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(54) Title: CARRIER WAVE TRANSMISSION

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Transmit, to at least one second device, a first DL transmission to trigger the at least one second device to perform at least one carrier wave transmission to at least one third device, wherein the at least one carrier wave transmission is used to carry at least one UL transmission of the at least one third device

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Fig. 11

(57) Abstract: Various aspects of the present disclosure relate to carrier wave transmission. In an aspect, a first device transmits a first DL transmission to at least one second device to trigger the at least one second device to perform at least one carrier wave transmission to at least one third device. The at least one carrier wave transmission is used to carry at least one UL transmission of the at least one third device. In this way, the at least one carrier wave transmission is triggered by the first device. Therefore, the UL transmission of at least one third device is carried by the at least one carrier wave transmission and the communication performance is improved.



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CARRIER WAVE TRANSMISSION

[0001] The present disclosure relates to wireless communications, and more specifically to carrier wave transmission.

BACKGROUND

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

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

SUMMARY

[0004] The present disclosure relates to methods, apparatuses, and systems that support carrier wave transmission.

[0005] Some implementations of the method and devices described herein include, transmitting, to at least one second device, a first downlink (DL) transmission to trigger the at least one second device to perform at least one carrier wave transmission to at least one third device, wherein the at least one carrier wave transmission is used to carry at least one uplink (UL) transmission of the at least one third device. In this way, the at least one carrier wave transmission is triggered by the first device.

[0006] Some implementations of the method and devices described herein may further include transmitting, to the at least one third device, a second DL transmission to schedule the at least one UL transmission of the at least one third device.

[0007] Some implementations of the method and devices described herein may further include transmitting, to the at least one third device, the first DL transmission to schedule the at least one UL transmission of the at least one third device.

[0008] Some implementations of the method and devices described herein may further include determining a list of one or more IDs of one or more third device; and transmitting the list to the at least one second device.

[0009] In some implementations of the method and devices described herein, the first DL transmission may comprise one or more of the following: identity (ID) information of the at least one second device; identity (ID) information of the at least one third device; region information of a region associated with the at least one second device; region information of a region associated with the at least one third device; an indication to activate or deactivate the at least one carrier wave transmission; a time gap between the first DL transmission and a start of at least one time interval of the at least one carrier wave transmission; a time duration of the at least one carrier wave transmission; a number of the at least one carrier wave transmission; or a period of the at least one carrier wave transmission.

[0010] In some implementations of the method and devices described herein, the first DL transmission may comprise a first stage transmission and a second stage transmission.

[0011] In some implementations of the method and devices described herein, the first stage transmission of the first DL transmission may comprises one or more of the

following: at least one ID of the at least one second device; at least one ID of the at least one third device; region information of a region associated with the at least one second device; region information of a region associated with the at least one third device; an indication to activate or deactivate the at least one carrier wave transmission; a time gap between the first DL transmission and a start of at least one time interval of the at least one carrier wave transmission; a time duration of the at least one carrier wave transmission; a number of the at least one carrier wave transmission; or a period of the at least one carrier wave transmission.

[0012] In some implementations of the method and devices described herein, the second stage transmission of the first DL transmission may comprise scheduling information for the at least one third device indicated by the at least one ID or the region information of at least one third device in the first stage transmission of the first DL transmission.

[0013] In some implementations of the method and devices described herein, the first DL transmission may further comprise: an ID of a group or a pair, wherein the group or the pair comprises: the at least one second device and at least one third device; or an ID of the region associated with the at least one second device within the region and at least one third device within the region.

[0014] In some implementations of the method and devices described herein, the first device may comprise a base station; the second device may comprise one of a terminal device or an integrated access and backhaul (IAB) node; the second device may act as one of: an assisting node, an intermediate node, a relay node, or a repeater for the at least one third device; or the third device may comprise an ambient Internet of thing (A-IoT) device.

[0015] In some implementations of the method and devices described herein, the first DL transmission may be transmitted via a physical layer control information or a medium access control (MAC) control element (MAC CE) or a radio resource control (RRC) message; or the second DL transmission may be transmitted via a physical layer control information or a MAC CE or a RRC message.

[0016] Some implementations of the method and devices described herein include receiving, from a first device, a first downlink (DL) transmission to trigger the second device to perform at least one carrier wave transmission to at least one third device,

wherein the at least one carrier wave transmission is used to carry at least one uplink (UL) transmission of the at least one third device; and performing, based on the first DL transmission, the at least one carrier wave transmission to the at least one third device. In this way, the at least one carrier wave transmission is triggered by the first device.

[0017] Some implementations of the method and devices described herein may further include receiving, from the first device, a list of one or more IDs of one or more third device; and determining the at least one third device based on the list and the first DL transmission.

[0018] Some implementations of the method and devices described herein may further include performing the at least one carrier wave transmission by performing the at least one carrier wave transmission based on determining that the first stage transmission of the first DL transmission comprises at least one ID or the region information of the at least one second device and the at least one second device comprises the second device.

[0019] Some implementations of the method and devices described herein may further include performing the at least one carrier wave transmission by performing the at least one carrier wave transmission based on determining that a first stage transmission of the first DL transmission comprises the region information of the region and the second device is located in the region.

[0020] Some implementations of the method and devices described herein may further include performing the at least one carrier wave transmission by performing the at least one carrier wave transmission based on determining that a third device scheduled by the first DL transmission is in a group or a pair and the second device is in the group or the pair of the third device.

[0021] In some implementations of the method and devices described herein, the first DL transmission may comprise one or more of the following: identity (ID) information of the at least one second device; identity (ID) information of the at least one third device; region information of a region associated with the at least one second device; region information of a region associated with at least one third device; an indication to activate or deactivate the at least one carrier wave transmission; a time gap between the first DL transmission and a start of at least one time interval of the at least one carrier wave transmission; a time duration of the at least one carrier wave transmission; a number of

the at least one carrier wave transmission; or a period of the at least one carrier wave transmission.

[0022] In some implementations of the method and devices described herein, the first DL transmission may be further transmitted to the at least one third device.

[0023] In some implementations of the method and devices described herein, the first DL transmission may comprise a first stage transmission and a second stage transmission.

[0024] In some implementations of the method and devices described herein, the first stage transmission of the first DL transmission may comprise one or more of the following: at least one ID of the at least one second device; at least one ID of the at least one third device; region information of a region associated with the at least one second device; region information of a region associated with the at least one third device; an indication to activate or deactivate the at least one carrier wave transmission; a time gap between the first DL transmission and a start of at least one time interval of the at least one carrier wave transmission; a time duration of the at least one carrier wave transmission; a number of the at least one carrier wave transmission; or a period of the at least one carrier wave transmission.

[0025] In some implementations of the method and devices described herein, the second stage transmission of the first DL transmission may comprise scheduling information for the at least one third device indicated by the at least one ID of at least one third device in the first stage transmission of the first DL transmission.

[0026] In some implementations of the method and devices described herein, the first DL transmission may further comprise an ID of a group or a pair, wherein the group or the pair comprises: the at least one second device and at least one third device; or an ID of the region associated with the at least one second device within the region and the at least one third device within the region.

[0027] In some implementations of the method and devices described herein, the first device may comprise a base station; the second device may comprise one of a terminal device or an integrated access and backhaul (IAB) node; the second device may act as one of: an assisting node, an intermediate node, a relay node, or a repeater for the at least one third device; or the third device may comprise an ambient Internet of thing (A-IoT) device.

[0028] In some implementations of the method and devices described herein, the first DL transmission may be transmitted via a physical layer control information or a medium access control (MAC) control element (MAC CE) or a radio resource control (RRC) message; or the second DL transmission may be transmitted via a physical layer control information or a MAC CE or a RRC message.

[0029] Some implementations of the method and devices described herein include receiving, from a first device, a first downlink (DL) transmission to trigger an uplink (UL) transmission of the third device, wherein the first DL transmission further triggers at least one second device to perform at least one carrier wave transmission to the third device; and performing, based on the first DL transmission, the UL transmission using the at least one carrier wave transmission. In this way, the UL transmission is triggered by the first device.

[0030] Some implementations of the method and devices described herein may further include performing the UL transmission by receiving, from the at least one second device, at least one carrier wave transmission; and performing the UL transmission based on the at least one carrier wave transmission and the first DL transmission.

[0031] Some implementations of the method and devices described herein may further include performing the UL transmission by: based on determining that at least one ID of at least one third device in a first stage transmission of the first DL transmission comprises an ID or the region information of the third device, performing the UL transmission based on the second stage transmission of the first DL transmission.

[0032] In some implementations of the method and devices described herein, the first DL transmission may comprise one or more of the following: identity (ID) information of at least one second device; identity (ID) information of at least one third device; region information of a region associated with at least one second device; region information of a region associated with at least one third device; an indication to activate or deactivate the at least one carrier wave transmission; a time gap between the first DL transmission and a start of at least one time interval of the at least one carrier wave transmission; a time duration of the at least one carrier wave transmission; a number of the at least one carrier wave transmission; or a period of the at least one carrier wave transmission.

[0033] In some implementations of the method and devices described herein, the first DL transmission may comprise a first stage transmission and a second stage transmission.

[0034] In some implementations of the method and devices described herein, the first stage transmission of the first DL transmission may comprise one of the following: at least one ID of the at least one second device; at least one ID of at least one third device; region information of a region associated with the at least one second device; region information of a region associated with the at least one third device; an indication to activate or deactivate the at least one carrier wave transmission; a time gap between the first DL transmission and a start of at least one time interval of the at least one carrier wave transmission; a time duration of the at least one carrier wave transmission; a number of the at least one carrier wave transmission; or a period of the at least one carrier wave transmission.

[0035] In some implementations of the method and devices described herein, the second stage transmission of the first DL transmission may comprise scheduling information for the at least one third device indicated by the at least one ID or the region information of at least one third device in the first stage transmission of the first DL transmission.

[0036] In some implementations of the method and devices described herein, the first device may comprise a base station; the second device may comprise one of a terminal device or an integrated access and backhaul (IAB) node; the second device may act as one of: an assisting node, an intermediate node, a relay node, or a repeater for the at least one third device; or the third device may comprise an ambient Internet of thing (A-IoT) device.

[0037] In some implementations of the method and devices described herein, the first DL transmission may be transmitted via a physical layer control information or a medium access control (MAC) control element (MAC CE) or a radio resource control (RRC) message; or the second DL transmission may be transmitted via a physical layer control information or a MAC CE or a RRC message.

BRIEF DESCRIPTION OF THE DRAWINGS

[0038] FIG. 1A illustrates an example of a wireless communications system that supports carrier wave transmission in accordance with aspects of the present disclosure.

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

[0040] FIG. 1C illustrates an example of topology 2 associated with aspects of the present disclosure.

[0041] FIG. 1D illustrates an example of topology 3 associated with aspects of the present disclosure.

[0042] FIG. 1E illustrates another example of topology 3 associated with aspects of the present disclosure.

[0043] FIG. 1F illustrates an example of topology 4 associated with aspects of the present disclosure.

[0044] FIG. 2A illustrates an example signaling chart illustrating an example process that supports carrier wave transmission in accordance with aspects of the present disclosure.

[0045] FIG. 2B illustrates an example signaling chart illustrating another example process that supports carrier wave transmission in accordance with aspects of the present disclosure.

[0046] FIG. 3 illustrates an example process in accordance with aspects of the present disclosure.

[0047] FIG. 4 illustrates another example process in accordance with aspects of the present disclosure.

[0048] FIGS. 5-7 illustrate examples of devices that support carrier wave transmission in accordance with aspects of the present disclosure.

[0049] FIGS. 8-10 illustrate examples of processors that support carrier wave transmission in accordance with aspects of the present disclosure.

[0050] FIG. 11 illustrates a flowchart of a method that supports carrier wave transmission in accordance with aspects of the present disclosure.

[0051] FIG. 12 illustrates a flowchart of a method that supports carrier wave transmission in accordance with aspects of the present disclosure.

[0052] FIG. 13 illustrates a flowchart of a method that supports carrier wave transmission in accordance with aspects of the present disclosure.

[0053] Throughout the drawings, the same or similar reference numerals represent the same or similar elements.

DETAILED DESCRIPTION

[0054] 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.

[0055] 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.

[0056] 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.

[0057] 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.

[0058] 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.

[0059] 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.

[0060] 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.

[0061] As used herein, the term “user equipment (UE)” generally refers to any end device that may be capable of wireless communications. By way of example rather than a limitation, a user equipment may also be referred to as a communication device, a terminal device, an end user device, a subscriber station (SS), an unmanned aerial vehicle (UAV), a portable subscriber station, a mobile station (MS), or an access terminal (AT). The user equipment may include, but is not limited to, a mobile phone, a cellular phone, a smart phone, a voice over IP (VoIP) phone, a wireless local loop phone, a tablet, a wearable user equipment, a personal digital assistant (PDA), a portable computer, a desktop computer, an image capture user equipment such as a digital camera, a gaming user equipment, a music storage and playback appliance, a vehicle-mounted wireless user equipment, a wireless endpoint, a mobile station, laptop-embedded equipment (LEE), laptop-mounted equipment (LME), a USB dongle, a smart device, wireless customer-premises equipment (CPE), an Internet of Things (IoT) device, a watch or other wearable, a head-mounted display (HMD), a vehicle, a drone, a medical device (for example, a remote surgery device), an industrial device (for example, a robot and/or other wireless devices operating in an industrial and/or an automated processing chain contexts), a consumer electronics device, a device operating on commercial and/or industrial wireless networks, and the like. In the following description, the terms: “user equipment,” “communication device,” “terminal,” “user equipment” and “UE,” may be used interchangeably.

