ENERGY-BASED DATA SEGMENTATION FOR AMBIENT INTERNET OF THINGS (AIOT) DEVICES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Patent Application No. 63/555,541, filed on February 20, 2024, entitled ENERGY-BASED DATA SEGMENTATION FOR AMBIENT INTERNET OF THINGS (AIOT) DEVICES, which is hereby incorporated by reference in its entirety.

TECHNICAL FIELD

[0002] The present disclosure relates to wireless communications, and more specifically to energy-based data segmentation for ambient Internet of Things (AIoT) devices.

BACKGROUND

[0003] A wireless communications system may include one or multiple network communication devices, such as base stations, which may support wireless communications for one or multiple user communication devices, which may be otherwise known as user equipment (UE), or other suitable terminology. The wireless communications system may support wireless communications with one or multiple user communication devices by utilizing resources of the wireless communications system (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers, or the like)). Additionally, the wireless communications system may support wireless communications across various radio access technologies including third generation (3G) radio access technology, fourth generation (4G) radio access technology, fifth generation (5G) radio access technology, among other suitable radio access technologies beyond 5G (e.g., sixth generation (6G)).

[0004] Ambient power-enabled devices, such as ambient Internet of Things (IoT) devices, or AIoT devices, include battery-less devices that have limited storage capabilities (e.g., store a limited amount of energy using capacitors) or other capability restrictions.

These ambient power-enabled devices may store energy by harvesting energy from the environment of the devices, such as via radio waves, light, heat, motion, and other energy/power sources available to the devices.

SUMMARY

[0005] 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.

[0006] The present disclosure relates to methods, apparatuses, and systems that enable an IoT device, such as an AIoT device, to perform data segmentation, for example, in response to a determination that available energy at the AIoT device is insufficient to transmit a data payload.

[0007] A wireless device for wireless communication is described. The wireless device may be configured to, capable of, or operable to perform one or more operations as described herein. For example, the wireless device may comprise at least one memory and at least one processor coupled with the at least one memory and configured to cause the wireless device to split a payload into a set of two or more segments based at least in part on an energy level of the wireless device satisfying an energy level threshold, and transmit, to a second wireless device, a packet comprising at least one first segment of the set of two or more segments associated with the payload, wherein the packet includes an indication of

at least one second segment of the set of two or more segments associated with the payload pending for transmission to the second wireless device.

[0008] A processor for wireless communication is described. The processor may be configured to, capable of, or operable to perform one or more operations as described herein. For example, the processor may comprise at least one controller coupled with at least one memory and configured to cause the processor to split a payload into a set of two or more segments based at least in part on an energy level of the processor satisfying an energy level threshold, and transmit, to a second processor, a packet comprising at least one first segment of the set of two or more segments associated with the payload, wherein the packet includes an indication of at least one second segment of the set of two or more segments associated with the payload pending for transmission to the second processor.

[0009] A method performed or performable by a wireless device is described. The method may comprise splitting a payload into a set of two or more segments based at least in part on an energy level of the wireless device satisfying an energy level threshold, and transmitting, to a second wireless device, a packet comprising at least one first segment of the set of two or more segments associated with the payload, wherein the packet includes an indication of at least one second segment of the set of two or more segments associated with the payload pending for transmission to the second wireless device.

[0010] In some implementations of the wireless device, processor, and method described herein, the wireless device, processor, and method may further be configured to, capable of, performed, performable, or operable to receive, from the second wireless device, a first request message for data, and determine whether the energy level of the wireless device satisfies the energy level threshold for transmission of the data to the second wireless device, wherein to split the payload into the set of two or more segments is based at least in part on the energy level of the wireless device being less than the energy level threshold for transmission of the data to the second wireless device.

[0011] In some implementations of the wireless device, processor, and method described herein, the request message comprises one or more of an uplink grant for the transmission of the data to the second wireless device and a configuration for a carrier wave associated with backscattering the transmission.

[0012] In some implementations of the wireless device, processor, and method described herein, the wireless device, processor, and method may further be configured to, capable of, performed, performable, or operable to receive, from the second wireless device, a second request message for the at least one second segment of the set of two or more segments associated with the payload pending for transmission to the second wireless device and transmit, to the second wireless device, a second packet comprising the at least one second segment of the set of two or more segments.

[0013] In some implementations of the wireless device, processor, and method described herein, the second request message comprises one or more of an uplink grant for the transmission of the at least one second segment of the set of two or more segments and a configuration for a carrier wave associated with backscattering the transmission.

[0014] In some implementations of the wireless device, processor, and method described herein, a size of the at least one first segment is based at least in part on the energy level of the wireless device.

[0015] In some implementations of the wireless device, processor, and method described herein, the energy level of the wireless device corresponds to a current stored energy level of the wireless device.

[0016] In some implementations of the wireless device, processor, and method described herein, to split the payload into the set of two or more segments, the wireless device, processor, and method may further be configured to, capable of, performed, performable, or operable to segment, at a radio resource control (RRC) protocol layer or an application (APP) protocol layer of a set of protocol layers of the wireless device, the payload into the set of two or more segments.

[0017] In some implementations of the wireless device, processor, and method described herein, the wireless device is an IoT device or an AIoT device.

[0018] A communication device for wireless communication is described. The communication device may be configured to, capable of, or operable to perform one or more operations as described herein. For example, the communication device may comprise at least one memory and at least one processor coupled with the at least one

memory and configured to cause the communication device to transmit, to an IoT device, a first request message to transmit a data payload to the communication device, and receive, from the IoT device, a response message that includes a first segment of the data payload and information that identifies a remaining data payload.

[0019] A processor for wireless communication is described. The processor may be configured to, capable of, or operable to perform one or more operations as described herein. For example, the processor may comprise at least one controller coupled with at least one memory and configured to cause the processor to transmit, to an IoT device, a first request message to transmit a data payload to the communication device, and receive, from the IoT device, a response message that includes a first segment of the data payload and information that identifies a remaining data payload.

[0020] A method performed or performable by a communication device is described. The method may comprise transmitting, to an IoT device, a first request message to transmit a data payload to the communication device, and receiving, from the IoT device, a response message that includes a first segment of the data payload and information that identifies a remaining data payload.

[0021] In some implementations of the communication device, processor, and method described herein, the communication device, processor, and method may further be configured to, capable of, performed, performable, or operable to transmit, to the IoT device, a second request message to transmit the remaining data payload, and receive the remaining data payload from the IoT device.

