

DATA TRANSPORT RELATED TO AMBIENT IOT DEVICE

TECHNICAL FIELD

[0001] The present disclosure relates to wireless communications, and more specifically to apparatuses, processors for wireless communication and methods for data transport for ambient internet of things (A-IoT) device.

BACKGROUND

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

[0003] Internet of things (IoT) devices have attracted much attention in the wireless communication world. The IoT device has a smaller size, a lower complexity, lower power consumption and huger number (e.g., tens or even hundreds of billion IoT devices) than the existing UE. The IoT devices are typically battery less devices with no energy storage capability, or devices with energy storage that do not need to be replaced or recharged manually, where the energy is provided through the harvesting of radio waves, light, motion, heat, or any other power source that could be seen suitable. For simplicity, these devices are named as ambient IoT (A-IoT) devices. Techniques related to A-IoT device need to be developed.

SUMMARY

[0004] The present disclosure relates to apparatuses, processors for wireless

communication, methods, and non-transitory computer readable media for data transport related to A-IoT devices. Embodiments of the present disclosure provides a data transport scheme related to A-IoT devices.

[0005] In a first aspect of the solution, a base station receives data from a first device, wherein the first device includes an ambient internet of things (A-IoT) device powered by energy harvesting; and transmits, to a second device, the data via a message.

[0006] In some implementations of the methods and apparatuses described herein, receiving the data includes: receiving, from the first device, a non-access stratum (NAS) message carrying the data.

[0007] In some implementations of the methods and apparatuses described herein, the NAS message includes at least one of the following: an indication that the NAS message is an A-IoT specific message; an indication that a type of a payload in the NAS message is a container for A-IoT data; an indication that a type of a payload in the NAS message is a container for an A-IoT management protocol message; or a correlation identifier of a third device to which a payload in the NAS message is to be routed.

[0008] In some implementations of the methods and apparatuses described herein, receiving the NAS message includes: receiving, from the first device, a medium access control (MAC) message, wherein the MAC message includes the NAS message.

[0009] In some implementations of the methods and apparatuses described herein, receiving the NAS message includes: receiving, from the first device, a radio resource control (RRC) message, wherein the RRC message includes the NAS message.

[0010] In some implementations of the methods and apparatuses described herein, the RRC message includes an indication of an establishment cause, and the establishment cause includes one of the following: a device terminated (DT) communication; a device originated – device terminated triggered (DO-DTT) communication; or a device originated (DO) communication.

[0011] In some implementations of the methods and apparatuses described herein, receiving the RRC message includes: receiving, from the first device, the RRC message using one of the following: a signaling radio bearer (SRB) without a packet data convergence protocol (PDCP) layer function; or a SRB without a PDCP layer function and a radio link control (RLC) function.

[0012] In some implementations of the methods and apparatuses described herein, the message is signaling message, the signaling message includes the NAS message carrying the data. In some implementations of the methods and apparatuses described herein, the signaling message further includes at least one of the following: an indication of an establishment cause; or an indication that the signaling message is for A-IoT data transmission.

[0013] In some implementations of the methods and apparatuses described herein, receiving the data includes: receiving, from the first device, a medium access control (MAC) protocol data unit (PDU) carrying the data.

[0014] In some implementations of the methods and apparatuses described herein, a MAC header of the MAC PDU includes at least one of the following: an indication that the MAC PDU is a transparent MAC; an indication of a length of a MAC service data unit (SDU) containing the data; an identifier of the first device; or an identifier of a first device group, wherein the first device belongs to the first device group.

[0015] In some implementations of the methods and apparatuses described herein, transmitting the data includes: transmitting, to the second device, piggyback data via the message, wherein the piggyback data is based on data from at least one first device, and the at least one first device includes the first device.

[0016] In some implementations of the methods and apparatuses described herein, the message includes at least one of the following: at least one identifier of the at least one first device; an identifier of a first device group, wherein the at least one first device belongs to the first device group; identifiers of one or more first devices, wherein the one or more first devices are remaining first devices among the first device group other than the at least one first device; an indication of a failure reason of receiving corresponding data from the one or more first devices; or a correlation identifier of a third device to which the piggyback data is to be routed.

[0017] Some implementations of the methods and apparatuses described herein may further include: transmitting, to the first device, a first message, wherein the first message includes one of the following: an identifier of the first device; or an identifier of a first device group, wherein the first device belongs to the first device group.

[0018] In some implementations of the methods and apparatuses described herein, the

first message further includes at least one of the following: an indication of a first transmission type of the data to be transmitted to the base station; or an indication of a purpose of the first message.

[0019] In some implementations of the methods and apparatuses described herein, the first transmission type is a NAS-based type or a non-NAS-based type, wherein the purpose of the first message is a DT communication or a DO-DTT communication.

[0020] Some implementations of the methods and apparatuses described herein may further include: receiving, from the second device, a second message, wherein the second message includes one of the following: the identifier of the first device; or the identifier of the first device group.

[0021] In some implementations of the methods and apparatuses described herein, the second message further includes at least one of the following: an indication of a second transmission type of the data from the base station to the second device; or an indication of a time duration to wait. In some implementations of the methods and apparatuses described herein, the second transmission type is a NAS-based type or a piggyback-based type.

[0022] In some implementations of the methods and apparatuses described herein, the first and second messages include the identifier of the first device group, the second message includes an indication of the time duration to wait, and wherein receiving the data includes: starting a timer when receiving first data from the first device group, and monitoring, from the first device group, corresponding data before the timer reaches the time duration to wait; wherein transmitting the data includes: transmitting, to the second device, piggyback data when the timer reaches the time duration to wait, wherein the piggyback data is obtained by concatenating data received from the first device group during the time duration to wait.

[0023] Some implementations of the methods and apparatuses described herein may further include: receiving, from the second device, an identifier of a first device group and at least one identifier of at least one first device being memberships of the first device group, wherein the first device belongs to the first device group.

[0024] Some implementations of the methods and apparatuses described herein may further include: transmitting, to the first device, an indication of successful reception of

the data.

[0025] In some implementations of the methods and apparatuses described herein, the second device includes an access and mobility management function (AMF). In some implementations of the methods and apparatuses described herein, the third device includes an A-IoT management function (AIMF).

[0026] In a second aspect of the solution, a first device obtains data of the first device, wherein the first device includes an ambient internet of things (A-IoT) device powered by energy harvesting; and transmits, to the base station, one of the following: a non-access stratum (NAS) message carrying the data; or a medium access control (MAC) protocol data unit (PDU) carrying the data.

[0027] In some implementations of the methods and apparatuses described herein, transmitting the NAS message includes: transmitting, from the first device, a MAC message, wherein the MAC message includes the NAS message.

[0028] In some implementations of the methods and apparatuses described herein, transmitting the NAS message includes: transmitting, from the first device, a radio resource control (RRC) message, wherein the RRC message includes the NAS message.

[0029] In some implementations of the methods and apparatuses described herein, the RRC message includes an indication of an establishment cause, and the establishment cause includes one of the following: a device terminated (DT) communication; a device originated – device terminated triggered (DO-DTT) communication; or a device originated (DO) communication.

[0030] In some implementations of the methods and apparatuses described herein, the NAS message includes at least one of the following: an indication that the NAS message is an A-IoT specific message; an indication that a type of a payload in the NAS message is a container for A-IoT data; an indication that a type of a payload in the NAS message is a container for an A-IoT management protocol message; or a correlation identifier of a third device to which a payload in the NAS message is to be routed.

[0031] In some implementations of the methods and apparatuses described herein, transmitting the RRC message includes: transmitting, to the base station, the RRC message using one of the following: a signaling radio bearer (SRB) without a packet data convergence protocol (PDCP) layer function; or a SRB without a PDCP layer function

and a radio link control (RLC) function.

[0032] In some implementations of the methods and apparatuses described herein, a MAC header of the MAC PDU includes at least one of the following: an indication that the MAC PDU is a transparent MAC; an indication of a length of a MAC service data unit (SDU) containing the data; an identifier of the first device; or an identifier of a first device group, wherein the first device belongs to the first device group.

[0033] Some implementations of the methods and apparatuses described herein may further include: receiving, from the base station, a first message, wherein the first message includes one of the following: an identifier of the first device; or an identifier of a first device group, wherein the first device belongs to the first device group.

[0034] In some implementations of the methods and apparatuses described herein, the first message further includes at least one of the following: an indication of a first transmission type of the data to be transmitted to the base station; or an indication of a purpose of the first message.

[0035] In some implementations of the methods and apparatuses described herein, the first transmission type is a NAS-based type or a non-NAS-based type, wherein the purpose of the first message is a DT communication or a DO-DTT communication.