[0062] As used herein, the term “A-IoT device” refers to a device without batteries or with limited energy storage capabilities. For the A-IoT device, energy is provided by harvesting radio waves, light, motion, heat, or any other suitable source. A-IoT device can also be called zero-power terminals, near-zero power terminals, passive IoT device, ambient backscatter communication (AmBC) device, tag, etc. Compared with low-power and wide-coverage services, such as narrow band (NB) IoT, enhance machine type communication (eMTC), A-IoT has lower complexity and lower power consumption, and is suitable for more application scenarios.

[0063] FIG. 1A illustrates an example of a wireless communications system 100 that supports store and forward operations 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 (UE)), 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.

[0064] 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.

[0065] 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.

[0066] 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.

[0067] 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.

[0068] 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.

[0069] 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).

[0070] 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.

[0071] 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)).

[0072] Split of functionality between a CU, a DU, and an RU may be flexible and may support different functionalities depending upon which functions (e.g., network layer functions, protocol layer functions, baseband functions, radio frequency functions, and any combinations thereof) are performed at a CU, a DU, or an RU. For example, a functional split of a protocol stack may be employed between a CU and a DU such that the CU may support one or more layers of the protocol stack and the DU may support one or more different layers of the protocol stack. In some implementations, the CU may host

upper protocol layer (e.g., a layer 3 (L3), a layer 2 (L2)) functionality and signaling (e.g., Radio Resource Control (RRC), service data adaptation protocol (SDAP), Packet Data Convergence Protocol (PDCP)). The CU may be connected to one or more DUs or RUs, and the one or more DUs or RUs may host lower protocol layers, such as a layer 1 (L1) (e.g., physical (PHY) layer) or an L2 (e.g., radio link control (RLC) layer, medium access control (MAC) layer) functionality and signaling, and may each be at least partially controlled by the CU 160.

[0073] 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).

[0074] 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.

[0075] 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.

[0076] 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).

[0077] 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.

[0078] One or more numerologies may be supported in the wireless communications system 100, and a numerology may include a subcarrier spacing and a cyclic prefix. A first numerology (e.g., $\mu=0$) may be associated with a first subcarrier spacing (e.g., 15 kHz) and a normal cyclic prefix. In some implementations, the first numerology (e.g., $\mu=0$) associated with the first subcarrier spacing (e.g., 15 kHz) may utilize one slot per subframe. A second numerology (e.g., $\mu=1$) may be associated with a second subcarrier spacing (e.g., 30 kHz) and a normal cyclic prefix. A third numerology (e.g., $\mu=2$) may be associated with a third subcarrier spacing (e.g., 60 kHz) and a normal cyclic prefix or an

extended cyclic prefix. A fourth numerology (e.g., $\mu=3$) may be associated with a fourth subcarrier spacing (e.g., 120 kHz) and a normal cyclic prefix. A fifth numerology (e.g., $\mu=4$) may be associated with a fifth subcarrier spacing (e.g., 240 kHz) and a normal cyclic prefix.

[0079] 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.

[0080] Additionally or alternatively, a time interval of a resource (e.g., a communication resource) may be organized according to slots. For example, a subframe may include a number (e.g., quantity) of slots. The number of slots in each subframe may also depend on the one or more numerologies supported in the wireless communications system 100. For instance, the first, second, third, fourth, and fifth numerologies (i.e., $\mu=0$, $\mu=1$, $\mu=2$, $\mu=3$, $\mu=4$) associated with respective subcarrier spacings of 15 kHz, 30 kHz, 60 kHz, 120 kHz, and 240 kHz may utilize a single slot per subframe, two slots per subframe, four slots per subframe, eight slots per subframe, and 16 slots per subframe, respectively. Each slot may include a number (e.g., quantity) of symbols (e.g., OFDM symbols). In some implementations, the number (e.g., quantity) of slots for a subframe may depend on a numerology. For a normal cyclic prefix, a slot may include 14 symbols. For an extended cyclic prefix (e.g., applicable for 60 kHz subcarrier spacing), a slot may include 12 symbols. The relationship between the number of symbols per slot, the number of slots per subframe, and the number of slots per frame for a normal cyclic prefix and an extended cyclic prefix may depend on a numerology. It should be understood that reference to a first numerology (e.g., $\mu=0$) associated with a first subcarrier spacing (e.g., 15 kHz) may be used interchangeably between subframes and slots.

[0081] 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.

[0082] FR1 may be associated with one or multiple numerologies (e.g., at least three numerologies). For example, FR1 may be associated with a first numerology (e.g., $\mu=0$), which includes 15 kHz subcarrier spacing; a second numerology (e.g., $\mu=1$), which includes 30 kHz subcarrier spacing; and a third numerology (e.g., $\mu=2$), which includes 60 kHz subcarrier spacing. FR2 may be associated with one or multiple numerologies (e.g., at least 2 numerologies). For example, FR2 may be associated with a third numerology (e.g., $\mu=2$), which includes 60 kHz subcarrier spacing; and a fourth numerology (e.g., $\mu=3$), which includes 120 kHz subcarrier spacing.

[0083] A-IoT is studied by the 3rd Generation Partnership Project (3GPP). Most of the wireless communication devices, such as A-IoT devices, are powered by batteries that need to be replaced or recharged manually. It is impossible to power all the IoT devices by battery that needs to be replaced or recharged manually, which leads to high maintenance cost, serious environmental issues, and even safety hazards for some use cases, for example, wireless sensors in electrical power, and petroleum industries. The automation and digitization of various industries requires new IoT technologies of supporting battery-less devices with no energy storage capability or devices with energy storage that do not need to be replaced or recharged manually. The form factor of such devices must be reasonably small to convey the validity of target use cases.

[0084] Technical Report (TR) 22.840 is being developed by technical specification group (TSG) service and system aspects working group 1 (SA1) to capture use cases, traffic scenarios, device constraints of ambient power-enabled Internet of things and identify new potential service requirements as well as new key performance indicators (KPIs). SA1 are considering devices being either battery-less or with limited energy

storage capability (i.e., using a capacitor) and the energy is provided through the harvesting of radio waves, light, motion, heat, or any other power source that could be seen suitable.

[0085] Considering the limited size and complexity required by practical applications for battery-less devices with no energy storage capability or devices with limited energy storage that do not need to be replaced or recharged manually, the output power of energy harvester is typically from $1\mu\text{W}$ to a few hundreds of μW .

[0086] Conventional cellular devices may not work well with energy harvesting due to their peak power consumption of higher than 10mW . An example type of A-IoT device is asset identification, which presently has to resort mainly to barcodes and radio-frequency identifications (RFIDs), also known as tags, in most industries. The main advantages of these two technologies is the ultra-low complexity and small form factor of the tags. However, the limited reading range of a few meters usually requires handheld scanning which leads to labor intensive and time-consuming operations, or RFID portals/gates which leads to costly deployments. Moreover, the lack of interference management scheme results in severe interference between RFID readers and capacity problems, especially in case of dense deployment. It is hard to support a large-scale network with seamless coverage for RFIDs.

[0087] There are 4 connectivity topologies for A-IoT networks, and 2 types of devices are defined. Both the device i and the device ii have energy storage function, the stored energy may be used for downlink control signalling reception and decoding, uplink transmission preparation and uplink transmission. Power of carrier wave source and/or incident power at the device i or the device ii may come from carrier wave source. A-IoT device (Device i/ii) may be provided with a carrier wave from other node(s) either inside or outside the topology.

[0088] TSG RAN has completed a Rel-18 RAN-level study item (SI) on A-IoT, which provides a terminological and scoping framework for future discussions of A-IoT. This has defined representative use cases, deployment scenarios, connectivity topologies, A-IoT devices, design targets, and required functionalities; it also conducted a preliminary feasibility assessment, and gave recommendations for down-selection in setting the scope of a further working group (WG)-level study.

[0089] The definitions provided in TR 38.848 are taken into this SI, and the following are the general scope, including aspects A to E as below.

[0090] Aspect A: The overall objective shall be to study a harmonized air interface design with minimized differences (where necessary) for A-IoT to enable the following devices. Device i: which has a peak power consumption of approximately 1 μW , energy storage, initial sampling frequency offset (SFO) up to 10^x ppm, neither downlink (DL) nor uplink (UL) amplification in the device. The UL transmission of the device i is backscattered on a carrier wave provided externally. Device ii: which has a peak power consumption of no more than a few hundred μW , energy storage, initial SFO up to 10^x ppm, both DL and/or UL amplification in the device. The UL transmission of the device ii may be generated internally by the device ii itself, or be backscattered on a carrier wave provided externally.

[0091] X is to be decided in WGs. It is to be understood that “no more than a few hundred μW ” means WGs are not tasked with setting a particular value, and that it will be for WG discussions to determine if a presented design with corresponding power consumption satisfies the “no more than a few hundred μW ” requirement. Coverage design target: maximum distance of 10-50m with device indoors as per TR 38.848: “...a range that WGs can sub-select within”. For topologies 1 & 2 (UE as intermediate node under NW control) per TR 38.848, with no RRC states, no mobility (i.e. at least no cell selection/re-selection -like function), no HARQ, no ARQ.

[0092] Aspect B: Deployment scenarios with the following characteristics, referenced to the tables in Clause 4.2.2 of TR 38.848. Deployment scenario 1 with topology 1: base station and coexistence characteristics: Micro-cell, co-site. Deployment scenario 2 with Topology 2 and UE as intermediate node, under network control: base station and coexistence characteristics: Macro-cell, co-site; and the location of intermediate node is indoor.

[0093] Aspect C: FR1 licensed spectrum in FDD. Aspect D: Spectrum deployment in-band to NR, in guard-band to LTE/NR, in standalone band(s). Aspect E: Traffic types DO-DTT, DT, with focus on rUC1 (indoor inventory) and rUC4 (indoor command). From RAN#104, the study will assess whether the harmonized air interface design (per bullet ‘A’ above) can address the DO-A (Device-originated autonomous) use case, only to identify which part(s) of the harmonized air interface design (per bullet ‘A’ above) is/are not sufficient for the DO-A use case.

[0094] Transmission from A-IoT device (including backscattering when used) can occur at least in UL spectrum.

[0095] The 4 connectivity topologies for A-IoT networks and devices are defined for the purposes of the study. In all these topologies, the A-IoT device may be provided with a carrier wave from other node(s) either inside or outside the topology. The links in each topology may be bidirectional or unidirectional.

[0096] The BS, UE, assisting node, or intermediate node could be multiple BSs or UEs, respectively. The mixture of indoor and outdoor placement of such nodes is regarded as a network implementation choice. Account would need to be taken of potential impact on device or node complexity. In the connectivity topologies, this does not imply the existence of multi-hop assisting or intermediate nodes.

[0097] FIG. 1B illustrates an example of topology 1 associated with aspects of the present disclosure. As shown in FIG. 1B, the ambient IoT device 121 communicates with a BS 122 directly and bi-directionally. The communication between the BS 122 and the ambient IoT device 121 includes ambient IoT data and/or signalling. This topology includes the possibility of a transmission from the BS 122 to the ambient IoT device 121 and a different possibility of a transmission from the ambient IoT device 121 to the BS 122.

[0098] FIG. 1C illustrates an example of topology 2 associated with aspects of the present disclosure. As shown in FIG. 1C, the ambient IoT device 131 communicates with an intermediate node 132 and the BS 133 bi-directionally. In this topology, the intermediate node 131 can be a relay node, a IAB node, a UE, a repeater, etc., which is capable of ambient IoT. The intermediate node 132 transfers ambient IoT data and/or signalling between the BS 133 and the ambient IoT device 131.

[0099] FIG. 1D illustrates an example of topology 3 associated with aspects of the present disclosure. As shown in FIG. 1D, the ambient IoT device 141 receives data and/or signalling from the assisting node 142 and transmits data and/or signalling to the BS 143. FIG. 1E illustrates another example of topology 3 associated with aspects of the present disclosure. The ambient IoT device 141 receives data and/or signalling from the BS 143 and transmits data/signalling to the assisting node 142. In this topology, the assisting node 142 can be a relay node, a IAB node, a UE, a repeater, etc., which is capable of ambient IoT.

[0100] FIG. 1F illustrates an example of topology 4 associated with aspects of the present disclosure. As shown in FIG. 1F, the ambient IoT device 151 communicates with a UE 152 bi-directionally. The communication between UE 152 and the ambient IoT device 151 includes ambient IoT data and/or signalling.

[0101] If the carrier wave from a BS cannot provide enough energy, whether/how additional trigger mechanism and procedure should be studied for topologies 1-4.

[0102] For UL transmission, the carrier wave from a BS cannot provide enough energy efficiently, whether/how to trigger a carrier wave from other node(s) (e.g., carrier wave source, intermedia node, assisting node) should be studied and related trigger mechanism and procedure should be designed. For example, as shown in FIG. 1B and FIG. 1C, the carrier wave source may be outside of the topology, or the intermediated node in topology 2 may be the carrier wave source. For topology 3, as shown in FIG. 1D and FIG. 1E, the assisting node 141 maybe the carrier wave source.

[0103] The A-IoT (e.g., tag) may not have energy, or its energy may not be enough, or there is long distance between the BS and A-IoT device. In other words, energy stored by the A-IoT device or the carrier wave/energy provided by the BS cannot ensure uplink transmission efficiently.

[0104] In addition, for both UL and DL transmission, how to select suitable carrier wave source to supply energy for a certain A-IoT device should be studied.

[0105] In view of the above discussions, some embodiments of the present disclosure provide a solution for carrier wave transmission. In one aspect of the solution of the present disclosure, a first device transmits, to at least one second device, a first DL transmission to trigger the at least one second device to perform at least one carrier wave transmission to at least one third device. The at least one carrier wave transmission is used to carry at least one UL transmission of the at least one third device. In this way, the at least one carrier wave transmission is triggered by the first device. Therefore, the UL transmission of at least one third device is carried by the at least one carrier wave transmission and the communication performance is improved. Principles and implementations of embodiments of the present disclosure will be described in detail below with reference to FIGS. 2-13.

