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(54) **Title:** RANDOM ACCESS PROCEDURE

1200

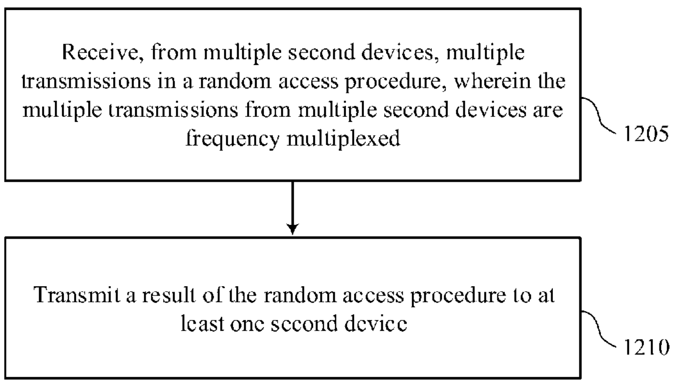

FIG. 12

(57) **Abstract:** Various aspects of the present disclosure relate to a random access procedure. In an aspect, a first device receives multiple transmissions from multiple second devices in a random access procedure, and the multiple transmissions from multiple second devices are frequency multiplexed. The first device then transmits a result of the random access procedure to at least one second device.

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RANDOM ACCESS PROCEDURE

TECHNICAL FIELD

[0001] The present disclosure relates to wireless communications, and more specifically to a random access 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. To increase the efficiency, frequency domain multiplexed (FDMed) resources are introduced to achieve frequency domain multiplexing (FDM) among multiple IoT devices. However, there are still some issues associated with devices in wireless communications systems, for example, ambient IoT devices to be addressed.

SUMMARY

[0004] The present disclosure relates to methods, apparatuses, and systems that support a random access procedure, especially for ambient IoT devices.

[0005] Some implementations of the method and apparatuses described herein include, receiving multiple transmissions in a random access procedure from multiple second devices, and the multiple transmissions from multiple second devices are frequency multiplexed, and transmitting a result of the random access procedure to at least one second device.

[0006] In some implementations of the method and apparatuses described herein, the random access procedure may comprise one of the following: a 2-step random access (RA) procedure comprising a message 1 (Msg1) transmitted by a second device and a message 2 (Msg2) transmitted by the first device, wherein the Msg2 comprises the result of the random access procedure which is corresponding to the success or failure of Msg1 reception at the first device, or a 4-step RA procedure comprising a Msg1 transmitted by a second device and a Msg2 transmitted by the first device, a message 3 (Msg3) transmitted by the second device and a message 4 (Msg4) transmitted by the first device, wherein the Msg4 comprises the result of the random access procedure which is corresponding to the success or failure of Msg3 reception at the first device.

[0007] In some implementations of the method and apparatuses described herein, the result of the random access procedure may comprise one of the following: at least one separate physical reader-to-device channel (PRDCH) transmission carrying at least one Msg2 for the at least one second device, at least one separate PRDCH transmission carrying at least one Msg4 for the at least one second device, one PRDCH transmission carrying a Msg2 for the at least one second device, or one PRDCH transmission carrying a Msg4 for the at least one second device.

[0008] In some implementations of the method and apparatuses described herein, a separate PRDCH transmission among the at least one separate PRDCH transmission carrying at least one Msg2 may comprise an identity (ID) of a second device among the at least one second device for indicating success of a Msg1 transmission from the second device, a random ID transmitted by a second device among the at least one second device for indicating success of a Msg1 transmission from the second device, channel information of a Msg1 transmission from a second device among the at least one second device for indicating success of the Msg1 transmission, frequency information of a Msg1 transmission from a second device among the at least one second device for indicating success of the Msg1 transmission, an acknowledgement (ACK) for indicating success of a Msg1 transmission from a second device among the at least one second device, wherein a resource for transmitting the ACK is associated with a resource of the Msg1 transmission, or any combination of two or more of the above-mentioned items.

[0009] In some implementations of the method and apparatuses described herein, a separate PRDCH transmission among the at least one separate PRDCH transmission carrying at least one Msg4 may comprise a random ID transmitted by a second device among the at least one second device for indicating a failure of a Msg3 transmission from the second device, channel information of a Msg3 transmission from a second device among the at least one second device for indicating a failure of the Msg3 transmission, frequency information of a Msg3 transmission from a second device among the at least one second device for indicating a failure of the Msg3 transmission, a NACK for indicating a failure of a Msg3 transmission from a second device, wherein a resource for transmitting the NACK is associated with a resource of the Msg3 transmission, or any combination of two or more of the above-mentioned items.

[0010] In some implementations of the method and apparatuses described herein, a number of bits of the channel information may be determined based on a number of channels for at least one Msg3 transmission of the at least one second device, or a number of bits of the frequency information may be determined based on a number of channels for at least one Msg3 transmission of the at least one second device.

[0011] In some implementations of the method and apparatuses described herein, the one PRDCH transmission carrying the Msg2 may comprise at least one ID of the at least one second device for indicating success of at least one Msg1 transmission from the at least one second device, at least one random ID transmitted by the at least one second device for indicating success of at least one Msg1 transmission from the at least one second device, at least one element of ACK or negative acknowledgement (NACK) for indicating at least one result of at least one Msg1 transmission from the at least one second device, wherein the at least one element is ordered in at least one frequency for transmitting the at least one Msg1 transmission, or any combination of two or more of the above-mentioned items.

[0012] In some implementations of the method and apparatuses described herein, the one PRDCH transmission carrying the Msg4 may comprise at least one random ID transmitted by the at least one second device for indicating a failure of at least one Msg3 transmission from the at least one second device, at least one element of ACK or NACK for indicating at least one result of at least one Msg3 transmission from the at least one second device, wherein the at least one element is ordered in at least one frequency for transmitting the at least one Msg3 transmission, at least one element of ACK or NACK associated with the at least one random ID for indicating at least one result of at least one Msg3 transmission from the at least one second device, wherein the at least one random ID is transmitted by the first device in Msg2 for indicating success of a Msg1 transmission from at least one second device, or any combination of two or more of the above-mentioned items.

[0013] In some implementations of the method and apparatuses described herein, a payload size of the Msg4 may be determined based on a number of the at least one second device.

[0014] In some implementations of the method and apparatuses described herein, the first device may comprise a reader of an Internet of things (IoT) device, or the second device may comprise an IoT device.

[0015] Some implementations of the method and apparatuses described herein include, transmitting a transmission to a first device in a random access procedure, and the transmission is frequency multiplexed with transmissions from other second devices, and receiving a result of the random access procedure from the first device.

[0016] Some implementations of the method and apparatuses described herein may further include, determining the random access procedure is successful by determining that a separate PRDCH transmission comprises an ID of the second device in the case that the random access procedure is the 2-step RA procedure, determining that a separate PRDCH transmission comprises a random ID transmitted by the second device in the case that the random access procedure is the 2-step RA procedure, determining that a separate PRDCH transmission comprises the channel information of the Msg1 transmission from the second device in the case that the random access procedure is the 2-step RA procedure, determining that a separate PRDCH transmission comprises the frequency information of the Msg1 transmission from the second device in the case that the random access procedure is the 2-step RA procedure, receiving a separate PRDCH transmission on a resource associated with a resource of the Msg1 transmission from the second device in the case that the random access procedure is the 2-step RA procedure, determining that one PRDCH transmission comprises an element for the second device indicating a ACK, or any combination of two or more of the above-mentioned items.

[0017] Some implementations of the method and apparatuses described herein may further include, determining the random access procedure failed by determining that a separate PRDCH transmission comprises a random ID transmitted by the second device in the case that the random access procedure is the 4-step RA procedure, determining that a separate PRDCH transmission comprises channel information of a Msg3 transmission from the second device in the case that the random access procedure is the 4-step RA procedure, determining that a separate PRDCH transmission comprises frequency information of a Msg3 transmission from the second device in the case that the random access procedure is the 4-step RA procedure, receiving a separate PRDCH transmission on a resource associated with a resource of a Msg3 transmission from the second device in the case that the random access procedure is the 4-step RA procedure, determining that one PRDCH transmission comprises an element for the second device indicating a NACK, or any combination of two or more of the above-mentioned items.

[0018] In some implementations of the method and apparatuses described herein, the random access procedure may comprise a 2-step random access (RA) procedure comprising a message 1 (Msg1) transmitted by the second device and a message 2 (Msg2) transmitted by the first device, wherein the Msg2 comprises the result of the random access procedure, or a 4-step RA procedure comprising a Msg1 transmitted by the second device and a Msg2 transmitted by the first device, a message 3 (Msg3) transmitted by the second device and a message 4 (Msg4) transmitted by the first device, wherein the Msg4 comprises the result of the random access procedure.

[0019] In some implementations of the method and apparatuses described herein, the result of the random access procedure may comprise a separate physical reader-to-device channel (PRDCH) transmission carrying a Msg2 for the second device, a separate PRDCH transmission carrying a Msg4 for the second device, one PRDCH transmission carrying a Msg2 for the second device and the other second devices, one PRDCH transmission carrying a Msg4 for the second device and the other second devices, or any combination of two or more of the above-mentioned items.

[0020] In some implementations of the method and apparatuses described herein, the separate PRDCH transmission carrying the Msg2 may comprise an identity (ID) of the second device for indicating success of a Msg1 transmission from the second device, a random ID transmitted by the second device for indicating success of a Msg1 transmission from the second device, channel information of a Msg1 transmission from the second device for indicating success of the Msg1 transmission, frequency information of a Msg1 transmission from the second device for indicating success of the Msg1 transmission, an acknowledgement (ACK)for indicating success of a Msg1 transmission from the second device, wherein a resource for transmitting the ACK is associated with a resource of the Msg1 transmission, or any combination of two or more of the above-mentioned items.

[0021] In some implementations of the method and apparatuses described herein, the separate PRDCH transmission carrying the Msg4 may comprise a random ID transmitted by the second device for indicating a failure of a Msg3 transmission of the second device, channel information of a Msg3 transmission from the second device among the at least one second device for indicating a failure of the Msg3 transmission, frequency information of a Msg3 transmission from the second device for indicating a failure of the Msg3 transmission, a NACK for indicating a failure of a Msg3 transmission from the second device, wherein a resource for transmitting the NACK is associated with a resource of the Msg3 transmission, or any combination of two or more of the above-mentioned items.

[0022] In some implementations of the method and apparatuses described herein, the one PRDCH transmission carrying the Msg2 may comprise IDs of the second device and the other second devices for indicating success of Msg1 transmissions from the second device and the other second devices, random IDs of the second device and the other second devices for indicating success of Msg1 transmissions from the second device and the other second devices, elements of ACK or negative acknowledgement (NACK) for indicating results of Msg1 transmissions from the second device and the other second devices, the elements are ordered in frequencies for transmitting the Msg1 transmissions, or any combination of two or more of the above-mentioned items.

[0023] In some implementations of the method and apparatuses described herein, the one PRDCH transmission carrying the Msg4 may comprise random IDs transmitted by the second device and the other second devices for indicating a failure of Msg3 transmissions of the second device and the other second devices, elements of ACK or NACK for indicating results of Msg3 transmissions from the second device and the other second devices, wherein the elements are ordered in frequencies for transmitting the Msg3 transmissions, elements of ACK or NACK associated with the random IDs for indicating results of Msg3 transmissions from the second device and the other second devices, the random IDs are transmitted by the first device in Msg2 for indicating success of a Msg1 transmission from at least one second device, or any combination of two or more of the above-mentioned items.

[0024] In some implementations of the method and apparatuses described herein, the first device may comprise a reader of an Internet of things (IoT) device, the second device may comprise an IoT device, or a combination of the above-mentioned two items.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] FIG. 1A illustrates an example of a wireless communications system that supports a random access procedure in accordance with aspects of the present disclosure.

[0026] FIG. 1B illustrates an example of 4-step access procedure associated with aspects of the present disclosure.

[0027] FIG. 1C illustrates an example of 2-step access procedure associated with aspects of the present disclosure.

[0028] FIG. 1D illustrates an example of an inventory procedure in a radio frequency identification (RFID) associated with aspects of the present disclosure.

[0029] FIG. 2 illustrates a flowchart of a method that supports a random access procedure in accordance with aspects of the present disclosure.

[0030] FIG. 3 illustrates an example of individual PRDCH transmissions in accordance with aspects of the present disclosure.

[0031] FIG. 4 illustrates an example association between resources for Msg3 transmissions and Msg4 transmissions in accordance with aspects of the present disclosure.

[0032] FIG. 5 illustrates an example of one PRDCH transmission in accordance with aspects of the present disclosure.

[0033] FIG. 6 illustrates an example codebook of a PRDCH transmission in accordance with aspects of the present disclosure.

[0034] FIG. 7 illustrates another example codebook of a PRDCH transmission in accordance with aspects of the present disclosure.

[0035] FIGS. 8-9 illustrate examples of devices that support a random access procedure in accordance with aspects of the present disclosure.

[0036] FIGS. 10-11 illustrate examples of processors that support a random access procedure in accordance with aspects of the present disclosure.

[0037] FIG. 12 illustrates a flowchart of a method that supports a random access procedure in accordance with aspects of the present disclosure.

[0038] FIG. 13 illustrates a flowchart of a method that supports a random access procedure in accordance with aspects of the present disclosure.

[0039] Throughout the drawings, the same or similar reference numerals represent the same or similar elements.

DETAILED DESCRIPTION

[0040] Principles of the present disclosure will now be described with reference to some embodiments. It is to be understood that these embodiments are described only for the purpose of illustration and help those skilled in the art to understand and implement the present disclosure, without suggesting any limitation as to the scope of the disclosure. The disclosure described herein may be implemented in various manners other than the ones described below.

[0041] 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.

[0042] 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.

[0043] It shall be understood that although the terms "first" and "second" or the like may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another element. For example, a first element could also be termed as a second element, and similarly, a second element could also be termed as a first element, without departing from the scope of embodiments. As used herein, the term "and/or" includes any and all combinations of one or more of the listed terms.

[0044] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of example embodiments. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises", "comprising", "has", "having", "includes" and/or "including", when used herein, specify the presence of stated features, elements, and/or components etc., but do not preclude the presence or addition of one or more other features, elements, components and/ or combinations thereof.

[0045] 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.

[0046] 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.

[0047] 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 (loT) 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.

[0048] FIG. 1A illustrates an example of a wireless communications system 100 that supports repetitions for a transmission 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.

[0049] The one or more network entities 102 may be dispersed throughout a geographic region to form the wireless communications system 100. One or more of the network entities 102 described herein may be or include or may be referred to as a network node, a base station, a network element, a radio access network (RAN), a base transceiver station, an access point, a NodeB, an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. A network entity 102 and a UE 104 may communicate via a communication link 110, which may be a wireless or wired connection. For example, a network entity 102 and a UE 104 may perform wireless communication (e.g., receive signaling, transmit signaling) over a Uu interface.

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

[0051] The one or more UEs 104 may be dispersed throughout a geographic region of the wireless communications system 100. A UE 104 may include or may be referred to as a mobile device, a wireless device, a remote device, a remote unit, a handheld device, or a subscriber device, or some other suitable terminology. In some implementations, the UE 104 may be referred to as a unit, a station, a terminal, or a client, among other examples. Additionally, or alternatively, the UE 104 may be referred to as an Internet-of-Things (IoT) device, an Internet-of-Everything (IoE) device, or machine-type communication (MTC) device, among other examples. In some implementations, a UE 104 may be stationary in the wireless communications system 100. In some other implementations, a UE 104 may be mobile in the wireless communications system 100.

