HANDLING OF PROCEDURE

[0001] The present disclosure relates to wireless communications, and more specifically to handling of an operation procedure, for example, an ambient Internet of Things (AIoT) procedure.

BACKGROUND

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

[0003] In recent years, Internet of things (IoT) has attracted much attention in the wireless communication world. More "things" are expected to be interconnected for improving productivity efficiency and increasing comforts of life. Further reduction of size, complexity, and power consumption of IoT devices can enable the deployment of tens or even hundreds of billions of IoT devices for various applications and provide added value across the entire value chain. However, it is impossible to power all the IoT devices by battery that needs to be replaced or recharged manually. Thus there are still some issues associated with communication devices, such as ambient IoT (A-IoT) devices, to be addressed.

SUMMARY

[0004] The present disclosure relates to methods, apparatuses, and systems that support handling of a procedure, such as an ambient Internet of Things (IoT) procedure.

[0005] Some implementations of the method and devices described herein include, determining that a link between the first device and a second device is unavailable for data transmission; suspending, based on the determination, an operation procedure for at least one third device; and based on determining that the link becomes available, transmitting, via the transceiver and to the second device, data associated with one or more of the at least one third device stored during suspending the operation procedure.

[0006] In some implementations of the method and devices described herein, determining that the link is unavailable based on one or more of the following: a first module in the first device for communicating with the second device determining that the link is unavailable; the first module determining that data from one of the at least one third device fails to be transmitted to the second device; or the first module predicting, with a model, that the link is to be unavailable.

[0007] Some implementations of the method and devices described herein may include, transmitting, from a first module to a second module in the first device, a first indication indicating that the link is unavailable. The first module may be used for communicating with the second device, and the second module is used for communicating with the at least one third device.

[0008] Some implementations of the method and devices described herein may include, transmitting, from a first module to a second module in the first device, a cause for unavailability of the link. The first module may be used for communicating with the second device, and the second module is used for communicating with the at least one third device.

[0009] In some implementations of the method and devices described herein, the cause may comprises one of the following: a radio link failure (RLF) in the link between the first device and the second device; handover of the first device; reestablishment of the link; the first device being in an idle state or an inactive state without small data transmission configuration; or random access failure of the first device.

[0010] Some implementations of the method and devices described herein may include, suspending the operation procedure after reception of the first indication by the

second module or after the first module determines that the link is unavailable for the data transmission.

[0011] Some implementations of the method and devices described herein may include, suspending the operation procedure at the following time point: when the second module receives the first indication; at the end of an access occasion in which the first device finishes the operation procedure with one of the at least one third device; or at the end of an access round comprising a plurality of access occasions. The plurality of access occasions comprises the access occasion.

[0012] Some implementations of the method and devices described herein may include, finishing the operation procedure based on one or more of the following: receiving a reported device identity (ID) from the one of the at least one third device; receiving data from the one of the at least one third device; transmitting an acknowledgement (ACK) to the one of the at least one third device; or transmitting, to the one of the at least one third device, a second indication indicating that the operation procedure in the access occasion ends.

[0013] In some implementations of the method and devices described herein, the time point is determined based on one or more of the following: configuration information for indicating the time point; resource configuration information for the operation procedure; or caching capability of the second module.

[0014] Some implementations of the method and devices described herein may include, continuing one of the following, after reception of the first indication by the second module and prior to suspending the operation procedure: the operation procedure in an access occasion in which the first device performs the operation procedure with one of the at least one third device and the link being unavailable occurs; or the operation procedure in an access round comprising a plurality of access occasions, wherein the plurality of access occasions comprises the access occasion.

[0015] In some implementations of the method and devices described herein, the operation procedure is continued in the access occasion, and some implementations of the method and devices described herein may include, transmitting, via the transceiver and to the at least one third device, a second indication indicating that the operation procedure in the access occasion ends.

[0016] In some implementations of the method and devices described herein, the second indication is an acknowledgement (ACK) for received data from one of the at least one third device.

[0017] Some implementations of the method and devices described herein may include, continuing the operation procedure in the access round by: based on receiving data from one of the at least one third device in the access occasion, determining that the access occasion ends; and starting a subsequent access occasion in which the first device performs the operation procedure with another one of the at least one third device.

[0018] Some implementations of the method and devices described herein may include, suspending the operation procedure by one of the following: preventing from transmitting, via the transceiver and to the at least one third device, a subsequent message associated with the operation procedure with one of the at least one third device; preventing from transmitting, via the transceiver and to the at least one third device, a message for starting a subsequent access occasion in which the first device performs the operation procedure with another one of the at least one third device; or preventing from transmitting, via the transceiver and to the at least one third device, a message for starting a subsequent access round after an access round in which the link being unavailable occurs.

[0019] Some implementations of the method and devices described herein may include, transmitting, via the transceiver and to the at least one third device, a third indication indicating that the operation procedure is suspended.

[0020] Some implementations of the method and devices described herein may include, after suspending the operation procedure and prior to transmitting the data, storing the data received from the one or more of the at least one third device.

[0021] Some implementations of the method and devices described herein may include, starting a timer based on one of the following: determining to suspend the operation procedure; suspending the operation procedure; a second module in the first device for communicating with the at least one third device receiving a first indication indicating that the link is unavailable; or a first module in the first device for communicating with the second device determining that the link is unavailable for the data transmission.

[0022] Some implementations of the method and devices described herein may include, receiving, via the transceiver and from the second device, one or more values of the timer.

[0023] In some implementations of the method and devices described herein, the one or more values of the timer are specific to a cause for unavailability of the link.

[0024] Some implementations of the method and devices described herein may include, stopping the timer based on one or more of the following: a second module in the first device for communicating with the at least one third device receiving a fourth indication indicating that the link is available for the data transmission; a first module in the first device for communicating with the second device determining that the link is available for the data transmission; the data being successfully transmitted to the second device during suspending the operation procedure; or uplink transmission between the first device and the second device being available.

[0025] Some implementations of the method and devices described herein may include, in the event that the timer is stopped, transmitting, via the transceiver and to the second device, the data stored during suspending the operation procedure.

[0026] Some implementations of the method and devices described herein may include, in the event that the timer is expired, aborting the operation procedure.

[0027] Some implementations of the method and devices described herein may include, aborting the operation procedure by: transmitting, via the transceiver and to the at least one third device, a fifth indication indicating that the operation procedure is aborted; and releasing the data stored in the first device.

[0028] Some implementations of the method and devices described herein may include, starting the timer at one of the following: a radio resource control (RRC) layer of a second module in the first device for communicating with the at least one third device; or a media access control (MAC) layer of the second module.

[0029] Some implementations of the method and devices described herein may include, receiving, via the transceiver and from a first device, a third indication indicating that an operation procedure for the third device performed by the first device is suspended; and stopping, based on the third indication, at least one operation associated with the operation procedure.

[0030] Some implementations of the method and devices described herein may include, setting the third device into a waiting status.

[0031] In some implementations of the method and devices described herein, the operation procedure is performed in a plurality of access occasions, and some implementations of the method and devices described herein may include, receiving, via the transceiver and from the first device, a second indication that the operation procedure in an access occasion among the plurality of access occasions ends.

[0032] Some implementations of the method and devices described herein may include, receiving, via the transceiver and from the first device, a fifth indication indicating that the operation procedure is aborted.

[0033] Some implementations of the method and devices described herein may include, transmitting, via the transceiver and to a first device, one or more values of a timer at the first device, wherein the one or more values are associated with a time length during which an operation procedure performed by the first device is suspended.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034] FIG. 1A illustrates an example of a wireless communications system that supports ambient Internet of Things (AIoT) procedure handling in accordance with aspects of the present disclosure.

[0035] FIG. 1B illustrates an example of topology 1 associated with aspects of the present disclosure.

[0036] FIG. 1C illustrates an example of topology 2 associated with aspects of the present disclosure.

[0037] FIG. 1D illustrates an example of topology 3 associated with aspects of the present disclosure.

[0038] FIG. 1E illustrates another example of topology 3 associated with aspects of the present disclosure.

[0039] FIG. 1F illustrates an example of topology 4 associated with aspects of the present disclosure.