[0106] FIG. 2A illustrates a signaling chart illustrating an example process 200A in accordance with aspects of the present disclosure. The process 200A may involve the first device 201, the second device 202 and the third device 203. It would be appreciated that although the process 200A is applied in the communication environment 100 of FIG. 1A, this process may be likewise applied to other communication scenarios with similar issues.

[0107] In the process 200A, the first device 201 transmits 210 a first DL transmission 215 to the second device 202, and further the second device 202 is triggered to perform at least one carrier wave transmission 250 to at least one third device. The at least one carrier wave transmission will be used by the third device to carry at least one UL transmission of itself. In other words, the first device 201 transmits the first DL transmission to trigger the second device 202 to provide carrier wave, which will be used for the UL transmission from the at least one third device.

[0108] In some embodiments, the first device 201 may comprise a base station. The third device 203 may comprise an A-IoT device. The first device 201 may also provide energy or carrier wave to the third device 203. In the case that the energy stored by the third device 203 or the carrier wave/energy provided by the first device 201 cannot ensure uplink transmission efficiently, the third device 203 need obtain carrier wave or energy from other nodes, e.g., the second device 202. The second device 202 may be a carrier wave source. For instance, the second device may comprise one of a terminal device or an integrated access and backhaul (IAB) node. Alternatively or additionally, the second device may act as one of: an assisting node, an intermediate node, a relay node, or a repeater for the at least one third device. It is to be understood that the number of first device, the second device or the third device is only for the purpose of illustration without suggesting any limitations. The process 200A may include any suitable number of devices adapted for implementing embodiments of the present disclosure. Although not shown, it would be appreciated that one or more second devices or second third devices may be comprised in the process 200A.

[0109] In an example, a BS may trigger carrier wave transmission independently. The BS may send a first DL transmission (via, e.g., a downlink control signalling or higher layer signalling, MAC CE/RRC signalling) to trigger carrier wave transmissions of a carrier wave source.

[0110] Alternatively or additionally, the first DL transmission may comprise: identity (ID) information of the at least one second device, e.g., ID information of at least one carrier wave source; ID information of the at least one third device, e.g., ID information of at least one ambient IoT device; region information of a region associated with the at least one second device e.g., a zone ID where the at least one carrier wave source is located; region information of a region associated with the at least one third device e.g., a zone ID where the at least one ambient IoT is located; an indication to activate or deactivate the at least one carrier wave transmission, e.g., a trigger flag or an on/off flag to active/inactive at least one carrier wave transmission; a time gap between the first DL transmission and a start of at least one time interval of the at least one carrier wave transmission; a time duration of the at least one carrier wave transmission; the number of the at least one carrier wave transmission, e.g., the number of timeslots; a period of the at least one carrier wave transmission e.g., 5ms or 10ms; or any combination of two or more of the above-mentioned items. It is to be understood that each carrier wave transmission may take a certain time duration unit, e.g., 1ms timeslot or several symbols.

[0111] In an example, a time gap refers to a duration between the first DL transmission and the starting time interval of multiple carrier wave transmissions. In another example, the time gap refers to a duration between the first DL transmission and the starting time interval of a carrier wave transmission, i.e., one shot transmission.

[0112] In an example, the value or offset value of the time gap may be an explicit indicator in first DL transmission, e.g., time gap value is equal to 4 time units. In another example, the value or offset value of the time gap may be indicated by the first DL transmission implicitly. In other words, the reference time is the time duration on which the first DL transmission is received, and the time gap is a default or (pre)configured time gap value, e.g., based on the capacity or processing time of the at least one third device (e.g., A-IoT device), or (pre)configured by higher layer signalling.

[0113] A time duration of carrier wave transmission or number of transmissions of carrier wave transmission (e.g., number of timeslots). and/or period value (e.g., 5ms or 10ms) of carrier wave transmission. Here, each carrier wave transmission may take a certain time duration unit, e.g., 1ms timeslot or several symbol(s).

[0114] Alternatively or additionally, the first device 201 may determine a list of one or more IDs of one or more third devices. The first device 201 then may transmit the list

to the at least one second device. For instance, in the case of the first device 201 transmits the first DL transmission to the second device 201 and the third device 203, the first device 201 may (pre)configure a list of one or more third devices.

[0115] In an example, a BS sends a first DL transmission to a carrier wave source meanwhile sends the first DL transmission to at least one A-IoT device. The BS may configure or preconfigure a list of one or more tag IDs or tag RNTIs (i.e., A-IoT device) to carrier wave source for decoding the first DL transmission. The list information can be included in a physical layer or higher layer signalling, e.g., a medium access control (MAC) control element (MAC CE) or radio resource control (RRC) signalling.

[0116] On the other side of the communication, the second device 202 may receive a list of one or more IDs of one or more third device from the first device, in a first DL transmission or in a separated transmission. Based on the list and the first DL transmission, the second device 202 may determine the at least one third device. In an example, after receiving the list, the carrier wave source may try to decode each first DL transmission, i.e., performing blind detection. If the detected tag RNTI or tag ID is matched to the one of tag RNTIs or tag IDs in the list, the carrier wave source may perform carrier wave transmission. Considering the carrier wave source has higher capacity, a larger amount of tag RNTI or tag ID information may be configured or preconfigured to the carrier wave source, and blind detection may be performed on all of the tag RNTIs or tag IDs in each time interval.

[0117] Additionally, the first DL transmission may comprise a first stage transmission and a second stage transmission. In some embodiments, the first stage transmission of the first DL transmission may comprise one or more of the following: at least one ID of the at least one second device; at least one ID of the at least one third device; region information of a region associated with the at least one second device; region information of a region associated with the at least one third device; an indication to activate or deactivate the at least one carrier wave transmission; a time gap between the first DL transmission and a start of at least one time interval of the at least one carrier wave transmission; a time duration of the at least one carrier wave transmission; a number of the at least one carrier wave transmission; a period of the at least one carrier wave transmission, or any combination of two or more of the above-mentioned items.

[0118] In some embodiments, the second stage transmission of the first DL transmission may comprise scheduling information for the at least one third device indicated by the at least one ID or the region information of at least one third device in the first stage transmission of the first DL transmission.

[0119] For example, the first DL transmission may include two stages. In first stage of the first DL transmission, the first DL transmission at least includes tag specific ID information and second ID information. The tag specific ID information indicates the tag (i.e., A-IoT device) scheduled by the first DL transmission. Alternatively, the tag specific ID can be a group ID for one more A-IoT devices. The second ID information indicates the carrier wave source triggered by the first DL transmission. In an example, the second ID information may be the carrier wave source ID information. The second ID information may be a carrier wave source ID or a group ID for one or more carrier wave sources. In another example, the second ID information may be a region related information, e.g., a zone ID. The zone ID indicates the scheduled A-IoT device located in a certain region associated with the zone ID. If the carrier wave source is also located the zone ID related region, the carrier wave source will perform carrier wave transmissions.

[0120] The second stage of the first DL transmission may be used to further provide scheduling information for the scheduled tag which is associated with the tag specific ID information. In addition, the second stage of the first DL transmission may be used to further provide scheduling information for the triggered carrier wave source which is associated with the second ID information.

[0121] After receiving 220 the first DL transmission 215 from the first device 201, the second device 202 performs 240 the at least one carrier wave transmission 250 to the at least one third device based on the first DL transmission 215. In an example, a carrier wave source (i.e. the second device) receives the first DL transmission and performs blind detection to determine whether the carrier wave source ID information in the first DL transmission matches to its own ID information, and if so, the carrier wave source performs carrier wave transmission. In another example, in addition to receives the first DL transmission and performs blind detection to determine whether the carrier wave source ID information matches its own ID, the carrier wave source further determines whether a trigger flag is on or positive, and if so, the carrier wave source performs carrier wave transmission.

[0122] Additionally, the carrier wave source may perform one or more carrier wave transmissions with the indicated time interval (e.g., time gap and/or time duration) and/or period. For example, the carrier wave source may perform the carrier wave transmission with time gap if there is one shot transmission. The carrier wave source may perform the carrier wave transmissions with time gap and duration if there are multiple transmission. The carrier wave source may perform the carrier wave transmissions with time duration if the time gap is default or (pre)configured. The carrier wave source may perform the carrier wave transmissions without period indication if there is one set of carrier wave transmissions is transmitted, e.g., one set of above 1 or 2 or more transmissions is transmitted. The carrier wave source may perform the carrier wave transmissions with period indication if there are multiple sets of carrier wave transmissions are transmitted periodically, e.g., multiple sets of above 1 or 2 or more transmissions are transmitted.

[0123] In some embodiments, if the first stage transmission of the first DL transmission comprises at least one ID or the region information of the at least one second device and the at least one second device indicated by the first stage transmission of the first DL transmission comprises the second device 202, the second device 202 may perform the at least one carrier wave transmission. In other words, if the ID information of the second device 202 is indicated by the first stage transmission of the first DL transmission, the second device 202 may perform the at least one carrier wave transmission. For example, the carrier wave source receives the first DL transmission and detects whether the carrier wave source ID or the group ID in the first stage of the first DL transmission matches its own ID, and if so, the carrier wave source performs carrier wave transmission.

[0124] In some embodiments, if the first stage transmission of the first DL transmission comprises the region information of the region and the second device is located in the region, the second device 202 may perform the at least one carrier wave transmission. For example, the carrier wave source receives the first DL transmission and detects whether the carrier wave source locates in the region associated with the region information, e.g., a zone ID, in the first stage of the first DL transmission, and if so, the carrier wave source may perform the carrier wave transmission.

[0125] In addition, the first DL transmission may further comprise an ID of a group or a pair. The group or the pair may comprise at least one second device and at least one

third device. Alternatively, the group or the pair may comprise an ID of the region associated with the at least one second device within the region and at least one third device within the region. For instance, the tag specific ID information and the second ID information can be one group ID or a pair ID, i.e., the BS (pre)configures the tag and the carrier wave source in a group or as a pair.

[0126] Alternatively or additionally, if a third device scheduled by the first DL transmission is in a group or a pair and the second device is in the group or the pair of the third device, the second device 202 may perform the at least one carrier wave transmission. For instance, the group may comprise one or more tags and one or more carrier wave sources. If the tag in the group is scheduled, the carrier wave source in the same group will perform carrier wave transmission.

[0127] In some embodiments, the first device 201 may further transmit 225 the the first DL transmission 215 to the third device 203 to schedule at least one UL transmission from the third device 203. On the other side of the communication, the third device 203 receives 235 the first DL transmission 215 from the first device 201 to trigger at least one UL transmission of the third device 203. The first DL transmission may be further transmitted to the at least one third device.

[0128] Based on the first DL transmission 215, the third device 203 performs 260 the UL transmission using the at least one carrier wave transmission. Alternatively or additionally, the third device 203 may receive 255 at least one carrier wave transmission 250 from the at least one second device. Based on the at least one carrier wave transmission and the first DL transmission, the third device 203 may perform the UL transmission. In an example, the A-IoT device may perform backscatter transmission based on an indication in the first transmission. The backscatter transmission is performed based on the carrier wave transmissions from the carrier wave source. A BS (e.g., in topology 1), an intermediate node (e.g., in topology 2) or an assisting node (e.g., in topology 3) receives the UL transmission from A-IoT device.

[0129] In some embodiments, if at least one ID of at least one third device in a first stage transmission of the first DL transmission comprises an ID or region information of the third device, the third device 203 may perform the UL transmission based on the second stage transmission of the first DL transmission. For example, the A-IoT device may receive the first stage of the first DL transmission and detect whether the tag specific

ID information or information of the group ID in the first stage of the first DL transmission matches it, and if so, the A-IoT device may further detect the second stage of the first DL transmission. The A-IoT device then may perform UL transmission based on the scheduling information in the first DL transmission. Additionally, the first DL transmission may be transmitted via a physical layer control information or a MAC CE or a RRC message.

[0130] FIG. 2B illustrates a signaling chart illustrating another example process 200B in accordance with aspects of the present disclosure. The process 200B may involve the first device 201, the second device 202 and the third device 203. It would be appreciated that although the process 200B is applied in the communication environment 100 of FIG. 1A, this process may be likewise applied to other communication scenarios with similar issues.

[0131] In the process 200B, the first device 201 transmits 265 a first DL transmission 218 to the second device 202 to trigger the second device 202 to perform at least one carrier wave transmission to at least one third device. The at least one carrier wave transmission is used to carry at least one UL transmission of the at least one third device. In other words, the first device 201 transmits the first DL transmission to trigger the second device 202 provide carrier wave for the UL transmission from the at least one third device.

[0132] Alternatively or additionally, the first device 201 may transmit 273 a second DL transmission 275 to the third device 203 to schedule the at least one UL transmission of the third device 203. Correspondingly, the third device 203 receives 278 the second DL transmission 275 from the first device 201. In an example, the BS may send a first DL transmission to an intermediate node, an assisting node or a carrier wave source for providing carrier wave transmission for backscatter transmission of an A-IoT device. The BS may further send a second DL transmission to the A-IoT device. In addition, the second DL transmission may be transmitted via a physical layer control information or a MAC CE or a RRC message.

[0133] After receiving 270 the first DL transmission 268 from the first device 201, the second device 202 performs 280 the at least one carrier wave transmission 283 to the third device 203 based on the first DL transmission 268. Based on the second DL transmission 275, the third device 203 performs 290 the UL transmission using the at

least one carrier wave transmission 283. Alternatively or additionally, the third device 203 may receive 285 at least one carrier wave transmission 283 from the at least one second device.

