device 101 may not respond to the current paging message again.

[0099] In some embodiments, the 'END' indication may be associated with a cause (also referred to as a paging cause herein) indicated in the paging message. For example, the 'END' indication may be indicated per paging cause. If the current paging message has the same paging cause (e.g., inventory, etc.) with the last responded paging message, the A-IoT device 101 may not respond to the current paging message again.

[0100] In some embodiments, the 'END' indication may be associated with identity information of the network entity 102-1. For example, the 'END' indication may be indicated per node ID (e.g., network entity ID, or UE ID, etc.). If the current paging message has the same node ID with the last responded paging message, the A-IoT device 101 may not respond to the current paging message again.

[0101] In some embodiments, the 'END' indication may be associated with ID information of a service or task indicated in the paging message. For example, the 'END' indication may be indicated per service ID or per task ID. If the current paging message has the same service/task ID with the last responded paging message, the A-IoT device 101 may not respond to the current paging message again.

[0102] In some embodiments, validity of the 'END' indication may be associated with at least one of the following: a time duration, number of paging for the A-IoT device 101, or energy of the A-IoT device 101.

[0103] In some embodiments, the 'END' indication may be valid during the time duration. In some embodiments, a node may configure the 'END' indication with a specified time duration or window during which an A-IoT device may not need to respond to the paging message. The time duration or window may be integer multiple

of the paging message. In some embodiments, the 'END' indication may be invalid when the time duration or window expires.

[0104] In some embodiments, the 'END' indication may be valid for a predefined paging number. In some embodiments, a node may configure the 'END' indication with a specified paging number, e.g., with the following pre-configured paging number (e.g., 5 paging messages or 10 paging messages). That is, an A-IoT device may not need to respond to the following 5 or 10 paging messages. In some embodiments, the 'END' indication may be invalid when the paging number expires.

[0105] In some embodiments, the 'END' indication may be valid when the energy of the A-IoT device 101 is not empty. In some embodiments, the 'END' indication may be invalid when the energy of the A-IoT device 101 is empty.

[0106] In some embodiments, when the A-IoT device 101 is re-activated by an energy carrier (from a node or an energy source), the 'END' indication may need to be updated.

[0107] In some embodiments, the condition of skipping the response may comprise that a status of the A-IoT device 101 indicates that the first operation has been performed. In some embodiments, if the status of the A-IoT device 101 indicates that the first operation has been performed, the A-IoT device 101 may not respond to the paging message. For example, if the status of the A-IoT device 101 indicates or reflects 'inventoried' when the same paging message for inventory is received, the A-IoT device 101 may not respond to the paging message.

[0108] In some embodiments, the status of the A-IoT device 101 may be changed by network command. In some embodiments, the A-IoT device 101 may receive, from the network entity 102-1, a command for changing the status of the A-IoT device 101. In some embodiments, the command may be comprised in a next paging message. In some embodiments, the command may be comprised in a message separately from the next paging message.

[0109] In some embodiments, the status of the A-IoT device 101 may be changed by itself. In some embodiments, if the first operation is successfully performed, the A-IoT device 101 may change the status of the A-IoT device 101 to indicate or reflect that the first operation is successfully performed. For example, the status of the A-IoT

device 101 may be changed to indicate or reflect ‘inventoried’ after successful inventory if allowed by network.

[0110] In some embodiments, the condition of skipping the response may comprise that identity information of the network entity 102-1 is the same as identity information of a node transmitting the further message that has been responded to. In other words, if the A-IoT device 101 receives the paging message from a node with the same node ID of the last responded paging message, with or without further limitation, e.g., for inventory purposes or same service/task ID, the A-IoT device 101 may not respond to the paging message.

[0111] In some embodiments, the condition of skipping the response may comprise that the network entity 102-1 is in a list of responded nodes. In some embodiments, the list of responded nodes may be comprised in the paging message. If the network entity 102-1 transmitting the paging message is comprised in the list of responded nodes indicated in the paging message, the A-IoT device 101 may not respond to the paging message.

[0112] In some embodiments, the condition of skipping the response may comprise that the paging message is not firstly received from a node. In other words, if the paging message is not the firstly received paging message, the A-IoT device 101 may not respond to the paging message.

