

PAGING MESSAGES FOR DEVICES

[0001] The present disclosure relates to wireless communications, and more specifically to paging messages for devices, for example, ambient Internet of Things (IoT) devices.

BACKGROUND

[0002] A wireless communications system may include one or multiple network communication devices, such as base stations (BSs), 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] In recent years, Internet of things (IoT) has attracted much attention in the wireless communication world. More “things” are expected to be interconnected for improving productivity efficiency and increasing comforts of life. Further reduction of size, complexity, and power consumption of IoT devices can enable the deployment of tens or even hundreds of billions of IoT devices for various applications and provide added value across the entire value chain. However, it is impossible to power all the IoT devices by battery that needs to be replaced or recharged manually. Thus there are still some issues associated with communication devices, such as ambient IoT (A-IoT) devices, to be addressed.

SUMMARY

[0004] The present disclosure relates to methods, apparatuses, and systems that support paging messages for devices, for example, ambient Internet of Things (IoT) devices.

[0005] Some implementations of the method and devices described herein include, receiving, a paging message from a second device, wherein the paging message is associated with first information and includes second information, and wherein the first information identifies at least one device and the second information indicates at least one paging cause; and in the case that the first information identifies the first device, performing at least one operation based on the second information. In this way, the content of paging message is re-designed and optimized for devices, such as, ambient IoT devices, thereby enabling paging procedure for the ambient IoT devices and improving efficiency of paging procedures for these devices.

[0006] In some implementations of the method and devices described herein, the first information may comprise one of the following: a paging identifier (ID) identifying the at least one device; a status indication identifying the at least one device having the same status; or the paging ID and the status indication combined for identifying the at least one device.

[0007] In some implementations of the method and devices described herein, the first information may be included in at least one of the paging message or a paging control signalling for the paging message.

[0008] In some implementations of the method and devices described herein, the paging control signalling may comprise: a group indication indicating the at least one device as a group; or a subgroup indication indicating the at least one device as a subgroup of a group.

[0009] In some implementations of the method and devices described herein, the paging ID may identify a device, and wherein the paging ID may comprise one of the following: a tag ID of the device; an electronic product code (EPC) ID associated with the device; a combination of at least part of the tag ID and the EPC ID; or at least part of data stored in an area in the device.

[0010] In some implementations of the method and devices described herein, the paging ID may identify a plurality of devices, and wherein the paging ID may comprise

one of the following: a common part of tag IDs of the plurality of devices; a common part of EPC IDs of the plurality of devices; a common part of data stored in areas in the plurality of devices; a class ID or a family ID identifying the plurality of devices or a plurality of products associated with the plurality of devices; an ID identifying an area or a shelf of the plurality of devices.

[0011] In some implementations of the method and devices described herein, the paging ID may be included in the paging control signalling, and some implementations of the method and devices described herein may further include receiving, the paging control signalling from the second device; and based on the paging ID mapping with an ID of the first device, receiving or decoding the paging message.

[0012] In some implementations of the method and devices described herein, the group indication or the subgroup indication may comprise one or more of the following: a part of the paging ID; the status indication; an ID of a network device associated with a group or a subgroup of devices, wherein the network device is the second device or a further device transmitting the paging message to the second device; a group number or a subgroup number; area ID of a group or a subgroup of devices; or a group ID and associated status indication.

[0013] In some implementations of the method and devices described herein, the group indication or the subgroup indication may be determined based on at least one criterion of a group or a subgroup configured by a third device, and wherein: the at least one criterion is valid until at least one updated criterion is received or the first device is powered off; or the group indication or the subgroup indication is valid until an updated group indication or an updated subgroup indication is received or the first device is powered off.

[0014] In some implementations of the method and devices described herein, the at least one criterion may comprise: an ID of a network device associated with a group or a subgroup of devices, wherein the network device is the second device or a further device transmitting the paging message to the second device; or an area ID of a group or a subgroup of devices.

[0015] Some implementations of the method and devices described herein, may include one of the following: the paging ID may be included in the paging control signalling and may indicate a device or a group of devices; the paging ID may be included

in the paging message and may indicate a device or a group of devices; or a first part of the paging ID may be included in the paging control signalling and may indicate a group of devices, and a second part of the paging ID may be included in the paging message and may indicate a device or a subgroup of devices among the group of devices.

[0016] Some implementations of the method and devices described herein may further include comparing the group indication or the subgroup indication with a stored group or subgroup indication; and based on the comparison, receiving or decoding a subsequent paging message.

[0017] Some implementations of the method and devices described herein may further include, based on a change of status of the first device, receiving an updated group ID of the first device; or based on a change of the status of the first device, updating the group ID of the first device with a mapping rule of the status indication and the group ID.

[0018] Some implementations of the method and devices described herein may further include receiving, via the second device, the mapping rule configured or preconfigured by a third device.

[0019] Some implementations of the method and devices described herein may further include receiving, from the second device, a paging control signalling for the paging message, and wherein the paging control signalling may comprises at least one of the following: a resource indication indicating a resource for receiving the paging message; or a paging indication indicating a message type of the paging message.

[0020] Some implementations of the method and devices described herein may further include storing or predefining a paging indication prior to receiving the paging message; comparing the stored or predefined paging indication with a paging indication scrambled with a paging control signalling for the paging message; and based on the comparison, receiving the paging message.

[0021] In some implementations of the method and devices described herein, the paging message may further comprise a paging indication indicating a message type of the paging message.

[0022] In some implementations of the method and devices described herein, the second information may comprise one of the following: a first paging cause associated with inventory, wherein the first paging cause indicates that an inventory status of the at

least one device is to be changed, or an ID of the at least one device is to be reported; a second paging cause associated with at least one sensor, wherein the second paging cause indicates that sensor data stored in the at least one device is to be transmitted; a third paging cause associated with positioning, wherein the third paging cause indicates that a positioning request is to be responded; or a fourth paging cause associated with at least one command, wherein the fourth paging cause indicates that at least one action in response to the at least one command is to be performed.

[0023] In some implementations of the method and devices described herein, the second information may comprises one of the following: a fifth paging cause associated with a response, wherein the fifth paging cause indicates that required information is to be responded to the second device; a sixth paging cause associated with at least one action without a response, wherein the sixth paging cause indicates that the at least one action is to be performed but no response to the second device; or a seventh paging cause associated with at least one action with a response, wherein the seventh paging cause indicates that the at least one action is to be performed and a response associated with at least one action is to be responded to the second device.

[0024] In some implementations of the method and devices described herein, the second information may comprise one of the following: an eighth paging cause associated with a reading operation, wherein the eighth paging cause indicates that required data in an area of the at least one device is to be transmitted to the second device; a ninth paging cause associated with a writing operation, wherein the ninth paging cause indicates that data from the second device is to be written into an area of the at least one device; or a tenth paging cause associated with an erasing operation, wherein the tenth paging cause indicates that data stored in an area of the at least one device is to be deleted.

[0025] In some implementations of the method and devices described herein, the tenth paging cause may further indicate that a response associated with the erasing operation is to be responded to the second device.

[0026] In some implementations of the method and devices described herein, the paging message may further comprise a response resource, wherein the response resource may indicate a resource for transmitting, to the second device, at least one of a first message or a subsequent response after the first message.

[0027] In some implementations of the method and devices described herein, the response resource may be associated with one of a paging cause, a paging ID or a paging area; or the response resource may be common to a plurality of paging causes, paging IDs or paging areas.

[0028] In some implementations of the method and devices described herein, the paging message may further comprise assistance information, wherein the assistance information may indicate the one or more of the following: an ID of a paging network device, wherein the paging network device is the second device or a further device transmitting the paging message to the second device; a resource for receiving a second message from the paging network device; configuration associated access control for accessing the paging network device; or a time window or response time for transmitting a response to the paging network device.