[0134] FIG. 3 illustrates an example process 300 in accordance with aspects of the present disclosure. The process 300 may involve BS 301, ambient IoT device 302 and carrier wave source 303. It is understood that the process 300 can be considered as a more specific example of the process 200A in FIG. 2A. Thus, the BS 301 in FIG. 3 may be an example of the first device 201 in FIG.2A, the ambient IoT device 302 in FIG. 3 may be an example of the third device 203 in FIG.2A, the carrier wave source 303 in FIG. 3 may be an example of the second device 202 in FIG.2A. In process 300, the carrier wave source 303 may be an assisting node, an intermediate node, a relay node, an IAB node, a UE, a repeater, etc. The ambient IoT device 302 may be a tag or a UE.

[0135] As shown in FIG. 3, UL transmission and carrier transmission are triggered based on a single DL transmission. At 305, the BS 301 transmits the first DL transmission to the ambient IoT device 302 to schedule UL transmission and the carrier wave source 303 to provide carrier wave for the UL backscatter transmission from ambient IoT device. The BS 301 may configure or preconfigure a list of tag (i.e., ambient IoT device) RNTIs or tag IDs to carrier wave source 303 for decoding the first DL transmission.

[0136] The BS 301 may configure or preconfigure the ambient IoT device 302 and the carrier wave source 303 in a group. If the ambient IoT device 302 in the group is scheduled, and the carrier wave source 303 detects the group ID or group RNTI, the carrier wave source 303 will perform the carrier wave transmission for the backscatter transmission of the ambient IoT device 302. Considering the carrier wave source 303 may have a dedicated service capacity, it may perform blind detection of a certain tag with the same group ID in each time interval.

[0137] At 310, the carrier wave source 303 performs a carrier wave transmission based on the first DL transmission. The carrier wave source 303 may perform multiple carrier wave transmissions, for example, at 310, 320, 330 and 340. The time interval between 305 and 310 is the time gap. The time interval between 310 and 340 is the time duration.

[0138] At 315, the ambient IoT device 302 performs a UL transmission. The ambient IoT device 302 may perform multiple UL transmissions, for example, at 325, 335, and

345. The BS 301 receives the UL transmission from the ambient IoT device 302. Alternatively or additionally, the first DL transmission may comprise two-stage indications, and the carrier wave source 303 may be triggered by the first DL transmission or the first stage of the first DL transmission. The first DL transmission at least includes a tag specific ID information and second ID information. The second ID information may comprise at least one of tag specific ID information or zone ID information. In first stage of the first DL transmission, the downlink control information (i.e., the first DL transmission) includes at least a tag specific ID information and zone ID information. In a further example, the downlink control information (i.e., the first DL transmission) includes at least a tag specific ID information and a carrier wave source ID information. The second stage of the first DL transmission is used to further schedule at least one tag (i.e., the ambient IoT device) associated with the tag specific ID information.

[0139] FIG. 4 illustrates an example process 400 in accordance with aspects of the present disclosure. The process 400 may involve BS 401, ambient IoT device 402 and carrier wave source 403. It is understood that the process 400 can be considered as a more specific example of the process 200B in FIG. 2B. Thus, the BS 401 in FIG. 4 may be an example of the first device 201 in FIG.2B, the ambient IoT device 402 in FIG. 4 may be an example of the third device 203 in FIG.2B, the carrier wave source 403 in FIG. 4 may be an example of the second device 202 in FIG.2B. In process 400, the carrier wave source 403 may be an assisting node, an intermediate node, a relay node, an IAB node, a UE, a repeater, etc. The ambient IoT device 402 may be a tag or a UE.

[0140] As shown in FIG. 4, UL transmission and carrier transmission are triggered based on separated DL transmissions. At 405, the BS 401 transmits the second DL transmission to the ambient IoT device 402. At 410, the BS 401 transmits the first DL transmission to the carrier wave source 403 to provide carrier wave for the UL backscatter transmission from ambient IoT device 402. At 415, the carrier wave source 403 performs a carrier wave transmission based on the first DL transmission. The carrier wave source 403 may perform multiple carrier wave transmissions, for example, at 425, 435, and 445. At 420, the ambient IoT device 402 performs a UL transmission. The ambient IoT device 402 may perform multiple UL transmissions, for example, at 430, 440, and 450.

[0141] For the second transmission, it can be a downlink control signalling and/or a DL data transmission (e.g., a MAC CE/RRC signalling) for uplink scheduling. For the

first DL transmission, it can be transmitted before or after or at the same time interval as the second transmission. The first DL transmission may be a physical control signalling or a higher layer signalling, e.g., a MAC CE/RRC signalling, including at least one or more the indicators. For example, the first DL transmission may include a trigger flag or an on/off flag to indicate whether to perform a transmission for energy supply within an associated time duration, e.g., a timeslot.

[0142] FIG. 5 illustrates an example of a device 500 that supports carrier wave transmission in accordance with aspects of the present disclosure. The device 500 may be an example of a network entity 102 as described herein. The device 500 may support wireless communication with one or more network entities 102, UEs 104, or any combination thereof. The device 500 may include components for bi-directional communications including components for transmitting and receiving communications, such as a processor 502, a memory 504, a transceiver 506, and, optionally, an I/O controller 508. 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).

[0143] The processor 502, the memory 504, the transceiver 506, 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 502, the memory 504, the transceiver 506, or various combinations or components thereof may support a method for performing one or more of the operations described herein.

[0144] In some implementations, the processor 502, the memory 504, the transceiver 506, 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 502 and the memory 504 coupled with the processor 502 may be configured to perform one or more of the functions described herein (e.g., executing, by the processor 502, instructions stored in the memory 504).

[0145] For example, the processor 502 may support wireless communication at the device 500 in accordance with examples as disclosed herein. The processor 502 may be configured to operable to support a means for transmitting, via the transceiver to at least one second device, a first downlink (DL) transmission to trigger the at least one second device to perform at least one carrier wave transmission to at least one third device, wherein the at least one carrier wave transmission is used to carry at least one uplink (UL) transmission of the at least one third device. The processor 502 may be configured to operable to support other means for other implementations of method 1100.

[0146] The processor 502 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 502 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 502. The processor 502 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 504) to cause the device 500 to perform various functions of the present disclosure.

[0147] The memory 504 may include random access memory (RAM) and read-only memory (ROM). The memory 504 may store computer-readable, computer-executable code including instructions that, when executed by the processor 502 cause the device 500 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. In some implementations, the code may not be directly executable by the processor 502 but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some implementations, the memory 504 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.

[0148] The I/O controller 508 may manage input and output signals for the device 500. The I/O controller 508 may also manage peripherals not integrated into the device 500. In some implementations, the I/O controller 508 may represent a physical connection or port to an external peripheral. In some implementations, the I/O controller 508 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 508 may be implemented as part of a processor, such as the processor 506. In some implementations, a user may interact with the device 500 via the I/O controller 508 or via hardware components controlled by the I/O controller 508.

[0149] In some implementations, the device 500 may include a single antenna 510. However, in some other implementations, the device 500 may have more than one antenna 510 (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 506 may communicate bi-directionally, via the one or more antennas 510, wired, or wireless links as described herein. For example, the transceiver 506 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 506 may also include a modem to modulate the packets, to provide the modulated packets to one or more antennas 510 for transmission, and to demodulate packets received from the one or more antennas 510. The transceiver 506 may include one or more transmit chains, one or more receive chains, or a combination thereof.

[0150] 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 510 for transmitting the amplified signal into the air or wireless medium.

[0151] 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 510 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.

[0152] FIG. 6 illustrates an example of a device 600 that supports carrier wave transmission in accordance with aspects of the present disclosure. The device 600 may be an example of a network entity 102 or a UE 104 as described herein. The device 600 may support wireless communication with one or more network entities 102, UEs 104, or any combination thereof. The device 600 may include components for bi-directional communications including components for transmitting and receiving communications, such as a processor 602, a memory 604, a transceiver 606, and, optionally, an I/O controller 608. These components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

[0153] The processor 602, the memory 604, the transceiver 606, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. For example, the processor 602, the memory 604, the transceiver 606, or various combinations or components thereof may support a method for performing one or more of the operations described herein.

[0154] In some implementations, the processor 602, the memory 604, the transceiver 606, or various combinations or components thereof may be implemented in hardware (e.g., in communications management circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), a field-programmable gate array (FPGA) or other programmable logic device, a discrete gate or transistor logic, discrete hardware components, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure. In some implementations, the processor 602 and the memory 604 coupled with the processor 602 may be configured to perform one or more of the functions described herein (e.g., executing, by the processor 602, instructions stored in the memory 604).

[0155] For example, the processor 602 may support wireless communication at the device 600 in accordance with examples as disclosed herein. The processor 602 may be

configured to operable to support a means for receiving, via the transceiver from a first device, a first downlink (DL) transmission to trigger the second device to perform at least one carrier wave transmission to at least one third device, wherein the at least one carrier wave transmission is used to carry at least one uplink (UL) transmission of the at least one third device; and a means for performing, based on the first DL transmission, the at least one carrier wave transmission to the at least one third device. The processor 602 may be configured to operable to support other means for other implementations of method 1200.

[0156] The processor 602 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, a microcontroller, an ASIC, an FPGA, a programmable logic device, a discrete gate or transistor logic component, a discrete hardware component, or any combination thereof). In some implementations, the processor 602 may be configured to operate a memory array using a memory controller. In some other implementations, a memory controller may be integrated into the processor 602. The processor 602 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 604) to cause the device 600 to perform various functions of the present disclosure.

[0157] The memory 604 may include random access memory (RAM) and read-only memory (ROM). The memory 604 may store computer-readable, computer-executable code including instructions that, when executed by the processor 602 cause the device 600 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. In some implementations, the code may not be directly executable by the processor 602 but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some implementations, the memory 604 may include, among other things, a basic I/O system (BIOS) which may control basic hardware or software operation such as the interaction with peripheral components or devices.

[0158] The I/O controller 608 may manage input and output signals for the device 600. The I/O controller 608 may also manage peripherals not integrated into the device 600. In some implementations, the I/O controller 608 may represent a physical connection or port to an external peripheral. In some implementations, the I/O controller 608 may utilize an operating system such as iOS®, ANDROID®, MS-WINDOWS®,

OS/2®, UNIX®, LINUX®, or another known operating system. In some implementations, the I/O controller 608 may be implemented as part of a processor, such as the processor 606. In some implementations, a user may interact with the device 600 via the I/O controller 608 or via hardware components controlled by the I/O controller 608.

[0159] In some implementations, the device 600 may include a single antenna 610. However, in some other implementations, the device 600 may have more than one antenna 610 (i.e., multiple antennas), including multiple antenna panels or antenna arrays, which may be capable of concurrently transmitting or receiving multiple wireless transmissions. The transceiver 606 may communicate bi-directionally, via the one or more antennas 610, wired, or wireless links as described herein. For example, the transceiver 606 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 606 may also include a modem to modulate the packets, to provide the modulated packets to one or more antennas 610 for transmission, and to demodulate packets received from the one or more antennas 610. The transceiver 606 may include one or more transmit chains, one or more receive chains, or a combination thereof.

[0160] A transmit chain may be configured to generate and transmit signals (e.g., control information, data, packets). The transmit chain may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature amplitude modulation (QAM). The transmit chain may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmit chain may also include one or more antennas 610 for transmitting the amplified signal into the air or wireless medium.

[0161] A receive chain may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receive chain may include one or more antennas 610 for receive the signal over the air or wireless medium. The receive chain may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receive chain may include at least one demodulator

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

[0162] FIG. 7 illustrates an example of a device 700 that supports carrier wave transmission in accordance with aspects of the present disclosure. The device 700 may be an example of a UE 104 as described herein. The device 700 may support wireless communication with one or more network entities 102, UEs 104, or any combination thereof. The device 700 may include components for bi-directional communications including components for transmitting and receiving communications, such as a processor 702, a memory 704, a transceiver 706, and, optionally, an I/O controller 708. 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).

[0163] The processor 702, the memory 704, the transceiver 706, 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 702, the memory 704, the transceiver 706, or various combinations or components thereof may support a method for performing one or more of the operations described herein.

[0164] In some implementations, the processor 702, the memory 704, the transceiver 706, 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 702 and the memory 704 coupled with the processor 702 may be configured to perform one or more of the functions described herein (e.g., executing, by the processor 702, instructions stored in the memory 704).

[0165] For example, the processor 702 may support wireless communication at the device 700 in accordance with examples as disclosed herein. The processor 702 may be

configured to operable to support a means for receiving, via the transceiver from a first device, a first downlink (DL) transmission to trigger an uplink (UL) transmission of the third device, wherein the first DL transmission further triggers at least one second device to perform at least one carrier wave transmission to the third device; and a means for performing, based on the first DL transmission, the UL transmission using the at least one carrier wave transmission. The processor 702 may be configured to operable to support other means for other implementations of method 1300.

[0166] The processor 702 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 702 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 702. The processor 702 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 704) to cause the device 700 to perform various functions of the present disclosure.

[0167] The memory 704 may include random access memory (RAM) and read-only memory (ROM). The memory 704 may store computer-readable, computer-executable code including instructions that, when executed by the processor 702 cause the device 700 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. In some implementations, the code may not be directly executable by the processor 702 but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some implementations, the memory 704 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.

[0168] The I/O controller 708 may manage input and output signals for the device 700. The I/O controller 708 may also manage peripherals not integrated into the device M02. In some implementations, the I/O controller 708 may represent a physical connection or port to an external peripheral. In some implementations, the I/O controller 708 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 708 may be implemented as part of a processor, such as the processor 706. In some implementations, a user may interact with the device 700 via the I/O controller 708 or via hardware components controlled by the I/O controller 708.