[0113] In some embodiments, the condition of skipping the response may comprise that the paging message is not a firstly responded message. In other words, if the paging message is not the firstly responded message, the A-IoT device 101 may not respond to the paging message. In some embodiments, the A-IoT device 101 may randomly select a paging message for response, and may not respond to other paging messages.

[0114] In some embodiments, the condition of skipping the response may comprise that an ongoing service or task is unfinished. In other words, if the ongoing service or task associated with the last responded paging message for a node is not finished, the A-IoT device 101 may not respond to the paging message.

[0115] Continuing to refer to FIG. 3, if the paging message does not fulfill the condition of skipping the response, the A-IoT device 101 may initiate 317 a random access to the network entity 102-1 and transmit the response to the network entity 102-1.

[0116] Correspondingly, the network entity 102-1 may receive the response from one or more A-IoT devices (e.g., the A-IoT device 101) in the set of A-IoT devices. As shown in FIG. 3, upon reception of the response, the network entity 102-1 may transmit 320 information of the A-IoT device 101 to the CN element 103. Alternatively or additionally, although not shown, the network entity 102-1 may transmit the information of the A-IoT device 101 to other nodes, e.g., involving the same service or task. In other words, the network entity 102-1 may exchange received response from an A-IoT device with other nodes and/or CN element.

[0117] In some embodiments, the information of the A-IoT device 101 may comprise the ID information of the A-IoT device 101. In some embodiments, the ID information of the A-IoT device 101 may comprise at least one of the following: a device ID, a tag ID, an EPC ID, a group ID, an area ID, or at least a part of data buffered in the A-IoT device 101.

[0118] In some embodiments, the information of the A-IoT device 101 may comprise the status of the A-IoT device 101, for example, inventoried, not being inventoried, etc.

[0119] In some embodiments, the information of the A-IoT device 101 may comprise the ID information of the network entity 102-1 receiving the response from the A-IoT device 101.

[0120] As shown in FIG. 3, upon reception of the information of the A-IoT device 101, the CN element 103 may generate 321 the list of responded nodes as mentioned above. The CN element 103 may indicate 322 the list of responded nodes in the next paging message to a network entity (e.g., the network entity 102-1).

[0121] Continuing to refer to FIG. 3, based on presence or absence of a response from an A-IoT device, the network entity 102-1 may determine 330 a failure (also referred to as a paging failure herein) occurs in the paging for the set of A-IoT devices.

[0122] In some embodiments, if no response from the set of A-IoT devices is received during a time window (for convenience, also referred to as a first time window

herein), the network entity 102-1 may determine that the paging failure occurs. For example, the network entity 102-1 may transmit or retransmit the paging message with a predefined repetition number, but not receive any response from the set of A-IoT devices during the time window. In this case, the network entity 102-1 may determine that the paging failure occurs.

[0123] In some embodiments, if no response from the set of A-IoT devices is received at a resource, the network entity 102-1 may determine that the paging failure occurs. In some embodiments, if the network entity 102-1 does not receive any response at predetermined time and/or frequency resources, the network entity 102-1 may determine that the paging failure occurs. For example, the network entity 102-1 may transmit or retransmit the paging message with a predefined repetition number, but not receive any response from the set of A-IoT devices in the predetermined time and/or frequency resources, e.g., time slot, frequency, etc. In this case, the network entity 102-1 may determine that the paging failure occurs.

[0124] In some embodiments, the network entity 102-1 may determine whether the paging failure occurs according to number of responded A-IoT devices during a time window. If the number of responded A-IoT devices is smaller than or equal to a number threshold in a time window (for convenience, also referred to as a second time window herein), the network entity 102-1 may determine that the paging failure occurs. In some embodiments, the number threshold may be varied in different paging causes. In some embodiments, the number threshold may be varied in different service/task IDs. It is to be understood that the number threshold may be predefined or configured in any suitable ways.

[0125] In some embodiments, the network entity 102-1 may determine whether the paging failure occurs according to a ratio of responded A-IoT devices in the set of A-IoT devices during a time window. If the ratio of responded A-IoT devices in the set of A-IoT devices is smaller than or equal to a ratio threshold in a time window (for convenience, also referred to as a third time window herein), the network entity 102-1 may determine that the paging failure occurs. In some embodiments, the ratio threshold may be varied in different paging causes. In some embodiments, the ratio threshold may be varied in different service/task IDs. It is to be understood that the ratio threshold may be predefined or configured in any suitable ways.