[0029] In some implementations of the method and devices described herein, the assistance information may be associated with one of a paging cause, a paging ID or a paging area; or the assistance information may be common to a plurality of paging causes, paging IDs or paging areas.

[0030] Some implementations of the method and devices described herein include, transmitting, a paging message to at least one device, wherein the paging message is associated with first information and includes second information, wherein the first information identifies the at least one device and the second information indicates at least one paging cause. In this way, the content of paging message is re-designed and optimized for devices, such as, ambient IoT devices, thereby enabling paging procedure for the ambient IoT devices and improving efficiency of paging procedures for these devices.

[0031] In some implementations of the method and devices described herein, the first information may comprise one of the following: a paging identifier (ID) identifying the at least one device; a status indication identifying the at least one device having the same status; or the paging ID and the status indication combined for identifying the at least one device.

[0032] In some implementations of the method and devices described herein, the first information may be included in the paging message or a paging control signalling for the paging message.

[0033] In some implementations of the method and devices described herein, the paging control signalling may comprise: a group indication indicating the at least one device as a group; or a subgroup indication indicating the at least one device as a subgroup of a group.

[0034] In some implementations of the method and devices described herein, the paging ID may identify a device, and wherein the paging ID may comprise one of the following: a tag ID of the device; an electronic product code (EPC) ID associated with the device; a combination of at least part of the tag ID and the EPC ID; or at least part of data stored in an area in the device.

[0035] In some implementations of the method and devices described herein, the paging ID may identify a plurality of devices, and wherein the paging ID may comprise one of the following: a common part of tag IDs of the plurality of devices; a common part of EPC IDs of the plurality of devices; a common part of data stored in areas in the plurality of devices; a class ID or a family ID identifying the plurality of devices or a plurality of products associated with the plurality of devices; an ID identifying an area or a shelf of the plurality of devices.

[0036] In some implementations of the method and devices described herein, the group indication or the subgroup indication may comprise one or more of the following: a part of the paging ID; the status indication; an ID of a network device associated with a group or a subgroup of devices, wherein the network device is the second device or a further device transmitting the paging message to the second device; a group number or a subgroup number; area ID of a group or a subgroup of devices; or a group ID and associated status indication.

[0037] In some implementations of the method and devices described herein, the group indication or the subgroup indication may be determined based on at least one criterion of a group or a subgroup configured by a third device, and some implementations of the method and devices described herein may further include receiving, the at least one criterion from the third device; and transmitting, the at least one criterion to a first device.

[0038] In some implementations of the method and devices described herein, the at least one criterion may comprise: an ID of a network device associated with a group or a subgroup of devices, wherein the network device is the second device or a further device

transmitting the paging message to the second device; or an area ID of a group or a subgroup of devices.

[0039] In some implementations of the method and devices described herein, wherein one of the following: the paging ID is included in the paging control signalling and indicates a device or a group of devices; the paging ID is included in the paging message and indicates a device or a group of devices; or a first part of the paging ID is included in the paging control signalling and indicates a group of devices, and a second part of the paging ID is included in the paging message and indicates a device or a subgroup of devices among the group of devices.

[0040] Some implementations of the method and devices described herein may further include, based on a change of status of a first device, transmitting, to the first device, one of the following: an updated group ID of the first device; or a mapping rule of the status information and the group ID.

[0041] Some implementations of the method and devices described herein may further include receiving, the mapping rule from a third device; and transmitting, the mapping rule to a first device.

[0042] Some implementations of the method and devices described herein may further include transmitting, to the first device, a paging control signalling for the paging message, and wherein the paging control signalling may comprise at least one of the following: a resource indication indicating a resource for receiving the paging message; or a paging indication indicating a message type of the paging message.

[0043] In some implementations of the method and devices described herein, the paging message may further comprise a paging indication indicating a message type of the paging message.

[0044] In some implementations of the method and devices described herein, the second information may comprise one of the following: a first paging cause associated with inventory, wherein the first paging cause indicates that an inventory status of the at least one device is to be changed, or an ID of the at least one device is to be reported; a second paging cause associated with at least one sensor, wherein the second paging cause indicates that sensor data stored in the at least one device is to be transmitted; a third paging cause associated with positioning, wherein the third paging cause indicates that a

positioning request is to be responded; or a fourth paging cause associated with at least one command, wherein the fourth paging cause indicates that at least one action in response to the at least one command is to be performed.

[0045] In some implementations of the method and devices described herein, the second information may comprise one of the following: a fifth paging cause associated with a response, wherein the fifth paging cause indicates that required information is to be responded to the second device; a sixth paging cause associated with at least one action without a response, wherein the sixth paging cause indicates that the at least one action is to be performed but no response to the second device; or a seventh paging cause associated with at least one action with a response, wherein the seventh paging cause indicates that the at least one action is to be performed and a response associated with at least one action is to be responded to the second device.

[0046] In some implementations of the method and devices described herein, the second information may comprise one of the following: an eighth paging cause associated with a reading operation, wherein the eighth paging cause indicates that required data in an area of the at least one device is to be transmitted to the second device; a ninth paging cause associated with a writing operation, wherein the ninth paging cause indicates that data from the second device is to be written into an area of the at least one device; or a tenth paging cause associated with an erasing operation, wherein the tenth paging cause indicates that data stored in an area of the at least one device is to be deleted.

[0047] In some implementations of the method and devices described herein, the tenth paging cause may further indicate that a response associated with the erasing operation is to be responded to the second device.

[0048] In some implementations of the method and devices described herein, the paging message may further comprise a response resource, wherein the response resource may indicate a resource for transmitting, to the second device, at least one of a first message or a subsequent response after the first message.

[0049] In some implementations of the method and devices described herein, the response resource may be associated with one of a paging cause, a paging ID or a paging area; or the response resource may be common to a plurality of paging causes, paging IDs or paging areas.

[0050] In some implementations of the method and devices described herein, the paging message may further comprise assistance information, wherein the assistance information may indicate the one or more of the following: an ID of a paging network device, wherein the paging network device is the second device or a further device transmitting the paging message to the second device; a resource for receiving a second message from the paging network device; configuration associated access control for accessing the paging network device; or a time window or response time for transmitting a response to the paging network device.

[0051] In some implementations of the method and devices described herein, the assistance information may be associated with one of a paging cause, a paging ID or a paging area; or the assistance information may be common to a plurality of paging causes, paging IDs or paging areas.

[0052] Some implementations of the method and devices described herein may further include determining at least one criterion of the group or the subgroup for assigning at least one first device to a group or a subgroup; and transmitting, to a second device, the at least one criterion and the assignment of the at least one first device to the group or the subgroup. In this way, network-controlled (sub)group indication may be implemented.

BRIEF DESCRIPTION OF THE DRAWINGS

[0053] FIG. 1A illustrates an example of a wireless communications system that supports paging message for ambient Internet of Things (IoT) in accordance with aspects of the present disclosure.

[0054] FIG. 1B illustrates an example of topology 1 associated with aspects of the present disclosure.

[0055] FIG. 1C illustrates an example of topology 2 associated with aspects of the present disclosure.

[0056] FIG. 2 illustrates an example signalling diagram illustrating an example process that supports paging messages for devices, such as A-IoT devices, in accordance with aspects of the present disclosure.

[0057] FIG. 3 illustrates an example signalling diagram illustrating an example of network-controlled (sub)group indication in accordance with aspects of the present disclosure.

[0058] FIG. 4 illustrates an example of a device that support paging messages for devices, such as A-IoT devices, in accordance with aspects of the present disclosure.

[0059] FIG. 5 illustrates an example of a processor that support paging messages for devices, such as A-IoT devices, in accordance with aspects of the present disclosure.

[0060] FIG. 6 illustrates a flowchart of a method that supports paging messages for devices, such as A-IoT devices, in accordance with aspects of the present disclosure.

[0061] FIG. 7 illustrates a flowchart of a method that supports paging messages for devices, such as A-IoT devices, in accordance with aspects of the present disclosure.