[0022] In some implementations of the communication device, processor, and method described herein, a radio frequency carrier of the second request message is transmitted with an increased power with respect to a radio frequency carrier of the first request message.

[0023] In some implementations of the communication device, processor, and method described herein, the second request message comprises an uplink grant that accommodates transmission of the remaining data payload and a configuration of a carrier wave used for backscattering by the IoT device.

[0024] In some implementations of the communication device, processor, and method described herein, the first request message comprises an uplink grant that accommodates transmission of the data payload and a configuration of a carrier wave used for backscattering by the IoT device.

[0025] In some implementations of the communication device, processor, and method described herein, the communication device is a network entity.

[0026] In some implementations of the communication device, processor, and method described herein, the communication device is an intermediate node.

[0027] In some implementations of the communication device, processor, and method described herein, the communication device, processor, and method may further be configured to, capable of, performed, performable, or operable to receive a request from another device to transmit the second request message to the IoT device.

[0028] In some implementations of the communication device, processor, and method described herein, the another device is an external client.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] Figure 1 illustrates an example of a wireless communications system in accordance with aspects of the present disclosure.

[0030] Figures 2A-2B illustrate example topologies for AIoT devices in accordance with aspects of the present disclosure.

[0031] Figure 3 illustrates an example radio protocol stack architecture for IoT devices in accordance with aspects of the present disclosure.

[0032] Figure 4 illustrates a flowchart of transmitting a data payload from an IoT device to a second device.

[0033] Figure 5 illustrates an example format of a PDU in accordance with aspects of the present disclosure.

[0034] Figure 6A illustrates a messaging flow for transmitting a data payload in accordance with aspects of the present disclosure.

[0035] Figure 6B illustrates an example segmentation of a data payload in accordance with aspects of the present disclosure.

[0036] Figure 7 illustrates another messaging flow for transmitting a data payload in accordance with aspects of the present disclosure.

[0037] Figure 8 illustrates an example of a UE in accordance with aspects of the present disclosure.

[0038] Figure 9 illustrates an example of a processor in accordance with aspects of the present disclosure.

[0039] Figure 10 illustrates an example of a network equipment (NE) in accordance with aspects of the present disclosure.

[0040] Figure 11 illustrates a flowchart of a method performed by a UE in accordance with aspects of the present disclosure.

[0041] Figure 12 illustrates a flowchart of a method performed by an NE in accordance with aspects of the present disclosure.

DETAILED DESCRIPTION

[0042] A wireless communications system may include one or more IoT devices, which may be an AIoT device, a passive-IoT device, and/or a passive radio frequency identification (RFID) tag (e.g., sticker, tag, badge, patch, or the like) that supports one or more functionalities at lower cost and maintenance compared to other devices. For example, an AIoT device may harvest and store energy from an environment, such as one or more of solar (e.g., via photovoltaic energy harvesting), vibration (e.g., via piezoelectric, electrostatic, or electromagnetic energy harvesting), thermal (e.g., via thermoelectric energy harvesting), or radio waves, such as radio frequency (e.g., via signals received through an antenna of the AIoT device). The AIoT device may perform one or more operations (e.g., transmission, reception, via backscattering) using the stored harvested energy. For example, the AIoT device may be a passive RFID tag equipped on an object or other device enabling for tracking of a location of the object or the other device using stored harvested energy.

[0043] An AIoT device may be classified according to one or more categories. A first category AIoT device may lack both energy harvesting capabilities and communication capabilities. As such, the first category AIoT device may be exclusively capable of performing backscattering operations (e.g., backscattering transmissions). A second category AIoT device may support energy harvesting capabilities but lack communication capabilities. As such, the second category AIoT device may be exclusively capable of performing backscattering operations (e.g., backscattering transmissions). However, in some cases, because the second category AIoT device supports energy harvesting capabilities, the second category AIoT device may be capable of amplifying reflected signals using stored harvested energy. A third category AIoT device may support both energy harvesting and communication capabilities. In this example, the third category AIoT device may be equipped with an active radio frequency circuitry to support active communication (e.g., transmission, reception of signals).

[0044] Example use cases for AIoT devices include inventory taking, sensor data collection, asset tracking, actuator control, and so on, where an AIoT device collects and transmits data payloads to the network (e.g., via uplink grants) that are below 1000 bits. However, the AIoT device may not have sufficient or available energy to transmit a whole data unit or data payload (e.g., an AIoT device may not yet have harvested enough energy to transmit the whole data payload to the network). Issues arise in such scenarios, as the AIoT device may delay its transmission and/or discard the data payload before transmission.

[0045] To overcome such issues, the technology described herein enables an AIoT device, or other IoT devices, to perform data segmentation, such as data segmentation based on a sufficient or available energy for transmission of data (e.g., via PDUs) to the network. Thus, the AIoT device can transmit a data payload in segments (e.g., splitting the data payload into segments), based on when energy is available to perform the transmissions. In doing so, the AIoT device can avoid issues associated with delays or failed transmissions of data due to lack of sufficient energy at the AIoT device, among other benefits.

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

[0047] Figure 1 illustrates an example of a wireless communications system 100 in accordance with aspects of the present disclosure. The wireless communications system 100 may include one or more NE 102, one or more UE 104, and a core network (CN) 106. The wireless communications system 100 may support various radio access technologies. In some implementations, the wireless communications system 100 may be a 4G network, such as an LTE network or an LTE-Advanced (LTE-A) network. In some other implementations, the wireless communications system 100 may be an NR network, such as a 5G network, a 5G-Advanced (5G-A) network, or a 5G ultrawideband (5G-UWB) network. In other implementations, the wireless communications system 100 may be a combination of a 4G network and a 5G network, or other suitable radio access technology including Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20. The wireless communications system 100 may support radio access technologies beyond 5G, for example, 6G. Additionally, the wireless communications system 100 may support technologies, such as time division multiple access (TDMA), frequency division multiple access (FDMA), or code division multiple access (CDMA), etc.

[0048] The one or more NE 102 may be dispersed throughout a geographic region to form the wireless communications system 100. One or more of the NE 102 described herein may be or include or may be referred to as a network node, a base station, a network element, a network function, a network entity, a radio access network (RAN), a NodeB, an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. An NE 102 and a UE 104 may communicate via a communication link, which may be a wireless or wired connection. For example, an NE 102 and a UE 104 may perform wireless communication (e.g., receive signaling, transmit signaling) over a Uu interface.