[0126] In some embodiments, if response from a subset of A-IoT devices in the set of A-IoT devices is missing, the network entity 102-1 may determine that the paging failure occurs. In some embodiments, the subset of A-IoT devices may comprise one or more specific or important A-IoT devices. For example, the network entity 102-1 may want to paging a specific A-IoT device. If a response from the specific A-IoT device may be missing after a period of time, the network entity 102-1 may determine that the paging failure occurs.

[0127] Continuing to refer to FIG. 3, upon determination that the paging failure occurs, the network entity 102-1 may perform 331 an operation for handling the paging failure.

[0128] In some embodiments, upon determination that the paging failure occurs, the network entity 102-1 may change a transmission of a set of energy carriers for the set of A-IoT devices. In some embodiments, the network entity 102-1 may transmit the energy carrier with increased power or time. In some embodiments, the network entity 102-1 may cause an energy source to transmit the energy carrier with increased power or time. For example, the network entity 102-1 may transmit to the energy source a command for more powerful energy carrier transmission, and the energy source may transmit the energy carrier with increased power or time based on the command. In this way, more power of energy carrier may be provided to an A-IoT device.

[0129] In some embodiments, upon determination that the paging failure occurs, the network entity 102-1 may change a retransmission of the paging message. In some embodiments, the network entity 102-1 may retransmit the paging message with an increased repetition number (i.e., larger repetition number).

[0130] In some embodiments, upon determination that the paging failure occurs, the network entity 102-1 may transmit information of the paging failure to the CN element 103. In some embodiments, the information of the paging failure may comprise a cause of the paging failure. For example, the information of the paging failure may indicate the paging failure is caused by receiving no response from the set of A-IoT devices during the first time window or at the indicted frequency resource. It is to be understood that the cause may be in any other suitable forms.

[0131] In some embodiments, the information of the paging failure may comprise ID information of an A-IoT device indicated in the paging message (i.e., paging ID) in

which the failure occurs. For example, the information of the paging failure may indicate the paging ID for which the network entity 102-1 does not receive a response from an A-IoT device. In some embodiments, the ID information of the A-IoT device may comprise at least one of the following: a device ID, a tag ID, an EPC ID, a group ID, an area ID, or at least a part of data buffered in the A-IoT device.

[0132] In some embodiments, the information of the paging failure may comprise ID information of the network entity 102-1 in which the failure occurs. For example, the information of the paging failure may indicate ID information of a node that does not receive a response from an A-IoT device.

[0133] In some embodiments, the information of the paging failure may comprise ID information of a service or task in which the failure occurs. For example, the information of the paging failure may indicate ID information of a service or a task that does not receive a response from an A-IoT device. In some embodiments, the information of the paging failure may comprise preferred number of a retransmission of the paging message. For example, the information of the paging failure may indicate required number of paging retransmission that changes the paging failure to paging success.

[0134] In some embodiments, upon determination that the paging failure occurs, the network entity 102-1 may update the paging message. In some embodiments, the network entity 102-1 may update the paging message with an increased paging area (i.e., a larger paging area). In some embodiments, the network entity 102-1 may change ID information of the set of A-IoT devices in the paging message. For example, the network entity 102-1 may change at least one of the following: a device ID, a tag ID, an EPC ID, a group ID, an area ID, or at least a part of data buffered in an A-IoT device.

[0135] So far, solutions for a communication with an A-IoT device are described in connection with the process 300. It is to be understood that operations in the process 300 may be carried out separately or in any combinations.

[0136] FIG. 4 illustrates an example of a device 400 that supports a communication with an A-IoT device in accordance with aspects of the present disclosure. The device 400 may be an example of a first device or a second device or a third device as described herein. The device 400 may support wireless communication with one or more network entities 102, UEs 104, the core network element 103, or any combination

thereof. The device 400 may include components for bi-directional communications including components for transmitting and receiving communications, such as a processor 402, a memory 404, a transceiver 406, and, optionally, an I/O controller 408. 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).

[0137] The processor 402, the memory 404, the transceiver 406, 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 402, the memory 404, the transceiver 406, or various combinations or components thereof may support a method for performing one or more of the operations described herein.

[0138] In some implementations, the processor 402, the memory 404, the transceiver 406, 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 402 and the memory 404 coupled with the processor 402 may be configured to perform one or more of the functions described herein (e.g., executing, by the processor 402, instructions stored in the memory 404).