[0062] FIG. 8 illustrates a flowchart of a method that supports paging messages for devices, such as A-IoT devices, in accordance with aspects of the present disclosure.

DETAILED DESCRIPTION

[0063] Principles of the present disclosure will now be described with reference to some embodiments. It is to be understood that these embodiments are described 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.

[0064] 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.

[0065] 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.

[0066] 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 used to distinguish one element from another element. For example, a first element could also be termed as a second element, and similarly, a second element could also be termed as a first element, without departing from the scope of embodiments. As used herein, the term “and/or” includes any and all combinations of one or more of the listed terms.

[0067] The terminology used herein is for the purpose of describing particular embodiments and is not intended to be limiting of example embodiments. As used herein, the singular forms “a”, “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises”, “comprising”, “has”, “having”, “includes” and/or “including”, when used herein, specify the presence of stated features, elements, and/or components etc., but do not preclude the presence or addition of one or more other features, elements, components and/or combinations thereof.

[0068] As used herein, the term “communication network” refers to a network following any suitable communication standards, such as, 5G new radio (NR), Long Term Evolution (LTE), LTE-Advanced (LTE-A), Wideband Code Division Multiple Access (WCDMA), High-Speed Packet Access (HSPA), Narrow Band Internet of Things (NB-IoT), and so on. Further, the communications between a user equipment and a network device in the communication network may be performed according to any suitable generation communication protocols, including but not limited to, the first generation (1G), the second generation (2G), 2.5G, 2.75G, the third generation (3G), the fourth generation (4G), 4.5G, the fifth generation (5G) communication protocols, and/or any other protocols either currently known or to be developed in the future. Embodiments of the present disclosure may be applied in various communication systems. Given the rapid development in communications, there will also be future type communication technologies and systems in which the present disclosure may be embodied. It should not be seen as limiting the scope of the present disclosure to only the aforementioned systems.

[0069] As used herein, the term “network device” generally refers to a node in a communication network via which a user equipment can access the communication network and receive services therefrom. The network device may refer to a base station (BS) or an access point (AP), for example, a node B (NodeB or NB), a radio access network (RAN) node, an evolved NodeB (eNodeB or eNB), a NR NB (also referred to as a gNB), a Remote Radio Unit (RRU), a radio header (RH), an infrastructure device for a V2X (vehicle-to-everything) communication, a transmission and reception point (TRP), a reception point (RP), a remote radio head (RRH), a relay, an integrated access and backhaul (IAB) node, a low power node such as a femto base station (BS), a pico BS, and so forth, depending on the applied terminology and technology. The network device may further refer to a network function (NF) in the core network, for example, a SMF, an AMF, a PCF, a UPF or devices with same function in future network architectures, and so forth.

[0070] As used herein, the term “user equipment (UE)” generally refers to any end device that may be capable of wireless communications. By way of example rather than a limitation, a user equipment may also be referred to as a communication device, a terminal device, an end user device, a subscriber station (SS), an unmanned aerial vehicle (UAV), a portable subscriber station, a mobile station (MS), or an access terminal (AT). The user equipment may include, but is not limited to, a mobile phone, a cellular phone, a smart phone, a voice over IP (VoIP) phone, a wireless local loop phone, a tablet, a wearable user equipment, a personal digital assistant (PDA), a portable computer, a desktop computer, an image capture user equipment such as a digital camera, a gaming user equipment, a music storage and playback appliance, a vehicle-mounted wireless user equipment, a wireless endpoint, a mobile station, laptop-embedded equipment (LEE), laptop-mounted equipment (LME), a USB dongle, a smart device, wireless customer-premises equipment (CPE), an Internet of Things (IoT) device, a watch or other wearable, a head-mounted display (HMD), a vehicle, a drone, a medical device (for example, a remote surgery device), an industrial device (for example, a robot and/or other wireless devices operating in an industrial and/or an automated processing chain contexts), a consumer electronics device, a device operating on commercial and/or industrial wireless networks, and the like. In the following description, the terms: “user equipment,” “communication device,” “terminal,” “user equipment” and “UE,” may be used interchangeably.

[0071] As used herein, the term “ambient IoT (A-IoT) device” refers to a device without batteries or with limited energy storage capabilities. For the A-IoT device, energy is provided by harvesting radio waves, light, motion, heat, or any other suitable source. A-IoT device can also be called zero-power terminals, near-zero power terminals, passive IoT device, ambient backscatter communication (AmBC) device, tag, etc. Compared with low-power and wide-coverage services, such as narrow band (NB) IoT, enhance machine type communication (eMTC), A-IoT has lower complexity and lower power consumption, and is suitable for more application scenarios.

[0072] Aspects of the present disclosure are described in the context of a wireless communications system.

[0073] FIG. 1A illustrates an example of a wireless communications system (or referred to as communication network) 100 that supports carrier wave node determination in accordance with aspects of the present disclosure. The wireless communications system 100 may include one or more network entities 102 (also referred to as network equipment), one or more UEs 104, a core network 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.

[0074] 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 signalling, transmit signalling) over a communication interface.

[0075] 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.

[0076] 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.

[0077] 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. 1A. 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 integrated access and backhaul (IAB) node, or another network equipment), as shown in FIG. 1A. 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.

[0078] 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 communication interface.

[0079] 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).

[0080] In some implementations, a network entity 102 may be configured in a disaggregated architecture, which may be configured to utilize a protocol stack physically or logically distributed among two or more network entities 102, such as an integrated access backhaul (IAB) network, an open Radio Access Network (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.

[0081] 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)).

[0082] 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 signalling (e.g., 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, MAC layer) functionality and signalling, and may each be at least partially controlled by the CU.

[0083] 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).

[0084] 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.

[0085] 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 (EPC), or a 5G core (5GC), which may include a control plane entity that manages access and mobility (e.g., a mobility management entity (MME), an access and mobility management functions (AMF)) and a user plane entity that routes packets or interconnects to external networks (e.g., a serving gateway (S-GW), a Packet Data Network (PDN) gateway (P-GW), or a user plane function (UPF)). In some implementations, the control plane entity may manage non-access stratum (NAS) functions, such as mobility, authentication, and bearer management (e.g., data bearers, signal bearers, etc.) for the one or more UEs 104 served by the one or more network entities 102 associated with the core network 106.

[0086] 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).

[0087] 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.

[0088] 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.

[0089] 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.

[0090] 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.

[0091] 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.

[0092] 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.

[0093] In A-IoT, paging procedures could be used to require the action and/or response from the specific device(s). Unlike legacy system, there may be no serving cell/gNB and system information in A-IoT, as it is challenging for A-IoT devices to monitor/measure the reference signal from neighboring cells actively and all the time, subject to their limited energy and weak capability. Therefore, A-IoT paging needs to be studied considering the passiveness, weakness and energy limitation of the devices. In light of the difference between a legacy system (e.g., NR system, LTE system) and an A-IoT system, the content of paging message may need to be re-designed or optimized.

[0094] According to RAN#102 study item description (SID), the study item targets a further assessment at RAN Working Group (WG)-level of ambient IoT, a new 3rd Generation Partnership Project (3GPP) IoT technology, suitable for deployment in a 3GPP system, which relies on ultra-low complexity devices with ultra-low power consumption for the very-low end IoT applications. The study shall provide clear differentiation, i.e. addressing use cases and scenarios that cannot otherwise be fulfilled based on existing 3GPP LPWA IoT technology, e.g., NB-IoT including with reduced peak Tx power. The definitions provided in TR 38.848 are taken into this study item (SI), and the following are the exclusive general scope, including aspects A to E as below:

[0095] Aspect A: The overall objective shall be to study a harmonized air interface design with minimized differences (where necessary) for ambient IoT to enable the following devices: i) The device has a peak power consumption approximately 1 μ W, and has energy storage, initial sampling frequency offset (SFO) up to 10^X ppm, neither downlink (DL) nor uplink (UL) amplification in the device. The UL transmission of the device is backscattered on a carrier wave provided externally. ii) The device has a peak power consumption of no more than a few hundred μ W, and has energy storage, initial sampling frequency offset (SFO) up to 10^X ppm, both DL and/or UL amplification in the device. The UL transmission of the device may be generated internally by the device, or be backscattered on a carrier wave provided externally. X is to be decided in WGs. It is

to be understood that “no more than a few hundred μW ” means WGs are not tasked with setting a particular value, and that it will be for WG discussions to determine if a presented design with corresponding power consumption satisfies the “no more than a few hundred μW ” requirement. A coverage design target is maximum distance of 10-50 m with device indoors as per TR 38.848: “...a range that WGs can sub-select within”. For Topologies 1 & 2 (UE as intermediate node under NW control) per TR 38.848, with no RRC states, no mobility (i.e. at least no cell selection/re-selection -like function), no HARQ, no ARQ.