[0052] The one or more UEs 104 may be devices in different forms or having different capabilities. Some examples of UEs 104 are illustrated in FIG. 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.

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

[0054] A network entity 102 may support communications with the core network 106, or with another network entity 102, or both. For example, a network entity 102 may interface with the core network 106 through one or more backhaul links 116 (e.g., via an S1, N2, N2, or another network interface). The network entities 102 may communicate with each other over the backhaul links 116 (e.g., via an X2, Xn, or another network interface). In some implementations, the network entities 102 may communicate with each other directly (e.g., between the network entities 102). In some other implementations, the network entities 102 may communicate with each other or indirectly (e.g., via the core network 106). In some implementations, one or more network entities 102 may include subcomponents, such as an access network entity, which may be an example of an access node controller (ANC). An ANC may communicate with the one or more UEs 104 through one or more other access network transmission entities, which may be referred to as a radio heads, smart radio heads, or transmission-reception points (TRPs).

[0055] In some implementations, a network entity 102 may be configured in a disaggregated architecture, which may be configured to utilize a protocol stack physically or logically distributed among two or more network entities 102, such as an integrated access backhaul (IAB) network, an open RAN (O-RAN) (e.g., a network configuration sponsored by the O-RAN Alliance), or a virtualized RAN (vRAN) (e.g., a cloud RAN (C-RAN)). For example, a network entity 102 may include one or more of a central unit (CU), a distributed unit (DU), a radio unit (RU), a RAN Intelligent Controller (RIC) (e.g., a Near-Real Time RIC (Near-RT RIC), a Non-Real Time RIC (Non-RT RIC)), a Service Management and Orchestration (SMO) system, or any combination thereof.

[0056] An RU may also be referred to as a radio head, a smart radio head, a remote radio head (RRH), a remote radio unit (RRU), or a transmission reception point (TRP). One or more components of the network entities 102 in a disaggregated RAN architecture may be co-located, or one or more components of the network entities 102 may be located in distributed locations (e.g., separate physical locations). In some implementations, one or more network entities 102 of a disaggregated RAN architecture may be implemented as virtual units (e.g., a virtual CU (VCU), a virtual DU (VDU), a virtual RU (VRU)).

[0057] Split of functionality between a CU, a DU, and an RU may be flexible and may support different functionalities depending upon which functions (e.g., network layer functions, protocol layer functions, baseband functions, radio frequency functions, and any combinations thereof) are performed at a CU, a DU, or an RU. For example, a functional split of a protocol stack may be employed between a CU and a DU such that the CU may support one or more layers of the protocol stack and the DU may support one or more different layers of the protocol stack. In some implementations, the CU may host upper protocol layer (e.g., a layer 3 (L3), a layer 2 (L2)) functionality and signaling (e.g., Radio Resource Control (RRC), service data 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, medium access control (MAC) layer) functionality and signaling, and may each be at least partially controlled by the CU 160.

[0058] Additionally, or alternatively, a functional split of the protocol stack may be employed between a DU and an RU such that the DU may support one or more layers of the protocol stack and the RU may support one or more different layers of the protocol stack. The DU may support one or multiple different cells (e.g., via one or more RUs). In some implementations, a functional split between a CU and a DU, or between a DU and an RU may be within a protocol layer (e.g., some functions for a protocol layer may be performed by one of a CU, a DU, or an RU, while other functions of the protocol layer are performed by a different one of the CU, the DU, or the RU).

[0059] A CU may be functionally split further into CU control plane (CU-CP) and CU user plane (CU-UP) functions. A CU may be connected to one or more DUs via a midhaul communication link (e.g., F1, F1-c, F1-u), and a DU may be connected to one or more RUs via a fronthaul communication link (e.g., open fronthaul (FH) interface). In some implementations, a midhaul communication link or a fronthaul communication link may be implemented in accordance with an interface (e.g., a channel) between layers of a protocol stack supported by respective network entities 102 that are in communication via such communication links.

[0060] The core network 106 may support user authentication, access authorization, tracking, connectivity, and other access, routing, or mobility functions. The core network 106 may be an evolved packet core (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.

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

[0062] In the wireless communications system 100, the network entities 102 and the UEs 104 may use resources of the wireless communications system 100 (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers)) to perform various operations (e.g., wireless communications). In some implementations, the network entities 102 and the UEs 104 may support different resource structures. For example, the network entities 102 and the UEs 104 may support different frame structures. In some implementations, such as in 4G, the network entities 102 and the UEs 104 may support a single frame structure. In some other implementations, such as in 5G and among other suitable radio access technologies, the network entities 102 and the UEs 104 may support various frame structures (i.e., multiple frame structures). The network entities 102 and the UEs 104 may support various frame structures based on one or more numerologies.

[0063] One or more numerologies may be supported in the wireless communications system 100, and a numerology may include a subcarrier spacing and a cyclic prefix. A first numerology (e.g., 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.

[0064] A time interval of a resource (e.g., a communication resource) may be organized according to frames (also referred to as radio frames). Each frame may have a duration, for example, a 10 millisecond (ms) duration. In some implementations, each frame may include multiple subframes. For example, each frame may include 10 subframes, and each subframe may have a duration, for example, a 1 ms duration. In some implementations, each frame may have the same duration. In some implementations, each subframe of a frame may have the same duration.

[0065] Additionally or alternatively, a time interval of a resource (e.g., a communication resource) may be organized according to slots. For example, a subframe may include a number (e.g., quantity) of slots. The number of slots in each subframe may also depend on the one or more numerologies supported in the wireless communications system 100. For instance, the first, second, third, fourth, and fifth numerologies (i.e., 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.

[0066] In the wireless communications system 100, an electromagnetic (EM) spectrum may be split, based on frequency or wavelength, into various classes, frequency bands, frequency channels, etc. By way of example, the wireless communications system 100 may support one or multiple operating frequency bands, such as frequency range designations FR1 (410 MHz – 7.125 GHz), FR2 (24.25 GHz – 52.6 GHz), FR3 (7.125 GHz – 24.25 GHz), FR4 (52.6 GHz – 114.25 GHz), FR4a or FR4-1 (52.6 GHz – 71 GHz), and FR5 (114.25 GHz – 300 GHz). In some implementations, the network entities 102 and the UEs 104 may perform wireless communications over one or more of the operating frequency bands. In some implementations, FR1 may be used by the network entities 102 and the UEs 104, among other equipment or devices for cellular communications traffic (e.g., control information, data). In some implementations, FR2 may be used by the network entities 102 and the UEs 104, among other equipment or devices for short-range, high data rate capabilities.

[0067] FR1 may be associated with one or multiple numerologies (e.g., at least three numerologies). For example, FR1 may be associated with a first numerology (e.g., 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.

[0068] Study on solutions for Ambient IoT (A-IoT) in NR has been approved, and frame structure, synchronization and timing, random access are studied in RAN1 for A-IoT downlink (DL) and uplink (UL).

[0069] For contention-based random access of A-IoT slotted-ALOHA based access has been studied. FIG. 1B illustrates an example of 4-step access procedure associated with aspects of the present disclosure. As shown in FIG. 1B, the device sends an ID to the reader in Msg1, and the ID is a random ID generated by device (e.g. randomly generated or generated based on device ID). In Msg2, the reader echoes the ID received in Msg1, and further information may be included in Msg2. The device sends device ID and/or any other upper layer data (depending on upper layer request) in Msg3. If the Msg2 including the same random ID in Msg1 is received, the device considers the contention resolution as successful. RAN2 assumes the size of random ID in Msg1 should be sufficient for contention resolution purpose. “Msg4” (i.e. the subsequent reader to device, R2D, transmission after device to reader, D2R, transmission) does not need to be always sent in random access. “Msg4” can be considered to handle the Msg3 transmission failure (due to various reasons).

[0070] FIG. 1C illustrates an example of 2-step access procedure associated with aspects of the present disclosure. As shown in FIG. 1C, the device sends Device ID and/or any other upper layer data (depending on upper layer request) in Msg1. In Msg2, the reader may echo some information from Msg1.

[0071] FIG. 1D illustrates an example of an inventory procedure in a radio frequency identification (RFID) associated with aspects of the present disclosure. As shown in FIG. 1D, the interrogator transmits a query command to the tag (i.e., RFID) and transmits a continuous wave (CW) to energize the tag. The Query command contains the uplink frequency and data encoding, the Q parameter for determining the number of slots for the following frame, and a target parameter. When a tag receives the Query command, it chooses a random number in the range and the value is stored in the slot counter of the tag. If a tag stores a 0 in its slot counter, it will immediately backscatter a 16 bit random number, denoted by RN16. Upon receiving RN16, the interrogator echoes RN16 in an ACK command. If the tag successfully receives RN16, it will backscatter its ID information (PC/XPC+EPC+PacketCRC). Then the interrogator sends a subsequent QueryRep command to the tag, signaling the end of the slot and toggling an inventoried flag in the tag to make it keep silent in the following rounds. If the ID is not successfully received by the reader, a NACK command is sent which resets the tag so as to keep the tag active in the next round. Upon receiving the QueryRep command, the remaining tags will decrement their slot counters, and respond with RN16 if their slot counters are set to 0. When the number of QueryReps is equal to 2^Q, the current QueryRound ends.

[0072] Due to RFID inventory is a kind of contention-based random access and supports pure time division multiplexed (TDMed) resource, one device could access successfully in one inventory slot. For A-IoT device, improving the access efficiency frequency division multiplexed (FDMed) resources has also agreed to be studied. Since only one device could access successfully in one inventory slot, the reader could transmit one “NACK” if the decoding of the device ID is failed. However, if multiple devices could access in one inventory slot because of FDMed resources, it is to be specified how to confirm the result of random-access procedure for one or more devices.

[0073] In view of the above discussions, some embodiments of the present disclosure provide a solution for a random access procedure, especially for A-IoT devices. In one aspect of the solution of the present disclosure, a first device receives multiple transmissions from multiple second devices in a random access procedure, and the multiple transmissions from multiple second devices are frequency multiplexed. The first device then transmits a result of the random access procedure to at least one second device. In this way, the result of the random access procedure is indicated to the at least one second device, and thus the efficiency of the random access is improved. Principles and implementations of embodiments of the present disclosure will be described in detail below with reference to FIGS. 2-13.

[0074] FIG. 2 illustrates a signaling chart illustrating an example process 200 in accordance with aspects of the present disclosure. The process 200 may involve a first device 201 and a second device 202. The process 200 may further involve a second device 203 and a second device 204. It would be appreciated that although the process 200 is applied in the communication environment 100 of FIG. 1A, this process may be likewise applied to other communication scenarios with similar issues.

[0075] The first device may comprise a reader of an IoT device. the second device may comprise an IoT device, e.g., A-IoT device. It is to be understood that the number of the first device 201 or the second device 202 is only for the purpose of illustration without suggesting any limitations. The process 200 may include any suitable number of devices adapted for implementing embodiments of the present disclosure. It would be appreciated that one or more second devices may be comprised in the process 200.

[0076] In the process 200, the second device 202 transmits 210 a transmission 215 to the first device 201 in a random access procedure. The transmission is frequency multiplexed with transmissions from other second devices, e.g., second device 203, second device 204. The second device 203 may transmit 225 a transmission 230 to the first device 201 in the random access procedure. The second device 204 may transmit 240 a transmission 245 to the first device 201 in the random access procedure.

[0077] In some embodiments, the random access procedure may comprise a 2-step RA procedure comprising a Msgl transmitted by a second device and a Msg2 transmitted by the first device. The transmission 215, the transmission 230 and the transmission 245 may be the Msg1. Alternatively, the random access procedure may comprise a 4-step RA procedure comprising a Msgl transmitted by a second device and a Msg2 transmitted by the first device, a Msg3 transmitted by the second device and a Msg4 transmitted by the first device. The transmission 215, the transmission 230 and the transmission 245 may be the Msg3.

[0078] Continuing with reference to FIG. 2, the first device 201 receives multiple transmissions from multiple second devices (e.g., the second device 202, the second device 203, and the second device 204) in a random access procedure, and the multiple transmissions from multiple second devices are frequency multiplexed. The first device 201 receives 220 the transmission 215 from the second device 202. The first device 201 may receive 235 the transmission 230 from the second device 202. The first device 201 may further receive 250 the transmission 245 from the second device 202.

[0079] The first device 201 transmits a result of the random access procedure to at least one second device(e.g., the second device 202 and the second device 203). The first device 201 transmits 255 the result of the random access procedure 260 to the second device 202. Correspondingly, the second device 202 receives 265 the result of the random access procedure 260 from the first device 201. The first device 201 may further transmit 270 the result of the random access procedure 275 to the second device 203. Correspondingly, the second device 203 receives 280 the result of the random access procedure 275 from the first device 201. The result of the random access procedure 260 and the result of the random access procedure 275 may be the same or different.

[0080] In the case of the random access procedure is a 2-step RA procedure, the result of the random access procedure 260 may comprise at least one separate PRDCH transmission carrying at least one Msg2 for the at least one second device, or one PRDCH transmission carrying a Msg2 for the at least one second device.

[0081] In the case of the random access procedure is a 4-step RA procedure, the result of the random access procedure 260 may comprise at least one separate PRDCH transmission carrying at least one Msg4 for the at least one second device, or one PRDCH transmission carrying a Msg4 for the at least one second device.

[0082] That is to say, for the second devices that has successfully sent the Msgl (of 2-step RA procedure) or Msg3(of 4-step RA procedure), the result of the random access procedure 260 may be indicated by separate PRDCH transmissions (may also be referred to as individual PRDCH transmissions) or one PRDCH transmission.

[0083] The Msg3 transmission failure may be handled on the transmission of Msg4. In order to inform the result of random access for one dedicated device, a separate PRDCH transmission carrying Msg4 may target to one second device. FIG. 3 illustrates an example of individual PRDCH transmissions in accordance with aspects of the present disclosure. As shown in FIG. 3, the first device 201 receives the Msg3 310-0, Msg3 310-1 Msg3 310-2, Msg3 310-3,…, Msg3 310-N-1 from multiple second devices successfully. The first device 201 may then transmit the Msg4 320-0, Msg3 320-1, Msg3 320-2, Msg3 320-3,…, Msg3 320-N-1 to multiple second devices by the individual PRDCH transmissions.

[0084] In some embodiments, a separate PRDCH transmission among the at least one separate PRDCH transmission carrying at least one Msg4 may comprise: a random ID transmitted by a second device among the at least one second device for indicating a failure of a Msg3 transmission from the second device; channel information of a Msg3 transmission from a second device among the at least one second device for indicating a failure of the Msg3 transmission; frequency information of a Msg3 transmission from a second device among the at least one second device for indicating a failure of the Msg3 transmission; a NACK for indicating a failure of a Msg3 transmission from a second device, and a resource for transmitting the NACK is associated with a resource of the Msg3 transmission; or any combination of two or more of the above mentioned items.

[0085] In the first example, the separate PRDCH transmission carrying the Msg4 for the second device 202 may include the random ID of the second device 202 which has been transmitted by for the second device 202 in Msgl and only "NACK" is informed. The first device 201 informs the second device 202 whose Msg3 transmission is failed. If the second device 202 receives a PRDCH transmission including the random ID transmitted by it in Msg1, it means that the previous Msg3 transmission is failed.