[0049] An NE 102 may provide a geographic coverage area for which the NE 102 may support services for one or more UEs 104 within the geographic coverage area. For example, an NE 102 and a UE 104 may support wireless communication of signals related to services (e.g., voice, video, packet data, messaging, broadcast, etc.) according to one or

multiple radio access technologies. In some implementations, an NE 102 may be moveable, for example, a satellite associated with a non-terrestrial network (NTN). In some implementations, different geographic coverage areas associated with the same or different radio access technologies may overlap, but the different geographic coverage areas may be associated with different NE 102.

[0050] The one or more UE 104 may be dispersed throughout a geographic region of the wireless communications system 100. A UE 104 may include or may be referred to as a remote unit, a mobile device, a wireless device, a remote device, a subscriber device, a transmitter device, a receiver device, or some other suitable terminology. In some implementations, the UE 104 may be referred to as a unit, a station, a terminal, or a client, among other examples. Additionally, or alternatively, the UE 104 may be referred to as an Internet-of-Things (IoT) device, an Internet-of-Everything (IoE) device, or machine-type communication (MTC) device, among other examples.

[0051] A UE 104 may be able to support wireless communication directly with other UEs 104 over a communication link. For example, a UE 104 may support wireless communication directly with another UE 104 over a device-to-device (D2D) communication link. In some implementations, such as vehicle-to-vehicle (V2V) deployments, vehicle-to-everything (V2X) deployments, or cellular-V2X deployments, the communication link may be referred to as a sidelink. For example, a UE 104 may support wireless communication directly with another UE 104 over a PC5 interface.

[0052] An NE 102 may support communications with the CN 106, or with another NE 102, or both. For example, an NE 102 may interface with other NE 102 or the CN 106 through one or more backhaul links (e.g., S1, N2, or network interface). In some implementations, the NE 102 may communicate with each other directly. In some other implementations, the NE 102 may communicate with each other indirectly (e.g., via the CN 106). In some implementations, one or more NE 102 may include subcomponents, such as an access network entity, which may be an example of an access node controller (ANC). An ANC may communicate with the one or more UEs 104 through one or more other access network transmission entities, which may be referred to as a radio heads, smart radio heads, or transmission-reception points (TRPs).

[0053] The CN 106 may support user authentication, access authorization, tracking, connectivity, and other access, routing, or mobility functions. The CN 106 may be an evolved packet core (EPC), or a 5G core (5GC), which may include a control plane entity that manages access and mobility (e.g., a mobility management entity (MME), an access and mobility management function (AMF)) and a user plane entity that routes packets or interconnects to external networks (e.g., a serving gateway (S-GW), a Packet Data Network (PDN) gateway (P-GW), or a user plane function (UPF)). In some implementations, the control plane entity may manage non-access stratum (NAS) functions, such as mobility, authentication, and bearer management (e.g., data bearers, signal bearers, etc.) for the one or more UEs 104 served by the one or more NE 102 associated with the CN 106.

[0054] The CN 106 may communicate with a packet data network over one or more backhaul links (e.g., via an S1, N2, or another network interface). The packet data network may include an application server. In some implementations, one or more UEs 104 may communicate with the application server. A UE 104 may establish a session (e.g., a protocol data unit (PDU) session, or the like) with the CN 106 via an NE 102. The CN 106 may route traffic (e.g., control information, data, and the like) between the UE 104 and the application server using the established session (e.g., the established PDU session). The PDU session may be an example of a logical connection between the UE 104 and the CN 106 (e.g., one or more network functions of the CN 106).

[0055] In the wireless communications system 100, the NEs 102 and the UEs 104 may use resources of the wireless communications system 100 (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers)) to perform various operations (e.g., wireless communications). In some implementations, the NEs 102 and the UEs 104 may support different resource structures. For example, the NEs 102 and the UEs 104 may support different frame structures. In some implementations, such as in 4G, the NEs 102 and the UEs 104 may support a single frame structure. In some other implementations, such as in 5G and among other suitable radio access technologies, the NEs 102 and the UEs 104 may support various frame structures (i.e., multiple frame structures). The NEs 102 and the UEs 104 may support various frame structures based on one or more numerologies.

[0056] One or more numerologies may be supported in the wireless communications system 100, and a numerology may include a subcarrier spacing and a cyclic prefix. A first numerology (e.g., μ=0) may be associated with a first subcarrier spacing (e.g., 15 kHz) and a normal cyclic prefix. In some implementations, the first numerology (e.g., μ=0) associated with the first subcarrier spacing (e.g., 15 kHz) may utilize one slot per subframe. A second numerology (e.g., μ=1) may be associated with a second subcarrier spacing (e.g., 30 kHz) and a normal cyclic prefix. A third numerology (e.g., μ=2) may be associated with a third subcarrier spacing (e.g., 60 kHz) and a normal cyclic prefix or an extended cyclic prefix. A fourth numerology (e.g., μ=3) may be associated with a fourth subcarrier spacing (e.g., 120 kHz) and a normal cyclic prefix. A fifth numerology (e.g., μ=4) may be associated with a fifth subcarrier spacing (e.g., 240 kHz) and a normal cyclic prefix.

[0057] 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.

[0058] Additionally or alternatively, a time interval of a resource (e.g., a communication resource) may be organized according to slots. For example, a subframe may include a number (e.g., quantity) of slots. The number of slots in each subframe may also depend on the one or more numerologies supported in the wireless communications system 100. For instance, the first, second, third, fourth, and fifth numerologies (i.e., μ=0, μ=1, μ=2, μ=3, μ=4) associated with respective subcarrier spacings of 15 kHz, 30 kHz, 60 kHz, 120 kHz, and 240 kHz may utilize a single slot per subframe, two slots per subframe, four slots per subframe, eight slots per subframe, and 16 slots per subframe, respectively.# Each slot may include a number (e.g., quantity) of symbols (e.g., OFDM symbols). In some implementations, the number (e.g., quantity) of slots for a subframe may depend on a numerology. For a normal cyclic prefix, a slot may include 14 symbols. For an extended cyclic prefix (e.g., applicable for 60 kHz subcarrier spacing), a slot may include 12

symbols. The relationship between the number of symbols per slot, the number of slots per subframe, and the number of slots per frame for a normal cyclic prefix and an extended cyclic prefix may depend on a numerology. It should be understood that reference to a first numerology (e.g., μ=0) associated with a first subcarrier spacing (e.g., 15 kHz) may be used interchangeably between subframes and slots.