[0096] Aspect B: Deployment Scenarios with the following characteristics, referenced to the tables in Clause 4.2.2 of TR 38.848. Deployment scenario 1 with topology 1: base station and coexistence characteristics: Micro-cell, co-site. Deployment scenario 2 with Topology 2 and UE as intermediate node, under network control: base station and coexistence characteristics: Macro-cell, co-site; and the location of intermediate node is indoor. Aspect C: FR1 licensed spectrum in FDD. Aspect D: Spectrum deployment in-band to NR, in guard-band to LTE/NR, in standalone band(s). Aspects E: Traffic types DO-DTT, DT, with focus on rUC1 (indoor inventory) and rUC4 (indoor command).

[0097] From RAN#104, the study will assess whether the harmonized air interface design (per aspect ‘A’ above) can address the DO-A (Device-originated autonomous) use case, only to identify which part(s) of the harmonized air interface design (per aspect ‘A’ above) is/are not sufficient for the DO-A use case.

[0098] Transmission from ambient IoT device (including backscattering when used) can occur at least in UL spectrum.

[0099] RAN2-led, studying and deciding which functions are needed for an ambient IoT compact protocol stack and lightweight signalling procedure to enable DO-DTT and DT data transmission, and study those functions. For example, paging, random access, data transmission (including necessary radio resource control aspects, respecting the limitation in the general scope), interactions with upper layers. For functionalities not listed above, they are studied if found essential.

[0100] According to RAN 38.348, study on ambient IoT (Internet of Things) in RAN involve to some representative use cases, specifically, two sets or levels of grouping were defined. The first, Grouping A, is on the basis of the deployment environment(s)

described for a use case in TR 22.840, and the second, Grouping B, is on the basis of functionality/application described in TR 22.840. For example, Grouping A: indoor, outdoor, or indoor/outdoor. Grouping B: inventory, sensors, positioning, or command. These two groupings are then used to form representative use cases (rUCs) as follows, which are used in Clause 4.2 – deployment scenarios and connectivity topologies. For example, rUC1 is indoor inventory, rUC2 is indoor sensors, rUC3 is indoor positioning, rUC4 is indoor command, rUC5 is outdoor inventory, rUC6 is outdoor sensors, rUC7 is outdoor positioning, and rUC8 is outdoor command.

[0101] FIG. 1B illustrates an example scenario of topology 1 associated with aspects of the present disclosure. As shown in FIG. 1B, in topology 1 (i.e. the first topology), the ambient IoT device 121 communicates with a base station (BS) 122 directly and bi-directionally. The communication between the BS 122 and the ambient IoT device 121 includes ambient IoT data and/or signalling. This topology includes the possibility of a transmission from the BS 122 to the ambient IoT device 121 and a different possibility of a transmission from the ambient IoT device 121 to the BS 122. The ambient IoT device 121 may be an example of a first device 201 below. The BS 122 may be an example of a second device 202 below.

[0102] FIG. 1C illustrates an example scenario of topology 2 (i.e. the second topology) associated with aspects of the present disclosure. As shown in FIG. 1C, in topology 2, the ambient IoT device 131 communicates bidirectionally with an intermediate node 132 (or referred to as an intermediate device) between the ambient IoT device 131 and base station 133. In this topology, the intermediate node 132 can be a relay node, an IAB node, a UE, a repeater, etc., which is capable of ambient IoT. The intermediate node 132 transfers ambient IoT data and/or signalling between the BS 133 and the ambient IoT device 131. The ambient IoT device 131 may be an example of a first device 201 below. The intermediate node 132 may be an example of a second device 202 below.

[0103] In view of the above discussions, some embodiments of the present disclosure provide a solution for paging messages for devices, such as, ambient Internet of Things (IoT) devices. In some embodiments, the paging indication and resource indication are designed. In some examples, if paging indication is scrambled with a paging control signalling for paging message reception, the paging indication needs to be stored/pre-defined in the A-IoT device before receiving the paging message. In some embodiments,

if the paging indication is explicitly indicated in the paging control signalling or the paging message, the paging indication indicates a message type of the paging message.

[0104] In some embodiments, the paging ID is designed, in some examples, the paging ID is used for identifying a device or a group of devices. In some examples, the paging ID may be carried by the paging message, alternatively, the paging ID may be carried by both the paging control signalling and the paging message, alternatively, the paging ID may be carried by the paging control signalling. In some embodiments, the (sub)group indication is designed, for example, the criteria and procedures for (sub)group indication with/without network control are designed.

[0105] In some embodiments, a paging cause for the A-IoT is designed. In some examples, the paging cause is carried by the paging message. In some examples, the paging cause may be divided into various categories based on different criteria, e.g., use case, device behavior, signalling set. In some embodiments, the response resource/assistance information is designed. In some examples, the association between response resource/assistance information and paging cause/paging ID/paging area is proposed. The content of response resource/assistance information may refer to the embodiments below. Principles and implementations of embodiments of the present disclosure will be described in detail below with reference to FIGS. 2-12.

[0106] FIG. 2 illustrates a signalling diagram illustrating an example process 200 that supports paging messages for devices, such as A-IoT devices, in accordance with aspects of the present disclosure. The process 200 may involve the first device 201, the second device 202 and the third device 203. An example of the first device 201 may be an A-IoT device. An example of the second device 202 may be a gNB or an intermediate device (e.g. an intermediate UE) between the gNB and the first device 201. An example of the third device 203 may be a network entity, e.g. an Access and Mobility Management Function (AMF) or an A-IoT server. It is noted that if the second device 202 is the intermediate device and the third device 203 is the network entity, then the second device 202 may communicate, via an access network device, e.g. via a gNB, with the third device 203, rather than directly communicate with the third device 203. It would be appreciated that although the process 200 is applied in the communication environment 100 of FIG. 1A, this process may be likewise applied to other communication scenarios with similar issues.

[0107] In the process 200, the second device 202 may transmit (210), for example via a transceiver of the second device 202, a paging message 205 to at least one device. In some examples, the paging message 205 may be associated with first information and includes second information. The first information may identify the at least one device. The second information may indicate at least one paging cause. One of the at least one device may be the first device 201. On the first device 201 side, the first device 201 may receive (220), for example via a transceiver or the first device 201, the paging message 205 from the second device 202. In the case that the first information identifies the first device 201, the first device 201 may perform (230) at least one operation based on the second information. The operation, for example, doing action(s) or sending a response.

[0108] In some examples, the first information may be included in the paging message 205 or a paging control signalling for the paging message 205 or both of them. In some examples, the paging message 205 being associated with the first information means that the paging message 205 includes the first information. In some other examples, the paging message 205 being associated with the first information means that the paging control signalling for the paging message 205 includes the first information.