[0036] Some implementations of the methods and apparatuses described herein may further include: receiving, from the base station, an indication of successful reception of the data. In some implementations of the methods and apparatuses described herein, the third device includes an A-IoT management function (AIMF).

[0037] In a third aspect of the solution, a second device receives, from a base station, data of a first device via a message, wherein the first device includes an ambient internet of things (A-IoT) device powered by energy harvesting; and one of the following: processes the data, or transmits the data to a third device.

[0038] In some implementations of the methods and apparatuses described herein, the message is a signaling message, the signaling message includes a non-access stratum (NAS) message carrying the data.

[0039] In some implementations of the methods and apparatuses described herein, the NAS message includes at least one of the following: an indication that the NAS message is an A-IoT specific message; an indication that a type of a payload in the NAS message

is a container for A-IoT data; an indication that a type of a payload in the NAS message is a container for an A-IoT management protocol message; or a correlation identifier of a third device to which a payload in the NAS message is to be routed.

[0040] In some implementations of the methods and apparatuses described herein, the signaling message further includes at least one of the following: an indication of an establishment cause; or an indication that the signaling message is for A-IoT data transmission.

[0041] In some implementations of the methods and apparatuses described herein, the establishment cause includes one of the following: a device terminated (DT) communication; a device originated - device terminated triggered (DO-DTT) communication; or a device originated (DO) communication.

[0042] In some implementations of the methods and apparatuses described herein, receiving the data includes: receiving, from the base station, piggyback data via the message, wherein the piggyback data is based on data from at least one first device, and the at least one first device includes the first device.

[0043] In some implementations of the methods and apparatuses described herein, the message includes at least one of the following: at least one identifier of the at least one first device; an identifier of a first device group, wherein the at least one first device belongs to the first device group; identifiers of one or more first devices, wherein the one or more first devices are remaining first devices among the first device group other than the at least one first device; an indication of a failure reason of receiving corresponding data from the one or more first devices; or a correlation identifier of the third device to which the piggyback data is to be routed.

[0044] Some implementations of the methods and apparatuses described herein may further include: transmitting, to the base station, a second message, wherein the second message includes one of the following: an identifier of the first device; or an identifier of a first device group, wherein the first device belongs to the first device group.

[0045] In some implementations of the methods and apparatuses described herein, the second message further includes at least one of the following: an indication of a second transmission type of the data from the base station to the second device; or an indication of a time duration to wait. In some implementations of the methods and apparatuses

described herein, the second transmission type is a NAS-based type or a piggyback-based type.

[0046] In some implementations of the methods and apparatuses described herein, receiving the data includes: receiving, from the base station, piggyback data obtained by concatenating data received from the first device group during the time duration to wait.

[0047] Some implementations of the methods and apparatuses described herein may further include: transmitting, to the base station, an identifier of a first device group and at least one identifier of at least one first device being memberships of the first device group, wherein the first device belongs to the first device group.

[0048] Some implementations of the methods and apparatuses described herein may further include one of the following: determining the first device group and the at least one first device being memberships of the first device group; or receiving, from the third device, an identifier of the first device group and at least one identifier of the at least one first device.

[0049] In some implementations of the methods and apparatuses described herein, the data is processed by the second device, and the second device includes an access and mobility management function (AMF) including an A-IoT management function (AIMF). In some implementations of the methods and apparatuses described herein, the third device includes an AIMF.

[0050] In a fourth aspect of the solution, a third device determines a first device group and at least one first device being memberships of the first device group, wherein each of the at least one first device includes an ambient internet of things (A-IoT) device powered by energy harvesting; and transmits, to a second device, an identifier of the first device group and at least one identifier of the at least one first device.

[0051] Some implementations of the methods and apparatuses described herein may further include cause the third device to: receiving, from the second device, data of one or more first device among the at least one first device.

[0052] In some implementations of the methods and apparatuses described herein, the second device includes an access and mobility management function (AMF), and the third device includes an A-IoT management function (AIMF).

[0053] It is to be understood that the summary section is not intended to identify key

or essential features of implementations of the present disclosure, nor is it intended to be used to limit the scope of the present disclosure. Other features of the present disclosure will become easily comprehensible through the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0054] FIG. 1A illustrates an example of a wireless communications system that supports data transport related to A-IoT device in accordance with aspects of the present disclosure;

[0055] FIGS. 1B through 1D illustrate examples of a network architecture that supports data transport related to A-IoT device in accordance with aspects of the present disclosure, respectively;

[0056] FIG. 2 illustrates a signaling diagram illustrating an example process that supports data transport related to A-IoT device in accordance with aspects of the present disclosure;

[0057] FIG. 3A illustrates a signaling diagram illustrating an example process of data transport related to A-IoT device based on NAS message in accordance with aspects of the present disclosure;

[0058] FIG. 3B illustrates an example of protocol stack for data transport related to A-IoT device based on NAS message in accordance with aspects of the present disclosure;

[0059] FIG. 4A illustrates a signaling diagram illustrating an example process of data transport related to A-IoT device based on non-NAS message in accordance with aspects of the present disclosure;

[0060] FIG. 4B illustrates an example of protocol stack for data transport related to A-IoT device based on non-NAS message in accordance with aspects of the present disclosure;

[0061] FIG. 4C illustrates an example of a structure of a MAC PDU for data transport related to A-IoT device based on non-NAS message in accordance with aspects of the present disclosure;

[0062] FIG. 5 illustrates a signaling diagram illustrating an example process of paging of A-IoT device(s) in accordance with aspects of the present disclosure;

[0063] FIG. 6 illustrates an example of a device that supports data transport related to A-IoT device in accordance with some aspects of the present disclosure;

[0064] FIG. 7 illustrates an example of a processor that supports data transport related to A-IoT device in accordance with other aspects of the present disclosure; and

[0065] FIGS. 8 through 11 illustrate flowcharts of methods that support data transport related to A-IoT device in accordance with other aspects of the present disclosure, respectively.

DETAILED DESCRIPTION

[0066] Principles of the present disclosure will now be described with reference to some implementations. It is to be understood that these implementations are described only for the purpose of illustration and help those skilled in the art to understand and implement the present disclosure, without suggesting any limitation as to the scope of the disclosure. The disclosure described herein may be implemented in various manners other than the ones described below.

[0067] 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.

[0068] References in the present disclosure to “one implementation,” “an example implementation,” “an implementation,” “some implementations,” and the like indicate that the implementation(s) described may include a particular feature, structure, or characteristic, but it is not necessary that every implementation includes the particular feature, structure, or characteristic. Moreover, such phrases do not necessarily refer to the same implementation(s). Further, when a particular feature, structure, or characteristic is described in connection with an implementation, 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 implementations whether or not explicitly described.

[0069] It shall be understood that although the terms “first” and “second” or the like may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another element. For example, a first element could also be termed as a second element, and similarly, a second element could also be termed as a first element, without departing from the scope

of implementations. As used herein, the term “and/or” includes any and all combinations of one or more of the listed terms.

[0070] The terminology used herein is for the purpose of describing particular embodiments only 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. For example, the term “includes” and its variants are to be read as open terms that mean “includes, but is not limited to.” The term “based on” is to be read as “based at least in part on.” The term “one embodiment” and “an embodiment” are to be read as “at least one embodiment.” The term “another embodiment” is to be read as “at least one other embodiment.” The use of an expression such as “A and/or B” can mean either “only A” or “only B” or “both A and B.” Other definitions, explicit and implicit, may be included below.

[0071] As used herein, the term “communication network” refers to a network following any suitable communication standards, such as, 5G 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 terminal device 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.

[0072] As used herein, the term “network device” generally refers to a node in a communication network via which a terminal device 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), an 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 BS, a pico BS, and so forth, depending on the applied terminology and technology.

[0073] As used herein, the term “terminal device” generally refers to any end device that may be capable of wireless communications. By way of example rather than a limitation, a terminal device may also be referred to as a communication device, a user equipment (UE), 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 terminal device 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 terminal device, a personal digital assistant (PDA), a portable computer, a desktop computer, an image capture terminal device such as a digital camera, a gaming terminal device, a music storage and playback appliance, a vehicle-mounted wireless terminal device, 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: “terminal device,” “communication device,” “terminal,” “user equipment” and “UE,” may be used interchangeably.