[0040] FIG. 2 illustrates an example signaling diagram illustrating an example process of ambient Internet of Things (AIoT) procedure handling in accordance with aspects of the present disclosure.

[0041] FIG. 3 illustrates an example of a device that support ambient Internet of Things (AIoT) procedure handling in accordance with aspects of the present disclosure.

[0042] FIG. 4 illustrates an example of a processor that support ambient Internet of Things (AIoT) procedure handling in accordance with aspects of the present disclosure.

[0043] FIG. 5 illustrates a flowchart of a method that supports ambient Internet of Things (AIoT) procedure handling in accordance with aspects of the present disclosure.

[0044] FIG. 6 illustrates a flowchart of a method that supports ambient Internet of Things (AIoT) procedure handling in accordance with aspects of the present disclosure.

[0045] FIG. 7 illustrates a flowchart of a method that supports ambient Internet of Things (AIoT) procedure handling in accordance with aspects of the present disclosure.

DETAILED DESCRIPTION

[0046] Principles of the present disclosure will now be described with reference to some embodiments. It is to be understood that these embodiments are described for the purpose of illustration and help those skilled in the art to understand and implement the present disclosure, without suggesting any limitation as to the scope of the disclosure. The disclosure described herein may be implemented in various manners other than the ones described below.

[0047] 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.

[0048] References in the present disclosure to "one embodiment," "an example embodiment," "an embodiment," "some embodiments," and the like indicate that the embodiment(s) described may include a particular feature, structure, or characteristic, but it is not necessary that every embodiment includes the particular feature, structure, or characteristic. Moreover, such phrases do not necessarily refer to the same embodiment(s). Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one

skilled in the art to affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

[0049] It shall be understood that although the terms "first" and "second" or the like may be used herein to describe various elements, these elements should not be limited by these terms. These terms are used to distinguish one element from another element. For example, a first element could also be termed as a second element, and similarly, a second element could also be termed as a first element, without departing from the scope of embodiments. As used herein, the term "and/or" includes any and all combinations of one or more of the listed terms.

[0050] The terminology used herein is for the purpose of describing particular embodiments and is not intended to be limiting of example embodiments. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises", "comprising", "has", "having", "includes" and/or "including", when used herein, specify the presence of stated features, elements, and/or components etc., but do not preclude the presence or addition of one or more other features, elements, components and/ or combinations thereof.

[0051] As used herein, the term "communication network" refers to a network following any suitable communication standards, such as, 5G new radio (NR), Long Term Evolution (LTE), LTE-Advanced (LTE-A), Wideband Code Division Multiple Access (WCDMA), High-Speed Packet Access (HSPA), Narrow Band Internet of Things (NB-IoT), and so on. Further, the communications between a user equipment and a network device in the communication network may be performed according to any suitable generation communication protocols, including but not limited to, the first generation (1G), the second generation (2G), 2.5G, 2.75G, the third generation (3G), the fourth generation (4G), 4.5G, the fifth generation (5G) communication protocols, and/or any other protocols either currently known or to be developed in the future. Embodiments of the present disclosure may be applied in various communication systems. Given the rapid development in communications, there will also be future type communication technologies and systems in which the present disclosure may be embodied. It should not be seen as limiting the scope of the present disclosure to only the aforementioned systems.

[0052] As used herein, the term "network device" generally refers to a node in a communication network via which a user equipment can access the communication network and receive services therefrom. The network device may refer to a base station (BS) or an access point (AP), for example, a node B (NodeB or NB), a radio access network (RAN) node, an evolved NodeB (eNodeB or eNB), a NR NB (also referred to as a gNB), a Remote Radio Unit (RRU), a radio header (RH), an infrastructure device for a V2X (vehicle-to-everything) communication, a transmission and reception point (TRP), a reception point (RP), a remote radio head (RRH), a relay, an integrated access and backhaul (IAB) node, a low power node such as a femto a base station (BS), a pico BS, and so forth, depending on the applied terminology and technology. The network device may further refer to a network function (NF) in the core network, for example, a SMF, an AMF, a PCF, a UPF or devices with same function in future network architectures, and so forth.

[0053] As used herein, the term "user equipment (UE)" generally refers to any end device that may be capable of wireless communications. By way of example rather than a limitation, a user equipment may also be referred to as a communication device, a terminal device, an end user device, a subscriber station (SS), an unmanned aerial vehicle (UAV), a portable subscriber station, a mobile station (MS), or an access terminal (AT). The user equipment may include, but is not limited to, a mobile phone, a cellular phone, a smart phone, a voice over IP (VoIP) phone, a wireless local loop phone, a tablet, a wearable user equipment, a personal digital assistant (PDA), a portable computer, a desktop computer, an image capture user equipment such as a digital camera, a gaming user equipment, a music storage and playback appliance, a vehicle-mounted wireless user equipment, a wireless endpoint, a mobile station, laptop-embedded equipment (LEE), laptop-mounted equipment (LME), a USB dongle, a smart device, wireless customer-premises equipment (CPE), an Internet of Things (IoT) device, a watch or other wearable, a head-mounted display (HMD), a vehicle, a drone, a medical device (for example, a remote surgery device), an industrial device (for example, a robot and/or other wireless devices operating in an industrial and/or an automated processing chain contexts), a consumer electronics device, a device operating on commercial and/or industrial wireless networks, and the like. In the following description, the terms: "user equipment," "communication device," "terminal," "user equipment" and "UE," may be used interchangeably.

[0054] As used herein, the term "ambient IoT (A-IoT) device" refers to a device without batteries or with limited energy storage capabilities. For the A-IoT device, energy is provided by harvesting radio waves, light, motion, heat, or any other suitable source. A-IoT device can also be called zero-power terminals, near-zero power terminals, passive IoT device, ambient backscatter communication (AmBC) device, tag, etc. Compared with low-power and wide-coverage services, such as narrow band (NB) IoT, enhance machine type communication (eMTC), A-IoT has lower complexity and lower power consumption, and is suitable for more application scenarios.

[0055] Aspects of the present disclosure are described in the context of a wireless communications system.

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

[0057] The one or more network entities 102 may be dispersed throughout a geographic region to form the wireless communications system 100. One or more of the network entities 102 described herein may be or include or may be referred to as a network node, a base station, a network element, a radio access network (RAN), a base transceiver station, an access point, a NodeB, an eNodeB (eNB), a next-generation NodeB (gNB), or

other suitable terminology. Alternatively, the network entity 102 may be a UE type device, e.g. an intermediate node in some embodiments. A network entity 102 and a UE 104 may communicate via a communication link 110, which may be a wireless or wired connection. For example, a network entity 102 and a UE 104 may perform wireless communication (e.g., receive signalling, transmit signalling) over a communication interface.

[0058] A network entity 102 may provide a geographic coverage area 112 for which the network entity 102 may support services (e.g., voice, video, packet data, 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.

[0059] The one or more UEs 104 may be dispersed throughout a geographic region of the wireless communications system 100. A UE 104 may include or may be referred to as a mobile device, a wireless device, a remote device, a remote unit, a handheld device, or a subscriber device, or some other suitable terminology. In some implementations, the UE 104 may be referred to as a unit, a station, a terminal, or a client, among other examples. Additionally, or alternatively, the UE 104 may be referred to as an Internet-of-Things (IoT) device, an Internet-of-Everything (IoE) device, or machine-type communication (MTC) device, among other examples. In some implementations, a UE 104 may be stationary in the wireless communications system 100. In some other implementations, a UE 104 may be mobile in the wireless communications system 100.

[0060] The one or more UEs 104 may be devices in different forms or having different capabilities. Some examples of UEs 104 are illustrated in FIG. 1A. A UE 104 may be

capable of communicating with various types of devices, such as the network entities 102, other UEs 104, or network equipment (e.g., the core network 106, the packet data network 108, a relay device, an integrated access and backhaul (IAB) node, or another network equipment), as shown in FIG. 1A. Additionally, or alternatively, a UE 104 may support communication with other network entities 102 or UEs 104, which may act as relays in the wireless communications system 100.

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

[0062] 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).