[0109] In some examples, the first information may comprise a paging identifier (ID) identifying the at least one device. For example, the paging ID may be used to identify an A-IoT device or a group of A-IoT devices. Specifically, in some examples, the paging ID may identify a device, and the paging ID may comprise a tag ID of the device, or an electronic product code (EPC) ID associated with the device, or a combination of at least part of the tag ID and the EPC ID, or at least part of data stored in an area in the device. In some other examples, the paging ID may identify a plurality of devices, and the paging ID may comprise a common part of tag IDs of the plurality of devices, or a common part of EPC IDs of the plurality of devices, or a common part of data stored in areas in the plurality of devices, or a class ID or a family ID identifying the plurality of devices or a plurality of products associated with the plurality of devices, or an ID identifying an area or a shelf of the plurality of devices.

[0110] The paging ID may be carried in the paging message and/or the paging control signalling. Specifically, in some examples, the paging ID may be included in the paging control signalling and indicates a device or a group of devices. Alternatively, the paging ID may be included in the paging message and indicates a device or a group of devices.

Alternatively, a first part of the paging ID is included in the paging control signalling and indicates a group of devices, and a second part of the paging ID is included in the paging message and indicates a device or a subgroup of devices among the group of devices.

[0111] As mentioned above, the paging ID may be included in the paging message. As an example (i), the paging ID is carried by the paging message, and is used to identify a device, then the paging ID may be a tag ID (TID) of the device, alternatively, the paging ID may be an EPC ID of the device, alternatively, the paging ID may be a combination of part of tag ID and EPC ID which can uniquely identify the device, alternatively, the paging ID may be part of the data buffered in the specific storage area of A-IoT device which can uniquely identify the device, or others. Alternatively, the paging ID is carried by the paging message, and is used to identify a group of devices, the paging ID may be a common part of tag ID/EPC ID for a group of devices, alternatively, the paging ID may be a common part of the data buffered in the specific storage area of an A-IoT device in a group of devices, alternatively, the paging ID may be a class ID of a group of devices/products, alternatively, the paging ID may be a family ID of a group of devices/products, alternatively, the paging ID may be an area ID or an shelf ID of a group of devices/products, or others.

[0112] As mentioned above, the paging ID may be included in the paging control signalling. As an example (ii), if the paging ID is carried by the paging control signalling, the paging ID may be used to identify a device or a group of devices, and the paging ID design is same as the above example (i). As an example (iii), as mentioned above, the first part of the paging ID may be included in the paging control signaling and the second part of the paging ID may be included in the paging message. For example, if the paging ID is carried by both the paging control signalling and the paging message, a part of paging ID may be carried by (sub)group indication in the paging control signalling, indicating device group_1. A different part of paging ID may be carried by paging message, indicating device group_2 or a device of the device group_1, where device group_2 is a subset of device group_1.

[0113] It should be noted that the example (i) above may be applied for the cases with or without paging control signaling, the example (i) above may be applied for the case with paging control signaling, and the example (iii) above may be applied for the case with the paging control signaling.

[0114] In some examples, the paging ID is included in the paging control signalling, the first device 201 may receive, for example via the transceiver of the first device 201, the paging control signalling from the second device 202. Based on the paging ID mapping with an ID of the first device 201, the first device 201 may receive or decode the paging message 205. In other words, for example, refer to the example (ii), if the paging ID in the paging control signalling doesn't map with the device ID, the device will not receive/decode paging message.

[0115] In above examples, the paging ID may be used to identify a device or a group of devices. In some other examples, except for the paging ID, other information may also be used for identify a (sub)group of devices, e.g., device status, gNB ID, area information, etc. The (sub)groups of devices which are not paged don't need to consume energy to decode further paging message. On the other hand, network can distribute A-IoT devices to avoid collision by using (sub)group indication. The details will be described below.

[0116] In some examples, the first information may comprise a status indication identifying the at least one device having the same status. For example, the status indication may be an indication about device status, e.g., inventory status. In some examples, the device status may be used to identify a group of A-IoT devices which have the same status, and may be specified in the paging message or the paging control signalling independently. In some examples, the device status can be used separately or associated with the paging ID. As an example, the paging ID and the status indication may be used separately for identifying the at least one device. As another example, the first information may comprise the paging ID and the status indication combined for identifying the at least one device. That is, the at least one device may be identified with the specific paging ID and device status.

[0117] In some examples, the paging control signalling may comprise a group indication indicating the at least one device as a group, or a subgroup indication indicating the at least one device as a subgroup of a group. In some examples, the group indication or the subgroup indication may comprise a part of the paging ID, the status indication (indicating the device status, e.g. have been inventoried), or an ID of a network device associated with a group or a subgroup of devices, in which the network device is the second device 202 or a further device transmitting the paging message 205 to the second device 202. Alternatively or additionally, the group indication or the subgroup indication

may comprise an area ID of a group or a subgroup of devices. Alternatively or additionally, the group indication or the subgroup indication may comprise a group ID and associated status indication. Alternatively or additionally, the group indication or the subgroup indication may comprise a group number or a subgroup number. In some other embodiments, the group indication or the subgroup indication can include any combination of the above-mentioned items. It should be noted that the above-mentioned item related to the group corresponds to the group indication, and similarly, the above-mentioned item related to the subgroup corresponds to the subgroup indication. For example, the group indication or the subgroup indication comprising the area ID of the group or the subgroup of devices, means that the group indication comprising the area ID of the group of devices, or means that the subgroup indication comprising the area ID of the subgroup of devices. The network device above, as an example, may be a gNB, and the ID of the network device above may be a gNB ID.

[0118] In some examples, the group indication or the subgroup indication may be determined based on at least one criterion (e.g. (sub)group criteria below) 215 of a group or a subgroup configured by the third device 203. The (sub)group criteria may be obtained from network (i.e. the third device 203). In some examples, the at least one criterion 215 is valid until at least one updated criterion is received or the first device is powered off. In some other examples, the group indication or the subgroup indication is valid until an updated group indication or an updated subgroup indication is received or the first device 201 is powered off. For example, the network (i.e. the third device 203) may configure the (sub)group criteria and (sub)group indication for the A-IoT devices before sending the paging message, and the (sub)group criteria and indication may keep valid until receiving the updates from network or power down. In some embodiments, the at least one criterion 215 may comprise an ID of a network device associated with a group or a subgroup of devices. The network device may be the second device (in this case, is a gNB) or a further device (e.g. a gNB) transmitting the paging message to the second device (in this case, the second device is an intermediate device). In the example above, the network device is a gNB, and the ID of the network device may be the gNB ID. Alternatively, the at least one criterion 215 may comprise an area ID (or referred to as area information) of a group or a subgroup of devices.

[0119] As mentioned above, the at least one criterion 215 of a group or a subgroup may be configured by the third device 203, in such examples, on the third device 203 side,

the third device 203 may determine (207) the at least one criterion 215 of a group or a subgroup for assigning at least one first device 201 to a group or a subgroup. The third device 203 may transmit (208), for example, via a transceiver of the third device 203, the at least one criterion 215 and assignment of the at least one first device 201 to the second device 202. On the second device 202 side, the second device 202 may receive (209), for example, via its transceiver, the at least one criterion 215 from the third device 203, and may transmit, for example, via its transceiver, the at least one criterion 215 to the first device 201.

[0120] With reference to FIG. 3, which illustrates an example signalling diagram 300 illustrating an example of network-controlled (sub)group indication in accordance with aspects of the present disclosure. The A-IoT devices 301 may be an example of the first device 201. The gNB 302 or an intermediate device (not shown) between the A-IoT devices 301 and the gNB 302 may be an example of the second device 202. The network entity 303 may be an example of the third device 203. As shown in FIG. 3, at 310, the network entity (e.g., AMF, A-IoT server) 303 may determine (310) the (sub)grouping criteria (e.g., gNB ID, area ID) and the (sub)group assignment. The network entity 303 may transmit the determined (sub)group criteria and the associated (sub)group assignment to the A-IoT devices (an A-IoT device is shown as an example) 301 via the gNB 302. Specifically, the network entity 303 (e.g., a AMF or A-IoT server) may transmit (320) third information 305 to the gNB 302. The gNB 302 may receive (330) the third information 305, and then may transmit (340) the third information 305 to the A-IoT devices 301. On the A-IoT devices 301 side, the A-IoT devices 301 may receive (350) the third information 305.