[0169] In some implementations, the device 700 may include a single antenna 710. However, in some other implementations, the device 700 may have more than one antenna 710 (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 706 may communicate bi-directionally, via the one or more antennas 710, wired, or wireless links as described herein. For example, the transceiver 706 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 706 may also include a modem to modulate the packets, to provide the modulated packets to one or more antennas 710 for transmission, and to demodulate packets received from the one or more antennas 710. The transceiver 706 may include one or more transmit chains, one or more receive chains, or a combination thereof.

[0170] 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 710 for transmitting the amplified signal into the air or wireless medium.

[0171] 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 710 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.

[0172] FIG. 8 illustrates an example of a processor 800 that supports carrier wave transmission in accordance with aspects of the present disclosure. The processor 800 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 800 may include a controller 802 configured to perform various operations in accordance with examples as described herein. The processor 800 may optionally include at least one memory 804. Additionally, or alternatively, the processor 800 may optionally include one or more arithmetic-logic units (ALUs) 800. 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).

[0173] The processor 800 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 800) 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).

[0174] The controller 802 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 800 to cause the processor 800 to support various operations in accordance with examples as described herein. For example, the controller 802 may operate as a control unit of the processor 800, generating control signals that manage the operation of various components of the processor 800. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[0175] The controller 802 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 804 and determine subsequent instruction(s) to be executed to cause the processor 800 to support various operations in accordance with examples as described herein. The controller 802 may be configured to track memory address of instructions associated with the memory 804. The controller 802 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 802 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 800 to cause the processor 800 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 802 may be configured to manage flow of data within the processor 800. The controller 802 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 800.

[0176] The memory 804 may include one or more caches (e.g., memory local to or included in the processor 800 or other memory, such as RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementation, the memory 804 may reside within or on a processor chipset (e.g., local to the processor 800). In some other implementations, the memory 804 may reside external to the processor chipset (e.g., remote to the processor 800).

[0177] The memory 804 may store computer-readable, computer-executable code including instructions that, when executed by the processor 800, cause the processor 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. The controller 802 and/or the processor 800 may be configured to execute computer-readable instructions stored in the memory 804 to cause the processor 800 to perform various functions (e.g., functions or tasks supporting transmit power prioritization). For example, the processor 800 and/or the controller 802 may be coupled with or to the memory 804, the processor 800, the controller 802, and the memory 804 may be configured to perform various functions described herein. In some examples, the processor 800 may include multiple processors and the memory 804 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.

[0178] The one or more ALUs 800 may be configured to support various operations in accordance with examples as described herein. In some implementation, the one or more ALUs 800 may reside within or on a processor chipset (e.g., the processor 800). In some other implementations, the one or more ALUs 800 may reside external to the processor chipset (e.g., the processor 800). One or more ALUs 800 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 800 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 800 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 800 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 800 to handle conditional operations, comparisons, and bitwise operations.

[0179] The processor 800 may support wireless communication in accordance with examples as disclosed herein. The processor 802 may be configured to or operable to support a means for transmitting, to at least one second device, a first downlink (DL) transmission to trigger the at least one second device to perform at least one carrier wave transmission to at least one third device, wherein the at least one carrier wave transmission is used to carry at least one uplink (UL) transmission of the at least one third device. The processor 800 may be configured to or operable to support other means for other implementations of method 1100.

[0180] FIG. 9 illustrates an example of a processor 900 that supports carrier wave transmission in accordance with aspects of the present disclosure. The processor 900 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 900 may include a controller 902 configured to perform various operations in accordance with examples as described herein. The processor 900 may optionally include at least one memory 904. Additionally, or alternatively, the processor 900 may optionally include one or more arithmetic-logic units (ALUs) 900. 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).

[0181] The processor 900 may be a processor chipset and include a protocol stack (e.g., a software stack) executed by the processor chipset to perform various operations (e.g., receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) in accordance with examples as described herein. The processor chipset may include one or more cores, one or more caches (e.g., memory local to or included in the processor chipset (e.g., the processor 900) or other memory (e.g., random access memory (RAM), read-only memory (ROM), dynamic RAM (DRAM), synchronous dynamic RAM (SDRAM), static RAM (SRAM), ferroelectric RAM (FeRAM), magnetic RAM (MRAM), resistive RAM (RRAM), flash memory, phase change memory (PCM), and others).

[0182] The controller 902 may be configured to manage and coordinate various operations (e.g., signaling, receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) of the processor 900 to cause the processor 900 to support various operations in accordance with examples as described herein. For example, the controller 902 may operate as a control unit of the processor 900, generating control signals that manage the operation of various components of the processor 900. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[0183] The controller 902 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 904 and determine subsequent instruction(s) to be executed to cause the processor 900 to support various operations in accordance with examples as described herein. The controller 902 may be configured to track memory address of instructions associated with the memory 904. The controller 902 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 902 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 900 to cause the processor 900 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 902 may be configured to manage flow of data within the processor 900. The controller 902 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 900.

[0184] The memory 904 may include one or more caches (e.g., memory local to or included in the processor 900 or other memory, such as RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementation, the memory 904 may reside within or on a processor chipset (e.g., local to the processor 900). In some other implementations, the memory 904 may reside external to the processor chipset (e.g., remote to the processor 900).

[0185] The memory 904 may store computer-readable, computer-executable code including instructions that, when executed by the processor 900, cause the processor 900 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. The controller 902 and/or the processor 900 may be configured to execute computer-readable instructions stored in the memory 904 to cause the processor 900 to perform various functions (e.g., functions or tasks supporting transmit power prioritization). For example, the processor 900 and/or the controller 902 may be coupled with or to the memory 904, the processor 900, the controller 902, and the memory 904 may be configured to perform various functions described herein. In some examples, the processor 900 may include multiple processors and the memory 904 may include multiple memories. One or more of the multiple processors may be coupled with one or more of the multiple memories, which may, individually or collectively, be configured to perform various functions herein.

[0186] The one or more ALUs 900 may be configured to support various operations in accordance with examples as described herein. In some implementation, the one or more ALUs 900 may reside within or on a processor chipset (e.g., the processor 900). In some other implementations, the one or more ALUs 900 may reside external to the processor chipset (e.g., the processor 900). One or more ALUs 900 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 900 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 900 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 900 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 900 to handle conditional operations, comparisons, and bitwise operations.

[0187] The processor 900 may support wireless communication in accordance with examples as disclosed herein. The processor 902 may be configured to or operable to support a means for receiving, from a first device, a first downlink (DL) transmission to trigger the second device to perform at least one carrier wave transmission to at least one third device, wherein the at least one carrier wave transmission is used to carry at least one uplink (UL) transmission of the at least one third device; and a means for performing, based on the first DL transmission, the at least one carrier wave transmission to the at least one third device. The processor 900 may be configured to or operable to support other means for other implementations of method 1200.

[0188] FIG. 10 illustrates an example of a processor 1000 that supports carrier wave transmission 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).

[0189] 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).

[0190] 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.

[0191] 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.

[0192] 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).

[0193] 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.

[0194] 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.

[0195] 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 a first device, a first downlink (DL) transmission to trigger an uplink (UL) transmission of the third device, wherein the first DL transmission further triggers at least one second device to perform at least one carrier wave transmission to the third device; and a means for performing, based on the first DL transmission, the UL transmission using the at least one carrier wave transmission. The processor 1000 may be configured to or operable to support other means for other implementations of method 1300.

[0196] FIG. 11 illustrates a flowchart of a method 1100 that supports carrier wave transmission in accordance with aspects of the present disclosure. The operations of the

method 1100 may be implemented by a device or its components as described herein. For example, the operations of the method 1100 may be performed by a network entity 102 as described herein. In some implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or alternatively, the device may perform aspects of the described functions using special-purpose hardware.

[0197] At 1105, the method includes transmitting, to at least one second device, a first downlink (DL) transmission to trigger the at least one second device to perform at least one carrier wave transmission to at least one third device, wherein the at least one carrier wave transmission is used to carry at least one uplink (UL) transmission of the at least one third device. 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.

[0198] At 1110, the method may include determining a staggered subband based on the configuration. The operations of 1110 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1110 may be performed by a device as described with reference to FIG. 1A.

[0199] At 1115, the method may include determining physical resources for a signal or a channel in the staggered subband. The operations of 1115 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1115 may be performed by a device as described with reference to FIG. 1A.

[0200] In some embodiment, the first DL transmission may comprise one or more of the following: identity (ID) information of the at least one second device; identity (ID) information of the at least one third device; region information of a region associated with the at least one second device; region information of a region associated with the at least one third device; an indication to activate or deactivate the at least one carrier wave transmission; a time gap between the first DL transmission and a start of at least one time interval of the at least one carrier wave transmission; a time duration of the at least one carrier wave transmission; a number of the at least one carrier wave transmission; or a period of the at least one carrier wave transmission.

[0201] In some embodiment, the method may further include transmitting, to the at least one third device, a second DL transmission to schedule the at least one UL transmission of the at least one third device.

[0202] In some embodiment, the method may further include transmitting, to the at least one third device, the first DL transmission to schedule the at least one UL transmission of the at least one third device.

[0203] In some embodiment, the method may further include determining a list of one or more IDs of one or more third device; and transmitting the list to the at least one second device.

[0204] In some embodiment, the first DL transmission may comprise a first stage transmission and a second stage transmission.

[0205] In some embodiment, the first stage transmission of the first DL transmission may comprises one or more of the following: at least one ID of the at least one second device; at least one ID of the at least one third device; region information of a region associated with the at least one second device; region information of a region associated with the at least one third device; an indication to activate or deactivate the at least one carrier wave transmission; a time gap between the first DL transmission and a start of at least one time interval of the at least one carrier wave transmission; a time duration of the at least one carrier wave transmission; a number of the at least one carrier wave transmission; or a period of the at least one carrier wave transmission.

[0206] In some embodiment, the second stage transmission of the first DL transmission may comprise scheduling information for the at least one third device indicated by the at least one ID or the region information of at least one third device in the first stage transmission of the first DL transmission.

[0207] In some embodiment, the first DL transmission may further comprise: an ID of a group or a pair, wherein the group or the pair comprises: the at least one second device and at least one third device; or an ID of the region associated with the at least one second device within the region and at least one third device within the region.

[0208] In some embodiment, the first device may comprise a base station; the second device may comprise one of a terminal device or an integrated access and backhaul (IAB) node; the second device may act as one of: an assisting node, an intermediate node, a

relay node, or a repeater for the at least one third device; or the third device may comprise an ambient Internet of thing (A-IoT) device.

[0209] In some embodiment, the first DL transmission may be transmitted via a physical layer control information or a medium access control (MAC) control element (MAC CE) or a radio resource control (RRC) message; or the second DL transmission may be transmitted via a physical layer control information or a MAC CE or a RRC message.

[0210] FIG. 12 illustrates a flowchart of a method 1200 that supports a carrier wave transmission 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 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.

[0211] At 1205, the method includes receiving, from a first device, a first downlink (DL) transmission to trigger the second device to perform at least one carrier wave transmission to at least one third device, wherein the at least one carrier wave transmission is used to carry at least one uplink (UL) transmission of the at least one third device. 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.

[0212] At 1210, the method includes performing, based on the first DL transmission, the at least one carrier wave transmission to the at least one third 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.

[0213] In some embodiment, the first DL transmission may comprise one or more of the following: identity (ID) information of the at least one second device; identity (ID) information of the at least one third device; region information of a region associated with the at least one second device; region information of a region associated with at least one third device; an indication to activate or deactivate the at least one carrier wave

transmission; a time gap between the first DL transmission and a start of at least one time interval of the at least one carrier wave transmission; a time duration of the at least one carrier wave transmission; a number of the at least one carrier wave transmission; or a period of the at least one carrier wave transmission.

[0214] In some embodiment, the first DL transmission may be further transmitted to the at least one third device.

[0215] In some embodiment, the method may further include receiving, from the first device, a list of one or more IDs of one or more third device; and determining the at least one third device based on the list and the first DL transmission.

[0216] In some embodiment, the first DL transmission may comprise a first stage transmission and a second stage transmission. In some embodiment, the first stage transmission of the first DL transmission may comprise one or more of the following: at least one ID of the at least one second device; at least one ID of the at least one third device; region information of a region associated with the at least one second device; region information of a region associated with the at least one third device; an indication to activate or deactivate the at least one carrier wave transmission; a time gap between the first DL transmission and a start of at least one time interval of the at least one carrier wave transmission; a time duration of the at least one carrier wave transmission; a number of the at least one carrier wave transmission; or a period of the at least one carrier wave transmission.

[0217] In some embodiment, the second stage transmission of the first DL transmission may comprise scheduling information for the at least one third device indicated by the at least one ID of at least one third device in the first stage transmission of the first DL transmission.

[0218] In some embodiment, the method may further include performing the at least one carrier wave transmission by performing the at least one carrier wave transmission based on determining that the first stage transmission of the first DL transmission comprises at least one ID or the region information of the at least one second device and the at least one second device comprises the second device.

[0219] In some embodiment, the method may further include performing the at least one carrier wave transmission by performing the at least one carrier wave transmission

based on determining that a first stage transmission of the first DL transmission comprises the region information of the region and the second device is located in the region.

[0220] In some embodiment, the first DL transmission may further comprise an ID of a group or a pair, wherein the group or the pair comprises: the at least one second device and at least one third device; or an ID of the region associated with the at least one second device within the region and the at least one third device within the region.

[0221] In some embodiment, the method may further include performing the at least one carrier wave transmission by performing the at least one carrier wave transmission based on determining that a third device scheduled by the first DL transmission is in a group or a pair and the second device is in the group or the pair of the third device.