[0063] In some implementations, a network entity 102 may be configured in a disaggregated architecture, which may be configured to utilize a protocol stack physically or logically distributed among two or more network entities 102, such as an integrated access backhaul (IAB) network, an open Radio Access Network (O-RAN) (e.g., a

network configuration sponsored by the O-RAN Alliance), or a virtualized RAN (vRAN) (e.g., a cloud RAN (C-RAN)). For example, a network entity 102 may include one or more of a central unit (CU), a distributed unit (DU), a radio unit (RU), a RAN Intelligent Controller (RIC) (e.g., a Near-Real Time RIC (Near-RT RIC), a Non-Real Time RIC (Non-RT RIC)), a Service Management and Orchestration (SMO) system, or any combination thereof.

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

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

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

performed by one of a CU, a DU, or an RU, while other functions of the protocol layer are performed by a different one of the CU, the DU, or the RU).

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

[0068] The 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.

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

[0070] In the wireless communications system 100, the network entities 102 and the UEs 104 may use resources of the wireless communications system 100 (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers)) to perform various operations (e.g., wireless communications). In some implementations, the network entities 102 and the UEs 104 may support different resource structures. For example, the network entities 102 and the UEs 104 may support different frame structures. In some implementations, such as in 4G, the network entities 102 and the UEs 104 may support a single frame structure. In some other implementations, such as in 5G and among other suitable radio access technologies, the network entities 102 and the UEs 104 may support various frame structures (i.e., multiple frame structures). The network entities 102 and the UEs 104 may support various frame structures based on one or more numerologies.

[0071] One or more numerologies may be supported in the wireless communications system 100, and a numerology may include a subcarrier spacing and a cyclic prefix. A first numerology (e.g., μ=0) may be associated with a first subcarrier spacing (e.g., 15 kHz) and a normal cyclic prefix. In some implementations, the first numerology (e.g., μ=0) associated with the first subcarrier spacing (e.g., 15 kHz) may utilize one slot per subframe. A second numerology (e.g., μ=1) may be associated with a second subcarrier spacing (e.g., 30 kHz) and a normal cyclic prefix. A third numerology (e.g., μ=2) may be associated with a third subcarrier spacing (e.g., 60 kHz) and a normal cyclic prefix or an extended cyclic prefix. A fourth numerology (e.g., μ=3) may be associated with a fourth subcarrier spacing (e.g., 120 kHz) and a normal cyclic prefix. A fifth numerology (e.g., μ=4) may be associated with a fifth subcarrier spacing (e.g., 240 kHz) and a normal cyclic prefix.

[0072] A time interval of a resource (e.g., a communication resource) may be organized according to frames (also referred to as radio frames). Each frame may have a duration, for example, a 10 millisecond (ms) duration. In some implementations, each frame may include multiple subframes. For example, each frame may include 10 subframes, and each subframe may have a duration, for example, a 1 ms duration. In some implementations, each frame may have the same duration. In some implementations, each subframe of a frame may have the same duration.

[0073] Additionally or alternatively, a time interval of a resource (e.g., a communication resource) may be organized according to slots. For example, a subframe may include a number (e.g., quantity) of slots. The number of slots in each subframe may also depend on the one or more numerologies supported in the wireless communications system 100. For instance, the first, second, third, fourth, and fifth numerologies (i.e., μ=0, μ=1, μ=2, μ=3, μ=4) associated with respective subcarrier spacings of 15 kHz, 30 kHz, 60 kHz, 120 kHz, and 240 kHz may utilize a single slot per subframe, two slots per subframe, four slots per subframe, eight slots per subframe, and 16 slots per subframe, respectively. Each slot may include a number (e.g., quantity) of symbols (e.g., OFDM symbols). In some implementations, the number (e.g., quantity) of slots for a subframe may depend on a numerology. For a normal cyclic prefix, a slot may include 14 symbols. For an extended cyclic prefix (e.g., applicable for 60 kHz subcarrier spacing), a slot may include 12 symbols. The relationship between the number of symbols per slot, the number of slots per subframe, and the number of slots per frame for a normal cyclic prefix and an extended cyclic prefix may depend on a numerology. It should be understood that reference to a first numerology (e.g., μ=0) associated with a first subcarrier spacing (e.g., 15 kHz) may be used interchangeably between subframes and slots.

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

[0075] FR1 may be associated with one or multiple numerologies (e.g., at least three numerologies). For example, FR1 may be associated with a first numerology (e.g., μ=0), which includes 15 kHz subcarrier spacing; a second numerology (e.g., μ=1), which

includes 30 kHz subcarrier spacing; and a third numerology (e.g., μ=2), which includes 60 kHz subcarrier spacing. FR2 may be associated with one or multiple numerologies (e.g., at least 2 numerologies). For example, FR2 may be associated with a third numerology (e.g., μ=2), which includes 60 kHz subcarrier spacing; and a fourth numerology (e.g., μ=3), which includes 120 kHz subcarrier spacing.

[0076] In recent years, IoT has attracted much attention in the wireless communication world. More 'things' are expected to be interconnected for improving productivity efficiency and increasing comforts of life. Most of the wireless IoT devices are powered by battery that needs to be replaced or recharged manually. The automation and digitalization of various industries open numbers of new markets requiring new IoT technologies of supporting battery-less devices with no energy storage capability or devices with energy storage that do not need to be replaced or recharged manually.

[0077] In 3GPP, TR 22.840 is being developed by 3GPP Technical Specification Group (TSG) SA WG1 (SA1) to capture use cases, traffic scenarios, device constraints of ambient power-enabled Internet of Things and identify new potential service requirements as well as new key performance indicators (KPIs). And TSG Radio Access Network (RAN) has completed a Rel-18 RAN-level study item (SI) on Ambient IoT, which provides a terminological and scoping framework for future discussions of Ambient IoT. In RAN#102 meeting, a new study item description (SID) was approved for continuous study for such kind of wireless IoT device, which called Ambient IoT device. One of the objective is to design the compact protocol stack and corresponding procedures e.g. paging, random access, data transmission etc.

[0078] It is studied and decided which functions are needed for an ambient IoT compact protocol stack and lightweight signaling procedure to enable Device-Originated – Device-Terminated Triggered (DO-DTT) and Device-Terminated (DT) data transmission, and study those functions. For example, paging, random access, data transmission, including necessary radio resource control aspects, respecting the limitation in the general scope, interactions with upper layers. For functionalities not listed above, they are studied only if found essential. It was also approved in SID about general scope as in the following aspects A to E.

[0079] For the aspect A, the overall objective shall be to study a harmonized air interface design with minimized differences (where necessary) for Ambient IoT to enable

the following Devices (i) and (ii) as below. Device (i) has a peak power consumption of approximately 1 μW, energy storage, initial sampling frequency offset (SFO) up to 10^X ppm, neither downlink (DL) nor uplink (UL) amplification in the device. The UL transmission of the device (i) is backscattered on a carrier wave provided externally. Device (ii) has a peak power consumption of no more than a few hundred μW, energy storage, initial sampling frequency offset (SFO) up to 10^X ppm, both DL and/or UL amplification in the device. The UL transmission of the device (ii) may be generated internally by the device (ii), or be backscattered on a carrier wave provided externally. X is to be decided in WGs. Coverage design target is maximum distance of 10-50 m with device indoors as per TR 38.848. For topology 1 and topology 2 (UE as intermediate node under network (NW) control) per TR 38.848, with no RRC states, no mobility (i.e. at least no cell selection/re-selection -like function), no HARQ, no ARQ. It is to be understood that "no more than a few hundred μW" means WGs are not tasked with setting a particular value, and that it will be for WG discussions to determine if a presented design with corresponding power consumption satisfies the "no more than a few hundred μW" requirement.

[0080] For the aspect B, it was approved in deployment scenarios with the following characteristics, referenced to the tables in Clause 4.2.2 of TR 38.848, such as deployment scenario 1 with topology 1, and deployment scenario 2 with Topology 2. In deployment scenario 1 with topology 1, base station and coexistence characteristics may be micro-cell, co-site. In deployment scenario 2 with topology 2, the UE is as an intermediate node, under network control. Base station and coexistence characteristics may be macro-cell, co-site. The location of intermediate node is indoor.