[0121] The third information 305 may comprise a (sub)group criteria and a mapping relationship between information of the A-IoT devices 301 (for example, the ID of the A-IoT devices 301, e.g. the TID of the A-IoT devices 301) and the associated (sub)group assignment. In some examples, the network entity 303 may configure multiple criteria and associated assignment result (e.g. the mapping relationship above) for the A-IoT devices. The step of transmitting the third information 305 from the network entity 303 to the A-IoT devices 301 via the gNB 302 may be performed by another paging message which is different with current paging message or performed after a random access procedure of the A-IoT devices 301. At 360, when there's arrival of paging message at the gNB 302, the gNB 302 may send (370) the (sub)group indication 315 to the A-IoT

devices 301 based on the guidance of network entity 303. The A-IoT devices 301 may receive (380) the (sub)group indication 315. In some examples, in the process of FIG. 3, third information 305 and the (sub)group indication 315 may be transmitted from the gNB 302 to the A-IoT devices 301 via the intermediate device (not shown) between the A-IoT devices 301 and the gNB 302.

[0122] In some embodiments, after receiving the paging control signalling including the group indication or the subgroup indication, the first device 201 may compare the group indication or the subgroup indication with a stored group or subgroup indication, and then may, based on the comparison (for example, the result of the comparison indicates the same), receive or decode a subsequent paging message. With reference to FIG. 3 above, for example, upon receiving the (sub)group indication 315, the A-IoT devices 301 compares the (sub)group indication (e.g., gNB ID, area ID, subgroup number, etc.) 315 with its stored data (e.g. the stored group or subgroup indication). If mapped, the A-IoT devices 301 will decode the subsequent paging message, otherwise, the A-IoT devices 301 will not receive/decode but just harvest energy from the signalling.

[0123] In some examples, the (sub)group criteria may be owned by the A-IoT devices themselves and not need to obtain from the network (e.g. the network entity 303). The network and devices may have the same understanding on the criteria. In some examples, if the A-IoT device stores the pre-defined subgroup ID for itself, the (sub)group indication may also include the subgroup ID.

[0124] In some examples, the group ID is associated with the status of the first device 201. In such examples, if group ID relates to the device status, the group ID needs to be updated after the device status changes. Specifically, in some examples, the network needs to send the updated group ID to the device after device status change. For example, based on a change of status of the first device 201, the second device 202 may transmit, for example, via its transceiver and to the first device 201, an updated group ID of the first device. On the first device 201 side, based on the change of status of the first device 201, the first device 201 may receive the updated group ID of the first device 201.

[0125] In some other examples, the second device 202 may transmit, for example, via its transceiver and to the first device 201, a mapping rule of the status information and the group ID. In some examples, the mapping rule may be configured or preconfigured by the third device 203, for example, the network preconfigures the mapping rule for the A-

IoT device (e.g., group 1 relates to ‘inventoried’ status, and group 2 relates to ‘not inventoried’ status, in which ‘inventoried’ status and ‘not inventoried’ status may be examples of the status of the first device 201). The second device 202 may receive, for example via its transceiver, the mapping rule from the third device 203, and transmits, for example via its transceiver, the mapping rule to the first device 201. On the first device 201 side, the first device 201 may receive, for example via the second device 202, the mapping rule preconfigured by the third device 203, and based on a change of the status of the first device, the first device 201 may update the group ID of the first device 201 with the mapping rule. For example, the A-IoT device may change, based on the mapping rule, its group ID autonomously after its status change.

[0126] In some examples, the paging control signalling may comprise a resource indication indicating a resource for receiving the paging message 205. The resource indication may indicate the resource to receive the subsequent paging message, and may be carried by a separate paging control signaling. If there’s no separate paging control signalling, resource indication may be not needed.

[0127] In some existing solutions, there are two intentions for Paging Radio Network Temporary Identifier (P-RNTI). On one hand, the P-RNTI is used to indicate this is a paging message. On the other hand, the P-RNTI is used to scramble the paging downlink control information (DCI), which indicates the resources to receive the paging message. For A-IoT, a paging indication is also required to indicate this is a paging message. As for scrambling, it depends on whether an ID similar to P-RNTI can be pre-defined for the A-IoT devices. As mentioned above, there’s a paging DCI indicating the resource to receive paging contents in a paging message in the existing solutions. The paging DCI is separate with the paging message. For A-IoT, it is to be first considered that whether to introduce separate paging control signalling. If there’s separate paging control signalling, a paging resource indication similar to the paging DCI in the existing solutions could also be introduced.

[0128] Different from the existing solutions, in the solution of the present disclosure, as mentioned above, the first device 201 may receive, for example via its transceiver and from the second device 202, the paging control signalling for the paging message 205. In some examples, the paging control signalling may comprise a paging indication indicating a message type of the paging message 205, e.g. indicating that this is a paging

message. In some other examples, the paging indication indicating a message type of the paging message 205 may be included in the paging message 205, for example, the paging indication is included in the paging control signalling or the paging message 205, and indicates this is a paging message. In this way, the paging indication for A-IoT is explicitly indicated in paging control signalling or paging message. In such examples, the paging indication doesn't need to be stored/pre-defined in the A-IoT device beforehand, and the paging indication for A-IoT cannot be used for being scrambling with the paging control signalling.

[0129] In some further examples, the paging indication for the first device 201 (e.g. the A-IoT device) may be scrambled with the paging control signalling for the paging message 205 reception. In such examples, the first device 201 may store or predefine a paging indication (e.g. in the form of a kind of ID) prior to receiving the paging message 205. The first device 201 may compare the stored or predefined paging indication with a paging indication scrambled with a paging control signalling for the paging message 205, and based on the comparison, for example, are the same, receive the paging message 205.

[0130] In some examples, the second information may comprise at least one paging cause. The paging cause may be carried by the paging message 205, and can be divided into various categories based on different criteria, e.g., use case, device behavior and signalling set. With paging cause information, the A-IoT devices can be aware of what to do next upon reception of paging message.

[0131] In some examples, the second information may comprise a first paging cause associated with inventory. The first paging cause indicates that an inventory status of the at least one device is to be changed, or an ID of the at least one device is to be reported. Alternatively, a second paging cause associated with at least one sensor. The second paging cause indicates that sensor data stored in the at least one device is to be transmitted. Alternatively, a third paging cause associated with positioning. The third paging cause indicates that a positioning request is to be responded. Alternatively, a fourth paging cause associated with at least one command. The fourth paging cause indicates that at least one action in response to the at least one command is to be performed.

[0132] For example, the paging cause is divided by use cases (e.g., inventory, sensors, positioning, command, etc.) of the first device 201, and the second information may comprise one of the following causes. Inventory paging cause may be an example of the

first paging cause. For example, upon reception of the paging message with inventory paging cause, the A-IoT device may change its inventory status for the paging gNB, and/or start random access to report its device ID to the network. Sensors paging cause may be an example of second paging cause. For example, upon reception of the paging message with sensors paging cause, the A-IoT device may start random access to send its stored sensor data associated with its device ID to the network. Positioning paging cause may be an example of the third paging cause. For example, upon reception of the paging message with positioning paging cause, the A-IoT device may start random access to response the positioning request. Command paging cause may be an example of the fourth paging cause. For example, upon reception of the paging cause with command paging cause, the A-IoT device may do the actions according to the guideline of the command.

[0133] In some examples, the second information may comprise a fifth paging cause associated with a response. The fifth paging cause indicates that required information is to be responded to the second device 202. Alternatively, a sixth paging cause associated with at least one action without a response. The sixth paging cause indicates that the at least one action is to be performed but no response to the second device 202. Alternatively, a seventh paging cause associated with at least one action with a response. The seventh paging cause indicates that the at least one action is to be performed and a response associated with at least one action is to be responded to the second device 202.