[0074] As used herein, the term “A-IoT device” refers to a device (e.g., an IoT device) powered by energy harvesting, being either battery-less or with limited energy storage capability (e.g., using a capacitor). The A-IoT device is typically 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. In one example, the A-IoT device has the following features: a peak power consumption of about $1\ \mu W$ (microwatt), having energy storage, an initial sampling frequency offset up to 10^x ppm (part per million, where the x is a natural number), no uplink amplification in the device, and the uplink transmission is backscattered on a carrier wave provided externally. In another example, the A-IoT device has the following features: a peak power consumption of no more than a few hundred μW , having energy storage, an initial sampling frequency offset up to 10^x ppm (part per million), with/without uplink amplification in the device, and the uplink transmission is backscattered on a carrier wave provided externally or generated internally by the device. In another example, the A-IoT device has no energy storage, no independent signal generation and/or amplification (e.g., backscattering transmission).

[0075] In 3GPP Release 19, a new study on A-IoT was approved. Specifically, an objective is identified in the study to study and decide which functions are needed for an A-IoT compact protocol stack and lightweight signaling procedure to enable DO-DTT and DT data transmission. For example, techniques for data transport related to A-IoT devices needs to be designed. Aspects of the present disclosure are described in the context of a wireless communications system.

[0076] FIG. 1A illustrates an example of a wireless communications system 100A that supports data transport related to A-IoT device in accordance with aspects of the present disclosure. The wireless communications system 100A may include one or more network entities 102 (also referred to as network equipment (NE)), one or more terminal devices or UEs 104, a core network 106, and a data network (DN) 108. The wireless communications system 100A may support various radio access technologies. In some implementations, the wireless communications system 100A 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 100A may be a 5G network, such as an NR network. In other implementations, the wireless communications system 100A 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 100A may support radio access technologies beyond 5G. Additionally, the wireless communications system 100A may support technologies, such as time division multiple access (TDMA), frequency division multiple access (FDMA), or code division multiple access (CDMA), etc.

[0077] The one or more network entities 102 may be dispersed throughout a geographic region to form the wireless communications system 100A. 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. Hereinafter, some implementations of the present disclosure will be described by taking an RAN node as an example of the network entity 102. Thus, the network entity 102 may be used interchangeably with the RAN node 102. A network entity 102 and a UE 104 may communicate via a communication link 110, which may be a wireless or wired connection. For example, a network entity 102 and a UE 104 may perform wireless communication (e.g., receive signaling, transmit signaling) over a Uu interface.

[0078] 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.

[0079] The one or more UEs 104 may be dispersed throughout a geographic region of the wireless communications system 100A. 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 100A. In some other implementations, a UE 104 may be mobile in the wireless communications system 100A.

[0080] The one or more UEs 104 may be devices in different forms or having different capabilities. Some examples of UEs 104 are illustrated in FIG. 1. A UE 104 may be capable of communicating with various types of devices, such as the network entities 102, other UEs 104, or network equipment (e.g., the core network 106, the data network 108, a relay device, an integrated access and backhaul (IAB) node, or another network equipment), as shown in FIG. 1. Additionally, or alternatively, a UE 104 may support communication with other network entities 102 or UEs 104, which may act as relays in the wireless communications system 100A.

[0081] A UE 104 may also be able to support wireless communication directly with other UEs 104 over a communication link 114. For example, a UE 104 may support wireless communication directly with another UE 104 over a device-to-device (D2D) communication link. In some implementations, such as vehicle-to-vehicle (V2V) deployments, vehicle-to-everything (V2X) deployments, or cellular-V2X deployments, the communication link 114 may be referred to as a sidelink. For example, a UE 104 may support wireless communication directly with another UE 104 over a PC5 interface.

[0082] 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).

[0083] In some implementations, a network entity 102 may be configured in a disaggregated architecture, which may be configured to utilize a protocol stack physically or logically distributed among two or more network entities 102, such as an integrated access backhaul (IAB) network, an open RAN (O-RAN) (e.g., a network configuration sponsored by the O-RAN Alliance), or a virtualized RAN (vRAN) (e.g., a cloud RAN (C-RAN)). For example, a network entity 102 may include one or more of a central unit (CU), a distributed unit (DU), a radio unit (RU), a RAN Intelligent Controller (RIC) (e.g., a Near-Real Time RIC (Near-RT RIC), a Non-Real Time RIC (Non-RT RIC)), a Service Management and Orchestration (SMO) system, or any combination thereof.

[0084] 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)).

[0085] Split of functionality between a CU, a DU, and an RU may be flexible and may support different functionalities depending upon which functions (e.g., network layer functions, protocol layer functions, baseband functions, radio frequency functions, and any combinations thereof) are performed at a CU, a DU, or an RU. For example, a functional split of a protocol stack may be employed between a CU and a DU such that the CU may support one or more layers of the protocol stack and the DU may support one or more different layers of the protocol stack. In some implementations, the CU may host upper protocol layer (e.g., a layer 3 (L3), a layer 2 (L2)) functionality and signaling (e.g., radio resource control (RRC), service data adaptation protocol (SDAP), packet data

convergence protocol (PDCP)). The CU may be connected to one or more DUs or RUs, and the one or more DUs or RUs may host lower protocol layers, such as a layer 1 (L1) (e.g., physical (PHY) layer) or an L2 (e.g., radio link control (RLC) layer, medium access control (MAC) layer) functionality and signaling, and may each be at least partially controlled by the CU 160.

[0086] 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).

[0087] 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.

[0088] 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.

[0089] The core network 106 may communicate with the data network 108 over one or more backhaul links 116 (e.g., via an S1, N2, N2, or another network interface). The 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).

[0090] In the wireless communications system 100A, the network entities 102 and the UEs 104 may use resources of the wireless communications system 100A (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.

[0091] One or more numerologies may be supported in the wireless communications system 100A, 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.

[0092] 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.

[0093] 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 100A. 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.

[0094] In the wireless communications system 100A, 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 100A 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.

[0095] 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., =0), which includes 15 kHz subcarrier spacing; a second numerology (e.g., =1), which includes 30 kHz subcarrier spacing; and a third numerology (e.g., =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., =2), which includes 60 kHz subcarrier spacing; and a fourth numerology (e.g., =3), which includes 120 kHz subcarrier spacing.

[0096] FIG. 1B illustrates an example of a network architecture 100B that supports data transport related to A-IoT device in accordance with aspects of the present disclosure. Specifically, the network architecture 100B may involve a network entity 102 and a core network 106 as illustrated in FIG. 1A. The network entity 102 may be implemented as a base station. The network architecture 100B may also involve an A-IoT device 120. It is to be understood that the network architecture 100B may further include additional devices not shown and/or omit some shown devices, and the scope of the present disclosure is not limited in this regard.

[0097] As shown in FIG. 1B, the A-IoT device 120 may communicate with the base station 102. The base station 102 may communicate with the core network 106. The core network 106 may include at least an access and mobility management function (AMF) 130 and a network function (NF) 140. The network function 140 may be implemented in a single logical entity in the core network 106 or in multiple logical entities in the core network 106. As an example, the network function 140 may be implemented as an A-IoT management function (AIMF).

[0098] In some implementations, the network function 140 may support A-IoT device data processing. For example, the network function 140 may support gathering the raw data of the A-IoT device, filtering and cleaning the raw data, and putting the raw data in

a usable format for processing, etc.

[0099] Alternatively or additionally, the network function 140 may support A-IoT device management. For example, the network function 140 may support monitoring, managing, controlling and coordination of the A-IoT devices and/or A-IoT readers (e.g., the base station). The A-IoT reader is a device that reads from A-IoT devices and writes data to A-IoT devices using radio frequency waves. In a more specific example, the network function 140 may support at least one of the following: identifying individual A-IoT devices; communication with an identified A-IoT device to perform an operation, such as inventorying, reading, writing, locking, or killing the A-IoT device; or A-IoT reader configuration, such as the configuration of the radio frequency receiver sensitivity, or radio frequency transmit power.

[0100] Alternatively or additionally, the network function 140 may support service management. For example, the network function 140 may support receiving service request from the external entities, authorizing the service request, and filtering the results from the data retrieved from the A-IoT devices and/or A-IoT readers.

[0101] FIG. 1C illustrates an example of a network architecture 100C that supports data transport related to A-IoT device in accordance with aspects of the present disclosure. Specifically, the network architecture 100C may involve a network entity 102 and a core network 106 as illustrated in FIG. 1A. The network entity 102 may be implemented as a base station. The network architecture 100C may also involve an A-IoT device 120. The same reference numerals are used to denote the elements or components described in FIG. 1C having the same operations as the elements or components described in FIG. 1B, and detailed description thereof will be omitted. It is to be understood that the network architecture 100C may further include additional devices not shown and/or omit some shown devices, and the scope of the present disclosure is not limited in this regard. As shown in FIG. 1C, the network function 140 may be implemented as a function in the AMF 130.