[0086] In the second example, the separate PRDCH transmission carrying the Msg4 for the second device 202 may include the channel/frequency information of the Msg3 transmission transmitted from the second device 202 and only "NACK" is informed. The first device 201 informs the second device 202 whose Msg3 transmission is failed. If the second device 202 detects Msg4 which includes the channel/frequency on which it has transmitted the Msg3, it means that its previous Msg3 transmission is failed.

[0087] Additionally, a number of bits of the channel information may be determined based on a number of channels for at least one Msg3 transmission of the at least one second device. In addition, a number of bits of the frequency information may be determined based on a number of channels for at least one Msg3 transmission of the at least one second device. For instance, as in RDIF the random ID transmitted by the second device 202 in Msg1 is 16bits. Since the channels/frequencies for Msg3 transmission is limited, the indication of channel/frequency information may require a smaller number of bits than the random ID. For example, total 100 PRBs and each PDRCH transmission occupies 1 PRB, only 7bits is needed even there is no guard band between each PDRCH transmission. In this way, the payload size of Msg4 transmission may be reduced. The indication on channel/frequency in Msg4 is M bits and $M = \lceil \log_2 N_{channels} \rceil$, where $N_{channels}$ is the total number of channels for PDRCH transmission carrying Msg3.

[0088] In the third example, a resource for the separate PRDCH transmission carrying the Msg4 for the second device 202 may be associated to the resource for a PDRCH transmission carrying Msg3. An association between resource for PDRCH transmission carrying Msg3 and resource for PRDCH transmission carrying Msg4 could be built. For example, a PDRCH transmission on frequency F_X is associated to a PRDCH transmission on a certain transmission occasion in time domain, e.g., for Msg3 transmission on frequency F_X the corresponding Msg4 transmission is in time occasion_x . As shown in FIG. 4, PDRCH transmission 410-0 on frequency F_0 is associated to PRDCH transmission 420-0 in time occasion_0, PDRCH transmission 410-1 on frequency F_1 is associated to PRDCH transmission 420-1 in time occasion_1, PDRCH transmission 410-2 on frequency F_2 is associated to PRDCH transmission 420-2 in time occasion_2, and PDRCH transmission 410-N-1 on frequency F_{N-1} is associated to PRDCH transmission

420-N-1 in time occasion_N-1. Since the mapping between resources are fixed or predefined, it is not needed to include any other information in Msg4 (e.g., ID information/channel information). The first device 201 may perform a PRDCH transmission carrying Msg4 on the associated resource if the corresponding Msg3 transmission is failed.

[0089] In the first example and the second example, each second device which has transmitted Msg3 may need to perform reception on each potential time occasion to detect the PRDCH transmission carrying Msg4. However, in the third example, the second device 202 may need to detect the PRDCH transmission carrying Msg4 on the associated resource which could reduce the power consumption for the second device 202 (e.g., A-IoT device).

[0090] In some embodiments, a separate PRDCH transmission among the at least one separate PRDCH transmission carrying at least one Msg2 may comprise an ID of a second device among the at least one second device for indicating success of a Msg1 transmission from the second device. For example, the separate PRDCH transmission carrying the Msg2 for the second device 202 may include the device ID of the second device 202, and the device ID has been successfully received in MSG1 by the first device 201 if only device ID is included in Msg1.

[0091] In some embodiments, a separate PRDCH transmission among the at least one separate PRDCH transmission carrying at least one Msg2 may comprise a random ID transmitted by a second device among the at least one second device for indicating success of a Msg1 transmission from the second device. For example, if both device ID and one additional ID (e.g., random ID) for the second device 202 are included in the Msg1, the Msg2 may include the random ID which has been successfully received in the Msg1 by the first device 201.

[0092] In some embodiments, a separate PRDCH transmission among the at least one separate PRDCH transmission carrying at least one Msg2 may comprise channel information of a Msg1 transmission from a second device among the at least one second device for indicating success of the Msg1 transmission or frequency information of a Msg1 transmission from a second device among the at least one second device for indicating success of the Msg1 transmission. For example, the separate PRDCH transmission carrying the Msg2 for the second device 202 may include the channel/frequency information of the Msg1 transmission is transmitted from the second device 202 and only “ACK” is informed.

[0093] In some embodiments, a separate PRDCH transmission among the at least one separate PRDCH transmission carrying at least one Msg2 may comprise an ACK for indicating success of a Msg1 transmission from a second device among the at least one second device, and a resource for transmitting the ACK is associated with a resource of the Msg1 transmission. For example, a resource for the separate PRDCH transmission carrying the Msg2 for the second device 202 may be associated to the resource for a PDRCH transmission carrying the Msg1, and only “ACK” is informed. If the first device 201 has received the Msg1 on one channel/frequency, it will transmit the Msg2 including “ACK” on the resource associated with the channel/frequency for receiving Msg1.

[0094] In order to inform the result of random access from multiple second devices, one PRDCH transmission carrying Msg4 may target to multiple devices. FIG. 4 illustrates an example of one PRDCH transmission in accordance with aspects of the present disclosure. As shown in FIG. 5, the first device 201 receives the Msg3 510-0, Msg3 510-1, Msg3 510-2, Msg3 510-3,…, Msg3 510-N-1 from multiple second devices successfully. The first device 201 may then transmit the Msg4 520 to multiple second devices by the one PRDCH transmission.

[0095] In some embodiments, the one PRDCH transmission carrying the Msg4 may comprise at least one random ID transmitted by the at least one second device for indicating a failure of at least one Msg3 transmission from the at least one second device. For example, the first device 201 may transmit the random ID(s) transmitted by second device(s) in Msg1 if the reception(s) of Msg3 transmission(s) is failed. The first device 201 only transmits the random IDs whose Msg3 transmission is failed. If one second device (e.g., the second device 202 or the second device 203) detects its random ID transmitted in Msg1 has be included in Msg4, the second device knows that its Msg3 transmission is failed.

[0096] Alternatively or additionally, the one PRDCH transmission carrying the Msg4 may comprise at least one element of ACK or NACK for indicating at least one result of at least one Msg3 transmission from the at least one second device, and the at least one element is ordered in at least one frequency for transmitting the at least one Msg3 transmission. Codebook based “ACK/NACK” may be used to inform the result of random access. For example, the codebook may be based on all channels/frequencies for Msg3 transmission. In order to handle the Msg3 transmission failure, the first device 201 may transmit ACK/NACK to the second devices, the mapping of ACK/NACK may be in the order of channel/frequency. As shown in FIG. 6, for PDRCH transmissions carrying Msg3 (610-0, 610-1, 610-2,..., 610-N-1), there may have N channels/frequencies (F_0, F_1, F_2 ,..., F_{N-1}). PRDCH transmissions carrying Msg4 may include N elements of "ACK/NACK" (620-0, 620-1, 620-2,..., 620-N-1), and each "ACK/NACK" is associated to the previous PDRCH transmission carrying MSG3 on each channel/frequency. For example, element 620-0 is associated with PDRCH transmission 610-0, element 620-1is associated with PDRCH transmission 610-1, element 620-2 is associated with PDRCH transmission 610-2, and element 620-N-1 is associated with PDRCH transmission 610-N-1.

[0097] Additionally, the one PRDCH transmission carrying the Msg4 may comprise at least one element of ACK or NACK associated with the at least one random ID for indicating at least one result of at least one Msg3 transmission from the at least one second device, and the at least one random ID is transmitted by the first device 201 in Msg2 for indicating success of a Msg1 transmission from at least one second device. For example, the codebook may be based on the transmission of Msg2. The first device 201 may transmit a list of random IDs in the Msg2 to trigger the PDRCH transmissions carrying Msg3. The PRDCH transmission carrying Msg4 may include multiple elements of "ACK/NACK" and the multiple elements of "ACK/NACK" may map in the order of random IDs as in Msg2. As shown in FIG. 7, the first device 201 may transmit PRDCH transmission carrying Msg2, and the PRDCH transmission may include a list of random IDs (RN_ID1, RN_ID2, RN_ID3,..., RN_ID_{L-1}) which the first device 201 has successfully received in previous PDRCH transmissions carrying Msg1. After the receptions of PDRCH transmissions carrying Msg3, the first device 201 may transmit a PRDCH transmission carrying Msg4 to inform the results of Msg3 transmissions. A list of "ACK/NACK" may be included in Msg4 and each "ACK/NACK" is associated to a random ID carried by Msg2. For example, element 720-1 is associated with RN_ID1, element 720-2 is associated with RN_ID1, element 720-3 is associated with RN_ID3, and element 720-L-1 is associated with RN_ID_{L-1}. After transmission of Msg3, the second device 202 or the second device 203 may receive Msg4 to check whether its Msg3 transmission is successful or failed. In Msg4, a list of "ACK/NACK" may be included and each "ACK/NACK" is associated to random ID included in Msg2.

[0098] In addition, a payload size of the Msg4 is determined based on a number of the at least one second device. For example, the payload size of Msg4 may be varied and depended on the number of second devices which have successfully transmitted Msg1.

[0099] In some embodiments, the one PRDCH transmission carrying the Msg2 may comprise at least one ID of the at least one second device for indicating success of at least one Msg1 transmission from the at least one second device. For example, if the Msg1 in 2-step RA procedure only includes the device ID of the second device, the first device 201 may transmit the device ID(s) of the second device(s) if the reception of Msg1 transmission(s) from the second device(s) is succeed.

[0100] Alternatively or additionally, the one PRDCH transmission carrying the Msg2 may comprise at least one random ID transmitted by the at least one second device for indicating success of at least one Msg1 transmission from the at least one second device. For example, if both device ID and one additional ID (e.g., random ID) are included in Msg1, the first device 201 may transmit random ID(s) in Msg2 if the reception of Msg1 transmission from the second device(s) is succeed.

[0101] Additionally, the one PRDCH transmission carrying the Msg2 may comprise at least one element of ACK or NACK for indicating at least one result of at least one Msg1 transmission from the at least one second device, and the at least one element is ordered in at least one frequency for transmitting the at least one Msg1 transmission. For example, the codebook may be based on all channels/frequencies for Msg1 transmission. In order to handle the Msg1 transmission failure, the first device 201 may transmit ACK/NACK to the second devices, the mapping of ACK/NACK may be in the order of channel/frequency.

[0102] Based on the result of the random access procedure, the second device 202 may determine whether the random access procedure is successful or failed. In some embodiments, if the random access procedure is the 2-step RA procedure, and a separate PRDCH transmission comprises an ID of the second device, the second device 202 may determine the random access procedure is successful. Alternatively or additionally, if the random access procedure is the 2-step RA procedure, and a separate PRDCH transmission comprises a random ID transmitted by the second device, the second device 202 may determine the random access procedure is successful. Additionally, if the random access procedure is the 2-step RA procedure, and a separate PRDCH transmission comprises the channel information of the Msg1 transmission from the second device, the second device 202 may determine the random access procedure is successful. In addition, if the random access procedure is the 2-step RA procedure, and a separate PRDCH transmission comprises the frequency information of the Msg1 transmission from the second device, the second device 202 may determine the random access procedure is successful.

[0103] In addition, if the random access procedure is the 2-step RA procedure, and the second device 202 receives a separate PRDCH transmission on a resource associated with a resource of the Msg1 transmission from the second device, the second device 202 may determine the random access procedure is successful. In some embodiments, if one PRDCH transmission comprises an element for the second device indicating an ACK, the second device 202 may determine the random access procedure is successful.

[0104] For failure, if the random access procedure is the 4-step RA procedure, and a separate PRDCH transmission comprises a random ID transmitted by the second device 202, the second device 202 may determine the random access procedure failed. In some embodiments, if the random access procedure is the 4-step RA procedure, and a separate PRDCH transmission comprises channel information of a Msg3 transmission from the second device 202, the second device 202 may determine the random access procedure failed. Alternatively or additionally, if the random access procedure is the 4-step RA procedure, and a separate PRDCH transmission comprises frequency information of a Msg3 transmission from the second device 202, the second device 202 may determine the random access procedure failed. Additionally, if the random access procedure is the 4-step RA procedure, and the second device 202 receives a separate PRDCH transmission on a resource associated with a resource of a Msg3 transmission from the second device 202, the second device 202 may determine the random access procedure failed. In addition, if one PRDCH transmission comprises an element for the second device indicating a NACK, the second device 202 may determine the random access procedure failed.

[0105] In general, in order to address issue of the confirmation of random access for 2-step and 4-step RA for A-IoT, individual Msg2/Msg4 carrying confirmation for each second device and one Msg2/Msg4 carrying confirmations for multiple devices are proposed. For the individual Msg2/Msg4 carrying confirmation for each second device, each Msg2 may carry the device ID or random ID to inform "ACK" and each Msg4 may carry the random ID to inform "NACK". The channel/frequency information may be included in Msg2 to inform "ACK" for the Msg transmission on the channel/frequency. The channel/frequency information may be included in Msg4 to inform "NACK" for the Msg1 transmission on the channel/frequency. Resource mapping between Msg2/Msg4 and Msg1/Msg3 are built to inform result of random access.

[0106] For the one Msg2/Msg4 carrying confirmations for multiple devices, a list of random ID(s) may be included in Msg4 to inform "NACK", a list of device ID(s) may be included in Msg2 to inform "ACK", and a list of random ID(s) may be included in Msg2 to inform "ACK". Codebook based on channels/frequencies in Msg2/Msg4 may be used to inform "ACK/NACK". Codebook based on MSG2 may be used to inform "ACK/NACK".

[0107] FIG. 8 illustrates an example of a device 800 that supports a random access procedure in accordance with aspects of the present disclosure. The device 800 may be an example of a network entity 102 or a UE 104 as described herein. The device 800 may support wireless communication with one or more network entities 102, UEs 104, or any combination thereof. The device 800 may include components for bi-directional communications including components for transmitting and receiving communications, such as a processor 802, a memory 804, a transceiver 806, and, optionally, an I/O controller 808. 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).

[0108] The processor 802, the memory 804, the transceiver 806, 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 802, the memory 804, the transceiver 806, or various combinations or components thereof may support a method for performing one or more of the operations described herein.

[0109] In some implementations, the processor 802, the memory 804, the transceiver 806, 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 802 and the memory 804 coupled with the processor 802 may be configured to perform one or more of the functions described herein (e.g., executing, by the processor 802, instructions stored in the memory 804).

[0110] For example, the processor 802 may support wireless communication at the device 800 in accordance with examples as disclosed herein. The processor 802 may be configured to operable to support a means for receiving, via the transceiver from multiple second devices, multiple transmissions in a random access procedure, wherein the multiple transmissions from multiple second devices are frequency multiplexed, and means for transmitting a result of the random access procedure to at least one second device. The processor 802 may be configured to operable to support other means for other implementations of method 1200.

[0111] The processor 802 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 802 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 802. The processor 802 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 804) to cause the device 800 to perform various functions of the present disclosure.

[0112] The memory 804 may include random access memory (RAM) and read-only memory (ROM). The memory 804 may store computer-readable, computer-executable code including instructions that, when executed by the processor 802 cause the device 800 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 802 but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some implementations, the memory 804 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.

[0113] The I/O controller 808 may manage input and output signals for the device 800. The I/O controller 808 may also manage peripherals not integrated into the device M02. In some implementations, the I/O controller 808 may represent a physical connection or port to an external peripheral. In some implementations, the I/O controller 808 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 808 may be implemented as part of a processor, such as the processor 806. In some implementations, a user may interact with the device 800 via the I/O controller 808 or via hardware components controlled by the I/O controller 808.