[0222] In some embodiment, the first device may comprise a base station; the second device may comprise one of a terminal device or an integrated access and backhaul (IAB) node; the second device may act as one of: an assisting node, an intermediate node, a relay node, or a repeater for the at least one third device; or the third device may comprise an ambient Internet of thing (A-IoT) device.

[0223] In some embodiment, the first DL transmission may be transmitted via a physical layer control information or a medium access control (MAC) control element (MAC CE) or a radio resource control (RRC) message; or the second DL transmission may be transmitted via a physical layer control information or a MAC CE or a RRC message.

[0224] FIG. 13 illustrates a flowchart of a method 1300 that supports carrier wave transmission 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.

[0225] At 1305, the method includes receiving, from a first device, a first downlink (DL) transmission to trigger an uplink (UL) transmission of the third device, wherein the first DL transmission further triggers at least one second device to perform at least one

carrier wave transmission to the third device. 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.

[0226] At 1310, the method includes performing, based on the first DL transmission, the UL transmission using the at least one carrier wave transmission. 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.

[0227] In some embodiment, the first DL transmission may comprise one or more of the following: identity (ID) information of at least one second device; identity (ID) information of at least one third device; region information of a region associated with at least one second device; region information of a region associated with at least one third device; an indication to activate or deactivate the at least one carrier wave transmission; a time gap between the first DL transmission and a start of at least one time interval of the at least one carrier wave transmission; a time duration of the at least one carrier wave transmission; a number of the at least one carrier wave transmission; or a period of the at least one carrier wave transmission.

[0228] In some embodiment, the method may further include performing the at least one carrier wave transmission by receiving, from the at least one second device, at least one carrier wave transmission; and performing the UL transmission based on the at least one carrier wave transmission and the first DL transmission.

[0229] In some embodiment, the first DL transmission may comprise a first stage transmission and a second stage transmission. In some embodiment, the first stage transmission of the first DL transmission may comprise one of the following: at least one ID of the at least one second device; at least one ID of at least one third device; region information of a region associated with the at least one second device; region information of a region associated with the at least one third device; an indication to activate or deactivate the at least one carrier wave transmission; a time gap between the first DL transmission and a start of at least one time interval of the at least one carrier wave transmission; a time duration of the at least one carrier wave transmission; a number of

the at least one carrier wave transmission; or a period of the at least one carrier wave transmission.

[0230] In some embodiment, the second stage transmission of the first DL transmission may comprise scheduling information for the at least one third device indicated by the at least one ID or the region information of at least one third device in the first stage transmission of the first DL transmission.

[0231] In some embodiment, the method may further include performing the UL transmission by: based on determining that at least one ID of at least one third device in a first stage transmission of the first DL transmission comprises an ID or region information of the third device, perform the UL transmission based on the second stage transmission of the first DL transmission.

[0232] In some embodiment, the first device may comprise a base station; the second device may comprise one of a terminal device or an integrated access and backhaul (IAB) node; the second device may act as one of: an assisting node, an intermediate node, a relay node, or a repeater for the at least one third device; or the third device may comprise an ambient Internet of thing (A-IoT) device.

[0233] In some embodiment, the first DL transmission may be transmitted via a physical layer control information or a medium access control (MAC) control element (MAC CE) or a radio resource control (RRC) message; or the second DL transmission may be transmitted via a physical layer control information or a MAC CE or a RRC message.

[0234] 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.

[0235] 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).

[0236] 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.

[0237] 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.

[0238] 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.

[0239] 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:
transmit, via the transceiver to at least one second device, a first downlink (DL) transmission to trigger the at least one second device to perform at least one carrier wave transmission to at least one third device, wherein the at least one carrier wave transmission is used to carry at least one uplink (UL) transmission of the at least one third device.
2. The first device of claim 1, wherein the first DL transmission comprises one or more of the following:
identity (ID) information of the at least one second device;
identity (ID) information of the at least one third device;
region information of a region associated with the at least one second device;
region information of a region associated with the at least one third device;
an indication to activate or deactivate the at least one carrier wave transmission;
a time gap between the first DL transmission and a start of at least one time interval of the at least one carrier wave transmission;
a time duration of the at least one carrier wave transmission;
a number of the at least one carrier wave transmission; or
a period of the at least one carrier wave transmission.
3. The first device of claim 1, wherein the processor is further configured to:
transmit, via the transceiver to the at least one third device, a second DL transmission to schedule the at least one UL transmission of the at least one third device.
4. The first device of claim 1, wherein the processor is further configured to:
transmit, via the transceiver to the at least one third device, the first DL transmission to schedule the at least one UL transmission of the at least one third device.

5. The first device of claim 4, wherein the processor is configured to:
determine a list of one or more IDs of one or more third devices; and
transmit, via the transceiver, the list to the at least one second device.
6. The first device of claim 4, wherein the first DL transmission comprises a first stage transmission and a second stage transmission.
7. The first device of claim 6, wherein the first stage transmission of the first DL transmission comprises one or more of the following:
at least one ID of the at least one second device;
at least one ID of the at least one third device;
region information of a region associated with the at least one second device;
region information of a region associated with the at least one third device;
an indication to activate or deactivate the at least one carrier wave transmission;
a time gap between the first DL transmission and a start of at least one time interval of the at least one carrier wave transmission;
a time duration of the at least one carrier wave transmission;
a number of the at least one carrier wave transmission; or
a period of the at least one carrier wave transmission.
8. The first device of claim 6, wherein the second stage transmission of the first DL transmission comprises scheduling information for the at least one third device indicated by the at least one ID or the region information of at least one third device in the first stage transmission of the first DL transmission.
9. The first device of claim 1, wherein the first DL transmission further comprises:
an ID of a group or a pair, wherein the group or the pair comprises: the at least one second device and at least one third device; or
an ID of the region associated with the at least one second device within the region and at least one third device within the region.
10. The first device of claim 1, wherein one of the following:
the first device comprises a base station;

the second device comprises one of a terminal device or an integrated access and backhaul (IAB) node;

the second device acts as one of: an assisting node, an intermediate node, a relay node, or a repeater for the at least one third device; or

the third device comprises an ambient Internet of thing (A-IoT) device.

11. The first device of any of claims 1-10, wherein one of the following:

the first DL transmission is transmitted via a physical layer control information or a medium access control (MAC) control element (MAC CE) or a radio resource control (RRC) message; or

the second DL transmission is transmitted via a physical layer control information or a MAC CE or a RRC message.

12. A second device comprising:

a processor; and

a transceiver coupled to the processor,

wherein the processor is configured to:

receive, via the transceiver from a first device, a first downlink (DL) transmission to trigger the second device to perform at least one carrier wave transmission to at least one third device, wherein the at least one carrier wave transmission is used to carry at least one uplink (UL) transmission of the at least one third device; and

perform, based on the first DL transmission, the at least one carrier wave transmission to the at least one third device.

13. The second device of claim 12, wherein the first DL transmission is further transmitted to the at least one third device.

14. The second device of claim 13, wherein the first DL transmission comprises a first stage transmission and a second stage transmission.

15. The second device of claim 14, wherein the first stage transmission of the first DL transmission comprises one or more of the following:

at least one ID of the at least one second device;

at least one ID of the at least one third device;

region information of a region associated with the at least one second device;
region information of a region associated with the at least one third device;
an indication to activate or deactivate the at least one carrier wave transmission;
a time gap between the first DL transmission and a start of at least one time interval of the at least one carrier wave transmission;
a time duration of the at least one carrier wave transmission;
a number of the at least one carrier wave transmission; or
a period of the at least one carrier wave transmission.

16. The second device of claim 15, wherein the processor is configured to perform the at least one carrier wave transmission by:

performing the at least one carrier wave transmission based on determining that the first stage transmission of the first DL transmission comprises at least one ID or the region information of the at least one second device and the at least one second device comprises the second device.

17. The second device of claim 12, wherein the processor is configured to perform the at least one carrier wave transmission by:

performing the at least one carrier wave transmission based on determining that a first stage transmission of the first DL transmission comprises the region information of the region and the second device is located in the region.

18. The second device of claim 12, wherein one of the following:
the first device comprises a base station;
the second device comprises one of a terminal device or an integrated access and backhaul (IAB) node;
the second device acts as one of: an assisting node, an intermediate node, a relay node, or a repeater for the at least one third device; or
the third device comprises an ambient Internet of thing (A-IoT) device.

19. A method performed by a first device, comprising:
transmitting, to at least one second device, a first downlink (DL) transmission to trigger the at least one second device to perform at least one carrier wave transmission to

at least one third device, wherein the at least one carrier wave transmission is used to carry at least one uplink (UL) transmission of the at least one third device.

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

receiving, from a first device, a first downlink (DL) transmission to trigger the second device to perform at least one carrier wave transmission to at least one third device, wherein the at least one carrier wave transmission is used to carry at least one uplink (UL) transmission of the at least one third device; and

performing, based on the first DL transmission, the at least one carrier wave transmission to the at least one third device.