[0059] In the wireless communications system 100, an electromagnetic (EM) spectrum may be split, based on frequency or wavelength, into various classes, frequency bands, frequency channels, etc. By way of example, the wireless communications system 100 may support one or multiple operating frequency bands, such as frequency range designations FR1 (410 MHz – 7.125 GHz), FR2 (24.25 GHz – 52.6 GHz), FR3 (7.125 GHz – 24.25 GHz), FR4 (52.6 GHz – 114.25 GHz), FR4a or FR4-1 (52.6 GHz – 71 GHz), and FR5 (114.25 GHz – 300 GHz). In some implementations, the NEs 102 and the UEs 104 may perform wireless communications over one or more of the operating frequency bands. In some implementations, FR1 may be used by the NEs 102 and the UEs 104, among other equipment or devices for cellular communications traffic (e.g., control information, data). In some implementations, FR2 may be used by the NEs 102 and the UEs 104, among other equipment or devices for short-range, high data rate capabilities.

[0060] FR1 may be associated with one or multiple numerologies (e.g., at least three numerologies). For example, FR1 may be associated with a first numerology (e.g., μ=0), which includes 15 kHz subcarrier spacing; a second numerology (e.g., μ=1), which includes 30 kHz subcarrier spacing; and a third numerology (e.g., μ=2), which includes 60 kHz subcarrier spacing. FR2 may be associated with one or multiple numerologies (e.g., at least 2 numerologies). For example, FR2 may be associated with a third numerology (e.g., μ=2), which includes 60 kHz subcarrier spacing; and a fourth numerology (e.g., μ=3), which includes 120 kHz subcarrier spacing.

[0061] The wireless communications system 100 may support managing (e.g., controlling, configuring) operation of IoT devices (e.g., which may be an example of a UE 104), such as ambient IoT devices. As described herein, an AIoT device may be associated with a low complexity profile (e.g., low power consumption, less capabilities) and/or be

implemented as an ambient-power enabled ultra-low complexity device with ultra-low power consumption.

[0062] In some embodiments, the wireless communications system 100 may implement various topologies and deployment scenarios, such as an example topology in which an NE (e.g., a base station or other network entity) functions as a reader and a source of a carrier wave (e.g., for exciting an AIoT device to perform backscattering), another example topology in which the NE functions as the reader and a different device (e.g., a UE) functions as the source of the carrier wave, another example topology in which the NE controls operations and other network entities (e.g., nodes) function as readers and/or carrier wave sources, and the like.

[0063] Figures 2A-2B illustrate example topologies for AIoT devices in accordance with aspects of the present disclosure. As shown in Figure 2A, in a first topology 200, an AIoT device 210 directly and bidirectionally communicates with the NE 102 (e.g., which may serve a micro cell). A communication link 220 between the NE 102 and the AIoT device 210 may include AIoT data (e.g., via backscattering 225) and/or signaling. In an example implementation, both the AIoT device 210 and the NE 102 are located indoors (with the micro cell being part of a group of cells or NEs 102).

[0064] Figure 2B illustrates a second topology 250, where the UE 104, or another node, acts as an intermediate node between the NE 102 and the AIoT device 210. For example, the UE 104 may function as an emitter, where the UE 104 sends carrier waves to the AIoT device 210, which excite the AIoT device 210, enabling or causing the AIoT device 210 to performing the backscattering transmissions 225, which are read by the UE 104.

[0065] In the second topology 250, the AIoT device 210 directly and bidirectionally communicates with the UE 104 (e.g., which may relay data to the NE 102, serving a macro cell). A communication link 260 between the UE 104 and the AIoT device 210 and/or a link 270 between the UE 104 and the NE 102 may include AIoT data (e.g., via backscattering 225) and/or signaling. In an example implementation, the AIoT device 210 and the UE 104 are located indoors and the NE 102 is located outdoors (with the macro cell being part of a group of cells or NEs 102).

[0066] The AIoT device 210 may communicate with the intermediate node and/or the network (e.g., via the NE 102) using a reduced set of components. For example, the AIoT device 210 may be an IoT device of ultra-low complexity with ultra-low power consumption (e.g., sufficient for low-end IoT applications), having a radio protocol stack architecture that is comparatively compact with respect to typical NR architectures for communication devices.

[0067] Figure 3 illustrates an example radio protocol stack architecture 300 for IoT devices in accordance with aspects of the present disclosure. The control plane, or C-plane, may only include a radio resource control (RRC) sublayer 322, which communicates with an RRC sublayer 312 of a second device 310 (e.g., a BS or intermediate node), a data link control (DLC) sublayer 324, which communicates with a DLC sublayer 314 of the second device 310, and a physical (PHY) sublayer 326, which communicates with a PHY sublayer 316 of the second device 310. The sublayers may function as follows:

[0068] The RRC sublayer 322 performs broadcasts of system information, paging, RRC connection control, AS security, and so on;

[0069] The DLC sublayer 324 performs transfers of data (U-plane or C-plane), ciphering, integrity protection, multiplexing of MAC SDUs belonging to one or different logical channels into transport blocks (TB) delivered to the PHY sublayer 326, and so on; and

[0070] The PHY sublayer 326 performs channel coding, error detection, modulation, frequency and time synchronization, measurements, and so on.

[0071] Thus, the AIoT device 210 may include components that facilitate a device of ultra-low complexity with ultra-low power consumption.

[0072] As described herein, an AIoT device may perform data segmentation when transmitting a data payload (e.g., UL data) to a network, such as to the NE 102 or an intermediate node (e.g., the UE 104). The AIoT device may split or segment a data payload based on, or in response to, insufficient energy at the AIoT device, even when an UL grant received from the network to transmit the data can accommodate a whole data payload (e.g., all data at the AIoT device).

[0073] Figure 4 illustrates a flowchart 400 of transmitting a data payload from an IoT device to a second device. In step 410, an AIoT device (e.g., the AIoT device 210) determines or selects a data payload to transmit to the network. In step 415, the AIoT device determines whether there is sufficient energy to transmit the determined data payload. When there is sufficient energy, the AIoT device, in step 420, includes the whole data payload into a PDU, and, in step 460, transfers the PDU to a lower layer for transmission to the network.