[0114] In some implementations, the device 800 may include a single antenna 810. However, in some other implementations, the device 800 may have more than one antenna 810 (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 806 may communicate bi-directionally, via the one or more antennas 810, wired, or wireless links as described herein. For example, the transceiver 806 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 806 may also include a modem to modulate the packets, to provide the modulated packets to one or more antennas 810 for transmission, and to demodulate packets received from the one or more antennas 810. The transceiver 806 may include one or more transmit chains, one or more receive chains, or a combination thereof.

[0115] 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 810 for transmitting the amplified signal into the air or wireless medium.

[0116] 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 810 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.

[0117] FIG. 9 illustrates an example of a device 900 that supports a random access procedure in accordance with aspects of the present disclosure. The device 900 may be an example of a UE 104 as described herein. The device 900 may support wireless communication with one or more network entities 102, UEs 104, or any combination thereof. The device 900 may include components for bi-directional communications including components for transmitting and receiving communications, such as a processor 902, a memory 904, a transceiver 906, and, optionally, an I/O controller 908. 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).

[0118] The processor 902, the memory 904, the transceiver 906, 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 902, the memory 904, the transceiver 906, or various combinations or components thereof may support a method for performing one or more of the operations described herein.

[0119] In some implementations, the processor 902, the memory 904, the transceiver 906, 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 902 and the memory 904 coupled with the processor 902 may be configured to perform one or more of the functions described herein (e.g., executing, by the processor 902, instructions stored in the memory 904).

[0120] For example, the processor 902 may support wireless communication at the device 900 in accordance with examples as disclosed herein. The processor 902 may be configured to operable to support a means for transmitting, via the transceiver to a first device, a transmission in a random access procedure, wherein the transmission is frequency multiplexed with transmissions from other second devices, and means for receiving, via the transceiver from the first device, a result of the random access procedure.. The processor 902 may be configured to operable to support other means for other implementations of method 1300.

[0121] The processor 902 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 902 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 902. The processor 902 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 904) to cause the device 900 to perform various functions of the present disclosure.

[0122] The memory 904 may include random access memory (RAM) and read-only memory (ROM). The memory 904 may store computer-readable, computer-executable code including instructions that, when executed by the processor 902 cause the device 900 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. In some implementations, the code may not be directly executable by the processor 902 but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some implementations, the memory 904 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.

[0123] The I/O controller 908 may manage input and output signals for the device 900. The I/O controller 908 may also manage peripherals not integrated into the device M02. In some implementations, the I/O controller 908 may represent a physical connection or port to an external peripheral. In some implementations, the I/O controller 908 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 908 may be implemented as part of a processor, such as the processor 906. In some implementations, a user may interact with the device 900 via the I/O controller 908 or via hardware components controlled by the I/O controller 908.

[0124] In some implementations, the device 900 may include a single antenna 910. However, in some other implementations, the device 900 may have more than one antenna 910 (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 906 may communicate bi-directionally, via the one or more antennas 910, wired, or wireless links as described herein. For example, the transceiver 906 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 906 may also include a modem to modulate the packets, to provide the modulated packets to one or more antennas 910 for transmission, and to demodulate packets received from the one or more antennas 910. The transceiver 906 may include one or more transmit chains, one or more receive chains, or a combination thereof.

[0125] 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 910 for transmitting the amplified signal into the air or wireless medium.

[0126] 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 910 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.

[0127] FIG. 10 illustrates an example of a processor 1000 that supports a random access procedure in accordance with aspects of the present disclosure. The processor 1000 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 1000 may include a controller 1002 configured to perform various operations in accordance with examples as described herein. The processor 1000 may optionally include at least one memory 1004. Additionally, or alternatively, the processor 1000 may optionally include one or more arithmetic-logic units (ALUs) 1000. 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).

[0128] The processor 1000 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 1000) 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).

[0129] The controller 1002 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 1000 to cause the processor 1000 to support various operations in accordance with examples as described herein. For example, the controller 1002 may operate as a control unit of the processor 1000, generating control signals that manage the operation of various components of the processor 1000. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[0130] The controller 1002 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 1004 and determine subsequent instruction(s) to be executed to cause the processor 1000 to support various operations in accordance with examples as described herein. The controller 1002 may be configured to track memory address of instructions associated with the memory 1004. The controller 1002 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 1002 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 1000 to cause the processor 1000 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 1002 may be configured to manage flow of data within the processor 1000. The controller 1002 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 1000.

[0131] The memory 1004 may include one or more caches (e.g., memory local to or included in the processor 1000 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementation, the memory 1004 may reside within or on a processor chipset (e.g., local to the processor 1000). In some other implementations, the memory 1004 may reside external to the processor chipset (e.g., remote to the processor 1000).

[0132] The memory 1004 may store computer-readable, computer-executable code including instructions that, when executed by the processor 1000, cause the processor 1000 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 1002 and/or the processor 1000 may be configured to execute computer-readable instructions stored in the memory 1004 to cause the processor 1000 to perform various functions (e.g., functions or tasks supporting transmit power prioritization). For example, the processor 1000 and/or the controller 1002 may be coupled with or to the memory 1004, the processor 1000, the controller 1002, and the memory 1004 may be configured to perform various functions described herein. In some examples, the processor 1000 may include multiple processors and the memory 1004 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.

[0133] The one or more ALUs 1000 may be configured to support various operations in accordance with examples as described herein. In some implementation, the one or more ALUs 1000 may reside within or on a processor chipset (e.g., the processor 1000). In some other implementations, the one or more ALUs 1000 may reside external to the processor chipset (e.g., the processor 1000). One or more ALUs 1000 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 1000 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 1000 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 1000 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 1000 to handle conditional operations, comparisons, and bitwise operations.

[0134] The processor 1000 may support wireless communication in accordance with examples as disclosed herein. The processor 1002 may be configured to or operable to support a means for receiving, from multiple second devices, multiple transmissions in a random access procedure, wherein the multiple transmissions from multiple second devices are frequency multiplexed, and means for transmitting a result of the random access procedure to at least one second device. The processor 1000 may be configured to or operable to support other means for other implementations of method 1200.

[0135] FIG. 11 illustrates an example of a processor 1100 that supports a random access procedure in accordance with aspects of the present disclosure. The processor 1100 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 1100 may include a controller 1102 configured to perform various operations in accordance with examples as described herein. The processor 1100 may optionally include at least one memory 1104. Additionally, or alternatively, the processor 1100 may optionally include one or more arithmetic-logic units (ALUs) 1100. 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).

[0136] The processor 1100 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 1100) 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).

[0137] The controller 1102 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 1100 to cause the processor 1100 to support various operations in accordance with examples as described herein. For example, the controller 1102 may operate as a control unit of the processor 1100, generating control signals that manage the operation of various components of the processor 1100. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[0138] The controller 1102 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 1104 and determine subsequent instruction(s) to be executed to cause the processor 1100 to support various operations in accordance with examples as described herein. The controller 1102 may be configured to track memory address of instructions associated with the memory 1104. The controller 1102 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 1102 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 1100 to cause the processor 1100 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 1102 may be configured to manage flow of data within the processor 1100. The controller 1102 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 1100.

[0139] The memory 1104 may include one or more caches (e.g., memory local to or included in the processor 1100 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementation, the memory 1104 may reside within or on a processor chipset (e.g., local to the processor 1100). In some other implementations, the memory 1104 may reside external to the processor chipset (e.g., remote to the processor 1100).

[0140] The memory 1104 may store computer-readable, computer-executable code including instructions that, when executed by the processor 1100, cause the processor 1100 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 1102 and/or the processor 1100 may be configured to execute computer-readable instructions stored in the memory 1104 to cause the processor 1100 to perform various functions (e.g., functions or tasks supporting transmit power prioritization). For example, the processor 1100 and/or the controller 1102 may be coupled with or to the memory 1104, the processor 1100, the controller 1102, and the memory 1104 may be configured to perform various functions described herein. In some examples, the processor 1100 may include multiple processors and the memory 1104 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.

[0141] The one or more ALUs 1100 may be configured to support various operations in accordance with examples as described herein. In some implementation, the one or more ALUs 1100 may reside within or on a processor chipset (e.g., the processor 1100). In some other implementations, the one or more ALUs 1100 may reside external to the processor chipset (e.g., the processor 1100). One or more ALUs 1100 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 1100 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 1100 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 1100 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 1100 to handle conditional operations, comparisons, and bitwise operations.

[0142] The processor 1100 may support wireless communication in accordance with examples as disclosed herein. The processor 1102 may be configured to or operable to support a means for transmitting, to a first device, a transmission in a random access procedure, wherein the transmission is frequency multiplexed with transmissions from other second devices, and means for receiving, from the first device, a result of the random access procedure. The processor 1100 may be configured to or operable to support other means for other implementations of method 1300.

[0143] FIG. 12 illustrates a flowchart of a method 1200 that supports a random access procedure in accordance with aspects of the present disclosure. The operations of the method 1200 may be implemented by a device or its components as described herein. For example, the operations of the method 1200 may be performed by a network entity 102 or a UE 104 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.

[0144] At 1205, the method may include receiving, from multiple second devices, multiple transmissions in a random access procedure, wherein the multiple transmissions from multiple second devices are frequency multiplexed. The operations of 1205 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1205 may be performed by a device as described with reference to FIG. 1A.

[0145] At 1210, the method may include transmitting a result of the random access procedure to at least one second device. The operations of 1210 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1210 may be performed by a device as described with reference to FIG. 1A.

[0146] In some embodiments, the random access procedure may comprise one of the following: a 2-step random access (RA) procedure comprising a message 1 (Msg1) transmitted by a second device and a message 2 (Msg2) transmitted by the first device, wherein the Msg2 comprises the result of the random access procedure, or a 4-step RA procedure comprising a Msg1 transmitted by a second device and a Msg2 transmitted by the first device, a message 3 (Msg3) transmitted by the second device and a message 4 (Msg4) transmitted by the first device, wherein the Msg4 comprises the result of the random access procedure.

[0147] In some embodiments, the result of the random access procedure may comprise one of the following: at least one separate physical reader-to-device channel (PRDCH) transmission carrying at least one Msg2 for the at least one second device, at least one separate PRDCH transmission carrying at least one Msg4 for the at least one second device, one PRDCH transmission carrying a Msg2 for the at least one second device, or one PRDCH transmission carrying a Msg4 for the at least one second device.

[0148] In some embodiments, a separate PRDCH transmission among the at least one separate PRDCH transmission carrying at least one Msg2 may comprise an identity (ID) of a second device among the at least one second device for indicating success of a Msg1 transmission from the second device, a random ID transmitted by a second device among the at least one second device for indicating success of a Msg1 transmission from the second device, channel information of a Msg1 transmission from a second device among the at least one second device for indicating success of the Msg1 transmission, frequency information of a Msg1 transmission from a second device among the at least one second device for indicating success of the Msg1 transmission, an acknowledgement (ACK) for indicating success of a Msg1 transmission from a second device among the at least one second device, wherein a resource for transmitting the ACK is associated with a resource of the Msg1 transmission, or any combination of two or more of the above-mentioned items.

[0149] In some embodiments, a separate PRDCH transmission among the at least one separate PRDCH transmission carrying at least one Msg4 may comprise a random ID transmitted by a second device among the at least one second device for indicating a failure of a Msg3 transmission from the second device, channel information of a Msg3 transmission from a second device among the at least one second device for indicating a failure of the Msg3 transmission, frequency information of a Msg3 transmission from a second device among the at least one second device for indicating a failure of the Msg3 transmission, a NACK for indicating a failure of a Msg3 transmission from a second device, wherein a resource for transmitting the NACK is associated with a resource of the Msg3 transmission, or any combination of two or more of the above-mentioned items.

[0150] In some embodiments, a number of bits of the channel information may be determined based on a number of channels for at least one Msg3 transmission of the at least one second device, or a number of bits of the frequency information may be determined based on a number of channels for at least one Msg3 transmission of the at least one second device.

[0151] In some embodiments, the one PRDCH transmission carrying the Msg2 may comprise at least one ID of the at least one second device for indicating success of at least one Msg1 transmission from the at least one second device, at least one random ID transmitted by the at least one second device for indicating success of at least one Msg1 transmission from the at least one second device, at least one element of ACK or negative acknowledgement (NACK) for indicating at least one result of at least one Msg1 transmission from the at least one second device, wherein the at least one element is ordered in at least one frequency for transmitting the at least one Msg1 transmission, or any combination of two or more of the above-mentioned items.

[0152] In some embodiments, the one PRDCH transmission carrying the Msg4 may comprises at least one random ID transmitted by the at least one second device for indicating a failure of at least one Msg3 transmission from the at least one second device, at least one element of ACK or NACK for indicating at least one result of at least one Msg3 transmission from the at least one second device, wherein the at least one element is ordered in at least one frequency for transmitting the at least one Msg3 transmission, at least one element of ACK or NACK associated with the at least one random ID for indicating at least one result of at least one Msg3 transmission from the at least one second device, wherein the at least one random ID is transmitted by the first device in Msg2 for indicating success of a Msg1 transmission from at least one second device, or any combination of two or more of the above-mentioned items.

[0153] In some embodiments, a payload size of the Msg4 may be determined based on a number of the at least one second device. In some embodiments, the first device may comprise a reader of an Internet of things (IoT) device, or the second device may comprise an IoT device.

[0154] FIG. 13 illustrates a flowchart of a method 1300 that supports a random access procedure in accordance with aspects of the present disclosure. The operations of the method 1300 may be implemented by a device or its components as described herein. For example, the operations of the method 1300 may be performed by a UE 104 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.

[0155] At 1305, the method may include transmitting, to a first device, a transmission in a random access procedure, wherein the transmission is frequency multiplexed with transmissions from other second devices. The operations of 1305 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1305 may be performed by a device as described with reference to FIG. 1A.

[0156] At 1310, the method may include receiving, from the first device, a result of the random access procedure. The operations of 1310 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1310 may be performed by a device as described with reference to FIG. 1A.

[0157] In some embodiments, the random access procedure may comprise a 2-step random access (RA) procedure comprising a message 1 (Msg1) transmitted by the second device and a message 2 (Msg2) transmitted by the first device, wherein the Msg2 comprises the result of the random access procedure, or a 4-step RA procedure comprising a Msg1 transmitted by the second device and a Msg2 transmitted by the first device, a message 3 (Msg3) transmitted by the second device and a message 4 (Msg4) transmitted by the first device, wherein the Msg4 comprises the result of the random access procedure.

[0158] In some embodiments, the result of the random access procedure may comprise a separate physical reader-to-device channel (PRDCH) transmission carrying a Msg2 for the second device, a separate PRDCH transmission carrying a Msg4 for the second device, one PRDCH transmission carrying a Msg2 for the second device and the other second devices, one PRDCH transmission carrying a Msg4 for the second device and the other second devices, or any combination of two or more of the above-mentioned items.

[0159] In some embodiments, the separate PRDCH transmission carrying the Msg2 may comprise an identity (ID) of the second device for indicating success of a Msg1 transmission from the second device, a random ID transmitted by the second device for indicating success of a Msg1 transmission from the second device, channel information of a Msg1 transmission from the second device for indicating success of the Msg1 transmission, frequency information of a Msg1 transmission from the second device for indicating success of the Msg1 transmission, an acknowledgement (ACK)for indicating success of a Msg1 transmission from the second device, wherein a resource for transmitting the ACK is associated with a resource of the Msg1 transmission, or any combination of two or more of the above-mentioned items.