[0139] For example, the processor 402 may support wireless communication at the device 400 in accordance with examples as disclosed herein. In some embodiments where the device 400 is implemented as a first device, the processor 402 may be configured to operable to support a means for: receiving, from a second device, a message for paging a set of first devices comprising the first device; determining that the message indicates a first operation requiring a response from the first device; and in accordance with a determination that the message fulfills a condition of skipping the response, making no response to the message.

[0140] In some embodiments where the device 400 is implemented as a second device, in one aspect, the processor 402 may be configured to operable to support a means for: transmitting a message for paging a set of first devices; receiving a response from a first device in the set of first devices; and transmitting information of the first device to at least one of a further second device or a third device. In another aspect, the processor 402 may be configured to operable to support a means for: transmitting a message for paging a set of first devices; determining that a failure occurs in the paging; and performing an operation comprising at least one of the following: changing a transmission of a set of energy carriers for the set of first devices, changing a retransmission of the message, transmitting information of the failure to a third device, or updating the message.

[0141] The processor 402 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 402 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 402. The processor 402 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 404) to cause the device 400 to perform various functions of the present disclosure.

[0142] The memory 404 may include random access memory (RAM) and read-only memory (ROM). The memory 404 may store computer-readable, computer-executable code including instructions that, when executed by the processor 402 cause the device 400 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 402 but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some implementations, the memory 404 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.

[0143] The I/O controller 408 may manage input and output signals for the device 400. The I/O controller 408 may also manage peripherals not integrated into the device

400. In some implementations, the I/O controller 408 may represent a physical connection or port to an external peripheral. In some implementations, the I/O controller 408 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 408 may be implemented as part of a processor, such as the processor 406. In some implementations, a user may interact with the device 400 via the I/O controller 408 or via hardware components controlled by the I/O controller 408.

[0144] In some implementations, the device 400 may include a single antenna 410. However, in some other implementations, the device 400 may have more than one antenna 410 (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 406 may communicate bi-directionally, via the one or more antennas 410, wired, or wireless links as described herein. For example, the transceiver 406 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 406 may also include a modem to modulate the packets, to provide the modulated packets to one or more antennas 410 for transmission, and to demodulate packets received from the one or more antennas 410. The transceiver 406 may include one or more transmit chains, one or more receive chains, or a combination thereof.

[0145] 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 410 for transmitting the amplified signal into the air or wireless medium.

[0146] 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 410 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.

[0147] FIG. 5 illustrates an example of a processor 500 that supports a communication with an A-IoT device in accordance with aspects of the present disclosure. The processor 500 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 500 may include a controller 502 configured to perform various operations in accordance with examples as described herein. The processor 500 may optionally include at least one memory 504, such as L1/L2/L3 cache. Additionally, or alternatively, the processor 500 may optionally include one or more arithmetic-logic units (ALUs) 506. 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).

[0148] The processor 500 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 500) 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).

[0149] The controller 502 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 500 to cause the processor 500 to support various operations in accordance with examples as described herein. For example, the controller 502 may operate as a control unit of the processor 500, generating control signals that manage the operation of various components of the processor 500. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[0150] The controller 502 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 504 and determine subsequent instruction(s) to be executed to cause the processor 500 to support various operations in accordance with examples as described herein. The controller 502 may be configured to track memory address of instructions associated with the memory 504. The controller 502 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 502 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 500 to cause the processor 500 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 502 may be configured to manage flow of data within the processor 500. The controller 502 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 500.

[0151] The memory 504 may include one or more caches (e.g., memory local to or included in the processor 500 or other memory, such as RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementation, the memory 504 may reside within or on a processor chipset (e.g., local to the processor 500). In some other implementations, the memory 504 may reside external to the processor chipset (e.g., remote to the processor 500).

[0152] The memory 504 may store computer-readable, computer-executable code including instructions that, when executed by the processor 500, cause the processor 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. The controller 502 and/or the processor 500 may be configured to execute computer-readable instructions stored in the memory 504 to cause the processor 500 to

perform various functions. For example, the processor 500 and/or the controller 502 may be coupled with or to the memory 504, and the processor 500, the controller 502, and the memory 504 may be configured to perform various functions described herein. In some examples, the processor 500 may include multiple processors and the memory 504 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.