[0081] For the aspect C, it was approved in FR1 licensed spectrum in FDD. For the aspect D, it was approved in spectrum deployment in-band to NR, in guard-band to LTE/NR, in standalone band(s). For the aspect E, it was approved in Traffic types DO-DTT, DT, with focus on rUC1 (indoor inventory) and rUC4 (indoor command). From RAN#104, the study will assess whether the harmonized air interface design (per aspect A above) can address the DO-A (device-originated autonomous) use case, only to identify which part(s) of the harmonized air interface design (per aspect A above) is/are not sufficient for the DO-A use case. Transmission from Ambient IoT device (including backscattering when used) can occur at least in UL spectrum.

[0082] Two sets or levels of grouping were defined for some representative use cases (or called purposes), in which grouping A is on the basis of the deployment environment(s) described for a use case in TR 22.840, and grouping B is on the basis of functionality/application described in TR 22.840. Grouping A may comprise: indoor, outdoor, and indoor/outdoor. Grouping B may comprise: inventory, sensors, positioning, and command. Deployment scenarios for ambient IoT have been studied on the basis of a list of characteristics, and the representative use case(s) applicable to a scenario. Deployment scenarios may comprise deployment scenarios 1 to 5 as shown in Table 1 to Table 5, respectively. Deployment scenario 1 involves device indoors, base station indoors. Deployment scenario 2 involves device indoors, base station outdoors. Deployment scenario 3 involves device indoors, UE-based reader. Deployment scenario 4 involves device outdoors, base station outdoors. Deployment scenario 5 involves device outdoors, UE-based reader.

[0083] With ambient IoT device indoors and base station indoors, deployment scenario 1 is characterized according to Table 1. It should be noted that descriptions in Table 1 may not be applicable for some devices (A, B).

[0084] Table 1

Applicable representative use cases	Characteristics	Description
Indoor inventory Indoor sensor Indoor positioning Indoor command	Environment (of device)	Indoor
	Base station characteristic (if any)	Micro- or pico-cell
	Connectivity topology	Topology (1), (2), (3)
	Spectrum	Licensed FDD, licensed TDD, unlicensed
	Coexistence with existing 3GPP technologies	Co-site or new site
	Traffic assumption	DT and DO
	Device characteristic	Device A or Device B or Device C

[0085] With Ambient IoT device indoors and base station outdoors, deployment scenario 2 is characterized according to Table 2. It should be noted that descriptions in Table 2 may not be applicable for some devices (A, B).

[0086] Table 2

Applicable representative use cases	Characteristics	Description
Indoor inventory Indoor sensor Indoor positioning Indoor command	Environment (of device)	Indoor
	Basestation characteristic (if any)	Macro- or Micro- cell BS
	Connectivity topology	Topology (1), (2), (3) Note: The location of intermediate or assisting node (if any) is indoor or outdoor
	Spectrum	Licensed FDD, licensed TDD, unlicensed
	Coexistence with existing 3GPP technologies	Co-site or new site
	Traffic assumption	DT and DO
	Device characteristic	Device C may support Topology (1), (2), (3), Device A may support Topology (2), Device B may support Topology (2), (3)

[0087] With Ambient IoT device indoors and UE-based reader, this deployment scenario 3 is characterized according to Table 3. It should be noted that descriptions in Table 3 may not be applicable for some devices (A, B).

[0088] Table 3

Applicable representative use cases	Characteristics	Description
Indoor inventory Indoor sensor Indoor positioning Indoor command	Environment (of device)	Indoor
	Basestation characteristic (if any)	None
	Connectivity topology	Topology (4)
	Spectrum	Licensed FDD, licensed TDD, unlicensed
	Coexistence with existing 3GPP technologies	NA
	Traffic assumption	DT and DO
	Device characteristic	Device A or Device B or Device C

[0089] With Ambient IoT device outdoors and basestation outdoors, this deployment scenario 4 is characterized according to Table 4. It should be noted that descriptions in Table 4 may not be applicable for some devices (A, B).

[0090] Table 4

Applicable representative use cases	Characteristics	Description
	Environment (of device)	Outdoor
	Basestation characteristic (if any)	Macro- or Micro- cell BS
	Connectivity topology	Topologies (1), (2), (3)

Outdoor inventory Outdoor sensor Outdoor positioning Outdoor command	Spectrum	Licensed FDD, licensed TDD, or unlicensed.
	Coexistence with existing 3GPP technologies	Co-site or new site
	Traffic assumption	DT and DO
	Device characteristic	Device C may support Topology (1), (2), (3), Device A may support Topology (2),Device B may support Topology (2), (3)

[0091] With Ambient IoT device outdoors and UE-based reader, this deployment scenario 5 is characterized according to Table 5. It should be noted that descriptions in Table 5 may not be applicable for some devices (A, B).

[0092] Table 5

Applicable representative use cases	Characteristics	Description
Outdoor inventory Outdoor sensor Outdoor positioning Outdoor command	Environment (of device)	Outdoor
	Base station characteristic (if any)	None
	Connectivity topology	Topology (4)
	Spectrum	Licensed FDD, licensed TDD, unlicensed
	Coexistence with existing 3GPP technologies	NA
	Traffic assumption	DT and DO
	Device characteristic	Device A or Device B or Device C

[0093] Device categorization will be described below. Ambient IoT devices are characterized according to their energy storage capacity, and capability of generating RF signals for their transmissions. It is considered that a device has no energy storage at all; or has limited energy storage. Relying on these storage capacities, the following set of ambient IoT devices (device A, device B, and device C) are considered. Device A has no energy storage, and no independent signal generation/amplification, i.e. backscattering transmission. Device B has energy storage, and no independent signal generation, i.e. backscattering transmission. Use of stored energy can includes amplification for reflected signals. Device C has energy storage, and has independent signal generation, i.e., active RF components for transmission. A limited energy storage can be different among implementations within device B or implementations within device C, and different between device B and device C. Such storage is expected to be order(s) of magnitude smaller than an NB-IoT device would typically include. Devices A, B, and C are able to

demodulate control, data, etc. from the relevant entity in RAN according to connectivity topology.

[0094] Several connectivity topologies for Ambient IoT networks and devices are defined, as shown in FIGS. 1B to 1F. In all these topologies, the ambient IoT device may be provided with a carrier wave from other node(s) either inside or outside the topology. The links in each topology may be bidirectional or unidirectional. BS, UE, assisting node, or intermediate node could be multiple BSs or UEs, respectively. The mixture of indoor and outdoor placement of such nodes is regarded as a network implementation choice. Account would need to be taken of potential impact on device or node complexity. In the connectivity topologies, this does not imply the existence of multi-hop assisting or intermediate nodes.

[0095] FIG. 1B illustrates an example scenario of topology 1 associated with aspects of the present disclosure. As shown in FIG. 1B, in topology 1, the ambient IoT device 121 communicates with a base station (BS) 122 directly and bi-directionally. The communication between the BS 122 and the ambient IoT device 121 includes ambient IoT data and/or signalling. This topology includes the possibility of a transmission from the BS 122 to the ambient IoT device 121 and a different possibility of a transmission from the ambient IoT device 121 to the BS 122.

[0096] FIG. 1C illustrates an example scenario of topology 2 associated with aspects of the present disclosure. As shown in FIG. 1C, in topology 2, the ambient IoT device 131 communicates bi-directionally with an intermediate node 132 (or referred to as an intermediate device) between the ambient IoT device 131 and the base station 133. In this topology, the intermediate node 132 can be a relay node, an IAB node, a UE, a repeater, etc., which is capable of ambient IoT. The intermediate node 132 transfers ambient IoT data and/or signalling between the BS 133 and the ambient IoT device 131. An example of the intermediate node 132 may be a first device 201 below. An example of the ambient IoT device 121 may be a third device 203 below. An example of the BS 122 may be a second device 202 below.

[0097] FIG. 1D illustrates an example of topology 3 associated with aspects of the present disclosure. As shown in FIG. 1D, in topology 3 with downlink assistance, the ambient IoT device 141 receives data and/or signalling from the assisting node 142 and transmits data and/or signalling to the BS 143. FIG. 1E illustrates another example of

topology 3 associated with aspects of the present disclosure. As shown in FIG. 1E, in topology 3 with uplink assistance, the ambient IoT device 141 receives data and/or signalling from the BS 143 and transmits data/signalling to the assisting node 142. The assisting node 142 can be a relay node, an IAB node, a UE, a repeater, etc., which is capable of ambient IoT.