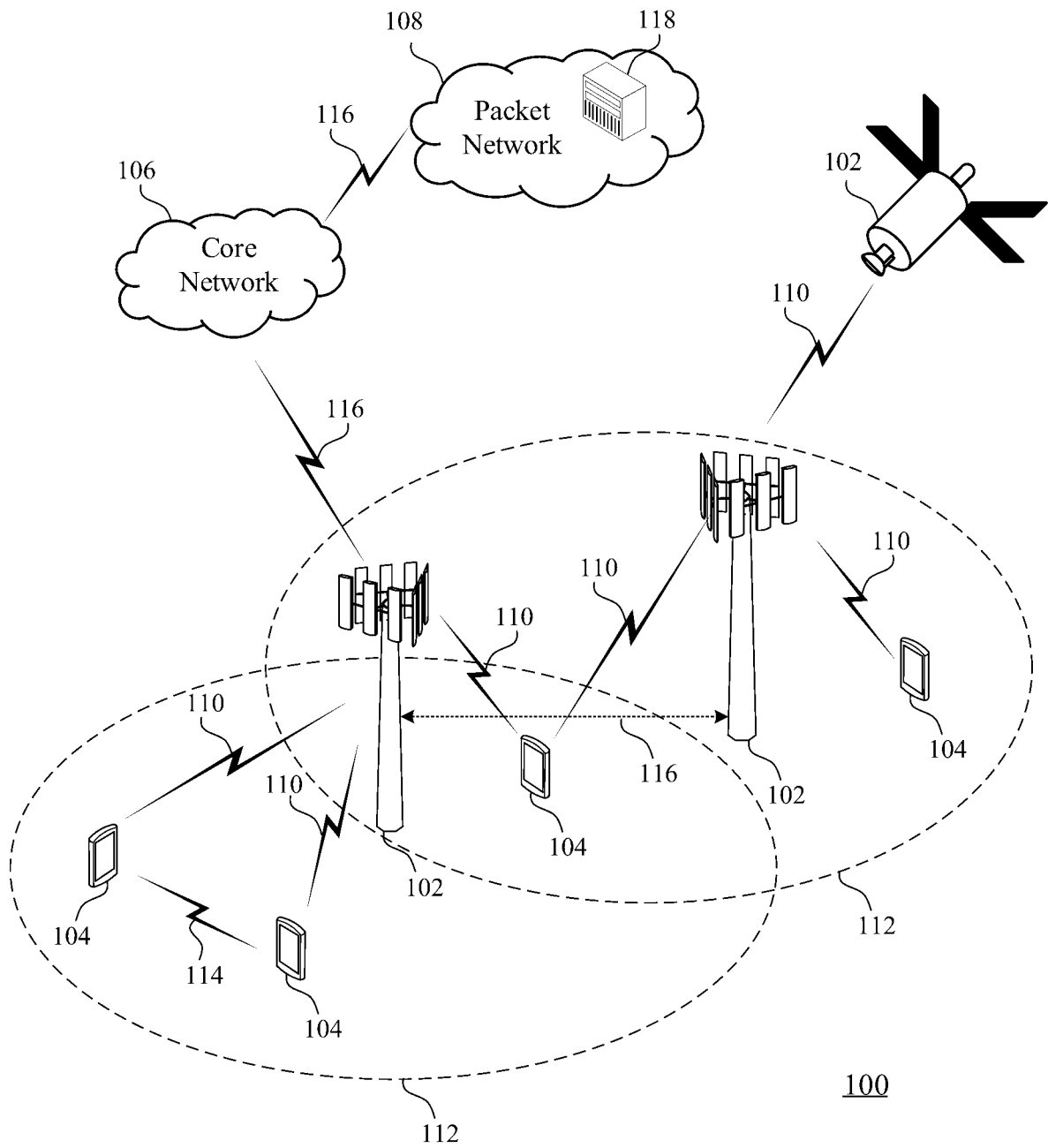


Fig. 1A

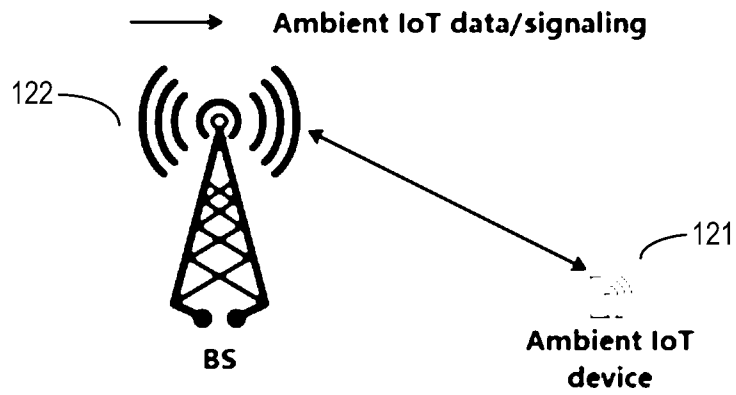


Fig. 1B

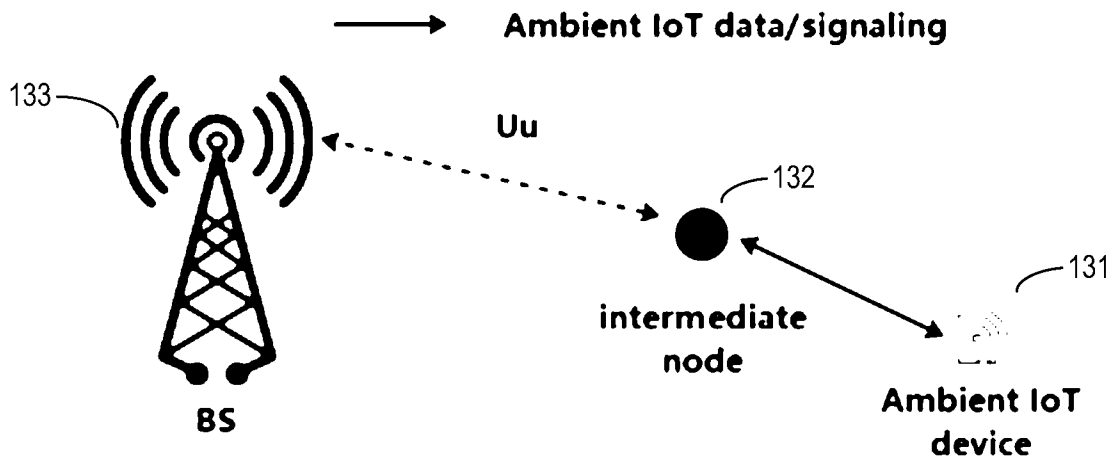


Fig. 1C

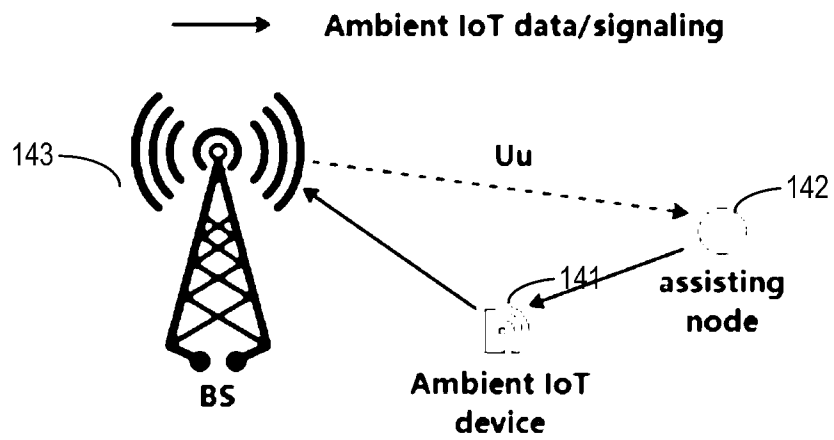


Fig. 1D

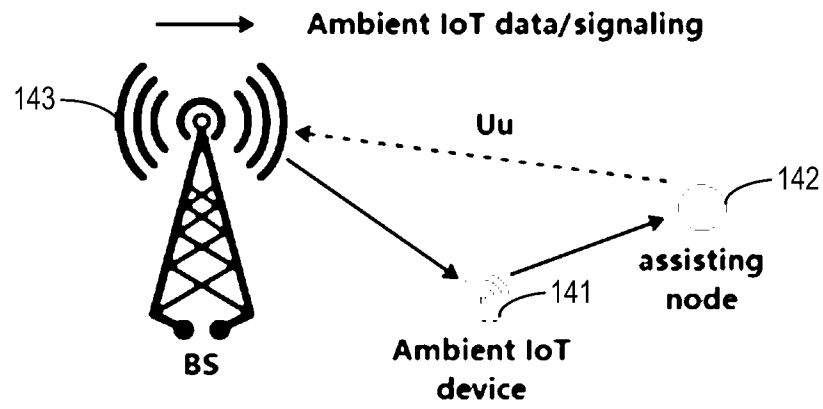


Fig. 1E

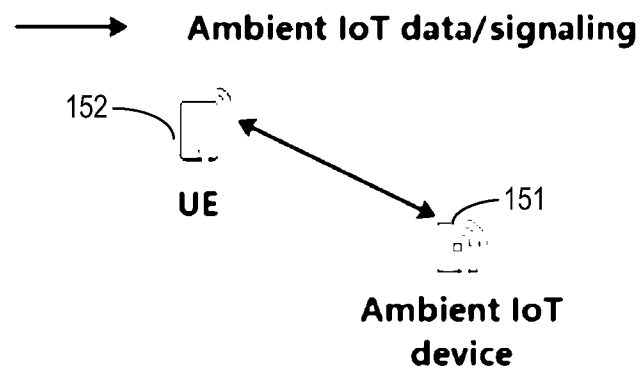


Fig. 1F

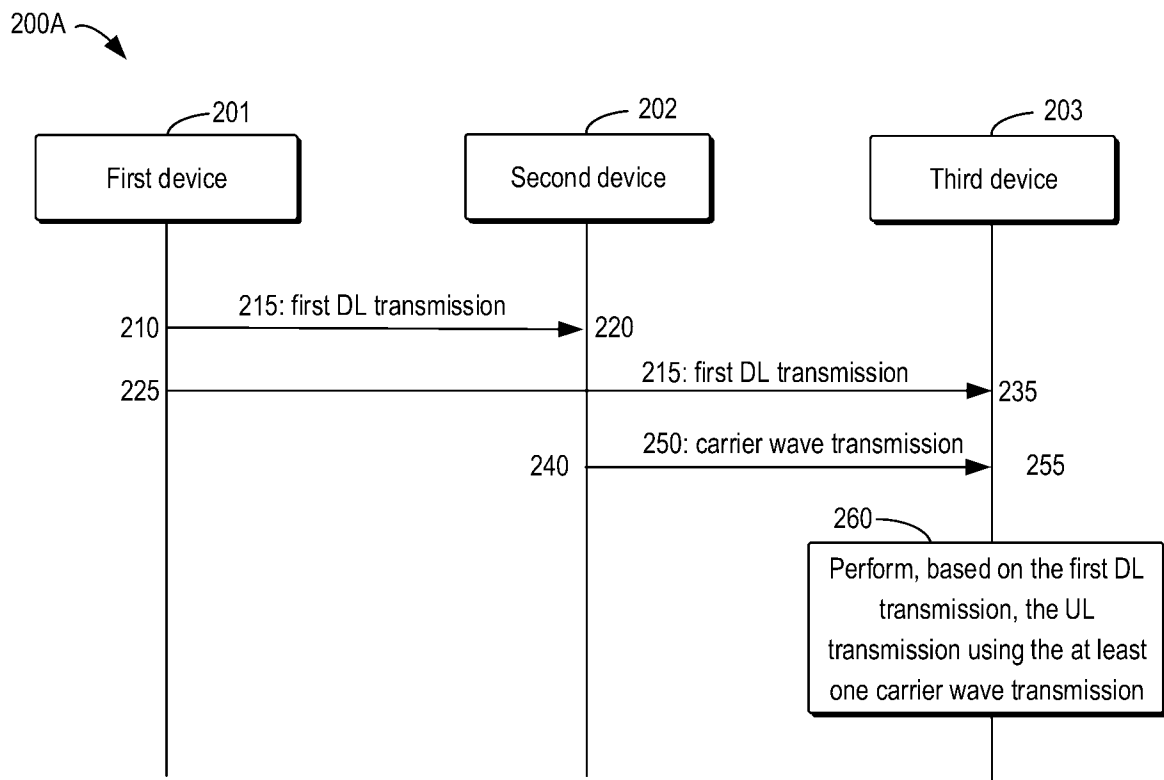