[0153] The one or more ALUs 506 may be configured to support various operations in accordance with examples as described herein. In some implementation, the one or more ALUs 506 may reside within or on a processor chipset (e.g., the processor 500). In some other implementations, the one or more ALUs 506 may reside external to the processor chipset (e.g., the processor 500). One or more ALUs 506 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 506 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 506 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 506 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 506 to handle conditional operations, comparisons, and bitwise operations.

[0154] The processor 500 may support wireless communication in accordance with examples as disclosed herein. In some embodiments where the processor 500 is implemented at a first device, the processor 500 may be configured to or operable to support a means for: receiving, from a second device, a message for paging a set of first devices comprising the first device; determining that the message indicates a first operation requiring a response from the first device; and in accordance with a determination that the message fulfills a condition of skipping the response, making no response to the message.

[0155] In some embodiments where the processor 500 is implemented at a second device, in one aspect, the processor 500 may be configured to or operable to support a means for: transmitting a message for paging a set of first devices; receiving a response

from a first device in the set of first devices; and transmitting information of the first device to at least one of a further second device or a third device. In another aspect, the processor 500 may be configured to operable to support a means for: transmitting a message for paging a set of first devices; determining that a failure occurs in the paging; and performing an operation comprising at least one of the following: changing a transmission of a set of energy carriers for the set of first devices, changing a retransmission of the message, transmitting information of the failure to a third device, or updating the message.

[0156] FIG. 6 illustrates a flowchart of a method 600 that supports a communication with an A-IoT device in accordance with aspects of the present disclosure. The operations of the method 600 may be implemented by a device or its components as described herein. For example, the operations of the method 600 may be performed by a first device as described herein. In some implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or alternatively, the device may perform aspects of the described functions using special-purpose hardware.

[0157] At block 610, the method 600 may comprise receiving, at a first device and from a second device, a message for paging a set of first devices comprising the first device. In this case, identity information of the first device matches one of identity information of the set of first devices. The operations of 610 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 610 may be performed by a device as described with reference to FIG. 1.

[0158] At block 620, the method 600 may comprise determining that the message indicates a first operation requiring a response from the first device. The operations of 620 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 620 may be performed by a device as described with reference to FIG. 1.

[0159] At block 630, the method 600 may comprise making no response to the message if the message fulfills a condition of skipping the response. The operations of 630 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 630 may be performed by a device as described with reference to FIG. 1.

[0160] In some embodiments, the method 600 may further comprise initiating a random access to the second device if the message does not fulfill the condition. In some embodiments, the method 600 may further comprise performing the second operation if the message indicates a second operation requiring no response from the first device. In some embodiments, the method 600 may further comprise performing no operation if the identity information of the set of first devices mismatches the identity information of the first device.

[0161] In some embodiments, the condition may comprise at least one of the following: the message is the same as a further message that has been responded to; an indication of ending the response is received; a status of the first device indicates that the first operation has been performed; identity information of the second device is the same as identity information of a further second device transmitting the further message; the second device is in a list of responded second devices; the message is not firstly received from the second device; the message is not a firstly responded message; or an ongoing service or task is unfinished.

[0162] In some embodiments, the indication of ending the response may be associated with at least one of the following: identity information of the first device indicated in the message, a cause indicated in the message, the identity information of the second device, or identity information of a service or task indicated in the message. In some embodiments, the identity information of the first device may comprise at least one of the following: a device identity of the first device; a tag identity of the first device; an EPC identity of the first device; a group identity of the first device; an area identity of the first device; or at least a part of data buffered in the first device. In some embodiments, validity of the indication of ending the response may be associated with at least one of the following: a time duration, number of paging for the first device, or energy of the first device.

[0163] In some embodiments, the method 600 may further comprise receiving, from the second device, a command for changing the status of the first device. In some embodiments, the method 600 may further comprise changing the status of the first device to indicate that the first operation is successfully performed if the first operation is successfully performed.

[0164] In some embodiments, the list of responded second devices may be comprised in the message.

[0165] FIG. 7 illustrates a flowchart of another method 700 that supports a communication with an A-IoT device 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 a second device as described herein. In some implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or alternatively, the device may perform aspects of the described functions using special-purpose hardware.

[0166] At block 710, the method 700 may comprise transmitting a message for paging a set of first 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 a device as described with reference to FIG. 1.