[0098] FIG. 1F illustrates an example of topology 4 associated with aspects of the present disclosure. As shown in FIG. 1F, in the topology 4, the ambient IoT device 151 communicates with a UE 152 bi-directionally. The communication between UE 152 and the ambient IoT device 151 includes ambient IoT data and/or signaling.

[0099] In topology 2 above, there is an intermediate node (e.g. the intermediate node 132) between a BS (e.g. the base station 133) and an AIoT device (shown as the ambient IoT device 131, for example). The intermediate node, e.g. a kind of UE, to behave as a reader, which is called intermediate UE or I-UE or UE reader in present disclosure. The I-UE has two modules, e.g. one is NR module which is to communicate with one of a BS, a gNB or an eNB via NR Uu interface; while another one is AIoT module which is to communicate with one or multiple AIoT devices via AIoT Uu interface. NR radio resource control (RRC) layer of the NR module in the I-UE needs to maintain RRC connected mode, so that it can transmit AIoT associated information to the network timely which will impact AIoT side procedure. For example, AIoT device identity (ID) needs to be transmitted to the network while the I-UE receives it, so that the network will determine the next step command e.g. whether to operate the AIoT device (write, read, kill (e.g. turn off) etc.) or determine to inventory the next AIoT device. In some cases, the NR module may not maintain RRC connected mode e.g. when there happens radio link failure, or handover, or RRC re-establishment, or entered into a RRC_IDLE mode. In these cases, a RRC connection is not available and AIoT associated information cannot be transmitted to network timely. Therefore, how to handle AIoT procedure needs to be defined, the issues, such as how the NR module indicate RRC connection unavailable to AIoT module, what is the I-UE behavior if RRC connection is unavailable, what is the I-UE behavior before RRC connection recovery, are need to be resolved. Some embodiments of the present disclosure propose some solutions in view of the above discussions and analysis. The details will be described with some embodiments below.

[0100] FIG. 2 illustrates an example signaling diagram illustrating an example process of ambient Internet of Things (AIoT) procedure handling in accordance with aspects of the present disclosure. The process 200 as shown in FIG. 2 involves a first device 201, a second device 202 and at least one third device 203. A third device 203 is shown as an example. In some embodiments, an example of the first device 201 may be an intermediate node (e.g. intermediate UE, or referred to as I-UE for short) between a BS and an AIoT device. The second device 202 may be an access network device, or a core network device, or a server for an AIoT device. As an example, the second device 202 may be a BS, e.g. the BS 133. The third device 203 may be an AIoT device, e.g. the AIoT device 131. In some examples, the AIoT device may be communicated with the intermediate node, which is connected to the network via the BS. The I-UE may have two modules, e.g. one is NR module which is to communicate with the BS/gNB/eNB via NR Uu interface. Another one is AIoT module which is to communicate with one or multiple AIoT devices via AIoT Uu interface.

[0101] In the process 200, the first device 201 may determine (210) that a link between the first device 201 and the second device 202 is unavailable for data transmission. In some examples, the link between the first device 201 and the second device 202 may be referred to as a NR Uu link. In some examples, the first device 201 may determine that the link is unavailable via its processor. In some examples, the first device 201 may determine that the link is unavailable based on a first module in the first device 201 for communicating with the second device 202 determining that the link is unavailable. In some other examples, the first device 201 may determine that the link is unavailable based on the first module determining that data from one of the at least one third device 203 fails to be transmitted to the second device 202. In some further examples, the first device 201 may determine that the link is unavailable based on the first module predicting, with a model, that the link is to be unavailable. In some further examples, one or more ways above may be combined. The first device 201 may suspend (212), based on the determination, an operation procedure for at least one third device 203. In some examples, the first device 201 may, e.g. via its processor, transmit, from the first module to the second module in the first device 201, a first indication indicating that the link is unavailable. The first module (e.g. the NR module) is used for communicating with the second device 202. The second module (e.g. the AIoT module) is used for communicating with the at least one third device 203.

[0102] For example, if a NR RRC layer in the NR module determines that the NR Uu link is not available for data transmission, the NR RRC layer may indicate to the AIoT module that the NR Uu link is unavailable or the NR Uu link has or will has problem. Alternatively, when the AIoT module delivers the AIoT associated data to the NR module, if the NR module determines that the associated data cannot be transmitted due to the NR Uu link unavailable for the data transmission, the NR RRC layer may indicate to AIoT module that the NR Uu link is unavailable. Alternatively, if potentially unavailable in the near future which was predicted by some AI module, the NR RRC layer may indicate to AIoT module that the NR Uu link is unavailable.

[0103] Additionally or alternatively, the first device 201 may, e.g. via its processor, transmit, from a first module to a second module in the first device 201, a cause for unavailability of the link. In some embodiments, the cause comprises a radio link failure (RLF) in the link between the first device 201 and the second device 202, or handover of the first device 201, or reestablishment of the link, or the first device 201 being in an idle state or an inactive state without small data transmission configuration, or random access failure of the first device 201.

[0104] For example, the NR Uu link is not available for the data transmission, e.g. due to the radio link failure, during handover, during RRC re-establishment, in RRC IDLE/INACTIVE state while has no UL transmission resource etc. Accordingly, the cause can be indicated which is to indicate the reason for RRC connection unavailable, e.g. the RLF, the handover, the reestablishment, the IDLE state, the random access failure, etc. Specifically, the cause can be indicated from the NR RRC layer in the NR module to the AIoT module which is to indicate the reason for the NR Uu link unavailable, e.g. the RLF, the handover, the reestablishment, the IDLE state, the random access failure, etc.

[0105] As an example, the network (i.e. the second device 202) sends a message to the I-UE e.g. AIoT inventory or AIoT paging, which triggers the I-UE to start an AIoT procedure, e.g. paging, random access etc. During a random access procedure, there are one or multiple access rounds. In one round, multiple AIoT devices will response by a TDMed way. And the additional rounds are used to receive the response from AIoT devices that does not response in previous round, e.g. because of collision or other reason. In one access round, there are multiple access occasions and in one access occasion, the

I-UE will perform the AIoT procedure with one AIoT device. The AIoT procedure may be an example of the operation procedure.

[0106] In some examples, the first device 201 may, e.g. via its processor, suspend the operation procedure after reception of the first indication by the second module or after the first module determines that the link is unavailable for the data transmission. Additionally, the first device 201 may suspend the operation procedure at a time point. In some examples, the time point may be when the second module receives the first indication. For example, the I-UE may suspend the AIoT procedure immediately. Specifically, as an example, if the indication (i.e. the first indication) is received after the AIoT module receives random access a message (MSG) 1 from the AIoT device, the I-UE will not transmit a message 2 to the AIoT device. Alternatively, if the indication is received after the AIoT module transmits the random access message 2 to the AIoT device, the I-UE will receive a random access message 3 from the AIoT device but not transmit a message 4 to the AIoT device.

[0107] In some other examples, the time point may be at the end of an access occasion in which the first device 201 finishes the operation procedure with one of the at least one third device 203. For example, the I-UE may suspend the AIoT procedure at the end of current access occasion. In other words, the I-UE continues the AIoT procedure till the end of current access occasion. For example, the indication is received after the AIoT module receives random access message 1 from the AIoT device, the I-UE will continue to transmit a message 2, and receives a message 3 from the AIoT device. The I-UE will transmit a message (e.g. an ACK for received message 3) to the AIoT device to indicate the end of the access procedure. Or in another example, the indication is received after the AIoT module transmits DL data to the AIoT device, the I-UE will continue to receive followed all UL data from this AIoT device. And the I-UE will not transmit the message to start the next access occasion, i.e. will not treat the next AIoT device.