[0102] FIG. 1D illustrates an example of a network architecture 100D that supports data transport related to A-IoT device in accordance with aspects of the present disclosure. Specifically, the network architecture 100D may involve a network entity 102 and a core network 106 as illustrated in FIG. 1A. The network entity 102 may be implemented as a base station. The network architecture 100D may also involve an A-IoT device 120. The

same reference numerals are used to denote the elements or components described in FIG. 1D having the same operations as the elements or components described in FIG. 1B, and detailed description thereof will be omitted. It is to be understood that the network architecture 100D may further include additional devices not shown and/or omit some shown devices, and the scope of the present disclosure is not limited in this regard. As shown in FIG. 1D, the network function 140 may be implemented as a logical entity different from AMF 130 and may communicate with the base station 102 directly.

[0103] It should be understood that the network architectures 100B and 100C are merely for illustration. Some other implementations are also possible. For example, some of the functionalities of the network function 140 may be implemented in the AMF 130 and other of the functionalities of the network function 140 may be implemented in a logical entity in the core network 106 different from AMF 130.

[0104] Hereinafter, principles of the present disclosure will be described with reference to FIGS. 2 through 10.

[0105] FIG. 2 illustrates a signaling diagram illustrating an example process 200 that supports data transport related to A-IoT device in accordance with aspects of the present disclosure. For the purpose of discussion, the process 300A will be described with reference to FIGS. 1B-1D. The process 200 may involve a first device 220 and a base station 102. In some implementations, the process 200 may further involve a second device 230. Alternatively or additionally, the process 200 may further involve a third device 240. The first device 220 may include the A-IoT device 102 in FIGS. 1B-1D. The second device 230 may include the AMF 130 in FIGS. 1B-1D. The third device 240 may include the network function 140 in FIG. 1B or 1D. It is to be understood that process 200 may further include additional blocks not shown and/or omit some shown blocks, and the scope of the present disclosure is not limited in this regard.

[0106] As shown in FIG. 2, the first device 220 obtains 205 data 207 of the first device 220. The first device 220 includes an A-IoT device powered by energy harvesting. In some example implementations, the first device 220 may include the A-IoT 120 in FIGS. 1B-1D. The first device 220 transmits 206 the data 207 to the base station 102. In some example implementations, the UL transmission may be backscattered on a carrier wave provided externally. The base station 102 receives 208 the data 207. In some embodiments, the base station 102 may transmit 209 the data 207 to the second device

230 via a message. The second device 230 may receive 210 the data 207. Alternatively, the base station may transmit 209' the data 207 to the third device 240 via a message. The the third device 240 may receive 210' the data 207.

[0107] In some implementations, when transmitting 206 the data 207 to the base station 102, the first device 220 may transmit a non-access stratum (NAS) message carrying the data 207 to the base station 102.

[0108] In some embodiments, in order to transmit the NAS message to the base station 102, the first device 220 may transmit a MAC message to the base station 102, wherein the MAC message includes the NAS message.

[0109] Alternatively, in order to transmit the NAS message to the base station 102, the first device 220 may transmit a RRC message to the base station 102, wherein the RRC message includes the NAS message. In a specific example, when transmitting the RRC message to the base station 102, the first device may transmit the RRC message using a signaling radio bearer (SRB) without a packet data convergence protocol (PDCP) layer function. In another specific example, when transmitting the RRC message to the base station 102, the first device may transmit the RRC message using a SRB without a PDCP layer function and a radio link control (RLC) function.

[0110] In some implementations, the RRC message or the MAC message including the NAS message may include an indication of an establishment cause. The establishment cause may include one of the following: a device terminated (DT) communication; a device originated – device terminated triggered (DO-DTT) communication; or a device originated (DO) communication. The DT communication refers to a communication that is initiated by the network and delivered to the A-IoT device. The DO-DTT communication refers to a communication that is initiated by the A-IoT device, but triggered by the network. The DO communication refers to a communication that is initiated by the A-IoT device and delivered to the network.

[0111] Based on the indication of the establishment cause of the received message, the base station 102 would not request the establishment of the PDU session and the RRC connection for the first device 220, e.g., no RRC state for the first device 220. After receiving the NAS message carrying the data, the base station 102 may forward the NAS message to the second device 230. For example, when transmitting the data 207 to the second device 230 or directly to the third device 240, the base station 102 may transmit a

signaling message to the second device 230 or directly to the third device 240. The signaling message may include the NAS message carrying the data 207. In a specific example, the signaling message may be an initial UE message. Other signaling messages are also possible.

[0112] In some implementations, the signaling message may further include an indication of the establishment cause. Alternatively or additionally, the signaling message may further include an indication that the signaling message is for A-IoT data transmission. In some embodiments, the second device 230 may include an AMF. In some embodiments, the third device 240 may include an AMF. Based on the signaling message, the core network will not trigger the PDU session establishment for the first device 220.

[0113] In some implementations, the NAS message may include an indication that the NAS message is an A-IoT specific message. Alternatively or additionally, the NAS message may include an indication that a type of a payload in the NAS message is a container for A-IoT data.

[0114] In some embodiments, after receiving 210 the data 207 carried in the NAS message, the second device 230 may process 211 the data of the first device 220. For example, the second device 230 may perform the AMF 130 in FIG. 1C where the network function 140 is an internal function in the AMF 130.

[0115] Alternatively, the second device 230 and the third device 240 may perform the AMF 130 and the network function 140 in FIG. 1B, respectively. The NAS message may include an indication that a type of a payload in the NAS message is a container for an A-IoT management protocol message. Alternatively or additionally, the NAS message may include a correlation identifier of the third device 240 to which a payload in the NAS message is to be routed. After receiving 210 the data 207 carried in the NAS message, the second device 230 may transmit 212 the data 207 to the third device 240. The third device 240 may receive 213 the data 207 of the first device 220 and process the received data.

[0116] Alternatively, the third device 240 may perform the network function 140 in FIG. 1D. The base station 102 may directly transmit the data 207 carried in the NAS message to the third device 240 and the third device 240 may process the data of the first device 220. For example, the third device 240 may perform the functionality of the

network function 140 in FIG. 1D.

[0117] In some implementations, when transmitting 206 the data 207 to the base station 102, the first device 220 may transmit a MAC protocol data unit (PDU) carrying the data 207 to the base station 102.

[0118] In some embodiments, a MAC header of the MAC PDU may include an indication that the MAC PDU is a transparent MAC; an indication of a length of a MAC service data unit (SDU) containing the data 207; an identifier of the first device 220; or an identifier of a first device group, wherein the first device 220 belongs to the first device group.

[0119] In some implementations, after receiving 208 the MAC PDU carrying the data 207, the base station 102 may transmit 209 the data 207 to the second device 230 via a message. Alternatively, after receiving 208 the MAC PDU carrying the data 207, the base station 102 may transmit 209' the data 207 to the third device 240 via a message. In some embodiments, in order to transmit the data 207 to the second device 230 or directly to the third device 240, the base station 102 may transmit the message carrying piggyback data. The piggyback data may be based on data from at least one first device, and the at least one first device includes the first device 220. For example, the base station 102 may monitor MAC PDUs from a first device group, concatenate data received from at least one first device among the first device group and transmit the concatenated data to the second device 230 or directly to the third device 240.

[0120] In some embodiments, the message carrying the piggyback data may include at least one identifier of the at least one first device. Alternatively or additionally, the message carrying the piggyback data may include an identifier of the first device group. Alternatively or additionally, the message carrying the piggyback data may include at least one of the following: identifiers of one or more first devices or an indication of a failure reason of receive corresponding data from the one or more first devices. The one or more first devices are remaining first devices among the first device group other than the at least one first device. In some embodiments, the process 200 may involve both the second device 230 and the third device 240. The message carrying the piggyback data transmitted from the base station 102 to the second device 230 may further include a correlation identifier of the third device 240 to which the piggyback data is to be routed.

[0121] In some embodiments, the base station 102 may receive from the second

device 230 or from the third device 240, an identifier of the first device group and at least one identifier of the at least one first device being memberships of the first device group. Each of the at least one first device includes an A-IoT device powered by energy harvesting. The first device 220 belongs to the first device group. The base station may monitor data from the first device group, concatenate the received data and transmit the concatenated data to the second device 230 or to the third device 240.

[0122] In a specific example, the second device 230 may determine the first device group and the at least one first device being memberships of the first device group and transmit the identifier of the first device group and the at least one identifier of the at least one first device to the base station 102.

[0123] In another specific example, the third device 240 may determine 201 the first device group and the at least one first device being memberships of the first device group; and transmit 202, to the second device 230, the identifier 203 of the first device group and the at least one identifier of the at least one first device. The second device 230 may receive 204 the identifier 203 of the first device group and the at least one identifier of the at least one first device and transmit the identifier of the first device group and the at least one identifier of the at least one first device to the base station 102.