[0167] At block 720, the method 700 may comprise receiving a response from a first device in the set of first 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 a device as described with reference to FIG. 1.

[0168] At block 730, the method 700 may comprise transmitting information of the first device to at least one of a further second device or a third device. The operations of 730 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 730 may be performed by a device as described with reference to FIG. 1.

[0169] In some embodiments, the information of the first device may comprise at least one of the following: identity information of the first device, a status of the first device, or identity information of the second device receiving the response from the first device. In some embodiments, the identity information of the first device may comprise at least one of the following: a device identity of the first device; a tag identity of the first device; an EPC identity of the first device; a group identity of the first device; an area identity of the first device; or at least a part of data buffered in the first device.

[0170] In some embodiments, the method 700 may further comprise receiving, from the third device, a further message for paging a further set of first devices, the further message comprising a list of responded second devices.

[0171] In some embodiments, the first device may be an A-IoT device, the second device may be a base station or a communication node between the base station and the A-IoT device, and the third device may be a CN element.

[0172] FIG. 8 illustrates a flowchart of another method 800 that supports a communication with an A-IoT device 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 a second device as described herein. In some implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or alternatively, the device may perform aspects of the described functions using special-purpose hardware.

[0173] At block 810, the method 800 may comprise transmitting a message for paging a set of first 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 a device as described with reference to FIG. 1.

[0174] At block 820, the method 800 may comprise determining that a failure occurs in the paging. 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 a device as described with reference to FIG. 1.

[0175] In some embodiments, determining that the failure occurs may comprise: determining that the failure occurs based on at least one of the following: no response from the set of first devices is received during a first time window; no response from the set of first devices is received at a resource; number of responded first devices is smaller than or equal to a number threshold in a second time window; a ratio of responded first devices in the set of first devices is smaller than or equal to a ratio threshold in a third time window; or response from a subset of first devices in the set of first devices is missing.

[0176] At block 830, the method 800 may comprise performing an operation comprising at least one of the following: changing a transmission of a set of energy carriers for the set of first devices, changing a retransmission of the message, transmitting information of the failure to a third device, or updating the message. 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 a device as described with reference to FIG. 1.

[0177] In some embodiments, changing the transmission of the energy carrier may comprise: transmitting the energy carrier with increased power or time; or causing an energy source to transmit the energy carrier with increased power or time.

[0178] In some embodiments, changing the retransmission of the message may comprise: retransmitting the message with an increased repetition number.

[0179] In some embodiments, the information of the failure may comprise at least one of the following: a cause of the failure; identity information of a first device indicated in the message, the failure occurring in a paging for the first device; identity information of the second device in which the failure occurs; identity information of a service or task in which the failure occurs; or preferred number of a retransmission of the message. In some embodiments, the identity information of the first device may comprise at least one of the following: a device identity of the first device; a tag identity of the first device; an EPC identity of the first device; a group identity of the first device; an area identity of the first device; or at least a part of data buffered in the first device.

[0180] In some embodiments, updating the message may comprise at least one of the following: updating the message with an increased paging area; or changing identity information of the set of first devices in the message.

[0181] In some embodiments, the first device may be an A-IoT device, the second device may be a base station or a communication node between the base station and the A-IoT device, and the third device may be a CN element.

[0182] It is to be understood that the operations of the methods 600 to 800 correspond to that described in connection with FIG. 3, and thus other details are not repeated here for conciseness.

[0183] 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.

[0184] 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.

[0185] 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.

[0186] 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.

[0187] 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.

[0188] 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 first device, comprising:
 - a processor; and
 - a transceiver coupled to the processor,wherein the processor is configured to:
 - receive, from a second device via the transceiver, a message for paging a set of first devices comprising the first device;
 - determine that the message indicates a first operation requiring a response from the first device; and
 - in accordance with a determination that the message fulfills a condition of skipping the response, make no response to the message.
2. The first device of claim 1, wherein the processor is further configured to at least one of the following:
 - in accordance with a determination the message does not fulfill the condition, initiate, via the transceiver, a random access to the second device; or
 - in accordance with a determination that the message indicates a second operation requiring no response from the first device, perform the second operation.
3. The first device of claim 1, wherein the condition comprises at least one of the following:
 - the message is the same as a further message that has been responded to;
 - an indication of ending the response is received;
 - a status of the first device indicates that the first operation has been performed;
 - identity information of the second device is the same as identity information of a further second device transmitting the further message;
 - the second device is in a list of responded second devices;
 - the message is not firstly received from the second device;
 - the message is not a firstly responded message; or
 - an ongoing service or task is unfinished.