[0108] In some examples, the time point may be at the end of an access round comprising a plurality of access occasions. The plurality of access occasions may comprises the access occasion above. For example, the I-UE may suspend the AIoT procedure at the end of current access round. In other words, the I-UE may continue the AIoT procedure till the end of current access round. For example, the indication is received during an access occasion, the I-UE will determine the current access occasion

is end after receive the AIoT device ID (access message 3) from the AIoT device, and send a message to the AIoT device to indicate the access is complete. Then the I-UE will continue the AIoT procedure e.g. to send a message to start the next access occasion, to treat the next AIoT device. In some examples, the time point may be determined based on configuration information for indicating the time point, or resource configuration information for the operation procedure, or caching capability of the second module, or any combination thereof. The details may further refer to the examples hereinafter, for example, description about options 1 to 3 below.

[0109] In some examples, the first device 201 may finish the operation procedure based on receiving a reported device identity (ID) from the one of the at least one third device 203, or receiving data from the one of the at least one third device 203, or transmitting an acknowledgement (ACK) to the one of the at least one third device 203, or transmitting, to the one of the at least one third device 203, a second indication indicating that the operation procedure in the access occasion ends, or any combination thereof. On the third device 203 side, the third device 203 may receive the second indication.

[0110] In some examples, after reception of the first indication by the second module and prior to suspending the operation procedure, the first device 201 may, e.g. via its processor, continue the operation procedure in an access occasion in which the first device 201 performs the operation procedure with one of the at least one third device 203 and the link being unavailable occurs. Additionally, the first device 201 may, e.g. via its processor, transmit, e.g. via its transceiver and to the at least one third device 203, a second indication indicating that the operation procedure in the access occasion ends. In some examples, the second indication may be an acknowledgement (ACK) for received data from one of the at least one third device 203.

[0111] In some examples, after reception of the first indication by the second module and prior to suspending the operation procedure, the first device 201 may, e.g. via its processor, continue the operation procedure in an access round comprising a plurality of access occasions. The plurality of access occasions comprises the access occasion above. In some examples, the first device 201 may continue the operation procedure in the access round by, based on receiving data from one of the at least one third device 203 in the access occasion, determining that the access occasion ends. In some other examples, the

first device 201 may continue the operation procedure in the access round by starting a subsequent access occasion in which the first device 201 performs the operation procedure with another one of the at least one third device 203.

[0112] The first device 201 may suspend the operation procedure in various ways. For example, the first device 201 may prevent from transmitting, e.g. via its transceiver and to the at least one third device 203, a subsequent message associated with the operation procedure with one of the at least one third device 203. Alternatively, the first device 201 may prevent from transmitting, e.g. via its transceiver and to the at least one third device 203, a message for starting a subsequent access occasion in which the first device 201 performs the operation procedure with another one of the at least one third device 203. Alternatively, the first device 201 may prevent from transmitting, e.g. via its transceiver and to the at least one third device 203, a message for starting a subsequent access round after an access round in which the link being unavailable occurs.

[0113] In some examples, the first device 201 may transmit (212a), via the transceiver of the first device 201 and to the at least one third device 203, a third indication 205a indicating that the operation procedure is suspended. On the third device 203 side, the third device 203 may receive (212b), e.g. via the transceiver of the third device 203 and from the first device 201, the third indication 205a. Then the third device 203 may stop (216a), based on the third indication 205a, at least one operation associated with the operation procedure. In some examples, after suspending the operation procedure and prior to transmitting the data 205, the first device 201 may store the data 205 received from the one or more of the at least one third device 203. On the third device 203 side, after receiving the third indication 205a, the third device 203 may be in a waiting status. For example, the processor of the third device 203 may set the third device 203 into the waiting status.

[0114] As an example for some aspects above related to the first device 201 suspending the operation procedure (e.g. the AIoT procedure), when the AIoT module receives the indication (e.g. the first indication) of NR Uu link problem (i.e. the NR Uu link is unavailable for the data transmission), the I-UE may suspend the AIoT procedure in various ways, such as option 1 to option 3 below.

[0115] In option 1, the I-UE may suspend the AIoT procedure immediately, e.g. will not transmit next message to AIoT device(s). In some examples, the I-UE may send a

message (an example of the third indication) to the AIoT device to indicate the AIoT procedure is suspending (or referred to as pending), the AIoT device stops the AIoT procedure and back to the waiting status. Alternatively, in option 2, the I-UE may continue the AIoT procedure till the end of current access occasion, e.g. receives the AIoT device ID, or receives the UL data from the AIoT device, and will not transmit the message to start the next access occasion i.e. will not treat the next AIoT device. The I-UE will transmit a message (an example of the second indication) to the AIoT device to indicate the end of the access procedure, e.g. an ACK for a received AIoT device ID. Alternatively, in option 3, the I-UE may continue the AIoT procedure till the end of access round, e.g. will not transmit the message to start next access round. When receives the AIoT device ID, and the NR Uu link has problem, the I-UE will determine the current access occasion is end and send an indication to the AIoT device. I-UE will continue to treat the next AIoT device (or in another word, start the next access occasion).

[0116] In some examples, the AIoT module determines to use one of the options above based on the configuration of the network. For example, the AIoT module receives the AIoT configuration from BS to indicate pending for current occasion, then if the suspending is determined, AIoT module use option 2 above to implement the suspending.In some examples, the AIoT module determines to use one of the options above based on the resource configuration by the BS. For example, if the AIoT module received the resource configuration for AIoT communication from the BS for one access round, then if the suspending is determined, the AIoT module may use option 3 above to implement the suspending. In some examples, the AIoT module determines to use one of the options above based on caching capability of the AIOT module of the I-UE. For the examples above, the I-UE may store all received AIoT associated information (an example of data 205) during suspending the AIoT procedure. The received AIoT associated information e.g. received AIoT device id(s) from one or multiple AIoT devices.

[0117] In some examples, the first device 201 may start a timer based on determining to suspend the operation procedure, or based on suspending the operation procedure, or based on a second module in the first device 201 for communicating with the at least one third device 203 receiving a first indication indicating that the link is unavailable, or based on a first module in the first device 201 for communicating with the second device determining that the link is unavailable for the data transmission. For example, the I-UE will start a timer in the AIoT module if the I-UE determines to suspend the AIoT

procedure, or the AIoT module receives the indication (i.e. the first indication) of the NR Uu link problem. In some examples, the first device 201 may start the timer at a radio resource control (RRC) layer of a second module in the first device 201 for communicating with the at least one third device 203, or at a media access control (MAC) layer of the second module. For example, the I-UE will start the timer in the AIoT module e.g. AIoT RRC layer, or AIoT media access control (MAC) layer, if the I-UE determines to suspend the AIoT procedure.

[0118] In some examples, the second device 202 may transmit (214a), e.g. via the transceiver of the second device 202 and to the first device 201, one or more values 205b of a timer at the first device 201. On the first device 201 side, the first device 201 may receive (214b), e.g. via the transceiver of the first device 201 and from the second device 202, the one or more values 205b of the timer. The one or more values 205b of the timer may be associated with a time length during which the operation procedure performed by the first device 201 is suspended. In some examples, the one or more values 205b of the timer may be specific to a cause for unavailability of the link. For example, the value of timer may be different for different cause of the NR Uu link unavailable, which is configured by the network.

[0119] In some examples, the first device 201 may stop the timer based on a second module in the first device 201 for communicating with the at least one third device 203 receiving a fourth indication indicating that the link is available for the data transmission, or based on a first module in the first device 201 for communicating with the second device 202 determining that the link is available for the data transmission, or based on the data 205 being successfully transmitted to the second device 202 during suspending the operation procedure, or based on uplink transmission between the first device 201 and the second device 202 being available, or based on any combination thereof. For example, the I-UE will stop the timer if the AIoT module receives an indication (refered to as the fourth indication) indicating that NR Uu link is available for data transmission, or stored data of AIoT module during pending period is successfully transmitted, or the NR Uu UL transmission is available (e.g. configured with preconfigured uplink resource (PUR), small data transmission (SDT) in an IDLE/INACTIVE mode etc.). In some examples, if the timer is stopped, the first device 201 may transmit, e.g. via its transceiver and to the second device 202, the data 205 stored during suspending the operation procedure. For

example, if the timer is stopped, the I-UE transmits all stored AIoT associated information during suspending period to the network.