[0134] For example, the paging cause is divided by expected device behavior (e.g. whether to response, required action, etc.) of the first device 201, and the second information may comprise one of the following causes. Response paging cause (an example of the fifth paging cause) may indicate that the A-IoT device starts random access to respond the required information (e.g., device ID, sensor data, ACK/NACK, etc.) to the paging gNB. In such examples, upon reception of the response paging cause, the device starts random access to response the required information (e.g., device ID, sensor data, ACK/NACK, etc.) to the paging gNB. The required information to response may be also indicated in the paging message 205. Action but not response paging cause (an example of the sixth paging cause) may indicate the A-IoT device performs the required actions (e.g., change the status, store the data, etc.) and not response.

[0135] In such examples, upon reception of the action but not response paging cause, the A-IoT device performs the required actions (e.g., change the status, store the data, etc.)

and not response. In some examples, the required action is also indicated in the paging message 205. Action and response paging cause (an example of the seventh paging cause) may indicate the A-IoT device performs the required actions and starts the random access to response the required information. In such examples, upon reception of paging message with action and response paging cause, the A-IoT device performs the required actions and starts the random access to response the required information. In some examples, the required action and the required information to response may be also indicated in the paging message 205.

[0136] In some examples, the second information may comprise an eighth paging cause associated with a reading operation, in which the eighth paging cause indicates that required data in an area of the at least one device is to be transmitted to the second device 202. Alternatively, a ninth paging cause associated with a writing operation, in which the ninth paging cause indicates that data from the second device 202 is to be written into an area of the at least one device. Alternatively, a tenth paging cause associated with an erasing operation, in which the tenth paging cause indicates that data stored in an area of the at least one device is to be deleted. In some examples, the tenth paging cause may further indicate that a response associated with the erasing operation is to be responded to the second device 202. In some examples, the paging cause is divided by signaling set (e.g. read, write, or erase, etc.) of the first device 201, and the second information may comprise one of the following causes. Read paging cause is an example of the eighth paging cause.

[0137] Upon reception of the paging message with read paging cause, the A-IoT device starts random access and sends the required data to the paging gNB. The required data (may be indicated by address) to be read is also indicated in the paging message. Write paging cause is an example of the ninth paging cause. Upon reception of the paging message with write paging cause, the A-IoT device starts random access and obtains the data to be written from the gNB, and then stored the data at the indicated address in its storage. The address to store the data may be indicated in the paging message. Erase paging cause may be an example of the tenth paging cause. Upon reception of the paging message with erase paging cause, the A-IoT device deletes the indicated data from its storage, and optionally starts random access to response ACK/NACK if required by the network. The address indicating data to be deleted may also be indicated in the paging message.

[0138] In some examples, the paging message needs to include response resource and assistance information if the paged device (e.g. the first device 201) is required to response the network (e.g. the gNB). For such cases, in some examples, the paging message 205 may comprise the response resource, in which the response resource indicates a resource for transmitting, to the second device 202, at least one of the first message or a subsequent response after the first message. In some examples, the first message may be Msg 1 transmitted from the A-IoT device to the gNB. In some examples, the paging message 205 may comprise the assistance information, in which the assistance information indicates: an ID of a paging network device (e.g. the gNB). The paging network device is the second device 202 or a further device transmitting the paging message to the second device 202. Additionally or alternatively, the assistance information indicates a resource for receiving a second message from the paging network device. Additionally or alternatively, the assistance information indicates configuration associated access control for accessing the paging network device. Additionally or alternatively, the assistance information indicates a time window or response time (i.e., additional time window/response time) for transmitting a response to the paging network device. The additional time window/response time may be configured to require the device (e.g. the A-IoT device) to response within this time window if the device is allowed to select resource within the resource pool randomly. In some examples, the second message may be Msg 2 transmitted from the gNB to the A-IoT device (if the resource to receive Msg 2 is not bound with the resource for Msg 1).

[0139] In some examples, the response resource may be associated with one of the paging cause, the paging ID or the paging area, alternatively, the response resource may be common to a plurality of paging causes, paging IDs or paging areas. In some examples, the assistance information may be associated with one of the paging cause, the paging ID or the paging area, alternatively, the assistance information may be common to a plurality of paging causes, paging IDs or paging areas. For example, the response resource and/or the assistance information may be associated with the specific paging cause (e.g., paging cause-response, paging cause-inventory, etc.), associated with specific paging ID (i.e., a device or a group of devices), or associated with specific paging area, or common to different paging causes, paging IDs and paging areas.

[0140] FIG. 4 illustrates an example of a device 400 that supports paging message for A-IoT in accordance with aspects of the present disclosure. The device 400 may be an

example of a UE 104 as described herein. The device 400 may support wireless communication with one or more network entities 102, UEs 104, 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).

[0141] 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.

[0142] 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).

[0143] For example, the processor 402 may support wireless communication at the device 400 in accordance with examples as disclosed herein. In some examples, the processor 402 may be configured to operable to support a means for receiving a paging message from a second device, wherein the paging message is associated with first information and includes second information, wherein the first information identifies at least one device and the second information indicates at least one paging cause; and a means for, in the case that the first information identifies the first device, performing at least one operation based on the second information. The processor 402 may be

configured to operable to support other means for other implementations of method 1000. In some other examples, the processor 402 may be configured to operable to support a means for transmitting a paging message to at least one device, wherein the paging message is associated with first information and includes second information, wherein the first information identifies the at least one device and the second information indicates at least one paging cause. The processor 402 may be configured to operable to support other means for other implementations of method 1100. In some further examples, the processor 402 may be configured to operable to support a means for determining at least one criterion of a group or a subgroup for assigning at least one first device to the group or the subgroup; and a means for transmitting, to a second device, the at least one criterion and the assignment of the at least one first device to the group or the subgroup. The processor 402 may be configured to operable to support other means for other implementations of method 1200.

[0144] 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.

[0145] 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.

[0146] 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 402. 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.

[0147] 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.

[0148] 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.

[0149] 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.

[0150] FIG. 5 illustrates an example of a processor 500 that supports paging message for A-IoT 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. 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).

[0151] 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).

[0152] 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.

[0153] 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.

[0154] The memory 504 may include one or more caches (e.g., memory local to or included in the processor 500 or other memory, such 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).

[0155] 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 (e.g., functions or tasks supporting transmit power prioritization). For example,

the processor 500 and/or the controller 502 may be coupled with or to the memory 504, 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.

[0156] 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.

[0157] The processor 500 may support wireless communication in accordance with examples as disclosed herein. In some examples the processor 502 may be configured to or operable to support a means for receiving a paging message from a second device, wherein the paging message is associated with first information and includes second information, wherein the first information identifies at least one device and the second information indicates at least one paging cause; and a means for, in the case that the first information identifies the first device, performing at least one operation based on the second information. The processor 500 may be configured to or operable to support other means for other implementations of method 1000. In some other examples, the processor 502 may be configured to or operable to support a means for transmitting a paging message to at least one device, wherein the paging message is associated with first information and includes second information, wherein the first information identifies the at least one device and the second information indicates at least one paging cause. The

processor 500 may be configured to or operable to support other means for other implementations of method 1100. In some further examples, the processor 502 may be configured to or operable to support a means for determining at least one criterion of a group or a subgroup for assigning at least one first device to the group or the subgroup; and a means for transmitting, to a second device, the at least one criterion and the assignment of the at least one first device to the group or the subgroup. The processor 500 may be configured to or operable to support other means for other implementations of method 1200.

[0158] FIG. 6 illustrates a flowchart of a method 600 that supports paging messages for devices, such as A-IoT devices, 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 the first device 201 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.