[0124] Alternatively, the third device 240 may transmit 202' the identifier 203 of the first device group and the at least one identifier of the at least one first device to the base station 102 directly. The base station 102 may receive 204' the identifier 203 of the first device group and the at least one identifier of the at least one first device from the third device 240.

[0125] In some embodiments, the first device 220 may transmit the data 207 periodically or based on a proactive determination or in response to a request from the base station 102. For example, before receiving the data 207 from the first device 220, the base station 102 may transmit a first message to the first device 220.

[0126] In some implementations, the first device 220 may determine to transmit the data 207 to the base station 102 via a NAS message or in a MAC PDU based on the first message. In some examples, the first message may include an identifier of the first device 220, indicating that the data of the first device 220 is required. The first device 220 may transmit data to the base station 102 in response to receiving the first message. Alternatively, the first message may include the identifier of the first device group,

indicating that the data of the first device group is required. The at least one first device being memberships of the first device group may transmit data to the base station 102 in response to receiving the first message.

[0127] In some implementations, the first message may further include an indication of a first transmission type of the data to be transmitted to the base station 102. In some examples, the first transmission type is a NAS-based type or a non-NAS-based type. In some implementations, the first message may further include an indication of a purpose of the first message. In some examples, the purpose of the first message is a DT communication or a DO-DTT communication.

[0128] In some implementations, before transmitting the first message, the base station 102 may receive a second message from the second device 230 or the third device 240. In some examples, the second message may include an identifier of the first device 220, indicating that the data of the first device 220 is required. The base station 102 may transmit the first message to the first device 220 in response to receiving the second message. Alternatively, the second message may include the identifier of the first device group, indicating that the data of the first device group is required. The base station 102 may transmit the first message to the at least one first device being memberships of the first device group in response to receiving the second message.

[0129] In some implementations, the second message may further include an indication of a second transmission type of the data to be transmitted from the base station 102 to the second device 230 or the third device 240. In some examples, the second transmission type is a NAS-based type or a piggyback-based type.

[0130] In some implementations, the first and second messages include the identifier of the first device group. The base station 102 may start a timer when receiving first data from the first device group and monitor corresponding data from the first device group before the timer reaches the time duration to wait. The base station 102 may transmit piggyback data when the timer reaches the time duration to wait, wherein the piggyback data is obtained by concatenating data received from the first device group during the time duration to wait. In some implementations, the second message may further include an indication of the time duration to wait. Alternatively, the time duration to wait may be predefined or preconfigured. The second device 230 may process the piggyback data or transmit the piggyback data to the third device 240.

[0131] In some implementations, the first message and the second message may be paging messages or other types of messages requesting data transport related to the A-IoT device. The base station 102 may transmit, to the first device 220, an indication of successful reception of the data 207.

[0132] FIG. 3A illustrates a signaling diagram illustrating an example process 300A of data transport related to A-IoT device based on NAS message in accordance with aspects of the present disclosure. For the purpose of discussion, the process 300A will be described with reference to FIGS. 1B-1D. The process 300A may involve the A-IoT device 120 and the base station 102 as shown in FIGS. 1B-1D. In some implementations, the process 300A may further involve the AMF 130 in FIGS. 1B-1D. In some implementations, the process 300A may further involve the network function 140 in FIG. 1B or 1D. It is to be understood that the steps and the order of the steps in FIG. 3A are merely for illustration, and not for limitation. It is to be understood that process 300A may further include additional blocks not shown and/or omit some shown blocks, and the scope of the present disclosure is not limited in this regard. The process 300A may be regarded as a specific example of the process 200 in FIG. 2.

[0133] In the process 300A, at 301, the A-IoT device 120 transmits a RRC message to the base station 102, where the RRC message is used for A-IoT data transport. The RRC message may include an indication of the establishment cause, where the establishment cause provides the establishment cause for the RRC message as provided by the upper layer. In addition, the base station 102 is not expected to request the establishment of the PDU session and the RRC connection for the A-IoT device 120.

[0134] In one example, the establishment cause is DT, which stands for device terminated. The DT indicates that the communication is initiated by the network and delivered to the A-IoT device 120. In another example, the establishment cause is DO-DTT, which stands for device originated and device-terminated triggered. The DO-DTT indicates that the communication is initiated by the A-IoT device 120, but is triggered by the network. In another example, the establishment cause is DO, which stands for device originated. The DO indicates that the communication is initiated by the A-IoT device 120 and delivered to the network.

[0135] In some embodiments, the RRC message may include the NAS message carrying the A-IoT data. In one example, the NAS message may include a first indicator,

which indicates the type of NAS message is an A-IoT specific message. Alternatively or additionally, the NAS message may include a second indicator, which indicates that the type of the payload in the NAS message is an A-IoT data container. In some embodiments, if an independent network function 140 is introduced in the core network, the second indicator may indicate that the type of the payload in the NAS message is an A-IoT management protocol message container. Alternatively or additionally, if an independent network function 140 is introduced in the core network, the NAS message may include a third indicator, which indicates the correlation identifier of the network function 140. The correlation identifier of the network function 140 is assigned by the network function 140, and enables the AMF 130 to distinguish one from the other network function for routing the payload in the NAS message.

[0136] In some embodiments, the RRC message may be transferred using an SRB, e.g., SRB0 or a default SRB. In one example, the SRB would not include the PDCP layer functions, such as header compression, ciphering and duplication. Additionally, the SRB would not include the RLC layer functions either, such as segmentation and duplication detection.

[0137] FIG. 3B illustrates an example of protocol stack between the A-IoT device 120 and the base station 102 for data transport related to A-IoT device based on NAS message in accordance with aspects of the present disclosure. As shown in FIG. 3B, the protocol stack may comprise four layers: NAS layer, RRC layer, MAC layer and PHY layer. The data may be transmitted from the A-IoT device 120 to the base station 102 via a signaling message, e.g., a NAS message over the RRC message using a default SRB without PDCP layer functions. Alternatively, the data may be transmitted from the A-IoT device 120 to the base station 102 via a signaling message, e.g., a NAS message over the RRC message using a default SRB without PDCP layer functions and RLC layer functions.

[0138] Returning back to FIG. 3A, at 302, the base station 102 may transmit an initial UE message signaling to the AMF 130. Alternatively, the base station 102 may transmit an initial UE message signaling to the network function 140 directly. The initial UE message may include the NAS message carrying the A-IoT data. In some embodiments, the initial UE message may further include the establishment cause received from the A-IoT device 120 in the RRC message, e.g., DT, DO-DTT or DO.

[0139] In some embodiments, the initial UE message may further include a fourth indicator, which indicates that the message is initiated by the A-IoT device 120 for data transport. On receipt of the fourth indicator, the AMF 130 would not trigger the PDU session establishment for the A-IoT device 120. For example, the fourth indicator is an A-IoT session, and if the value of the fourth indicator is set to TRUE, the AMF 130 would consider that the initial UE message is received as a result of an A-IoT data transport.

[0140] In some embodiments, the AMF 130 may comprise the network function 140 as shown in FIG. 1C. In other words, the network function 140 is an internal function in the AMF 130. The AMF 130 determines that the NAS message in the initial UE message should be decoded and processed by the AMF 130. That is, the destination of the NAS message is the AMF 130 itself, and the AMF 130 should not forward the NAS message to any other entities.

[0141] In some embodiments, at 303, after receiving the NAS message carrying the data, the AMF 130 may determine the network function 140 for routing the payload in the NAS message. For example, if the third indicator is included in the NAS message in the initial UE message, the AMF 130 may transparently forward the payload in the NAS message to the corresponding network function 140 identified by the third indicator. At 304, the AMF 130 forwards the A-IoT data to the network function 140.

[0142] At 305, the base station 102 may transmit a message to the A-IoT device 120, to confirm the successful completion of the A-IoT data transport procedure. In one example, the message is a DCI. In another example, the message is a MAC control element (CE).

[0143] In this way, the A-IoT device may transmit data to the base station without establishing a RRC connection with the base station. It should be understood that the protocol stack in FIG. 3B is merely shown for illustration without limiting the protection scope of the present disclosure. Other protocol stacks are also possible. In some embodiments, the protocol stack may comprise three layers: NAS layer, MAC layer and PHY layer. The data may be transmitted from the A-IoT device 120 to the base station 102 via a signaling message, e.g., a NAS message over a MAC message using a default SRB without RRC layer functions, PDCP layer functions and RLC layer functions. Similarly, the MAC message may include an indication of an establishment cause and the NAS message carrying the data. With the network function 140 implemented in the AMF

130 or separate from the AMF 130, a functionality for A-IoT management is introduced in the core network and data support for A-IoT device 120 with no RRC state is supported.