[0120] In some examples, if the timer is expired, the first device 201 may abort the operation procedure. In a process of abort the operation procedure may comprise transmitting, e.g. via the transceiver of the first device 201 and to the at least one third device 203, a fifth indication indicating that the operation procedure is aborted, and releasing the data 205 stored in the first device 201. On the third device 203 side, the third device 203 may receive, e.g. via the transceiver of the third device 203 and from the first device 201, the fifth indication. For example, if the timer is expired, the I-UE aborts the AIoT side procedure, e.g. the I-UE sends abort/end indication (i.e. the fifth indication) to all AIoT devices. The I-UE releases all AIoT associated pending data (data 205 received from the AIoT devices during the suspending.

[0121] In some embodiments, the timer is maintained for the AIoT procedure suspending by the AIoT module. For example, the timer is started when receive the indication of the NR Uu link unavailable for the data transmission. The timer is stopped when the NR Uu link recovered. The timer is expired, then AIoT procedure is aborted, and determined failure.

[0122] The first device 201 may, based on determining (214) that the link becomes available, transmit (216), e.g. via a transceiver of the first device 201 and to the second device 202, data 205 associated with one or more of the at least one third device 203 stored during suspending the operation procedure. On the second device 202 side, the second device 202 may receive (218) the data 205.

[0123] In some embodiments of present disclosure, a solution for handling a procedure is proposed, especially for an AIoT intermediate node to handle an AIoT procedure if NR Uu link is unavailable for data transmission is proposed, thereby improving communication performance such as in AIoT communications.

[0124] FIG. 3 illustrates an example of a device 300 that supports ambient Internet of Things (AIoT) procedure handling in accordance with aspects of the present disclosure. The device 300 may be an example of a UE 104 as described herein. The device 300 may support wireless communication with one or more node entities 102, UEs 104, or any combination thereof. The device 300 may include components for bi-directional communications including components for transmitting and receiving communications,

such as a processor 302, a memory 304, a transceiver 306, and, optionally, an I/O controller 308. 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).

[0125] The processor 302, the memory 304, the transceiver 306, 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 302, the memory 304, the transceiver 306, or various combinations or components thereof may support a method for performing one or more of the operations described herein.

[0126] In some implementations, the processor 302, the memory 304, the transceiver 306, 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 302 and the memory 304 coupled with the processor 302 may be configured to perform one or more of the functions described herein (e.g., executing, by the processor 302, instructions stored in the memory 304).

[0127] For example, the processor 302 may support wireless communication at the device 300 in accordance with examples as disclosed herein. In some examples, the processor 302 may be configured to operable to support a means for determining that a link between the first device and a second device is unavailable for data transmission; a means for suspending, based on the determination, an operation procedure for at least one third device; and a means for, based on determining that the link becomes available, transmitting, via the transceiver and to the second device, data associated with one or more of the at least one third device stored during suspending the operation procedure. The processor 302 may be configured to operable to support other means for other implementations of method 500. In some other examples, the processor 302 may be configured to operable to support a means for receiving, via the transceiver and from a first device, a third indication indicating that an operation procedure for the third device

performed by the first device is suspended; and a means for stopping, based on the third indication, at least one operation associated with the operation procedure. The processor 302 may be configured to operable to support other means for other implementations of method 600. In some further examples, the processor 302 may be configured to operable to support a means for transmitting, via the transceiver and to a first device, one or more values of a timer at the first device, wherein the one or more values are associated with a time length during which an operation procedure performed by the first device is suspended. The processor 302 may be configured to operable to support other means for other implementations of method 700.

[0128] The processor 302 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 302 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 302. The processor 302 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 304) to cause the device 300 to perform various functions of the present disclosure.

[0129] The memory 304 may include random access memory (RAM) and read-only memory (ROM). The memory 304 may store computer-readable, computer-executable code including instructions that, when executed by the processor 302 cause the device 300 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 302 but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some implementations, the memory 304 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.

[0130] The I/O controller 308 may manage input and output signals for the device 300. The I/O controller 308 may also manage peripherals not integrated into the device M02. In some implementations, the I/O controller 308 may represent a physical connection or port to an external peripheral. In some implementations, the I/O controller

308 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 308 may be implemented as part of a processor, such as the processor 302. In some implementations, a user may interact with the device 300 via the I/O controller 308 or via hardware components controlled by the I/O controller 308.

[0131] In some implementations, the device 300 may include a single antenna 310. However, in some other implementations, the device 300 may have more than one antenna 310 (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 306 may communicate bi-directionally, via the one or more antennas 310, wired, or wireless links as described herein. For example, the transceiver 306 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 306 may also include a modem to modulate the packets, to provide the modulated packets to one or more antennas 310 for transmission, and to demodulate packets received from the one or more antennas 310. The transceiver 306 may include one or more transmit chains, one or more receive chains, or a combination thereof.

[0132] 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 310 for transmitting the amplified signal into the air or wireless medium.

[0133] 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 310 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.

[0134] FIG. 4 illustrates an example of a processor 400 that supports ambient Internet of Things (AIoT) procedure handling in accordance with aspects of the present disclosure. The processor 400 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 400 may include a controller 402 configured to perform various operations in accordance with examples as described herein. The processor 400 may optionally include at least one memory 404. Additionally, or alternatively, the processor 400 may optionally include one or more arithmetic-logic units (ALUs) 406. 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).

[0135] The processor 400 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 400) 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).

[0136] The controller 402 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 400 to cause the processor 400 to support various operations in accordance with examples as described herein. For example, the controller 402 may operate as a control unit of the processor 400, generating control signals that manage the operation of various components of the processor 400. These control signals include enabling or disabling

functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[0137] The controller 402 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 404 and determine subsequent instruction(s) to be executed to cause the processor 400 to support various operations in accordance with examples as described herein. The controller 402 may be configured to track memory address of instructions associated with the memory 404. The controller 402 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 402 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 400 to cause the processor 400 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 402 may be configured to manage flow of data within the processor 400. The controller 402 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 400.

[0138] The memory 404 may include one or more caches (e.g., memory local to or included in the processor 400 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementation, the memory 404 may reside within or on a processor chipset (e.g., local to the processor 400). In some other implementations, the memory 404 may reside external to the processor chipset (e.g., remote to the processor 400).

[0139] The memory 404 may store computer-readable, computer-executable code including instructions that, when executed by the processor 400, cause the processor 400 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. The controller 402 and/or the processor 400 may be configured to execute computer-readable instructions stored in the memory 404 to cause the processor 400 to perform various functions (e.g., functions or tasks supporting transmit power prioritization). For example, the processor 400 and/or the controller 402 may be coupled with or to the memory 404, the processor 400, the controller 402, and the memory 404 may be configured to perform various functions described herein. In some examples, the processor 400 may include multiple processors and the memory 404 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.

[0140] The one or more ALUs 406 may be configured to support various operations in accordance with examples as described herein. In some implementation, the one or more ALUs 406 may reside within or on a processor chipset (e.g., the processor 400). In some other implementations, the one or more ALUs 406 may reside external to the processor chipset (e.g., the processor 400). One or more ALUs 406 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 406 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 406 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 406 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 406 to handle conditional operations, comparisons, and bitwise operations.

[0141] The processor 400 may support wireless communication in accordance with examples as disclosed herein. In some examples the processor 402 may be configured to or operable to support a means for determining that a link between the first device and a second device is unavailable for data transmission; a means for suspending, based on the determination, an operation procedure for at least one third device; and a means for, based on determining that the link becomes available, transmitting, via the transceiver and to the second device, data associated with one or more of the at least one third device stored during suspending the operation procedure. The processor 400 may be configured to or operable to support other means for other implementations of method 500. In some other examples, the processor 402 may be configured to or operable to support a means for receiving, via the transceiver and from a first device, a third indication indicating that an operation procedure for the third device performed by the first device is suspended; and stopping, based on the third indication, at least one operation associated with the operation procedure. The processor 400 may be configured to or operable to support other means for other implementations of method 600. In some examples the processor 402 may be configured to or operable to support a means for transmitting, via the transceiver and to a first device, one or more values of a timer at the first device, wherein the one or more

values are associated with a time length during which an operation procedure performed by the first device is suspended. The processor 400 may be configured to or operable to support other means for other implementations of method 700.