[0074] When there is not sufficient energy, the AIoT device, in step 430, segments or splits the data payload based on the energy available for transmission, and, in step 440, determines a remaining data payload (e.g., a data payload pending for transmission). For example, a size of the segment of the data payload may be based on energy available to transmit a PDU containing the data segment and additional header information that indicates information about the data segment and/or remaining data to be transmitted (see Figure 5). In step 450, the AIoT device generates a PDU that includes the data segment and the header information, and, in step 460, transfers the PDU (with the data segment) to the lower layer for transmission to the network.

[0075] Figure 5 illustrates an example format of a PDU 500 in accordance with aspects of the present disclosure. The PDU 500 includes a header 510, which contains information about the data segment and/or remaining data to be transmitted, and the data segment 520 transmitted to the network. The format of the header 510 may be configured in a variety of ways.

[0076] As a first example, the header 510 of the PDU 500 may include a parameter "remainingPayloadSize", which indicates a remaining payload at the AIoT device. Table 1 depicts a PDU header format for data payload segmentation:

Parameter	**Value**	**Description**
>segmentNumber	INTEGER (0..L-1)	Identifies the sequence number of the segment within the PDU. The AIoT device transmits the segments with continuously increasing segmentNumber order so that the network expects to obtain them in the correct order. A payload can be segmented into maximum L segments. The value L may be set to, for example, 8 or 16.

>segmentSize	INTEGER (1..M)	Indicates the size of the segment in bits. The value M may be set to, e.g., 1000. Alternatively, the size of the segment may be given in bytes in order to further reduce the size of the header.
>remainingPayloadSize	INTEGER (0..N)	Indicates the size of the remaining payload in bits. The value N may be set to, e.g., 1000. Alternatively, the size of the remaining payload may be given in bytes in order to further reduce the size of the header.

Table 1

[0077] As another example, the header 510 of the PDU 500 may include a parameter "segmentType", which indicates information about the remaining data payload. Table 2 depicts another PDU header format for data payload segmentation:

Parameter	**Value**	**Description**
>segmentNumber	INTEGER (0..L-1)	Identifies the sequence number of the segment within the PDU. The AIoT device transmits the segments with continuously increasing segmentNumber order so that the network expects to obtain them in the correct order. A payload can be segmented into maximum L segments. The value L may be set to, e.g., 8 or 16.
>segmentSize	INTEGER (1..M)	Indicates the size of the segment in bits. The value M may be set to, e.g.. 1000. Alternatively, the size of the segment may be given in bytes in order to further reduce the size of the header.
>segmentType	ENUMERATED {notLastSegment, lastSegment}	Indicates whether the included segment is the last segment of a payload or not.

Table 2

[0078] In some embodiments, the network, upon receiving a segmented payload, may trigger transmission of a remaining data payload by the AIoT device. Further, in some cases, the network receives at the lower layer a PDU having a segmented data unit and header information and performs data assembly for the data unit.

[0079] In some embodiments, an external client, upon receiving a segmented payload, may trigger transmission of a remaining data payload by the AIoT device. Further, in some cases, the external client receives at the application layer a PDU having a segmented data unit and header information and performs data assembly for the data unit.

[0080] As described herein, the segmentation of a data payload may be performed in different protocol layers. For example, the AIoT device may perform data segmentation in the radio protocol stack (e.g., in the DLC sublayer). The network (or intermediate node) may be aware that the AIoT device is capable of data segmentation and can trigger transmission of remaining payloads after receiving a PDU containing a segment of a payload. The network (or intermediate node) may reassemble received segments and forward/transfer the reassembled data to a recipient entity or device, such as an external client.

[0081] As another example, the AIoT device may perform data segmentation in the application layer. The data segmentation may be transparent to the radio protocol stack, and the network (or intermediate node) may simply forward received PDUs, containing data segments, to a recipient entity or device. The recipient entity or device may trigger transmission of the remaining payload and/or reassemble received data segments to realize the whole data payload.

[0082] As described herein, the technology, in some embodiments, may be implemented as one or more messaging flows between nodes (e.g., between an external client, a network node, and an IoT device (an AIoT device)). Figure 6A illustrates a messaging flow 600 for transmitting a data payload in accordance with aspects of the present disclosure.

[0083] The messaging flow 600 may be performed for the following deployment scenario (see the topology 200 described herein where a base station is part of the CN and RAN of a network). An external client 610 requests a network 620 to retrieve data from an AIoT device 630, such as collected sensor data. The external client 610 may be part of a UE that is served by the network 620 and/or part of a 3rd party measurement collection entity that is attached to the network 620. The AIoT device 630 may be a Type 1 or Type 2 capable of transmitting UL data via backscattering of an unmodulated carrier wave received by the network 620. The AIoT device 630 may harvest energy using the carrier wave and/or a modulated radio frequency (RF) carrier via which DL data is received from the network 620.

[0084] Further, the network 620 may transmit DL messages to the AIoT device, for triggering UL data transmission, which contain a configuration of an UL grant and the carrier wave (e.g., used once by the AIoT device 630). The AIoT device 630 may be known by the network 620. The AIoT device 630 may perform data segmentation in the radio protocol stack (e.g., in the DLC sublayer), and utilizes a certain PDU header format (see Table 1).

[0085] In step 1, the external client 610 sends a DataCollectionRequest message to request the network 620 to retrieve collected sensor data from the AIoT device 630.

[0086] In step 2, based on the received DataCollectionRequest message, the network 620 sends a DataTransmissionRequest message to request the AIoT device 630 to send collected sensor data. The DataTransmissionRequest message contains a UL grant that accommodates the transmission of UL data of 1000 bits and the configuration of the carrier wave (e.g., the resources allocated in time and frequency) to be used for backscattering.

[0087] In step 3, the AIoT device 630 has collected sensor data of 800 bits that is available for transmission. In response to the received DataTransmissionRequest message, the AIoT device 630 determines whether there is sufficient energy available to transmit the whole payload. For example, the AIoT device 630 determines that there is energy available to transmit only 200 bits of the whole payload. The AIoT device 630 performs data segmentation by creating a PDU containing a segment of 200 bits.