[0160] In some embodiments, the separate PRDCH transmission carrying the Msg4 may comprise a random ID transmitted by the second device for indicating a failure of a Msg3 transmission of the second device, channel information of a Msg3 transmission from the second device among the at least one second device for indicating a failure of the Msg3 transmission, frequency information of a Msg3 transmission from the second device for indicating a failure of the Msg3 transmission, a NACK for indicating a failure of a Msg3 transmission from the second device, wherein a resource for transmitting the NACK is associated with a resource of the Msg3 transmission, or any combination of two or more of the above-mentioned items.

[0161] In some embodiments, the one PRDCH transmission carrying the Msg2 may comprise IDs of the second device and the other second devices for indicating success of Msg1 transmissions from the second device and the other second devices, random IDs of the second device and the other second devices for indicating success of Msg1 transmissions from the second device and the other second devices, elements of ACK or negative acknowledgement (NACK) for indicating results of Msg1 transmissions from the second device and the other second devices, the elements are ordered in frequencies for transmitting the Msg1 transmissions, or any combination of two or more of the above-mentioned items.

[0162] In some embodiments, the one PRDCH transmission carrying the Msg4 may comprise random IDs transmitted by the second device and the other second devices for indicating a failure of Msg3 transmissions of the second device and the other second devices, elements of ACK or NACK for indicating results of Msg3 transmissions from the second device and the other second devices, wherein the elements are ordered in frequencies for transmitting the Msg3 transmissions, elements of ACK or NACK associated with the random IDs for indicating results of Msg3 transmissions from the second device and the other second devices, the random IDs are transmitted by the first device in Msg2 for indicating success of a Msg1 transmission from at least one second device, or any combination of two or more of the above-mentioned items.

[0163] In some embodiments, the method may further include determining the random access procedure is successful by determining that a separate PRDCH transmission comprises an ID of the second device in the case that the random access procedure is the 2-step RA procedure, determining that a separate PRDCH transmission comprises a random ID transmitted by the second device in the case that the random access procedure is the 2-step RA procedure, determining that a separate PRDCH transmission comprises the channel information of the Msg1 transmission from the second device in the case that the random access procedure is the 2-step RA procedure, determining that a separate PRDCH transmission comprises the frequency information of the Msg1 transmission from the second device in the case that the random access procedure is the 2-step RA procedure, receiving a separate PRDCH transmission on a resource associated with a resource of the Msg1 transmission from the second device in the case that the random access procedure is the 2-step RA procedure, determining that one PRDCH transmission comprises an element for the second device indicating a ACK, or any combination of two or more of the above-mentioned items.

[0164] In some embodiments, the method may further include determining the random access procedure failed by determining that a separate PRDCH transmission comprises a random ID transmitted by the second device in the case that the random access procedure is the 4-step RA procedure, determining that a separate PRDCH transmission comprises channel information of a Msg3 transmission from the second device in the case that the random access procedure is the 4-step RA procedure, determining that a separate PRDCH transmission comprises frequency information of a Msg3 transmission from the second device in the case that the random access procedure is the 4-step RA procedure, receiving a separate PRDCH transmission on a resource associated with a resource of a Msg3 transmission from the second device in the case that the random access procedure is the 4-step RA procedure, determining that one PRDCH transmission comprises an element for the second device indicating a NACK, or any combination of two or more of the above-mentioned items.

[0165] In some embodiments, the first device may comprise a reader of an Internet of things (IoT) device, the second device may comprise an IoT device, or a combination of the above-mentioned two items.

[0166] It should be noted that the methods described herein describes possible implementations, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible. Further, aspects from two or more of the methods may be combined.

[0167] The various illustrative blocks and components described in connection with the disclosure herein may be implemented or performed with a general-purpose processor, a DSP, an ASIC, a CPU, an FPGA or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but in the alternative, the processor may be any processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices (e.g., a combination of a DSP and a microprocessor, multiple microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

[0168] The functions described herein may be implemented in hardware, software executed by a processor, firmware, or any combination thereof. If implemented in software executed by a processor, the functions may be stored on or transmitted over as one or more instructions or code on a computer-readable medium. Other examples and implementations are within the scope of the disclosure and appended claims. For example, due to the nature of software, functions described herein may be implemented using software executed by a processor, hardware, firmware, hardwiring, or combinations of any of these. Features implementing functions may also be physically located at various positions, including being distributed such that portions of functions are implemented at different physical locations.

[0169] Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage medium may be any available medium that may be accessed by a general-purpose or special-purpose computer. By way of example, non-transitory computer-readable media may include RAM, ROM, electrically erasable programmable ROM (EEPROM), flash memory, compact disk (CD) ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other non-transitory medium that may be used to carry or store desired program code means in the form of instructions or data structures and that may be accessed by a general-purpose or special-purpose computer, or a general-purpose or special-purpose processor.

[0170] As used herein, including in the claims, an article "a" before an element is unrestricted and understood to refer to "at least one" of those elements or "one or more" of those elements. The terms "a," "at least one," "one or more," and "at least one of one or more" may be interchangeable. As used herein, including in the claims, "or" as used in a list of items (e.g., a list of items prefaced by a phrase such as "at least one of" or "one or more of" or "one or both of") indicates an inclusive list such that, for example, a list of at least one of A, B, or C means A or B or C or AB or AC or BC or ABC (i.e., A and B and C). Also, as used herein, the phrase "based on" shall not be construed as a reference to a closed set of conditions. For example, an example step that is described as "based on condition A" may be based on both a condition A and a condition B without departing from the scope of the present disclosure. In other words, as used herein, the phrase "based on" shall be construed in the same manner as the phrase "based at least in part on. Further, as used herein, including in the claims, a "set" may include one or more elements.

[0171] The description herein is provided to enable a person having ordinary skill in the art to make or use the disclosure. Various modifications to the disclosure will be apparent to a person having ordinary skill in the art, and the generic principles defined herein may be applied to other variations without departing from the scope of the disclosure. Thus, the disclosure is not limited to the examples and designs described herein but is to be accorded the broadest scope consistent with the principles and novel features disclosed herein.

CLAIMS

What is claimed is:

1. A first device, comprising

a processor; and

a transceiver coupled to the processor,

wherein the processor is configured to:

receive, via the transceiver from multiple second devices, multiple transmissions in a random access procedure, wherein the multiple transmissions from multiple second devices are frequency multiplexed; and

transmit a result of the random access procedure to at least one second device.

2. The first device of claim 1, wherein the random access procedure comprises one of the following:

a 2-step random access (RA) procedure comprising a message 1 (Msg1) transmitted by a second device and a message 2 (Msg2) transmitted by the first device, wherein the Msg2 comprises the result of the random access procedure; or

a 4-step RA procedure comprising a Msg1 transmitted by a second device and a Msg2 transmitted by the first device, a message 3 (Msg3) transmitted by the second device and a message 4 (Msg4) transmitted by the first device, wherein the Msg4 comprises the result of the random access procedure.

3. The first device of claim 1, wherein the result of the random access procedure comprises one of the following:

at least one separate physical reader-to-device channel (PRDCH) transmission carrying at least one Msg2 for the at least one second device;

at least one separate PRDCH transmission carrying at least one Msg4 for the at least one second device;

one PRDCH transmission carrying a Msg2 for the at least one second device; or

one PRDCH transmission carrying a Msg4 for the at least one second device.

4. The first device of claim 3, wherein a separate PRDCH transmission among the at least one separate PRDCH transmission carrying at least one Msg2 comprises at least one of the following:

an identity (ID) of a second device among the at least one second device for indicating success of a Msg1 transmission from the second device;

a random ID transmitted by a second device among the at least one second device for indicating success of a Msg1 transmission from the second device;

channel information of a Msg1 transmission from a second device among the at least one second device for indicating success of the Msg1 transmission;

frequency information of a Msg1 transmission from a second device among the at least one second device for indicating success of the Msg1 transmission; or

an acknowledgement (ACK) for indicating success of a Msg1 transmission from a second device among the at least one second device, wherein a resource for transmitting the ACK is associated with a resource of the Msg1 transmission.

5. The first device of claim 3, wherein a separate PRDCH transmission among the at least one separate PRDCH transmission carrying at least one Msg4 comprises at least one of the following:

a random ID transmitted by a second device among the at least one second device for indicating a failure of a Msg3 transmission from the second device;

channel information of a Msg3 transmission from a second device among the at least one second device for indicating a failure of the Msg3 transmission;

frequency information of a Msg3 transmission from a second device among the at least one second device for indicating a failure of the Msg3 transmission; or

a NACK for indicating a failure of a Msg3 transmission from a second device, wherein a resource for transmitting the NACK is associated with a resource of the Msg3 transmission.

6. The first device of claim 5, wherein at least one of the following:

a number of bits of the channel information is determined based on a number of channels for at least one Msg3 transmission of the at least one second device; or

a number of bits of the frequency information is determined based on a number of channels for at least one Msg3 transmission of the at least one second device.

7. The first device of claim 3, wherein the one PRDCH transmission carrying the Msg2 comprises at least one of the following:

at least one ID of the at least one second device for indicating success of at least one Msg1 transmission from the at least one second device;

at least one random ID transmitted by the at least one second device for indicating success of at least one Msg1 transmission from the at least one second device; or

at least one element of ACK or negative acknowledgement (NACK) for indicating at least one result of at least one Msg1 transmission from the at least one second device, wherein the at least one element is ordered in at least one frequency for transmitting the at least one Msg1 transmission.

8. The first device of claim 3, wherein the one PRDCH transmission carrying the Msg4 comprises at least one of the following:

at least one random ID transmitted by the at least one second device for indicating a failure of at least one Msg3 transmission from the at least one second device;

at least one element of ACK or NACK for indicating at least one result of at least one Msg3 transmission from the at least one second device, wherein the at least one element is ordered in at least one frequency for transmitting the at least one Msg3 transmission; or

at least one element of ACK or NACK associated with the at least one random ID for indicating at least one result of at least one Msg3 transmission from the at least one second device, wherein the at least one random ID is transmitted by the first device in Msg2 for indicating success of a Msg1 transmission from at least one second device.

9. A second device, comprising

a processor; and

a transceiver coupled to the processor,

wherein the processor is configured to:

transmit, via the transceiver to a first device, a transmission in a random access procedure, wherein the transmission is frequency multiplexed with transmissions from other second devices; and receive, via the transceiver from the first device, a result of the random access procedure.

10. The second device of claim 9, wherein the random access procedure comprises one of the following:

a 2-step random access (RA) procedure comprising a message 1 (Msg1) transmitted by the second device and a message 2 (Msg2) transmitted by the first device, wherein the Msg2 comprises the result of the random access procedure; or

a 4-step RA procedure comprising a Msg1 transmitted by the second device and a Msg2 transmitted by the first device, a message 3 (Msg3) transmitted by the second device and a message 4 (Msg4) transmitted by the first device, wherein the Msg4 comprises the result of the random access procedure.

11. The second device of claim 9, wherein the result of the random access procedure comprises one of the following:

a separate physical reader-to-device channel (PRDCH) transmission carrying a Msg2 for the second device;

a separate PRDCH transmission carrying a Msg4 for the second device;

one PRDCH transmission carrying a Msg2 for the second device and the other second devices; or

one PRDCH transmission carrying a Msg4 for the second device and the other second devices.

12. The second device of claim 11, wherein the separate PRDCH transmission carrying the Msg2 comprises at least one of the following:

an identity (ID) of the second device for indicating success of a Msg1 transmission from the second device;

a random ID transmitted by the second device for indicating success of a Msg1 transmission from the second device;

channel information of a Msg1 transmission from the second device for indicating success of the Msg1 transmission;

frequency information of a Msg1 transmission from the second device for indicating success of the Msg1 transmission; or an acknowledgement (ACK)for indicating success of a Msg1 transmission from the second device, wherein a resource for transmitting the ACK is associated with a resource of the Msg1 transmission.

13. The second device of claim 11, wherein the separate PRDCH transmission carrying the Msg4 comprises at least one of the following:

a random ID transmitted by the second device for indicating a failure of a Msg3 transmission of the second device;

channel information of a Msg3 transmission from the second device among the at least one second device for indicating a failure of the Msg3 transmission;

frequency information of a Msg3 transmission from the second device for indicating a failure of the Msg3 transmission; or

a NACK for indicating a failure of a Msg3 transmission from the second device, wherein a resource for transmitting the NACK is associated with a resource of the Msg3 transmission.

14. The second device of claim 11, wherein the one PRDCH transmission carrying the Msg2 comprises at least one of the following:

IDs of the second device and the other second devices for indicating success of Msg1 transmissions from the second device and the other second devices;

random IDs of the second device and the other second devices for indicating success of Msg1 transmissions from the second device and the other second devices; or

elements of ACK or negative acknowledgement (NACK) for indicating results of Msg1 transmissions from the second device and the other second devices, wherein the elements are ordered in frequencies for transmitting the Msg1 transmissions.

15. The second device of claim 11, wherein the one PRDCH transmission carrying the Msg4 comprises at least one of the following:

random IDs transmitted by the second device and the other second devices for indicating a failure of Msg3 transmissions of the second device and the other second devices;

elements of ACK or NACK for indicating results of Msg3 transmissions from the second device and the other second devices, wherein the elements are ordered in frequencies for transmitting the Msg3 transmissions; or

elements of ACK or NACK associated with the random IDs for indicating results of Msg3 transmissions from the second device and the other second devices, wherein the random IDs are transmitted by the first device in Msg2 for indicating success of a Msg1 transmission from at least one second device.

16. The second device of any of claims 9-15, wherein the processor is further configured to determine the random access procedure is successful by at least one of the following:

determining that a separate PRDCH transmission comprises an ID of the second device in the case that the random access procedure is the 2-step RA procedure;

determining that a separate PRDCH transmission comprises a random ID transmitted by the second device in the case that the random access procedure is the 2-step RA procedure;

determining that a separate PRDCH transmission comprises the channel information of the Msg1 transmission from the second device in the case that the random access procedure is the 2-step RA procedure;

determining that a separate PRDCH transmission comprises the frequency information of the Msg1 transmission from the second device in the case that the random access procedure is the 2-step RA procedure;

receiving a separate PRDCH transmission on a resource associated with a resource of the Msg1 transmission from the second device in the case that the random access procedure is the 2-step RA procedure; or

determining that one PRDCH transmission comprises an element for the second device indicating a ACK.

17. The second device of any of claims 9-15, wherein the processor is further configured to determine the random access procedure failed by at least one of the following:

determining that a separate PRDCH transmission comprises a random ID transmitted by the second device in the case that the random access procedure is the 4-step RA procedure;

determining that a separate PRDCH transmission comprises channel information of a Msg3 transmission from the second device in the case that the random access procedure is the 4-step RA procedure;

determining that a separate PRDCH transmission comprises frequency information of a Msg3 transmission from the second device in the case that the random access procedure is the 4-step RA procedure;

receiving a separate PRDCH transmission on a resource associated with a resource of a Msg3 transmission from the second device in the case that the random access procedure is the 4-step RA procedure; or

determining that one PRDCH transmission comprises an element for the second device indicating a NACK.

18. The second device of claim 9, wherein at least one of the following:

the first device comprises a reader of an Internet of things (IoT) device; or

the second device comprises an IoT device.