4. The first device of claim 3, wherein the indication of ending the response is associated with at least one of the following:

- identity information of the first device indicated in the message,
- a cause indicated in the message,
- the identity information of the second device, or
- identity information of a service or task indicated in the message.

5. The first device of claim 4, wherein the identity information of the first device comprises at least one of the following:

- a device identity of the first device;
- a tag identity of the first device;
- an electronic product code (EPC) identity of the first device;
- a group identity of the first device;
- an area identity of the first device; or
- at least a part of data buffered in the first device.

6. The first device of claim 3, wherein validity of the indication of ending the response is associated with at least one of the following:

- a time duration,
- number of paging for the first device, or
- energy of the first device.

7. The first device of claim 3, wherein the processor is further configured to:
receive, from the second device, a command for changing the status of the first device; or

in accordance with a determination that the first operation is successfully performed, change the status of the first device to indicate that the first operation is successfully performed.

8. The first device of claim 3, wherein the list of responded second devices is comprised in the message.

9. A second device, comprising:

a processor; and
a transceiver coupled to the processor,
wherein the processor is configured to:
transmit, via the transceiver, a message for paging a set of first devices;
receive, via the transceiver, a response from a first device in the set of first devices; and
transmit, via the transceiver, information of the first device to at least one of a further second device or a third device.

10. The second device of claim 9, wherein the processor is further configured to:
receive, from the third device via the transceiver, a further message for paging a further set of first devices, the further message comprising a list of responded second devices.

11. The second device of claim 9, wherein the information of the first device comprises at least one of the following:
identity information of the first device,
a status of the first device, or
identity information of the second device receiving the response from the first device.

12. A second device, comprising:
a processor; and
a transceiver coupled to the processor,
wherein the processor is configured to:
transmit, via the transceiver, a message for paging a set of first devices;
determine that a failure occurs in the paging; and
perform an operation comprising at least one of the following:
changing a transmission of a set of energy carriers for the set of first devices,
changing a retransmission of the message,
transmitting information of the failure to a third device, or
updating the message.

13. The second device of claim 12, wherein the processor is configured to determine that the failure occurs by:

determining that the failure occurs based on at least one of the following:

no response from the set of first devices is received during a first time window;

no response from the set of first devices is received at a resource;

number of responded first devices is smaller than or equal to a number threshold in a second time window;

a ratio of responded first devices in the set of first devices is smaller than or equal to a ratio threshold in a third time window; or

response from a subset of first devices in the set of first devices is missing.

14. The second device of claim 12, wherein the processor is configured to change the transmission of the energy carrier by:

transmitting the energy carrier with increased power or time; or

causing an energy source to transmit the energy carrier with increased power or time.

15. The second device of claim 12, wherein the processor is configured to change the retransmission of the message by:

retransmitting the message with an increased repetition number.

16. The second device of claim 12, wherein the information of the failure comprises at least one of the following:

a cause of the failure;

identity information of a first device indicated in the message, the failure occurring in a paging for the first device;

identity information of the second device in which the failure occurs;

identity information of a service or task in which the failure occurs; or

preferred number of a retransmission of the message.

17. The second device of claim 11 or 16, wherein the identity information of the first device comprises at least one of the following:

a device identity of the first device;

- a tag identity of the first device;
- an electronic product code (EPC) identity of the first device;
- a group identity of the first device;
- an area identity of the first device; or
- at least a part of data buffered in the first device.

18. The second device of claim 12, wherein the processor is configured to update the message by at least one of the following:

- updating the message with an increased paging area; or
- changing identity information of the set of first devices in the message.

19. The second device of claim 9 or 12, wherein the first device is an ambient Internet of things (A-IoT) device, the second device is a base station or a communication node between the base station and the A-IoT device, and the third device is a core network element.

20. A processor for wireless communication, comprising:

- at least one memory; and

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

- receive, from a second device, a message for paging a set of first devices comprising the first device;

- determine that the message indicates a first operation requiring a response from the first device; and

- in accordance with a determination that the message fulfills a condition of skipping the response, make no response to the message.