[0088] In step 4, the AIoT device 630 sends to the network 620 a DataTransmissionResponse message that includes the PDU containing a first segment (e.g., segment #1). The PDU header contains the following information:

a. segmentNumber: “1”
b. segmentSize: “200”
c. remainingPayloadSize: “600”

[0089] In step 5, the network 620 stores the first segment #1 in its reception buffer and in response to the PDU format information received in the DataTransmissionResponse message, sends a further DataTransmissionRequest message to request the AIoT device 630 to send the remaining payload. The DataTransmissionRequest message contains a UL grant that accommodates the transmission of the remaining payload and the configuration of the

carrier wave. The RF carrier that carries the DataTransmissionRequest message may be sent with an increased power.

[0090] In step 6, in response to the received DataTransmissionRequest message, the AIoT device 630 determines that there is energy available to transmit only 500 bits of the remaining payload and performs data segmentation by creating a PDU containing a segment of 500 bits.

[0091] In step 7, the AIoT device 630 sends to the network 620 a DataTransmissionResponse message that includes the PDU containing a next segment (e.g., segment #2). The PDU header contains the following information:

d. segmentNumber: “2”

e. segmentSize: “500”

f. remainingPayloadSize: “100”

[0092] In step 8, the network 620 stores the second segment #2 in its reception buffer and in response to the PDU format information received in the DataTransmissionResponse message, sends a further DataTransmissionRequest message to request the AIoT device 630 to send the remaining payload. The DataTransmissionRequest message contains a UL grant that accommodates the transmission of the remaining payload and the configuration of the carrier wave.

[0093] In step 9, in response to the received DataTransmissionRequest message, the AIoT device 630 determines that there is energy available to transmit the remaining data payload (e.g., no further segmentation to be performed). The AIoT device 630 sends to the network 620 a DataTransmissionResponse message that includes the PDU containing a final segment (e.g, segment #3). The PDU header contains the following information:

g. segmentNumber: “3”

h. segmentSize: “100”

i. remainingPayloadSize: “0”

[0094] In step 10, the network 620 stores the third segment #3 in its reception buffer and reassembles the stored segments in the order of reception.

[0095] In step 11, the network 620 sends to the external client 610 a DataCollectionResponse message containing the reassembled payload.

[0096] Figure 6B illustrates an example segmentation 650 of a data payload 660 in accordance with aspects of the present disclosure. As described with respect to Figure 6A, the whole data payload 660 is 800 bits, and based on energy available to the AIoT device 630 when receiving requests to transmit data, is segmented into three segments, a first segment 662 of 200 bits, a second segment 664 of 500 bits, and a final segment 666 of 100 bits. The AIoT device 630 transmits each of segments via PDUs (e.g., PDU 672, PDU 674, PDU 676) to the network 620, which reassembles the whole data payload 660 from the segments 662, 664, 666.

[0097] In some cases, the initial DataTransmissionRequest message (e.g., received by the AIoT device 630 in step 2) may include a configuration of UL grant and carrier wave that the AIoT device 630 can use autonomously for a certain period of time. In such cases, the AIoT device 630 may transmit segments autonomously (and without receiving request messages), such as by perfoming steps 7 and/or 9 at a next available transmission occasion, assuming the AIoT device 630 has harvested energy to perform the transmission.

[0098] In some embodiments, the AIoT device 630 may perform the data segmentation at the application layer. Figure 7 illustrates another messaging flow 700 for transmitting a data payload in accordance with aspects of the present disclosure. The messaging flow 700 reflects the AIoT device 630 segmenting data at the application layer.

[0099] In step 1, the external client 610 sends a DataCollectionRequest message to request the network 620 to retrieve collected sensor data from the AIoT device 630.

[0100] In step 2, based on the received DataCollectionRequest message, the network 620 sends a DataTransmissionRequest message to request the AIoT device 630 to send collected sensor data. The DataTransmissionRequest message contains a UL grant that accommodates the transmission of UL data of 1000 bits and the configuration of the carrier wave.

[0101] In step 3, the AIoT device 630 has collected sensor data of 800 bits that is available for transmission. In response to the received DataTransmissionRequest message, the AIoT device 630 determines that there is energy available to transmit only 200 bits of

the whole payload, and performs data segmentation by creating a PDU containing a segment of 200 bits.

[0102] In step 4, the AIoT device 630 sends to the network 620 a DataTransmissionResponse message that includes the PDU containing a first segment (e.g., segment #1). The PDU header contains the following information:

j. segmentNumber: “1”

k. segmentSize: “200”

l. remainingPayloadSize: “600”

[0103] In step 5, the network 620 sends to the external client 610 a DataCollectionResponse message that includes the PDU containing segment #1.

[0104] In step 6, the external client 610 stores the first segment #1 in its reception buffer and in response to the PDU format information received in the DataCollectionResponse message, sends a further DataCollectionRequest message to request the network 620 to retrieve the remaining payload of 600 bits from the AIoT device 630.

[0105] In step 7, the network 620 sends a further DataTransmissionRequest message to request the AIoT device 630 to send the remaining payload. The DataTransmissionRequest message contains a UL grant that accommodates the transmission of the remaining payload and the configuration of the carrier wave. The RF carrier that carries the DataTransmissionRequest message is sent with an increased power.

[0106] In step 8, in response to the received DataTransmissionRequest message, the AIoT device 630 determines that there is energy available to transmit only 500 bits of the remaining payload. Therefore, the AIoT device 630 performs data segmentation by creating a PDU containing a segment of 500 bits.

[0107] In step 9, the AIoT device 630 sends to the network 620 a DataTransmissionResponse message that includes the PDU containing a second segment (e.g., segment #2). The PDU header contains the following information:

m. segmentNumber: “2”

n. segmentSize: “500”

o. remainingPayloadSize: “100”

[0108] In step 10, the network 620 sends to the external client 610 a DataCollectionResponse message that includes the PDU containing segment #2.

[0109] In step 11, the external client 610 stores the second segment #2 in its reception buffer and in response to the PDU format information received in the DataCollectionResponse message, sends a further DataCollectionRequest message to request the network 620 to retrieve the remaining payload of 100 bits from the AIoT device 630.

[0110] In step 12, the network 620 sends a further DataTransmissionRequest message to request the AIoT device 630 to send the remaining payload. The DataTransmissionRequest message contains a UL grant that accommodates the transmission of the remaining payload and the configuration of the carrier wave.