19. 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:

receive, from multiple second devices, multiple transmissions in a random access procedure, wherein the multiple transmissions from multiple second devices are frequency multiplexed; and

transmit a result of the random access procedure to at least one second device.

20. A method performed by a first device, comprising:

receiving, from multiple second devices, multiple transmissions in a random access procedure, wherein the multiple transmissions from multiple second devices are frequency multiplexed; and

transmitting a result of the random access procedure to at least one second device.

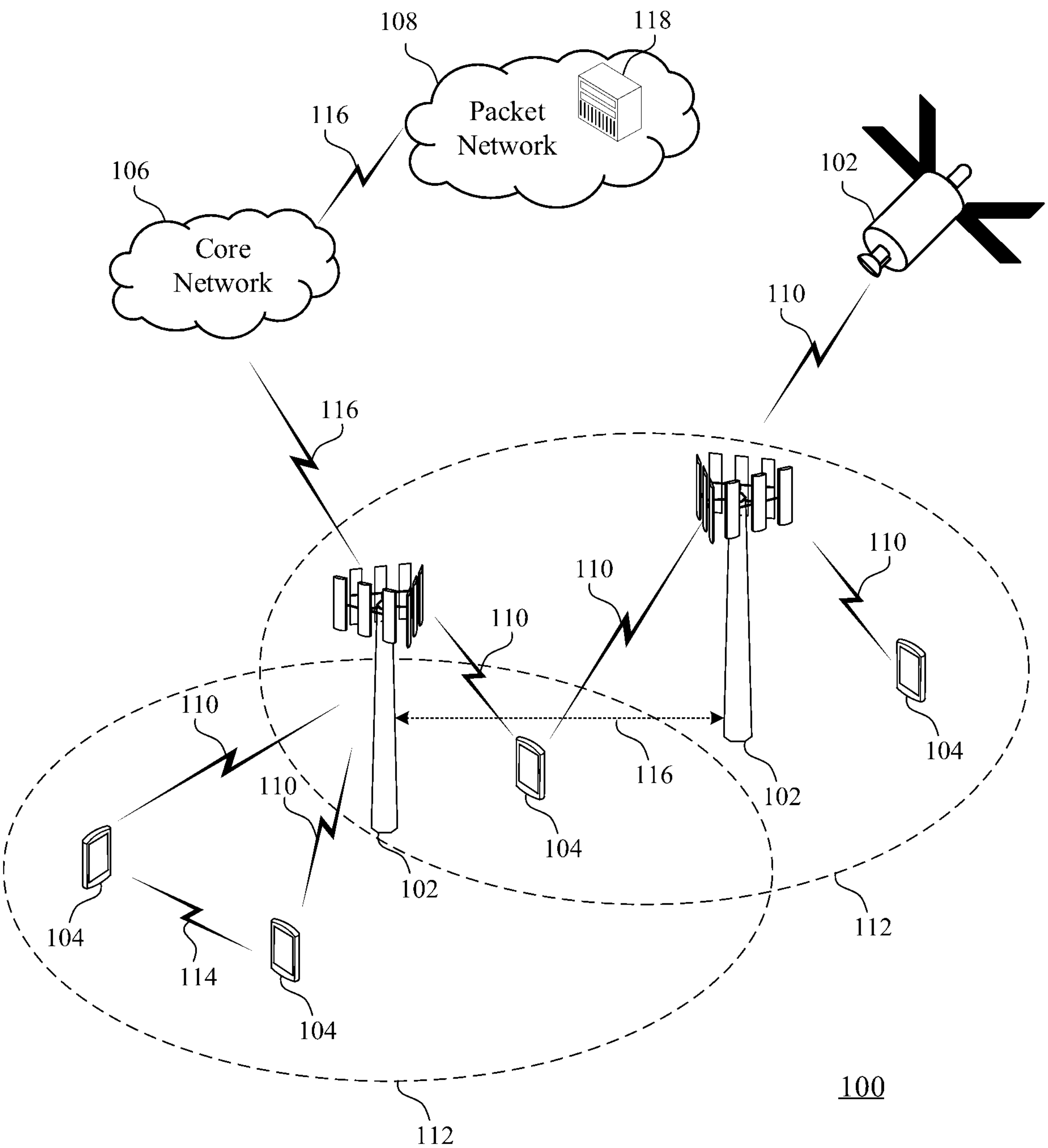

108
118
116
Packet
Network
106
102
Core
Network
110
116
110
110
110
110
110
104
110
116
102
104
104
102
112
104
114
104
100
112

FIG. 1A

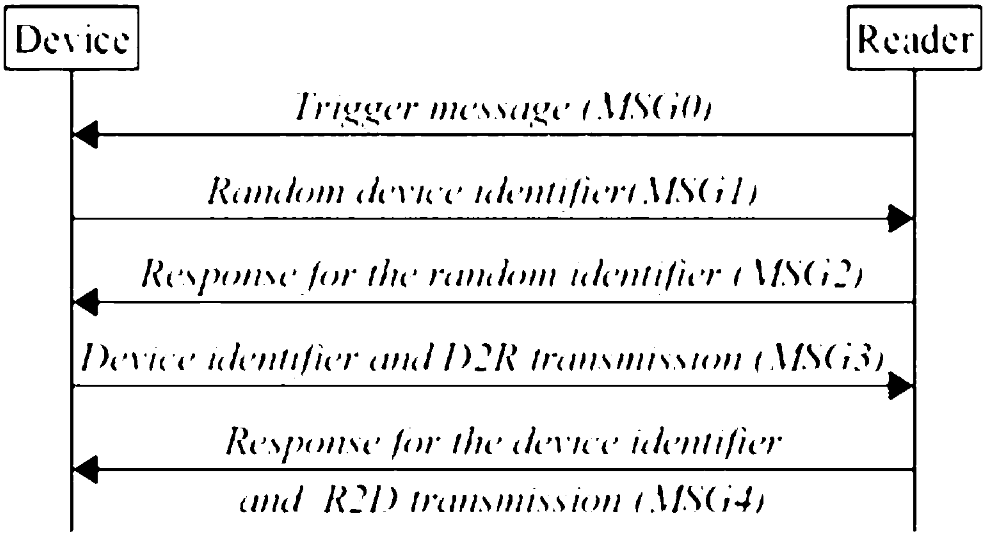

Device
Reader
Trigger message (MSG0)
Random device identifier(MSG1)
Response for the random identifier (MSG2)
Device identifier and D2R transmission (MSG3)
Response for the device identifier
and R2D transmission (MSG4)

FIG. 1B

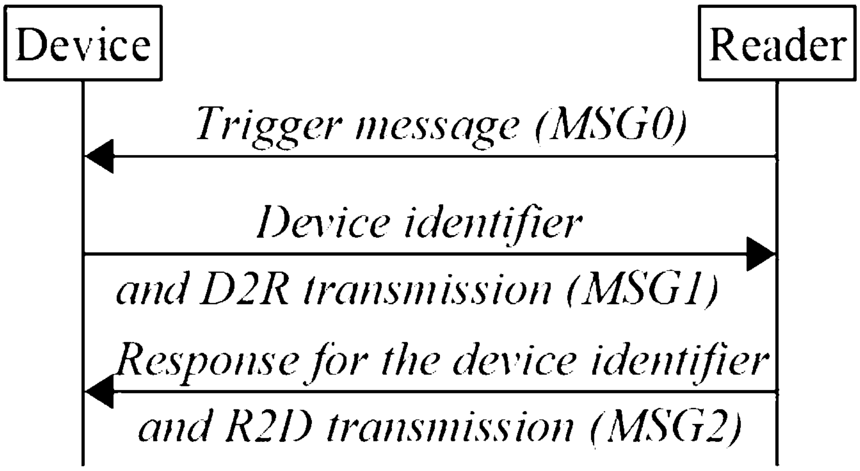

Device
Reader
Trigger message (MSG0)
Device identifier
and D2R transmission (MSG1)
Response for the device identifier
and R2D transmission (MSG2)

FIG. 1C

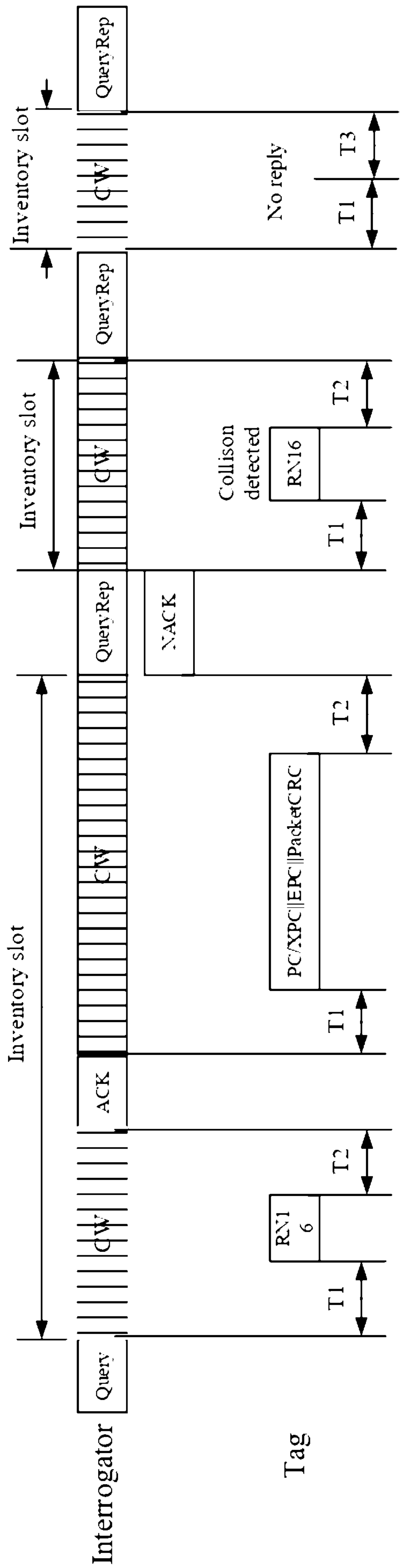

Interrogator
Tag
Query
QueryRep
ACK
NACK
CW
Inventory slot
RN16
Collison detected
No reply
PC/XPC||EPC||PacketCRC
T1
T2
T3

FIG. 1D

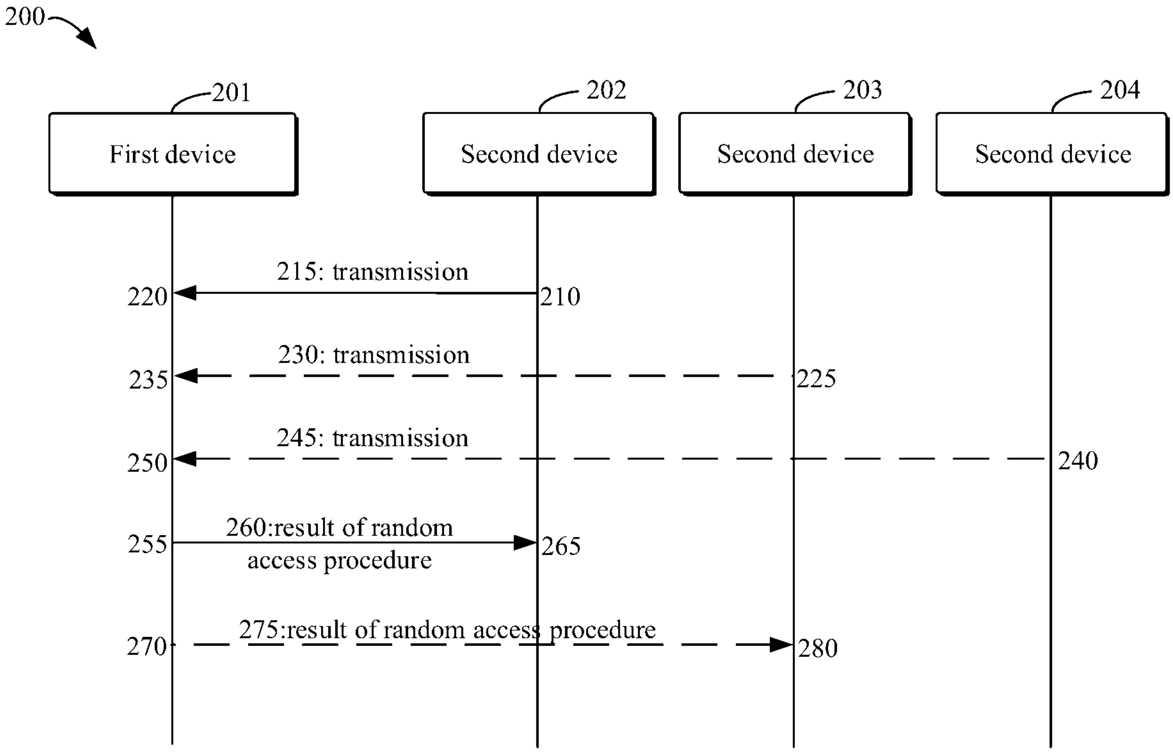

200
201
First device
202
Second device
203
Second device
204
Second device
215: transmission
220
210
230: transmission
235
225
245: transmission
250
240
260:result of random access procedure
255
265
275:result of random access procedure
270
280