[0144] FIG. 4A illustrates a signaling diagram illustrating an example process 400A of data transport related to A-IoT device based on non-NAS message in accordance with aspects of the present disclosure. For the purpose of discussion, the process 400A will be described with reference to FIGS. 1B-1D. The process 400A may involve the A-IoT device 120 and the base station 102 as shown in FIGS. 1B-1D. In some implementations, the process 400A may further involve the AMF 130 in FIGS. 1B-1D. In some implementations, the process 400A may further involve the network function 140 in FIG. 1B or 1D. It is to be understood that the steps and the order of the steps in FIG. 4A are merely for illustration, and not for limitation. It is to be understood that process 400A may further include additional blocks not shown and/or omit some shown blocks, and the scope of the present disclosure is not limited in this regard. The process 400A may be regarded as a specific example of the process 200 in FIG. 2.

[0145] In the process 400A, at 401, the A-IoT device 120 transmits a MAC PDU to the base station 102, where the MAC PDU is used for A-IoT data transport. The MAC PDU may include a MAC SDU, where the MAC SDU contains the A-IoT data.

[0146] FIG. 4B illustrates an example of protocol stack between the A-IoT device 120 and the base station 102 for data transport related to A-IoT device based on non-NAS message in accordance with aspects of the present disclosure. In some embodiments, the protocol stack may comprise two layers: MAC layer and PHY layer. The data may be transmitted from the A-IoT device 120 to the base station 102 in a MAC PDU.

[0147] FIG. 4C illustrates an example of a structure of a MAC PDU for data transport related to A-IoT device based on non-NAS message in accordance with aspects of the present disclosure. The MAC PDU may include a MAC header 411 and a MAC SDU 412. The MAC SDU 412 contains the data of the A-IoT device 120. The MAC header contains one or more of the first field 413, the second field 414, the third field 415 and the fourth field 416. The first field 413 may indicate that the MAC PDU is a transparent MAC. If the MAC PDU is a transparent MAC, the MAC layer is transparent for the A-IoT data. That is, the base station 102 should not decode the MAC SDU. The second field 414 may indicate the length of the corresponding MAC SDU 412. The third field 415 may indicate the ID of the A-IoT device 120. The fourth field 416 may indicate the A-

IoT group ID which the A-IoT device 120 belongs to.

[0148] Returning back to FIG. 4A, at 402, the base station 102 transmits a message to the AMF 130. Alternatively, the base station 102 may transmit a message to the network function 140 directly. The message may be implemented as a non-UE associated signaling or a user plane message. The message may include the piggyback data from multiple A-IoT devices. In one example, the message may include IDs of the multiple A-IoT devices corresponding to the piggyback data. In another example, the message may include an ID of an A-IoT group, which indicates the piggyback data transport for the multiple A-IoT devices within the A-IoT group.

[0149] Alternatively or additionally, the message may further include ID(s) of A-IoT device(s) without the data transport. For example, if the base station receives an ID of an A-IoT group from the AMF 130 for data transport of the A-IoT group, and the base station 102 cannot obtain the data of one or more A-IoT device within the group, the base station 102 may include the ID(s) of A-IoT device(s) without the data transport in the message. Alternatively or additionally, the message may further include a cause value, which indicates the failure reason for data transport, e.g., the A-IoT device(s) without the data transport has insufficient power.

[0150] In some embodiments, the process 400A may involve the network function 140 in FIG. 1B. If an independent network function 140 is introduced in the core network, the message may further include a fifth indicator, which indicates the correlation identifier of the network function 140. The correlation identifier of the network function 140 is assigned by the network function 140, and enables the AMF 130 to distinguish one from the other network function for routing the piggyback data.

[0151] If the fifth indicator is included in the message received at 402, the AMF 130 should transparently forward the piggyback data to the corresponding network function 140 identified by the fifth indicator. At 403, the AMF 130 may determine the network function 140 for routing the piggyback data based on the fifth indicator. At 404, the AMF 130 forwards the A-IoT data to the network function 140.

[0152] In some embodiments, the AMF 130 may comprise the network function 140 as shown in FIG. 1C. In other words, the network function 140 is an internal function in the AMF 130. The AMF 130 determines that the piggyback data in the message should be decoded and processed by the AMF 130. That is, the destination of the piggyback data

is the AMF 130 itself, and the AMF 130 should not forward the piggyback data to any other entities.

[0153] At 405, the base station 102 may transmit a message to the A-IoT device 120, to confirm the successful completion of the A-IoT data transport procedure. In one example, the message is a DCI. In another example, the message is a MAC CE.

[0154] In this way, the base station may concatenate the data from multiple A-IoT devices, and then transmit the data to the AMF, thereby supporting data transport for the huge number of A-IoT devices without DL or UL amplification.

[0155] FIG. 5 illustrates a signaling diagram illustrating an example process of paging of A-IoT device(s) in accordance with aspects of the present disclosure. For the purpose of discussion, the process 500 will be described with reference to FIGS. 1B-1D. The process 500 may involve the A-IoT device 120 and the base station 102 as shown in FIGS. 1B-1D. In some implementations, the process 500 may further involve the AMF 130 in FIGS. 1B-1D. In some implementations, the process 500 may further involve the network function 140 in FIG. 1B or 1D. It is to be understood that the steps and the order of the steps in FIG. 5 are merely for illustration, and not for limitation. It is to be understood that process 500 may further include additional blocks not shown and/or omit some shown blocks, and the scope of the present disclosure is not limited in this regard. The process 500 may be regarded as a specific example of the process 200 in FIG. 2.

[0156] In the process 500, at 501, the network function 140 may transmit the A-IoT device group information to the AMF 130. In some embodiments the A-IoT device group information may include one or more A-IoT device groups, where each A-IoT device group includes the A-IoT group ID and the corresponding A-IoT device IDs that are memberships of the A-IoT group. The A-IoT device 120 may belong to one or more A-IoT device groups. The A-IoT device group information may be determined by the network function 140 based on the A-IoT device capability, location, or the A-IoT device service provision (e.g., indoor inventory, indoor command). In one example, the A-IoT device ID may be a short temporary mobile subscription identifier. In another example, the A-IoT device ID may be an electronic product code, which identifies the object to which the corresponding A-IoT device is affixed. The electronic product code is a universal identifier for any physical object, which is used in information systems that need to track or otherwise refer to physical objects, including trade items, logistics units,

documents, service relations, locations or other identifiable entity playing a role in business operations. In another example, the A-IoT device ID may be a tag identifier, which is a unique identification number of the manufacturer while constructing the integrated circuits of the tag. It should be understood that step 501 is optional.

[0157] At 502, the AMF 130 may determine the A-IoT device group and the corresponding A-IoT devices in the group. It should be understood that step 502 is optional.

[0158] In one example, the AMF 130 receives the A-IoT device group information from the network function 140 and determines the A-IoT device group and the corresponding A-IoT devices based on the A-IoT device group information.

[0159] In another example, the AMF 130 may determine the A-IoT device group information by itself, where the A-IoT device group information is implemented within the AMF 130. For example, the operator may pre-configure the A-IoT device group information at the AMF 130.

[0160] In another example, the AMF 130 may determine the A-IoT device group information based on the A-IoT device capability, location, or the A-IoT device service provision (e.g., indoor inventory, indoor command). For example, the AMF 130 obtains the A-IoT device capability from the network function 140 or from the A-IoT device 120.

[0161] At 503, the AMF 130 may transmit the A-IoT device group information to the base station 102. The A-IoT device group information may include one or more A-IoT device groups, where each A-IoT device group includes the A-IoT group ID and the corresponding A-IoT device IDs that are memberships of the A-IoT group. In some examples, the AMF 130 may transmit the A-IoT device group information to the base station 102 via a non-UE associated signaling, e.g., RAN configuration update acknowledge message, AMF configuration update message, NG setup response message, or other messages. It should be understood that step 503 is optional. Alternatively, the network function 140 may directly transmit the A-IoT device group information to the base station 102.

[0162] At 504, the AMF 130 may trigger the data transport procedure by transmitting a second paging message to the base station 102. In one example, the second paging message may include the A-IoT device ID, which indicates the A-IoT device 120 that is

paged. In another example, the second paging message may include the A-IoT group ID, which indicates the A-IoT devices in the A-IoT device group that are paged. Alternatively, the network function 140 may trigger the data transport procedure by transmitting a second paging message to the base station 102 directly.