[0111] In step 13, in response to the received DataTransmissionRequest message, the AIoT device 630 determines that there is now enough energy available (e.g., no further segmentation to be peformed). The AIoT device 630 sends to the network 620 a DataTransmissionResponse message that includes the PDU containing a final segment (e.g., segment #3). The PDU header contains the following information:

p. segmentNumber: “3”

q. segmentSize: “100”

r. remainingPayloadSize: “0”

[0112] In step 14, the network 620 sends to the external client 610 a DataCollectionResponse message that includes the PDU containing segment #3.

[0113] In step 15, the external client 610 stores the third segment #3 in its reception buffer and reassembles the stored segments in the order of reception to realize the whole data payload (e.g., the payload 660).

[0114] In some cases, the initial DataTransmissionRequest message (e.g., received by the AIoT device 630 in step 2) may include a configuration of UL grant and carrier wave that the AIoT device 630 can use autonomously for a certain period of time. In such cases, the AIoT device 630 may transmit segments autonomously (and without receiving request

messages), such as by perfoming steps 9 and/or 13 at a next available transmission occasion, assuming the AIoT device 630 has harvested energy to perform the transmission.

[0115] Thus, in various embodiments, the technology described herein enables an AIoT device, or other IoT devices, to perform data segmentation based on energy available to the AIoT device, in order to facilitate the transmission of data collected by the AIoT device regardless of the energy available to the AIoT device.

[0116] Figure 8 illustrates an example of a UE 800 in accordance with aspects of the present disclosure. The UE 800 may include a processor 802, a memory 804, a controller 806, and a transceiver 808. The processor 802, the memory 804, the controller 806, or the transceiver 808, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. These components may be coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces.

[0117] The processor 802, the memory 804, the controller 806, or the transceiver 808, or various combinations or components thereof may be implemented in hardware (e.g., circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), or other programmable logic device, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure.

[0118] The processor 802 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, an ASIC, an FPGA, or any combination thereof). In some implementations, the processor 802 may be configured to operate the memory 804. In some other implementations, the memory 804 may be integrated into the processor 802. The processor 802 may be configured to execute computer-readable instructions stored in the memory 804 to cause the UE 800 to perform various functions of the present disclosure.

[0119] The memory 804 may include volatile or non-volatile memory. The memory 804 may store computer-readable, computer-executable code including instructions when executed by the processor 802 cause the UE 800 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as the

memory 804 or another type of memory. Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage medium may be any available medium that may be accessed by a general-purpose or special-purpose computer.

[0120] In some implementations, the processor 802 and the memory 804 coupled with the processor 802 may be configured to cause the UE 800 to perform one or more of the functions described herein (e.g., executing, by the processor 802, instructions stored in the memory 804). For example, the processor 802 may support wireless communication at the UE 800 in accordance with examples as disclosed herein. The UE 800 may be configured to support a means for splitting a payload into a set of two or more segments based at least in part on an energy level of the wireless device satisfying an energy level threshold and transmitting, to a second wireless device, a packet comprising at least one first segment of the set of two or more segments associated with the payload, wherein the packet includes an indication of at least one second segment of the set of two or more segments associated with the payload pending for transmission to the second wireless device.

[0121] The controller 806 may manage input and output signals for the UE 800. The controller 806 may also manage peripherals not integrated into the UE 800. In some implementations, the controller 806 may utilize an operating system such as iOS®, ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 806 may be implemented as part of the processor 802.

[0122] In some implementations, the UE 800 may include at least one transceiver 808. In some other implementations, the UE 800 may have more than one transceiver 808. The transceiver 808 may represent a wireless transceiver. The transceiver 808 may include one or more receiver chains 810, one or more transmitter chains 812, or a combination thereof.

[0123] A receiver chain 810 may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receiver chain 810 may include one or more antennas for receiving the signal over the air or wireless medium. The receiver chain 810 may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 810 may include at

least one demodulator configured to demodulate the received signal and obtain the transmitted data by reversing the modulation technique applied during transmission of the signal. The receiver chain 810 may include at least one decoder for decoding and/or processing the demodulated signal to receive the transmitted data.

[0124] A transmitter chain 812 may be configured to generate and transmit signals (e.g., control information, data, packets). The transmitter chain 812 may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature amplitude modulation (QAM). The transmitter chain 812 may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmitter chain 812 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

[0125] Figure 9 illustrates an example of a processor 900 in accordance with aspects of the present disclosure. The processor 900 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 900 may include a controller 902 configured to perform various operations in accordance with examples as described herein. The processor 900 may optionally include at least one memory 904, which may be, for example, an L1/L2/L3 cache. Additionally, or alternatively, the processor 900 may optionally include one or more arithmetic-logic units (ALUs) 906. One or more of these components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

[0126] The processor 900 may be a processor chipset and include a protocol stack (e.g., a software stack) executed by the processor chipset to perform various operations (e.g., receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) in accordance with examples as described herein. The processor chipset may include one or more cores, one or more caches (e.g., memory local to or included in the processor chipset (e.g., the processor 900)) or other memory

(e.g., random access memory (RAM), read-only memory (ROM), dynamic RAM (DRAM), synchronous dynamic RAM (SDRAM), static RAM (SRAM), ferroelectric RAM (FeRAM), magnetic RAM (MRAM), resistive RAM (RRAM), flash memory, phase change memory (PCM), and others)).

[0127] The controller 902 may be configured to manage and coordinate various operations (e.g., signaling, receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) of the processor 900 to cause the processor 900 to support various operations in accordance with examples as described herein. For example, the controller 902 may operate as a control unit of the processor 900, generating control signals that manage the operation of various components of the processor 900. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[0128] The controller 902 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 904 and determine subsequent instruction(s) to be executed to cause the processor 900 to support various operations in accordance with examples as described herein. The controller 902 may be configured to track memory address of instructions associated with the memory 904. The controller 902 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 902 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 900 to cause the processor 900 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 902 may be configured to manage flow of data within the processor 900. The controller 902 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 900.

[0129] The memory 904 may include one or more caches (e.g., memory local to or included in the processor 900) or other memory, such as RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementations, the memory 904 may reside within or on a processor chipset (e.g., local to the processor 900). In some other

implementations, the memory 904 may reside external to the processor chipset (e.g., remote to the processor 900).