FIG. 2

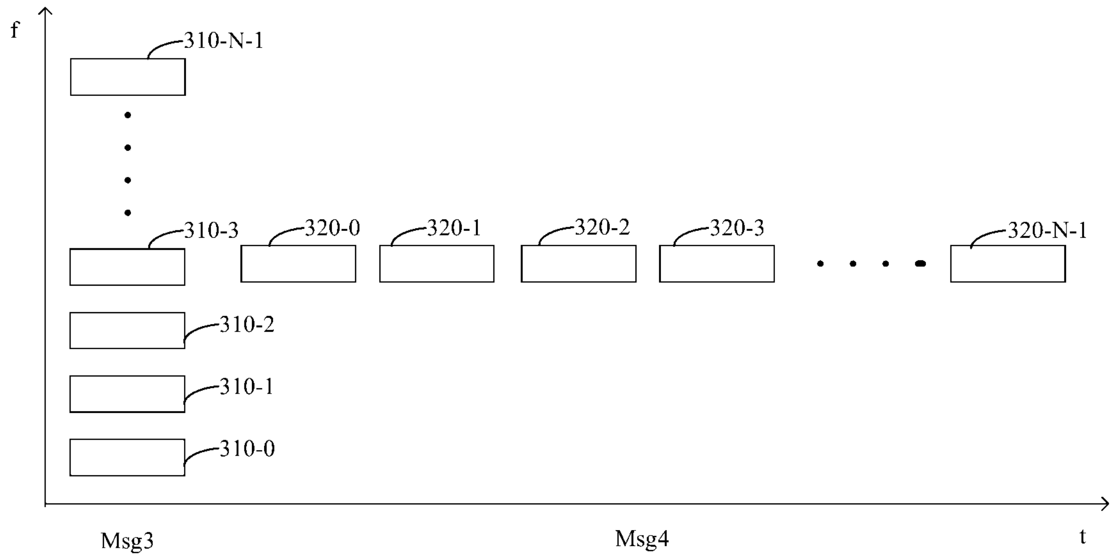

f
310-N-1
310-3
320-0
320-1
320-2
320-3
320-N-1
310-2
310-1
310-0
Msg3
Msg4
t

FIG. 3

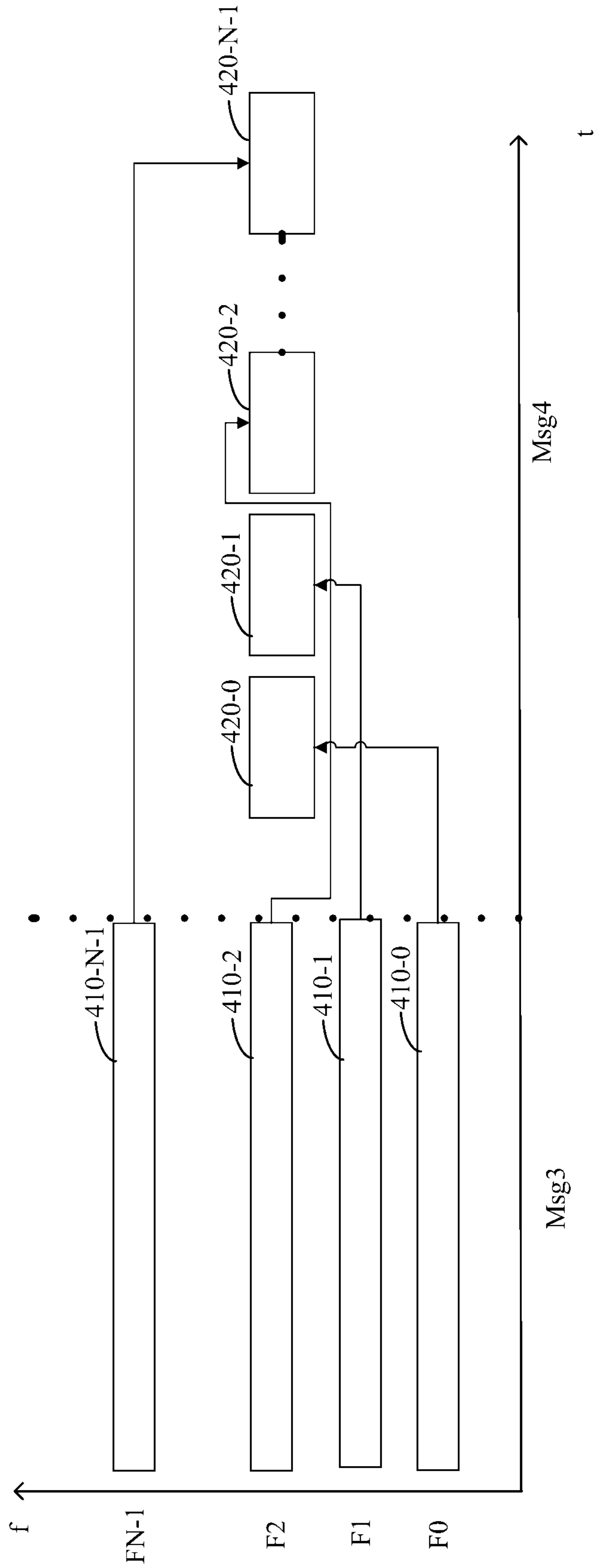

420-N-1
420-2
420-1
420-0
t
Msg4
Msg3
410-N-1
410-2
410-1
410-0
f
FN-1
F2
F1
F0

FIG. 4

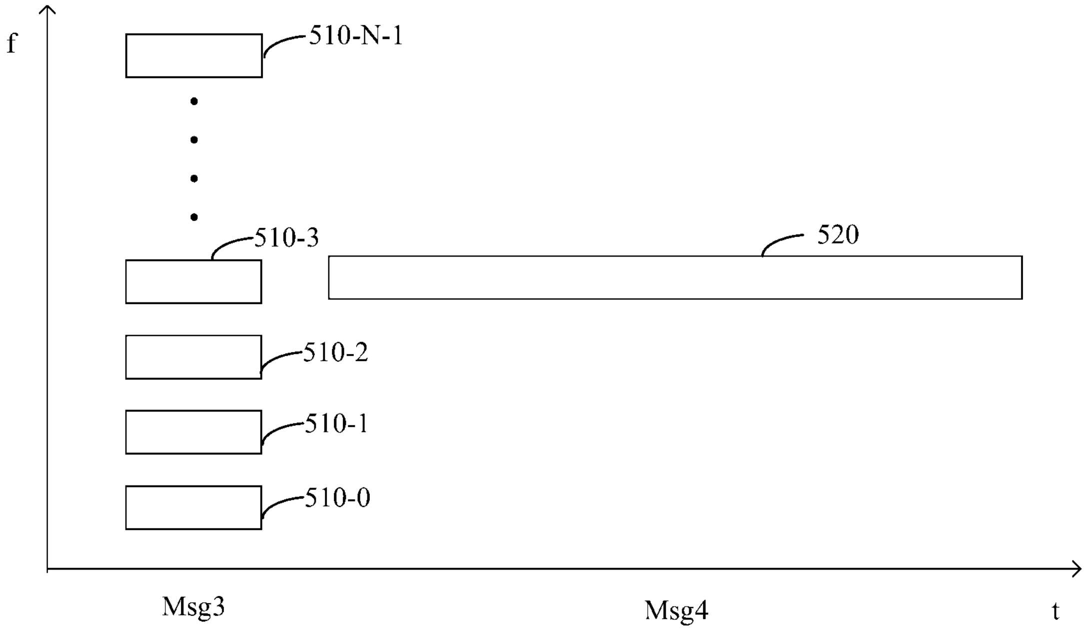


FIG. 5

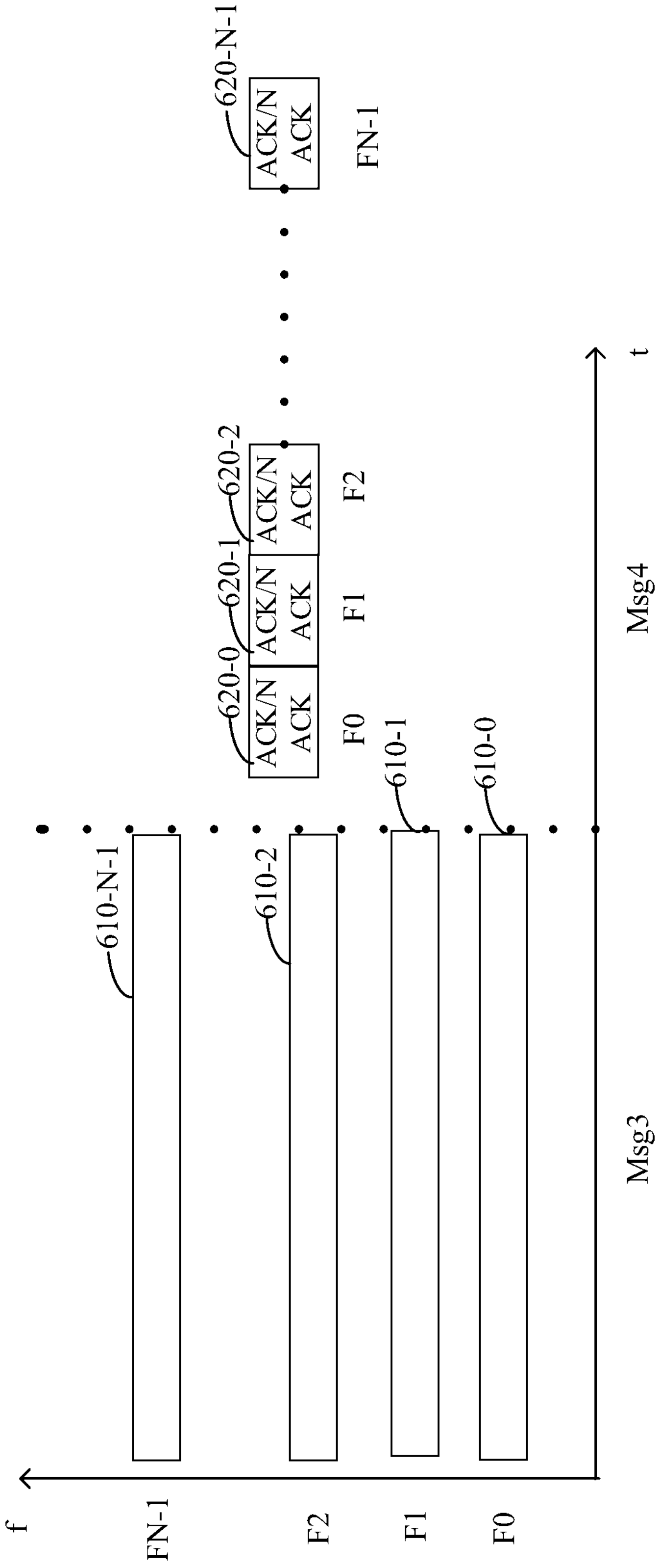

620-N-1
ACK/NACK
FN-1
620-2
620-1
620-0
ACK/NACK
ACK/NACK
ACK/NACK
F0
F1
F2
t
Msg4
610-0
610-1
610-2
610-N-1
Msg3
f
FN-1
F2
F1
F0

FIG. 6

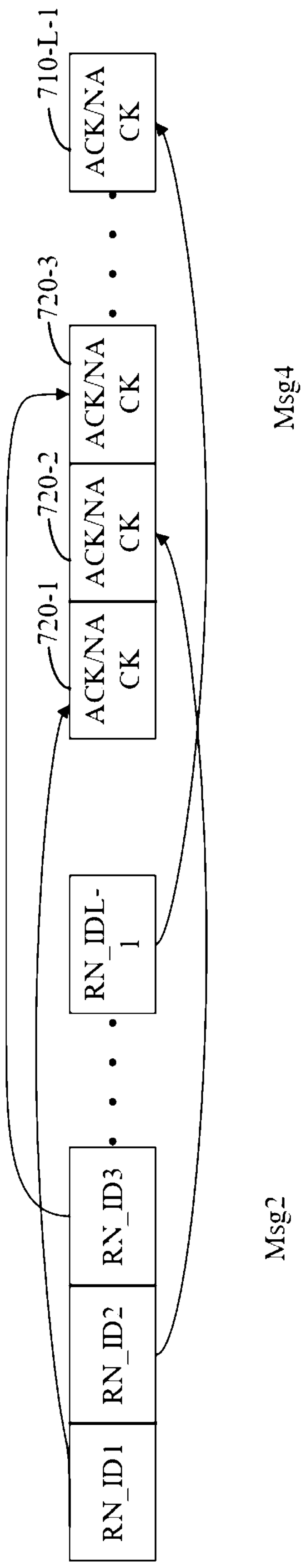

RN_ID1
RN_ID2
RN_ID3
RN_IDL-1
ACK/NACK
ACK/NACK
ACK/NACK
ACK/NACK
720-1
720-2
720-3
710-L-1
Msg2
Msg4

FIG. 7

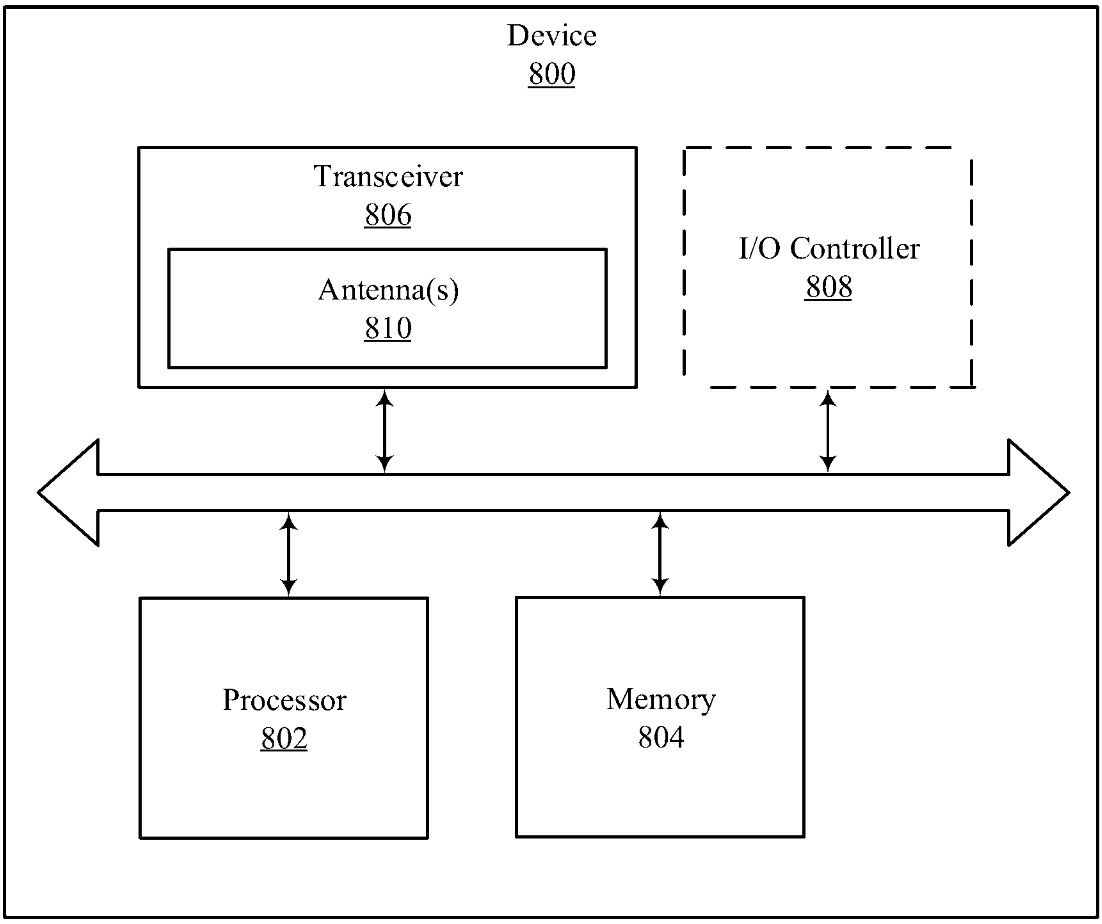

Device
800
Transceiver
806
Antenna(s)
810
I/O Controller
808
Processor
802
Memory
804