[0159] At 605, the method includes receiving a paging message from a second device, wherein the paging message is associated with first information and includes second information, wherein the first information identifies at least one device and the second information indicates at least one paging cause. The operations of 605 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 605 may be performed by a device as described with reference to FIG. 1A.

[0160] At 610, the method may include, in the case that the first information identifies the first device, perform at least one operation based on the second information. 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. 1A.

[0161] FIG. 7 illustrates a flowchart of a method 700 that supports paging messages for devices, such as A-IoT devices, in accordance with aspects of the present disclosure. The operations of the method 700 may be implemented by a device or its components as described herein. For example, the operations of the method 700 may be performed by

the second device 202 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.

[0162] At 705, the method includes transmitting, via the transceiver, a paging message to at least one device, wherein the paging message is associated with first information and includes second information, wherein the first information identifies the at least one device and the second information indicates at least one paging cause. The operations of 705 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 705 may be performed by a device as described with reference to FIG. 1A.

[0163] FIG. 8 illustrates a flowchart of a method 800 that supports paging messages for devices, such as A-IoT devices, in accordance with aspects of the present disclosure. The operations of the method 800 may be implemented by a device or its components as described herein. For example, the operations of the method 800 may be performed by the third device 203 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.

[0164] At 805, the method includes determining at least one criterion of a group or a subgroup for assigning at least one first device to the group or the subgroup. The operations of 805 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 805 may be performed by a device as described with reference to FIG. 1A.

[0165] At 810, the method may include transmitting, to a second device, the at least one criterion and the assignment of the at least one first device to the group or the subgroup. 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. 1A.

[0166] 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.

[0167] 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.

[0168] 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.

[0169] 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.

[0170] 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.

[0171] 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, via the transceiver, a paging message from a second device,
wherein the paging message is associated with first information and includes second information, wherein the first information identifies at least one device and the second information indicates at least one paging cause; and
in the case that the first information identifies the first device, perform at least one operation based on the second information.
2. The first device of claim 1, wherein the first information is included in at least one of the paging message or a paging control signalling for the paging message, and wherein the first information comprises one of the following:
a paging identifier (ID) identifying the at least one device;
a status indication identifying the at least one device having the same status; or
the paging ID and the status indication combined for identifying the at least one device.
3. The first device of claim 2, wherein the paging control signalling comprises:
a group indication indicating the at least one device as a group; or
a subgroup indication indicating the at least one device as a subgroup of a group.
4. The first device of claim 2, wherein the paging ID identifies a device, and wherein the paging ID comprises one of the following:
a tag ID of the device;
an electronic product code (EPC) ID associated with the device;
a combination of at least part of the tag ID and the EPC ID; or
at least part of data stored in an area in the device.

5. The first device of claim 2, wherein the paging ID identifies a plurality of devices, and wherein the paging ID comprises one of the following:

- a common part of tag IDs of the plurality of devices;
- a common part of EPC IDs of the plurality of devices;
- a common part of data stored in areas in the plurality of devices;
- a class ID or a family ID identifying the plurality of devices or a plurality of products associated with the plurality of devices;
- an ID identifying an area or a shelf of the plurality of devices.

6. The first device of claim 3, wherein the group indication or the subgroup indication comprises at least one of the following:

- a part of the paging ID;
- the status indication;
- an ID of a network device associated with a group or a subgroup of devices, wherein the network device is the second device or a further device transmitting the paging message to the second device;
- a group number or a subgroup number;
- area ID of a group or a subgroup of devices; or
- a group ID and associated status indication.

7. The first device of claim 3, wherein the group indication or the subgroup indication is determined based on at least one criterion of a group or a subgroup configured by a third device, wherein the at least one criterion comprises (i) an ID of a network device associated with a group or a subgroup of devices, wherein the network device is the second device or a further device transmitting the paging message to the second device; or (ii) an area ID of a group or a subgroup of devices; and

wherein:

the at least one criterion is valid until at least one updated criterion is received or the first device is powered off; or

the group indication or the subgroup indication is valid until an updated group indication or an updated subgroup indication is received or the first device is powered off.

8. The first device of claim 2, wherein one of the following:

the paging ID is included in the paging control signalling and indicates a device or a group of devices;

the paging ID is included in the paging message and indicates a device or a group of devices; or

a first part of the paging ID is included in the paging control signalling and indicates a group of devices, and a second part of the paging ID is included in the paging message and indicates a device or a subgroup of devices among the group of devices.

9. The first device of claim 6, wherein the processor is further configured to:
based on a change of status of the first device, receive an updated group ID of the first device; or

based on a change of the status of the first device, update the group ID of the first device with a mapping rule of the status indication and the group ID.

10. The first device of claim 9, wherein the processor is further configured to:
receive, via the second device, the mapping rule configured or preconfigured by a third device.

11. The first device of claim 1, wherein the processor is further configured to receive, via the transceiver and from the second device, a paging control signalling for the paging message, and wherein the paging control signalling comprises at least one of the following:

a resource indication indicating a resource for receiving the paging message; or
a paging indication indicating a message type of the paging message.

12. The first device of claim 1, wherein the second information comprises one of the following:

a first paging cause associated with inventory, wherein the first paging cause indicates that an inventory status of the at least one device is to be changed, or an ID of the at least one device is to be reported;

a second paging cause associated with at least one sensor, wherein the second paging cause indicates that sensor data stored in the at least one device is to be transmitted;

a third paging cause associated with positioning, wherein the third paging cause indicates that a positioning request is to be responded; or

a fourth paging cause associated with at least one command, wherein the fourth paging cause indicates that at least one action in response to the at least one command is to be performed.

13. The first device of claim 1, wherein the second information comprises one of the following:

a fifth paging cause associated with a response, wherein the fifth paging cause indicates that required information is to be responded to the second device;

a sixth paging cause associated with at least one action without a response, wherein the sixth paging cause indicates that the at least one action is to be performed but no response to the second device; or

a seventh paging cause associated with at least one action with a response, wherein the seventh paging cause indicates that the at least one action is to be performed and a response associated with at least one action is to be responded to the second device.

14. The first device of claim 1, wherein the second information comprises one of the following:

an eighth paging cause associated with a reading operation, wherein the eighth paging cause indicates that required data in an area of the at least one device is to be transmitted to the second device;

a ninth paging cause associated with a writing operation, wherein the ninth paging cause indicates that data from the second device is to be written into an area of the at least one device; or

a tenth paging cause associated with an erasing operation, wherein the tenth paging cause indicates that data stored in an area of the at least one device is to be deleted.

15. The first device of claim 1, wherein the paging message further comprises a response resource, wherein the response resource indicates a resource for transmitting, to the second device, at least one of a first message or a subsequent response after the first message.

16. The first device of claim 15, wherein:

the response resource is associated with one of a paging cause, a paging ID or a paging area; or

the response resource is common to a plurality of paging causes, paging IDs or paging areas.

17. The first device of claim 1, wherein the paging message further comprises assistance information, wherein the assistance information indicates at least one of the following:

an ID of a paging network device, wherein the paging network device is the second device or a further device transmitting the paging message to the second device;
a resource for receiving a second message from the paging network device;
configuration associated access control for accessing the paging network device;
or

a time window or response time for transmitting a response to the paging network device.

18. The first device of claim 17, wherein:

the assistance information is associated with one of a paging cause, a paging ID or a paging area; or

the assistance information is common to a plurality of paging causes, paging IDs or paging areas.

19. A second device comprising:

a processor; and

a transceiver coupled to the processor,

wherein the processor is configured to:

transmit, via the transceiver, a paging message to at least one device, wherein the paging message is associated with first information and includes second information, wherein the first information identifies the at least one device and the second information indicates at least one paging cause.

20. A third device comprising:

a processor; and

a transceiver coupled to the processor,

wherein the processor is configured to:

determine at least one criterion of a group or a subgroup for assigning at least one first device to the group or the subgroup; and

transmit, via the transceiver and to a second device, the at least one criterion and the assignment of the at least one first device to the group or the subgroup.