[0130] The memory 904 may store computer-readable, computer-executable code including instructions that, when executed by the processor 900, cause the processor 900 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. The controller 902 and/or the processor 900 may be configured to execute computer-readable instructions stored in the memory 904 to cause the processor 900 to perform various functions. For example, the processor 900 and/or the controller 902 may be coupled with or to the memory 904, the processor 900, the controller 902, and the memory 904 may be configured to perform various functions described herein. In some examples, the processor 900 may include multiple processors and the memory 904 may include multiple memories. One or more of the multiple processors may be coupled with one or more of the multiple memories, which may, individually or collectively, be configured to perform various functions herein.

[0131] The one or more ALUs 906 may be configured to support various operations in accordance with examples as described herein. In some implementations, the one or more ALUs 906 may reside within or on a processor chipset (e.g., the processor 900). In some other implementations, the one or more ALUs 906 may reside external to the processor chipset (e.g., the processor 900). One or more ALUs 906 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 906 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 906 be configured with a variety of logical and arithmetic circuits, including adders, subtractors, shifters, and logic gates, to process and manipulate the data according to the operation. Additionally, or alternatively, the one or more ALUs 906 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 906 to handle conditional operations, comparisons, and bitwise operations.

[0132] The processor 900 may support wireless communication in accordance with examples as disclosed herein. The UE processor 900 may be configured to support a means

for splitting a payload into a set of two or more segments based at least in part on an energy level of the wireless device satisfying an energy level threshold and transmitting, to a second wireless device, a packet comprising at least one first segment of the set of two or more segments associated with the payload, wherein the packet includes an indication of at least one second segment of the set of two or more segments associated with the payload pending for transmission to the second wireless device.

[0133] Figure 10 illustrates an example of an NE 1000 in accordance with aspects of the present disclosure. The NE 1000 may include a processor 1002, a memory 1004, a controller 1006, and a transceiver 1008. The processor 1002, the memory 1004, the controller 1006, or the transceiver 1008, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. These components may be coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces.

[0134] The processor 1002, the memory 1004, the controller 1006, or the transceiver 1008, or various combinations or components thereof may be implemented in hardware (e.g., circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), or other programmable logic device, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure.

[0135] The processor 1002 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, an ASIC, an FPGA, or any combination thereof). In some implementations, the processor 1002 may be configured to operate the memory 1004. In some other implementations, the memory 1004 may be integrated into the processor 1002. The processor 1002 may be configured to execute computer-readable instructions stored in the memory 1004 to cause the NE 1000 to perform various functions of the present disclosure.

[0136] The memory 1004 may include volatile or non-volatile memory. The memory 1004 may store computer-readable, computer-executable code including instructions when executed by the processor 1002 cause the NE 1000 to perform various functions described

herein. The code may be stored in a non-transitory computer-readable medium such as the memory 1004 or another type of memory. Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage medium may be any available medium that may be accessed by a general-purpose or special-purpose computer.

[0137] In some implementations, the processor 1002 and the memory 1004 coupled with the processor 1002 may be configured to cause the NE 1000 to perform one or more of the functions described herein (e.g., executing, by the processor 1002, instructions stored in the memory 1004). For example, the processor 1002 may support wireless communication at the NE 1000 in accordance with examples as disclosed herein. The NE 1000 may be configured to support a means for transmitting, to an IoT device, a first request message to transmit a data payload to the communication device and receiving, from the IoT device, a response message that includes a first segment of the data payload and information that identifies a remaining data payload.

[0138] The controller 1006 may manage input and output signals for the NE 1000. The controller 1006 may also manage peripherals not integrated into the NE 1000. In some implementations, the controller 1006 may utilize an operating system such as iOS®, ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 1006 may be implemented as part of the processor 1002.

[0139] In some implementations, the NE 1000 may include at least one transceiver 1008. In some other implementations, the NE 1000 may have more than one transceiver 1008. The transceiver 1008 may represent a wireless transceiver. The transceiver 1008 may include one or more receiver chains 1010, one or more transmitter chains 1012, or a combination thereof.

[0140] A receiver chain 1010 may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receiver chain 1010 may include one or more antennas for receiving the signal over the air or wireless medium. The receiver chain 1010 may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 1010 may include at

least one demodulator configured to demodulate the received signal and obtain the transmitted data by reversing the modulation technique applied during transmission of the signal. The receiver chain 1010 may include at least one decoder for decoding and/or processing the demodulated signal to receive the transmitted data.

[0141] A transmitter chain 1012 may be configured to generate and transmit signals (e.g., control information, data, packets). The transmitter chain 1012 may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature amplitude modulation (QAM). The transmitter chain 1012 may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmitter chain 1012 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

[0142] Figure 11 illustrates a flowchart of a method in accordance with aspects of the present disclosure. The operations of the method may be implemented by a UE as described herein (e.g., such as an IoT device). In some implementations, the UE may execute a set of instructions to control the function elements of the UE to perform the described functions.

[0143] At 1102, the method may include splitting a payload into a set of two or more segments based at least in part on an energy level of the wireless device satisfying an energy level threshold. The operations of 1102 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1102 may be performed by a UE as described with reference to Figure 8.

[0144] At 1104, the method may include transmitting, to a second wireless device, a packet comprising at least one first segment of the set of two or more segments associated with the payload, wherein the packet includes an indication of at least one second segment of the set of two or more segments associated with the payload pending for transmission to the second wireless device. The operations of 1104 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1104 may be performed by a UE as described with reference to Figure 8.

[0145] It should be noted that the method described herein describes a possible implementation, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible.

[0146] Figure 12 illustrates a flowchart of a method in accordance with aspects of the present disclosure. The operations of the method may be implemented by an NE as described herein. In some implementations, the NE may execute a set of instructions to control the function elements of the NE to perform the described functions.

[0147] At 1202, the method may include transmitting, to an IoT device, a first request message to transmit a data payload to the communication device. The operations of 1202 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1202 may be performed by an NE as described with reference to Figure 10.

[0148] At 1204, the method may include receiving, from the IoT device, a response message that includes a first segment of the data payload and information that identifies a remaining data payload. The operations of 1204 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1204 may be performed by an NE as described with reference to Figure 10.

[0149] It should be noted that the method described herein describes a possible implementation, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible.

[0150] 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.