[0142] FIG. 5 illustrates a flowchart of a method 500 that supports ambient Internet of Things (AIoT) procedure handling in accordance with aspects of the present disclosure. The operations of the method 500 may be implemented by a device or its components as described herein. For example, the operations of the method 500 may be performed by the first device 201 or the I-UE 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.

[0143] At 505, the method includes determining that a link between the first device and a second device is unavailable for data transmission. The operations of 505 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 505 may be performed by a device as described with reference to FIG. 1A or FIG. 2.

[0144] At 510, the method includes suspending, based on the determination, an operation procedure for at least one third device. The operations of 510 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 510 may be performed by a device as described with reference to FIG. 1A or FIG. 2.

[0145] At 515, the method includes, based on determining that the link becomes available, transmitting, to the second device, data associated with one or more of the at least one third device stored during suspending the operation procedure. The operations of 515 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 515 may be performed by a device as described with reference to FIG. 1A or FIG. 2.

[0146] FIG. 6 illustrates a flowchart of a method 600 that supports ambient Internet of Things (AIoT) procedure handling in accordance with aspects of the present disclosure. The operations of the method 600 may be implemented by a device or its components as described herein. For example, the operations of the method 600 may be performed by the third device 203 or the AIoT 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.

[0147] At 605, the method includes receiving, from a first device, a third indication indicating that an operation procedure for the third device performed by the first device is suspended. The operations of 605 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 605 may be performed by a device as described with reference to FIG. 1A or FIG. 2.

[0148] At 610, the method may include stopping, based on the third indication, at least one operation associated with the operation procedure. The operations of 610 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 610 may be performed by a device as described with reference to FIG. 1A or FIG. 2.

[0149] FIG. 7 illustrates a flowchart of a method that supports ambient Internet of Things (AIoT) procedure handling in accordance with aspects of the present disclosure. The operations of the method 700 may be implemented by a device or its components as described herein. For example, the operations of the method 700 may be performed by the second device 202 or the network device (e.g. 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.

[0150] At 705, the method includes transmitting, to a first device, one or more values of a timer at the first device, wherein the one or more values are associated with a time length during which an operation procedure performed by the first device is suspended. The operations of 705 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 705 may be performed by a device as described with reference to FIG. 1A or FIG. 2.

[0151] 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.

[0152] 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.

[0153] 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.

[0154] 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.

[0155] 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.

[0156] The description herein is provided to enable a person having ordinary skill in the art to make or use the disclosure. Various modifications to the disclosure will be apparent to a person having ordinary skill in the art, and the generic principles defined herein may be applied to other variations without departing from the scope of the disclosure. Thus, the disclosure is not limited to the examples and designs described herein but is to be accorded the broadest scope consistent with the principles and novel features disclosed herein.

CLAIMS

What is claimed is:

1. A first device comprising:

a processor; and

a transceiver coupled to the processor,

wherein the processor is configured to:

determine that a link between the first device and a second device is unavailable for data transmission;

suspend, based on the determination, an operation procedure for at least one third device; and

based on determining that the link becomes available, transmit, via the transceiver and to the second device, data associated with one or more of the at least one third device stored during suspending the operation procedure.

2. The first device of claim 1, wherein the processor is configured to determine that the link is unavailable based on at least one of the following:

a first module in the first device for communicating with the second device determining that the link is unavailable;

the first module determining that data from one of the at least one third device fails to be transmitted to the second device; or

the first module predicting, with a model, that the link is to be unavailable.

3. The first device of claim 1, wherein the processor is further configured to:

transmit, from a first module to a second module in the first device, a first indication indicating that the link is unavailable, wherein the first module is used for communicating with the second device, and the second module is used for communicating with the at least one third device.

4. The first device of any of claims 1-3, wherein the processor is further configured to:

transmit, from a first module to a second module in the first device, a cause for unavailability of the link, wherein the first module is used for communicating with the

second device, and the second module is used for communicating with the at least one third device.

5. The first device of claim 4, wherein the cause comprises one of the following:

a radio link failure (RLF) in the link between the first device and the second device;

handover of the first device;

reestablishment of the link;

the first device being in an idle state or an inactive state without small data transmission configuration; or

random access failure of the first device.

6. The first device of claim 3, wherein the processor is configured to suspend the operation procedure after reception of the first indication by the second module or after the first module determines that the link is unavailable for the data transmission.

7. The first device of claim 6, wherein the processor is configured to suspend the operation procedure at the following time point:

when the second module receives the first indication;

at the end of an access occasion in which the first device finishes the operation procedure with one of the at least one third device; or

at the end of an access round comprising a plurality of access occasions, wherein the plurality of access occasions comprises the access occasion.

8. The first device of claim 3, wherein the processor is further configured to continue one of the following, after reception of the first indication by the second module and prior to suspending the operation procedure:

the operation procedure in an access occasion in which the first device performs the operation procedure with one of the at least one third device and the link being unavailable occurs; or

the operation procedure in an access round comprising a plurality of access occasions, wherein the plurality of access occasions comprises the access occasion.

9. The first device of claim 8, wherein the operation procedure is continued in the access occasion, and wherein the processor is further configured to:

transmit, via the transceiver and to the at least one third device, a second indication indicating that the operation procedure in the access occasion ends.

10. The first device of claim 1, wherein the processor is configured to suspend the operation procedure by one of the following:

preventing from transmitting, via the transceiver and to the at least one third device, a subsequent message associated with the operation procedure with one of the at least one third device;

preventing from transmitting, via the transceiver and to the at least one third device, a message for starting a subsequent access occasion in which the first device performs the operation procedure with another one of the at least one third device; or

preventing from transmitting, via the transceiver and to the at least one third device, a message for starting a subsequent access round after an access round in which the link being unavailable occurs.

11. The first device of claim 1, wherein the processor is further configured to:

transmit, via the transceiver and to the at least one third device, a third indication indicating that the operation procedure is suspended.

12. The first device of claim 1, wherein the processor is further configured to:

after suspending the operation procedure and prior to transmitting the data, store the data received from the one or more of the at least one third device.

13. The first device of claim 1, wherein the processor is further configured to start a timer based on one of the following:

determining to suspend the operation procedure;

suspending the operation procedure;

a second module in the first device for communicating with the at least one third device receiving a first indication indicating that the link is unavailable; or

a first module in the first device for communicating with the second device determining that the link is unavailable for the data transmission.

14. The first device of claim 13, wherein the processor is further configured to:

receive, via the transceiver and from the second device, one or more values of the timer.

15. The first device of claim 13, wherein the processor is further configured to stop the timer based on at least one of the following:

a second module in the first device for communicating with the at least one third device receiving a fourth indication indicating that the link is available for the data transmission;

a first module in the first device for communicating with the second device determining that the link is available for the data transmission;

the data being successfully transmitted to the second device during suspending the operation procedure; or

uplink transmission between the first device and the second device being available; and wherein:

the processor is further configured to:

in the event that the timer is stopped, transmit, via the transceiver and to the second device, the data stored during suspending the operation procedure.

16. The first device of any of claims 13, wherein the processor is further configured to:

in the event that the timer is expired, abort the operation procedure.

17. A third device comprising:

a processor; and

a transceiver coupled to the processor,

wherein the processor is configured to:

receive, via the transceiver and from a first device, a third indication indicating that an operation procedure for the third device performed by the first device is suspended; and

stop, based on the third indication, at least one operation associated with the operation procedure.

18. The third device of claim 17, wherein the processor is further configured to:

set the third device into a waiting status.

19. A second device comprising:

a processor; and

a transceiver coupled to the processor,

wherein the processor is configured to:

transmit, via the transceiver and to a first device, one or more values of a timer at the first device, wherein the one or more values are associated with a time length during which an operation procedure performed by the first device is suspended.

20. A processor for wireless communication, comprising:

at least one memory; and

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

determine that a link between the first device and a second device is unavailable for data transmission;

suspend, based on the determination, an operation procedure for at least one third device; and

based on determining that the link becomes available, transmit, to the second device, data associated with one or more of the at least one third device stored during suspending the operation procedure.