FIG. 8

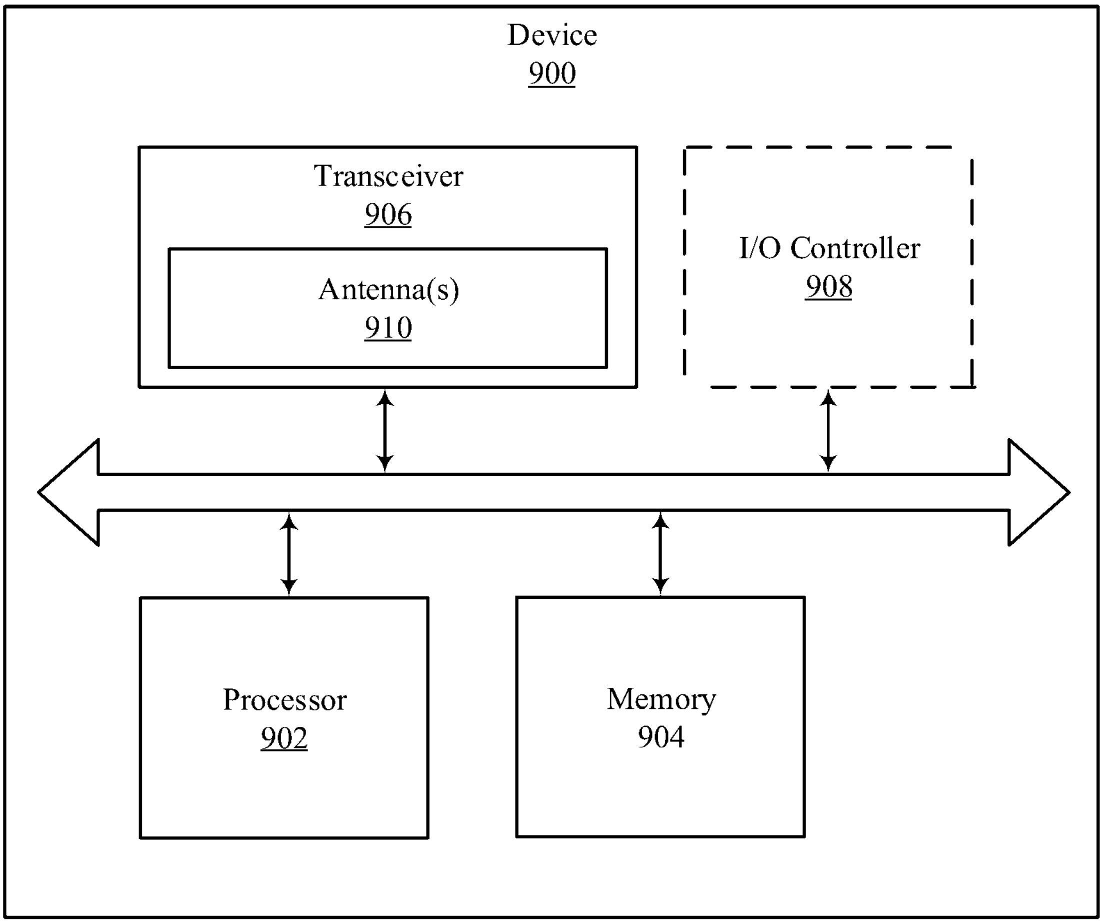
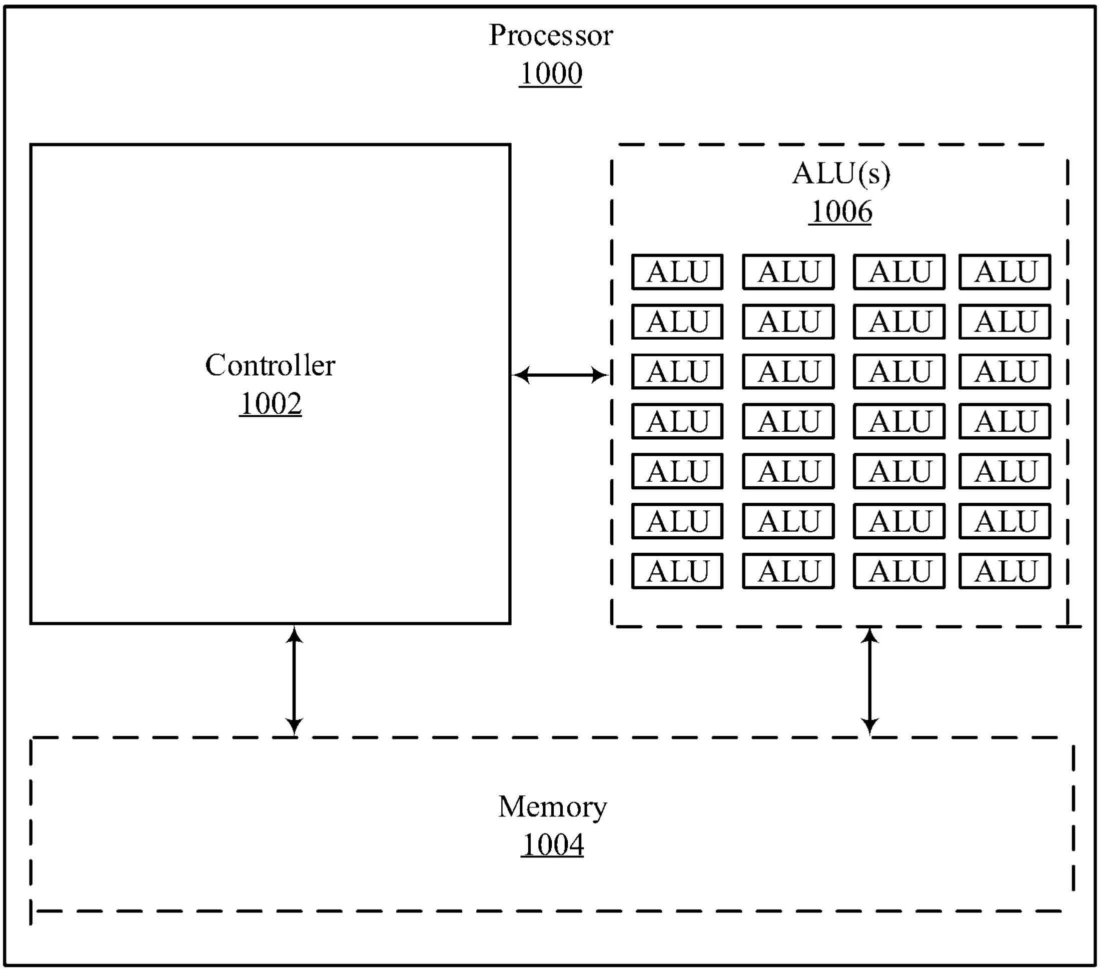

Device
900
Transceiver
906
Antenna(s)
910
I/O Controller
908
Processor
902
Memory
904

FIG. 9


Processor
1000
Controller
1002
ALU(s)
1006
ALU ALU ALU ALU
ALU ALU ALU ALU
ALU ALU ALU ALU
ALU ALU ALU ALU
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ALU ALU ALU ALU
Memory
1004

FIG. 10

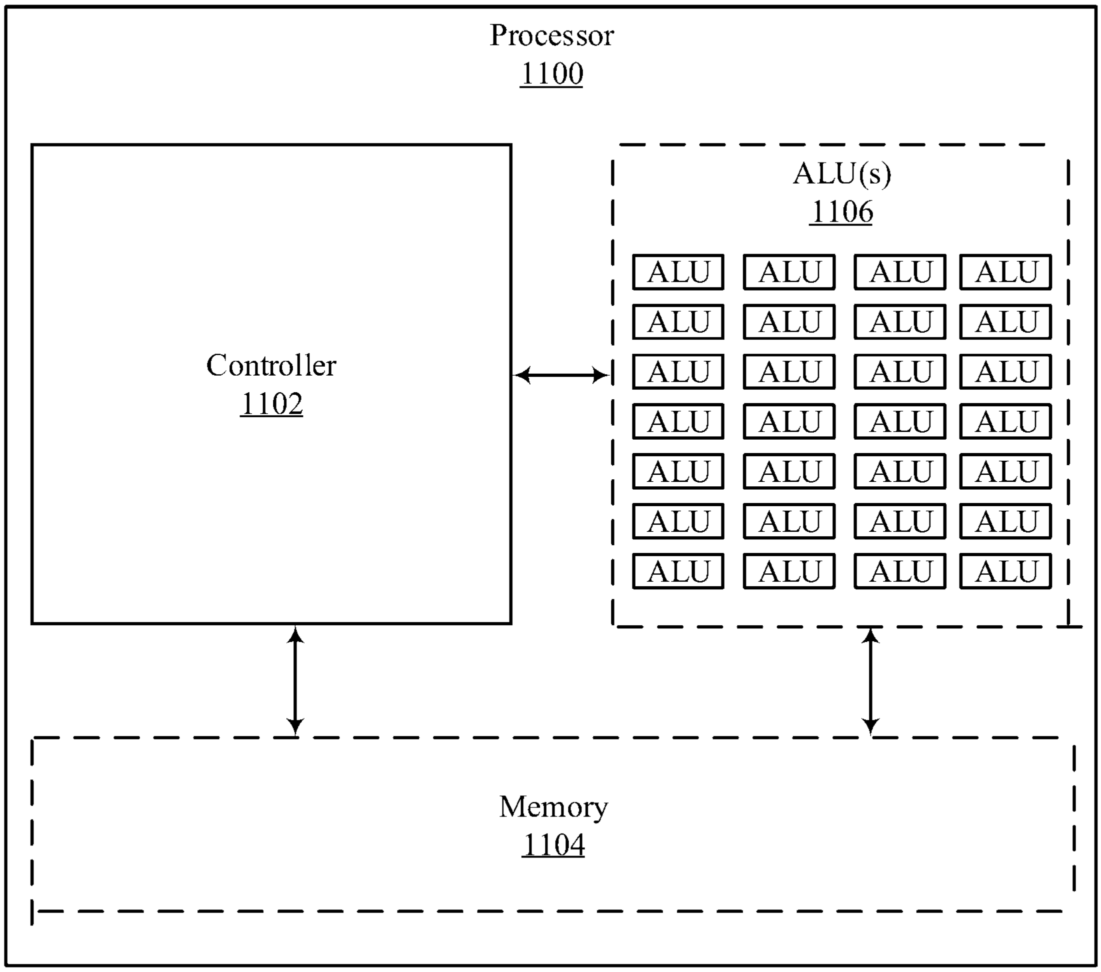

FIG. 11

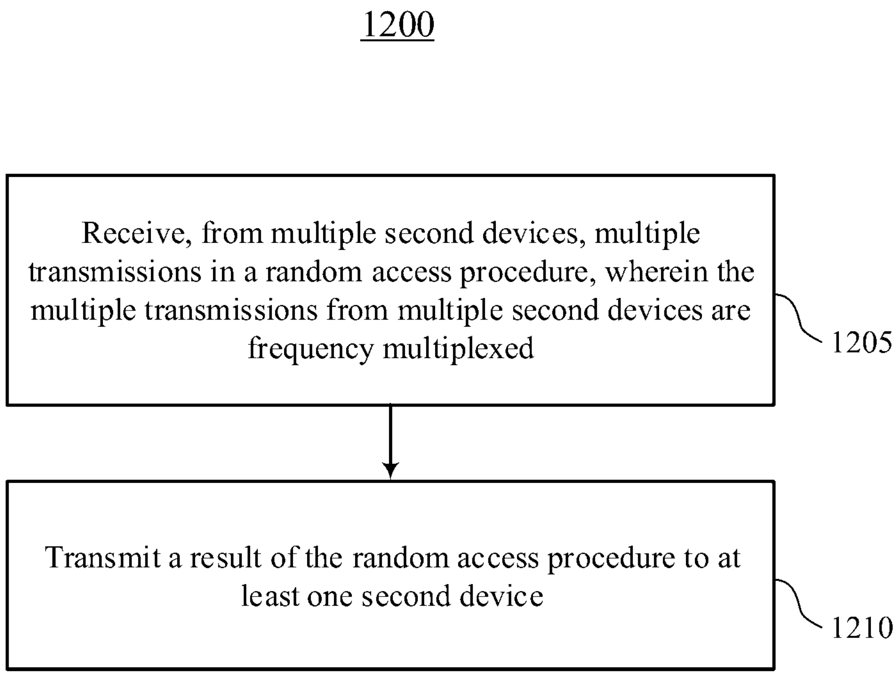
1200
Receive, from multiple second devices, multiple transmissions in a random access procedure, wherein the multiple transmissions from multiple second devices are frequency multiplexed
1205
Transmit a result of the random access procedure to at least one second device
1210

FIG. 12

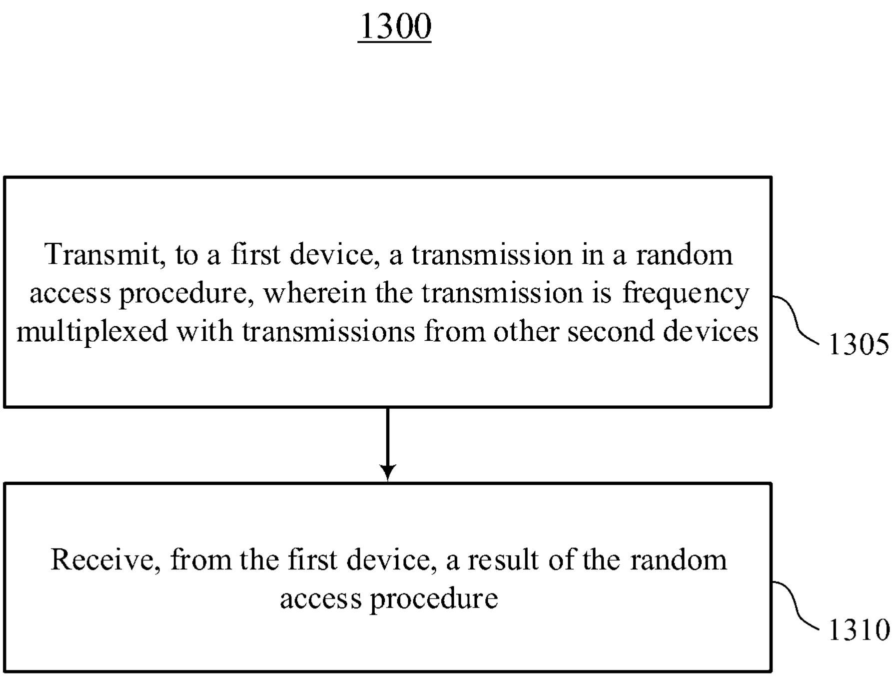
1300
Transmit, to a first device, a transmission in a random access procedure, wherein the transmission is frequency multiplexed with transmissions from other second devices
1305
Receive, from the first device, a result of the random access procedure
1310

FIG. 13

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2024/110786

A. CLASSIFICATION OF SUBJECT MATTER

H04W 74/0833(2024.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

3GPP,CNTXT,ENTXTC,DWPI,ENTXT,IEEE,CNKI:random access, multiple, transmi+, UE, equipment, terminal, request, identity, result, response, ACK, NACK, FDM, OFDM, ID, IoT, msg2, msg4, PRDCH, RACH

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 112470540 A (QUALCOMM INCORPORATED) 09 March 2021 (2021-03-09) description, paragraphs [0008], [0070]-[0224]	1-20
X	CN 113924815 A (QUALCOMM INCORPORATED) 11 January 2022 (2022-01-11) description, paragraphs [0085]-[0087]	1-20
X	US 2024129957 A1 (QUALCOMM INCORPORATED) 18 April 2024 (2024-04-18) description, paragraphs [0110]-[0116]	1-20
A	CN 111480386 A (QUALCOMM INCORPORATED) 31 July 2020 (2020-07-31) the whole document	1-20
A	LG ELECTRONICS. "Frame structure and timing aspects for Ambient IoT" *3GPP TSG RAN WG1 #117 R1-2404891,* 24 May 2024 (2024-05-24), the whole document	1-20

☐ Further documents are listed in the continuation of Box C.   ☑ See patent family annex.

* Special categories of cited documents:
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- "D" document cited by the applicant in the international application
- "E" earlier application or patent but published on or after the international filing date
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- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 April 2025	**30 April 2025**

Name and mailing address of the ISA/CN	Authorized officer
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2024/110786

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
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				WO	2020019138	A1	30 January 2020
				EP	3827638	A1	02 June 2021
				KR	20210033478	A	26 March 2021
				US	2021274568	A1	02 September 2021
CN	113924815	A	11 January 2022	US	2023345542	A1	26 October 2023
				KR	20220018490	A	15 February 2022
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				WO	2020251853	A1	17 December 2020
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				EP	3725125	A1	21 October 2020
				US	2019190668	A1	20 June 2019