[0163] In some embodiments, the second paging message may include an indication of the type of A-IoT data transport by the base station 102. In one example, the type is the NAS-based data transport. Based on the indication of the NAS-based data transport, the base station 102 may forward the A-IoT data in the NAS message to the AMF 130 or directly to the network function 140, e.g., via a UE-associated signaling. That is, the NAS message carrying the data is transparent to the base station 102. In another example, the type is the piggyback-based data transport. Based on the indication of the piggyback-based data transport, the base station 102 may concatenate the data from multiple A-IoT devices, and then transmit the data to the AMF 130 or directly to the network function 140, e.g., via a non-UE associated signaling.

[0164] The second paging message may further include an indication of the time to wait, which is used by the base station 102 to transmit the A-IoT data to the AMF 130 or directly to the network function 140. For example, the base station 102 transmits the A-IoT data using the piggyback-based data transport, and the base station 102 starts the timer when receiving the data from an A-IoT device. When the time to wait is approached, the base station 102 transmits the concatenated data from multiple A-IoT devices to the AMF 130 or directly to the network function 140.

[0165] At 505, the base station 102 transmits a first paging message to the A-IoT device 120 to trigger the data transport. In one example, the first paging message may include the A-IoT device ID, which indicates the A-IoT device 120 that is paged. In another example, the first paging message may include the A-IoT group ID, which indicates the A-IoT devices in the group that are paged.

[0166] In some embodiments, the first paging message may include the type of data transport by the A-IoT device 120. In one example, the type is the NAS-based data transport. Based on the indication of the NAS-based data transport, the A-IoT device 120 may transmit the data in the NAS message to the base station 102. In another example, the type is the non-NAS based data transport. Based on the indication of the non-NAS based data transport, the A-IoT device 120 may transmit the data via a pre-defined MAC

format to the base station 102.

[0167] The first paging message may further include an indication of the purpose of the first paging message. In one example, the purpose of the first paging message is for DT data transport by the A-IoT device. In another example, the purpose of the first paging message is for DO-DTT data transport by the A-IoT device.

[0168] In this way, a message is defined for the notification of one or more A-IoT devices. It should be understood that the first paging message and the second paging message are for illustration without suggesting any limitation. Other types of messages are also possible.

[0169] FIG. 6 illustrates an example of a device 600 that supports data transport related to A-IoT device in accordance with some aspects of the present disclosure. The device 600 may be an example of a first device 220, a base station 102, a second device 230 or a third device 240 as described herein. The device 600 may support wireless communication with one or more network entities 102, UEs 104, or any combination thereof. The device 600 may include components for bi-directional communications including components for transmitting and receiving communications, such as a processor 602, a memory 604, a transceiver 606, and, optionally, an I/O controller 608. 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).

[0170] The processor 602, the memory 604, the transceiver 606, 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 602, the memory 604, the transceiver 606, or various combinations or components thereof may support a method for performing one or more of the operations described herein.

[0171] In some implementations, the processor 602, the memory 604, the transceiver 606, 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 602 and the memory 604 coupled with the processor 602 may be configured to perform one or more of the functions described herein (e.g., executing, by the processor 602, instructions stored in the memory 604).

[0172] For example, the processor 602 may support wireless communication at the device 600 in accordance with examples as disclosed herein. The processor 602 may be configured to operable to support a means for receiving data from a first device, wherein the first device comprises an ambient internet of things (A-IoT) device powered by energy harvesting; and a means for transmitting, to a second device or a third device, the data via a message.

[0173] Alternatively, in some implementations, the processor 602 may be configured to operable to support a means for obtaining data of the first device, wherein the first device comprises an ambient internet of things (A-IoT) device powered by energy harvesting; and a means for transmitting, to the base station, one of the following: a non-access stratum (NAS) message carrying the data; or a medium access control (MAC) protocol data unit (PDU) carrying the data.

[0174] Alternatively, in some implementations, the processor 602 may be configured to operable to support a means for receiving, from a base station, data of a first device via a message, wherein the first device comprises an ambient internet of things (A-IoT) device powered by energy harvesting; and a means for one of the following: processing the data, or transmitting the data to a third device.

[0175] Alternatively, in some implementations, the processor 602 may be configured to operable to support a means for determining a first device group and at least one first device being memberships of the first device group, wherein each of the at least one first device comprises an ambient internet of things (A-IoT) device powered by energy harvesting; and a means for transmitting, to a second device or a base station, an identifier of the first device group and at least one identifier of the at least one first device.

[0176] The processor 602 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 602 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 602. The processor 602 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 604) to cause the device 600 to perform various functions of the present disclosure.

[0177] The memory 604 may include random access memory (RAM) and read-only memory (ROM). The memory 604 may store computer-readable, computer-executable code including instructions that, when executed by the processor 602 cause the device 600 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. In some implementations, the code may not be directly executable by the processor 602 but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some implementations, the memory 604 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.

[0178] The I/O controller 608 may manage input and output signals for the device 600. The I/O controller 608 may also manage peripherals not integrated into the device 602. In some implementations, the I/O controller 608 may represent a physical connection or port to an external peripheral. In some implementations, the I/O controller 608 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 608 may be implemented as part of a processor, such as the processor 606. In some implementations, a user may interact with the device 600 via the I/O controller 608 or via hardware components controlled by the I/O controller 608.

[0179] In some implementations, the device 600 may include a single antenna 610. However, in some other implementations, the device 600 may have more than one antenna 610 (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 606 may communicate bi-directionally, via the one or more antennas 610, wired, or wireless links as described herein. For example, the transceiver 606 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 606 may also include a

modem to modulate the packets, to provide the modulated packets to one or more antennas 610 for transmission, and to demodulate packets received from the one or more antennas 610. The transceiver 606 may include one or more transmit chains, one or more receive chains, or a combination thereof.

[0180] 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 610 for transmitting the amplified signal into the air or wireless medium.

[0181] 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 610 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.

[0182] FIG. 7 illustrates an example of a processor 700 that supports data transport related to A-IoT device in accordance with other aspects of the present disclosure. The processor 700 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 700 may include a controller 702 configured to perform various operations in accordance with examples as described herein. The processor 700 may optionally include at least one memory 704. Additionally, or alternatively, the processor 700 may optionally include one or more arithmetic-logic units (ALUs) 706. 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).

[0183] The processor 700 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 700) 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).

[0184] The controller 702 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 700 to cause the processor 700 to support various operations in accordance with examples as described herein. For example, the controller 702 may operate as a control unit of the processor 700, generating control signals that manage the operation of various components of the processor 700. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[0185] The controller 702 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 704 and determine subsequent instruction(s) to be executed to cause the processor 700 to support various operations in accordance with examples as described herein. The controller 702 may be configured to track memory address of instructions associated with the memory 704. The controller 702 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 702 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 700 to cause the processor 700 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 702 may be configured to manage flow of data within the processor 700. The controller 702 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional

units of the processor 700.

[0186] The memory 704 may include one or more caches (e.g., memory local to or included in the processor 700 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementation, the memory 704 may reside within or on a processor chipset (e.g., local to the processor 700). In some other implementations, the memory 704 may reside external to the processor chipset (e.g., remote to the processor 700).

[0187] The memory 704 may store computer-readable, computer-executable code including instructions that, when executed by the processor 700, cause the processor 700 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 702 and/or the processor 700 may be configured to execute computer-readable instructions stored in the memory 704 to cause the processor 700 to perform various functions (e.g., functions or tasks supporting transmit power prioritization). For example, the processor 700 and/or the controller 702 may be coupled with or to the memory 704, the processor 700, the controller 702, and the memory 704 may be configured to perform various functions described herein. In some examples, the processor 700 may include multiple processors and the memory 704 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.

[0188] The one or more ALUs 706 may be configured to support various operations in accordance with examples as described herein. In some implementation, the one or more ALUs 706 may reside within or on a processor chipset (e.g., the processor 700). In some other implementations, the one or more ALUs 706 may reside external to the processor chipset (e.g., the processor 700). One or more ALUs 706 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 706 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 706 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 706 may support logical operations such as AND,

OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 706 to handle conditional operations, comparisons, and bitwise operations.

[0189] The processor 700 may support wireless communication in accordance with examples as disclosed herein. The processor 700 may be configured to operable to support a means for receiving data from a first device, wherein the first device comprises an ambient internet of things (A-IoT) device powered by energy harvesting; and a means for transmitting, to a second device or a third device, the data via a message.

[0190] Alternatively, in some implementations, the processor 700 may be configured to operable to support a means for obtaining data of the first device, wherein the first device comprises an ambient internet of things (A-IoT) device powered by energy harvesting; and a means for transmitting, to the base station, one of the following: a non-access stratum (NAS) message carrying the data; or a medium access control (MAC) protocol data unit (PDU) carrying the data.

[0191] Alternatively, in some implementations, the processor 700 may be configured to operable to support a means for receiving, from a base station, data of a first device via a message, wherein the first device comprises an ambient internet of things (A-IoT) device powered by energy harvesting; and a means for one of the following: processing the data, or transmitting the data to a third device.

[0192] Alternatively, in some implementations, the processor 700 may be configured to operable to support a means for determining a first device group and at least one first device being memberships of the first device group, wherein each of the at least one first device comprises an ambient internet of things (A-IoT) device powered by energy harvesting; and a means for transmitting, to a second device or a base station, an identifier of the first device group and at least one identifier of the at least one first device.

[0193] FIG. 8 illustrates a flowchart of a method 800 that supports data transport related to A-IoT device in accordance with aspects of the present disclosure. The operations of the method 800 may be implemented by a device or its components as described herein. For example, the operations of the method 800 may be performed by a base station 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.

[0194] At 805, the method may include receiving data from a first device, wherein the first device comprises an ambient internet of things (A-IoT) device powered by energy harvesting. 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 FIGS. 1A-1D.

[0195] At 810, the method may include transmitting, to a second device or a third device, the data via a message. 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 FIGS. 1A-1D.

[0196] FIG. 9 illustrates a flowchart of a method 900 that supports data transport related to A-IoT device in accordance with aspects of the present disclosure. The operations of the method 900 may be implemented by a device or its components as described herein. For example, the operations of the method 900 may be performed by a first device as described herein. In some implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or alternatively, the device may perform aspects of the described functions using special-purpose hardware.

[0197] At 905, the method may include obtaining data of the first device, wherein the first device comprises an ambient internet of things (A-IoT) device powered by energy harvesting. The operations of 905 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 905 may be performed by a device as described with reference to FIGS. 1A-1D.

[0198] At 910, the method may include transmitting, to the base station, one of the following: a non-access stratum (NAS) message carrying the data; or a medium access control (MAC) protocol data unit (PDU) carrying the data. The operations of 910 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 910 may be performed by a device as described with reference to FIGS. 1A-1D.

[0199] FIG. 10 illustrates a flowchart of a method 1000 that supports data transport related to A-IoT device in accordance with aspects of the present disclosure. The operations of the method 1000 may be implemented by a device or its components as described herein. For example, the operations of the method 1000 may be performed by

a second device as described herein. In some implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or alternatively, the device may perform aspects of the described functions using special-purpose hardware.

[0200] At 1005, the method may include receiving, from a base station, data of a first device via a message, wherein the first device comprises an ambient internet of things (A-IoT) device powered by energy harvesting. The operations of 1005 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1005 may be performed by a device as described with reference to FIGS. 1A-1D.

[0201] At 1010, the method may include one of the following: processing the data, or transmitting the data to a third device. The operations of 1010 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1010 may be performed by a device as described with reference to FIGS. 1A-1D.

[0202] FIG. 11 illustrates a flowchart of a method 1100 that supports data transport related to A-IoT device in accordance with aspects of the present disclosure. The operations of the method 1100 may be implemented by a device or its components as described herein. For example, the operations of the method 1100 may be performed by a third device as described herein. In some implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or alternatively, the device may perform aspects of the described functions using special-purpose hardware.

[0203] At 1105, the method may include determining a first device group and at least one first device being memberships of the first device group, wherein each of the at least one first device comprises an ambient internet of things (A-IoT) device powered by energy harvesting. The operations of 1105 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1105 may be performed by a device as described with reference to FIGS. 1A-1D.

[0204] At 1110, the method may include transmitting, to a second device or a base station, an identifier of the first device group and at least one identifier of the at least one first device. The operations of 1110 may be performed in accordance with examples as

described herein. In some implementations, aspects of the operations of 1110 may be performed by a device as described with reference to FIGS. 1A-1D.

[0205] 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.

[0206] 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.

[0207] 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.

[0208] 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.

[0209] 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.

[0210] 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.

WHAT IS CLAIMED IS:

1. A base station, comprising:
a processor; and
a transceiver coupled to the processor,
wherein the processor is configured to:
receive data via the transceiver from a first device, wherein the first device comprises an ambient internet of things (A-IoT) device powered by energy harvesting;
and
transmit, via the transceiver to a second device, the data via a message.
2. The base station of claim 1, wherein receiving the data comprises:
receiving, via the transceiver from the first device, a non-access stratum (NAS) message carrying the data.
3. The base station of claim 2, wherein the message is signaling message, the signaling message comprises the NAS message carrying the data.
4. The base station of claim 3, wherein the signaling message further comprises at least one of the following:
an indication of an establishment cause; or
an indication that the signaling message is for A-IoT data transmission.
5. The base station of claim 1, wherein transmitting the data comprises:
transmitting, via the transceiver to the second device, piggyback data via the message, wherein the piggyback data is based on data from at least one first device, and the at least one first device comprises the first device.
6. The base station of claim 5, wherein the message comprises at least one of the following:
at least one identifier of the at least one first device;
an identifier of a first device group, wherein the at least one first device belongs to the first device group;

identifiers of one or more first devices, wherein the one or more first devices are remaining first devices among the first device group other than the at least one first device;
an indication of a failure reason of receiving corresponding data from the one or more first devices; or
a correlation identifier of a third device to which the piggyback data is to be routed.

7. The base station of claim 1, wherein the processor is further configured to:
receive, via the transceiver from the second device, a second message, wherein the second message comprises one of the following:

an identifier of the first device; or
an identifier of a first device group, wherein the first device belongs to the first device group.

8. The base station of claim 1, wherein the processor is further configured to:
receive, via the transceiver from the second device, an identifier of a first device group and at least one identifier of at least one first device being memberships of the first device group, wherein the first device belongs to the first device group.

9. A first device comprising:
a processor; and
a transceiver coupled to the processor,
wherein the processor is configured to:
obtain data of the first device, wherein the first device comprises an ambient internet of things (A-IoT) device powered by energy harvesting; and
transmit, via the transceiver to the base station, one of the following:
a non-access stratum (NAS) message carrying the data; or
a medium access control (MAC) protocol data unit (PDU) carrying the data.

10. The first device of claim 9, wherein transmitting the NAS message comprises:

transmitting, via the transceiver from the first device, a MAC message, wherein the MAC message comprises the NAS message.

11. The first device of claim 9, wherein transmitting the NAS message comprises:

transmitting, via the transceiver from the first device, a radio resource control (RRC) message, wherein the RRC message comprises the NAS message.

12. The first device of claim 11, wherein the RRC message comprises an indication of an establishment cause, and the establishment cause comprises one of the following:

- a device terminated (DT) communication;
- a device originated – device terminated triggered (DO-DTT) communication; or
- a device originated (DO) communication.

13. The first device of claim 9, wherein the NAS message comprises at least one of the following:

- an indication that the NAS message is an A-IoT specific message;
- an indication that a type of a payload in the NAS message is a container for A-IoT data;
- an indication that a type of a payload in the NAS message is a container for an A-IoT management protocol message; or
- a correlation identifier of a third device to which a payload in the NAS message is to be routed.

14. The first device of claim 11, wherein transmitting the RRC message comprises:

transmitting, via the transceiver to the base station, the RRC message using one of the following:

- a signaling radio bearer (SRB) without a packet data convergence protocol (PDCP) layer function; or
- a SRB without a PDCP layer function and a radio link control (RLC) function.

15. The first device of claim 9, wherein a MAC header of the MAC PDU comprises at least one of the following:

- an indication that the MAC PDU is a transparent MAC;

an indication of a length of a MAC service data unit (SDU) containing the data;
an identifier of the first device; or
an identifier of a first device group, wherein the first device belongs to the first device group.

16. The first device of claim 9, wherein the processor is further configured to:
receive, via the transceiver from the base station, a first message, wherein the first message comprises one of the following:

an identifier of the first device; or
an identifier of a first device group, wherein the first device belongs to the first device group.

17. The first device of claim 16, wherein the first message further comprises at least one of the following:

an indication of a first transmission type of the data to be transmitted to the base station; or
an indication of a purpose of the first message.

18. The first device of claim 17, wherein the first transmission type is a NAS-based type or a non-NAS-based type,

wherein the purpose of the first message is a DT communication or a DO-DTT communication.

19. A second device comprising:

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

receive, from a base station, data of a first device via a message, wherein the first device comprises an ambient internet of things (A-IoT) device powered by energy harvesting; and

one of the following:

process the data, or
transmit the data to a third device.

20. A third device comprising:
- at least one memory; and
 - at least one processor coupled with the at least one memory and configured to cause the third device to:
 - determine a first device group and at least one first device being memberships of the first device group, wherein each of the at least one first device comprises an ambient internet of things (A-IoT) device powered by energy harvesting; and
 - transmit, to a second device, an identifier of the first device group and at least one identifier of the at least one first device.