Fig. 2A

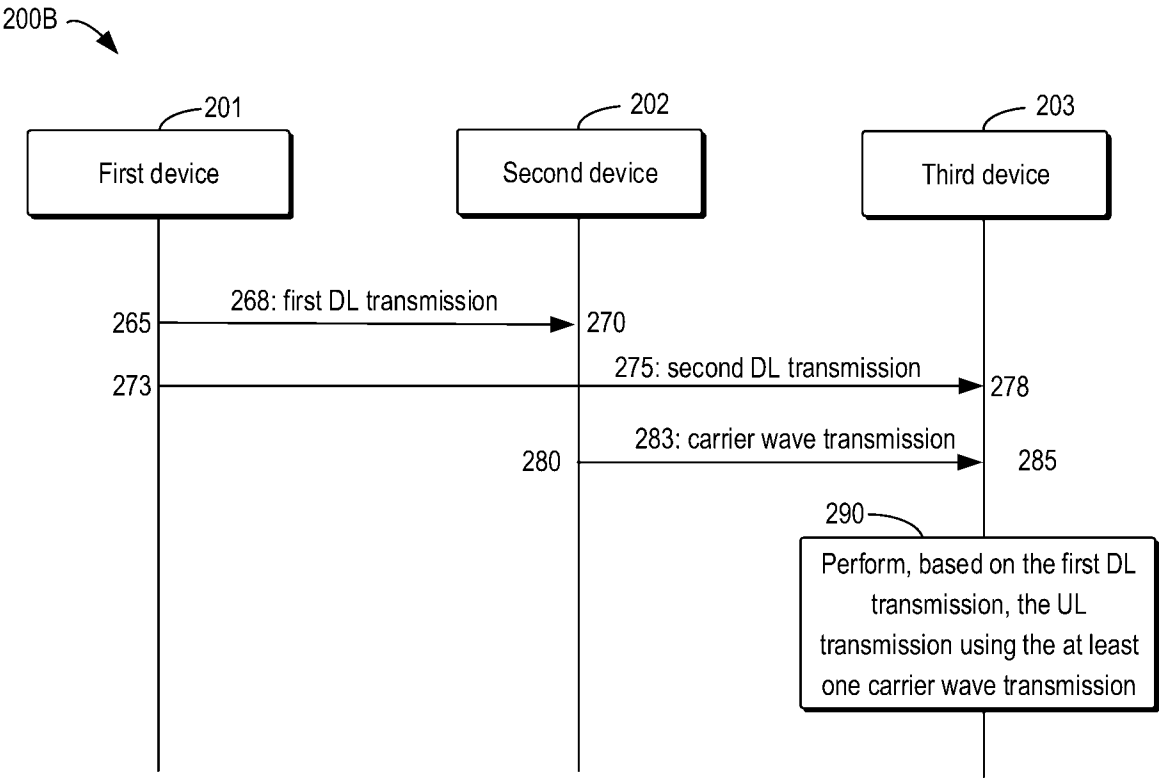


Fig. 2B

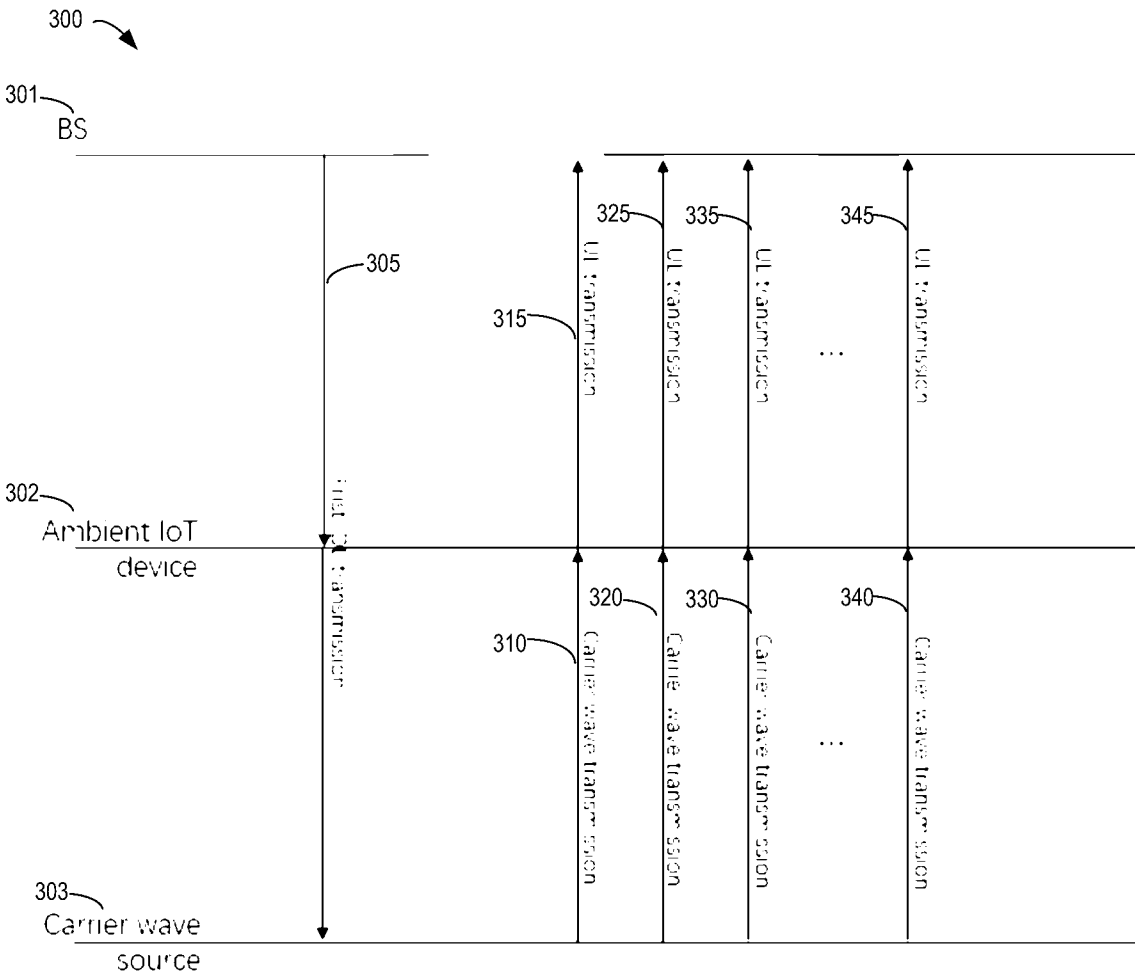


Fig. 3

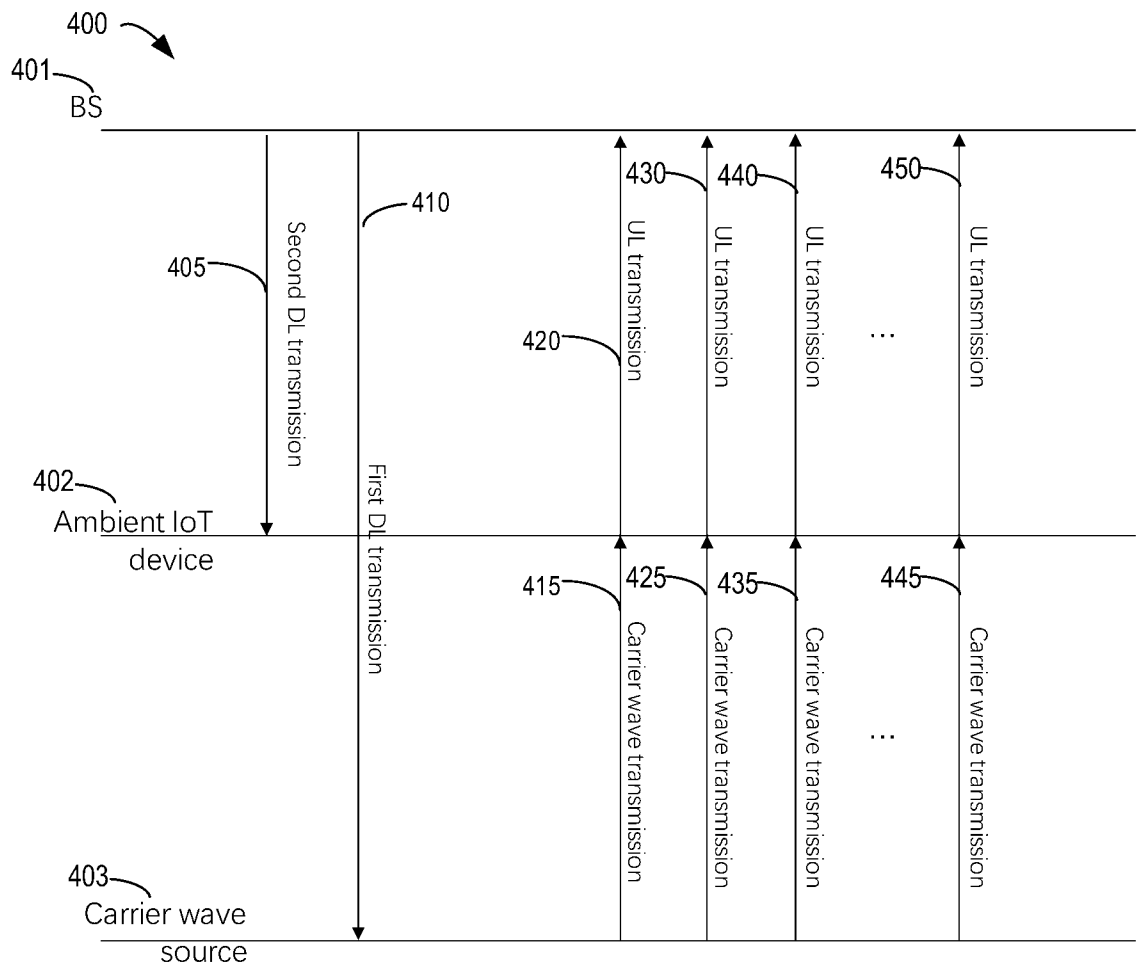


Fig. 4

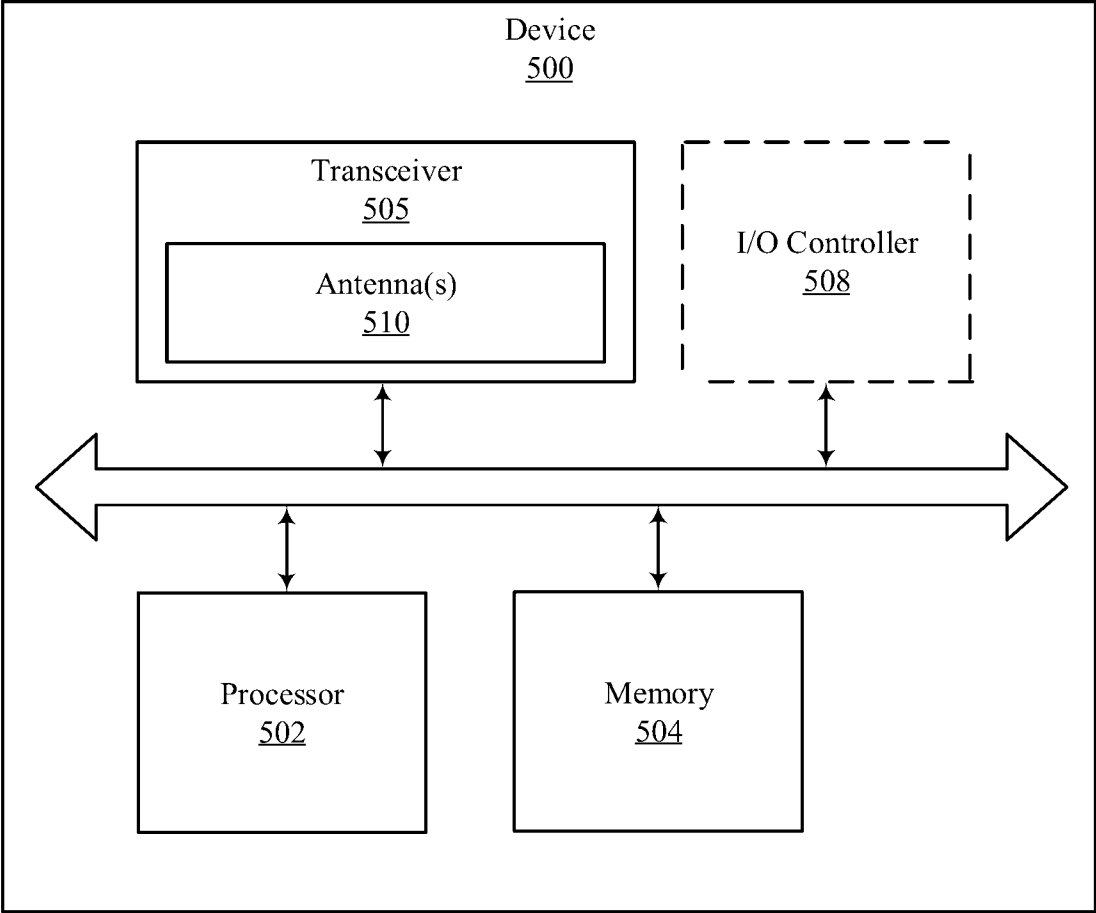


Fig. 5

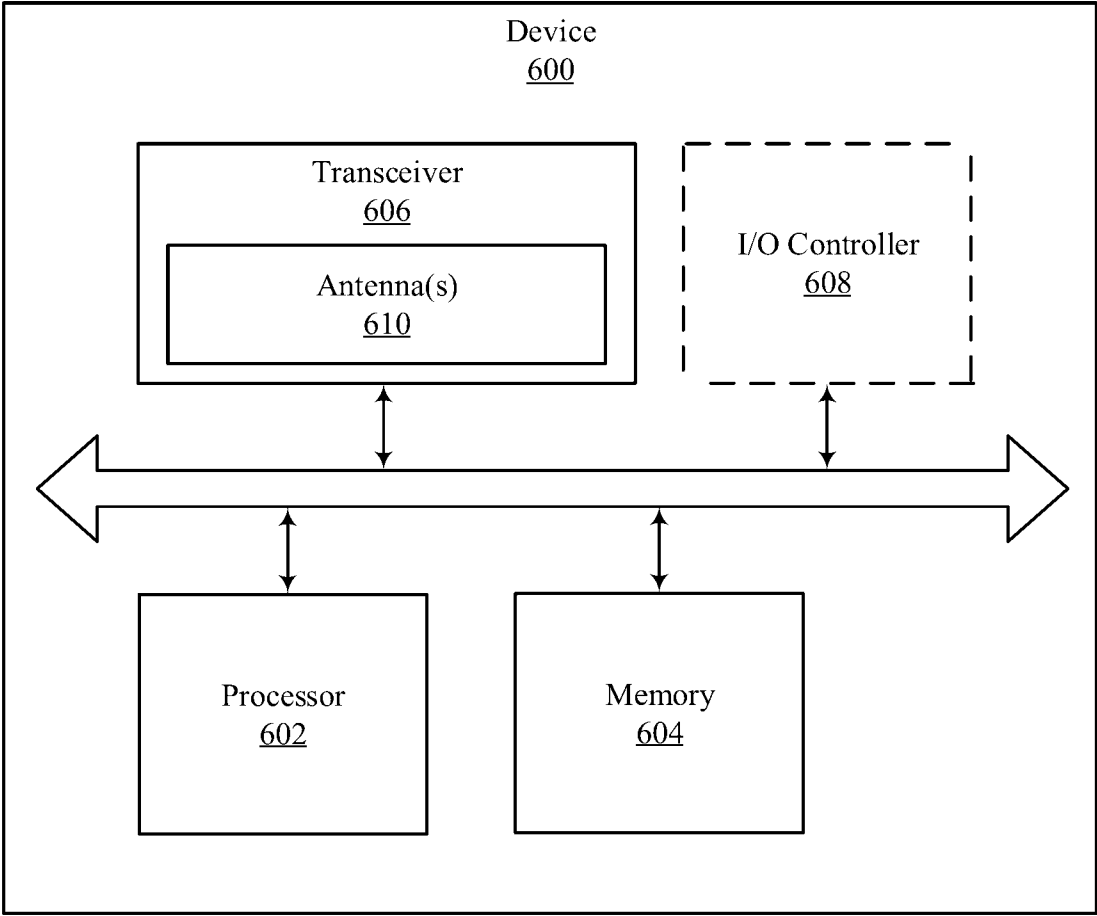


Fig. 6

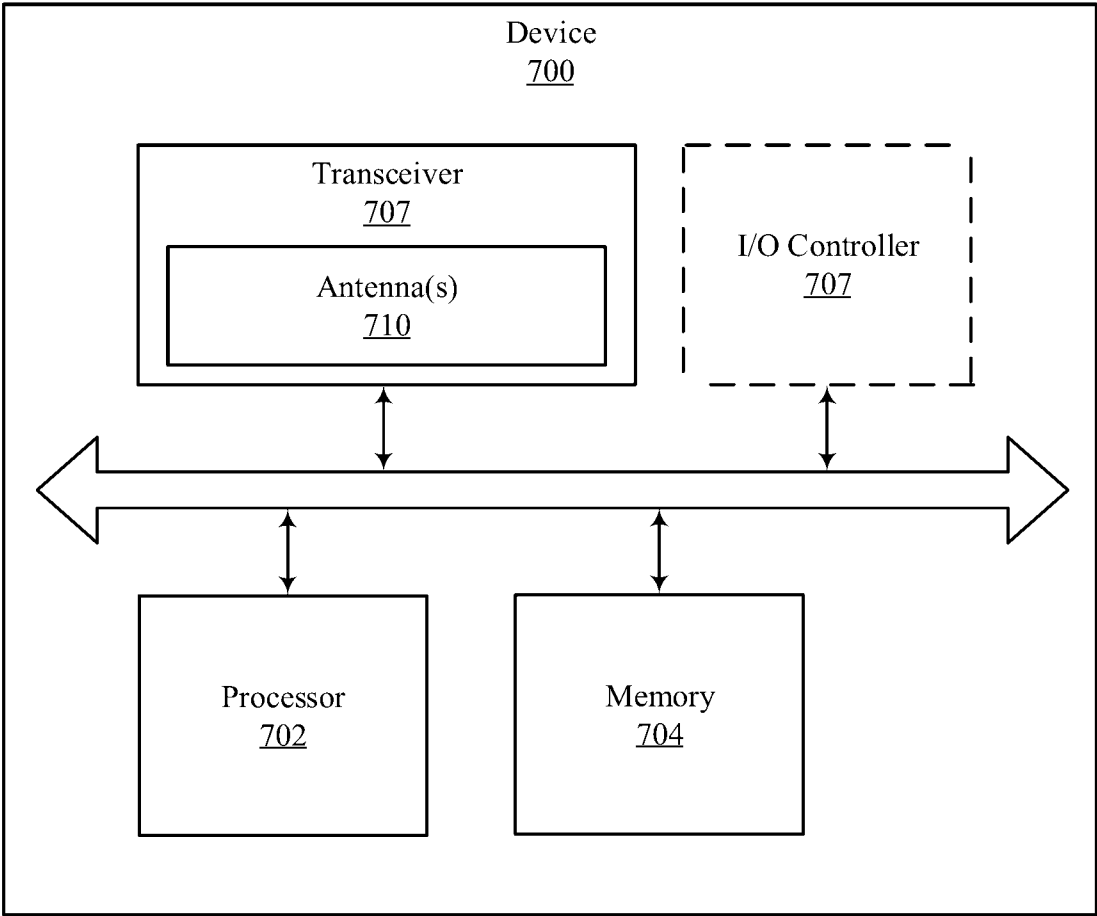


Fig. 7

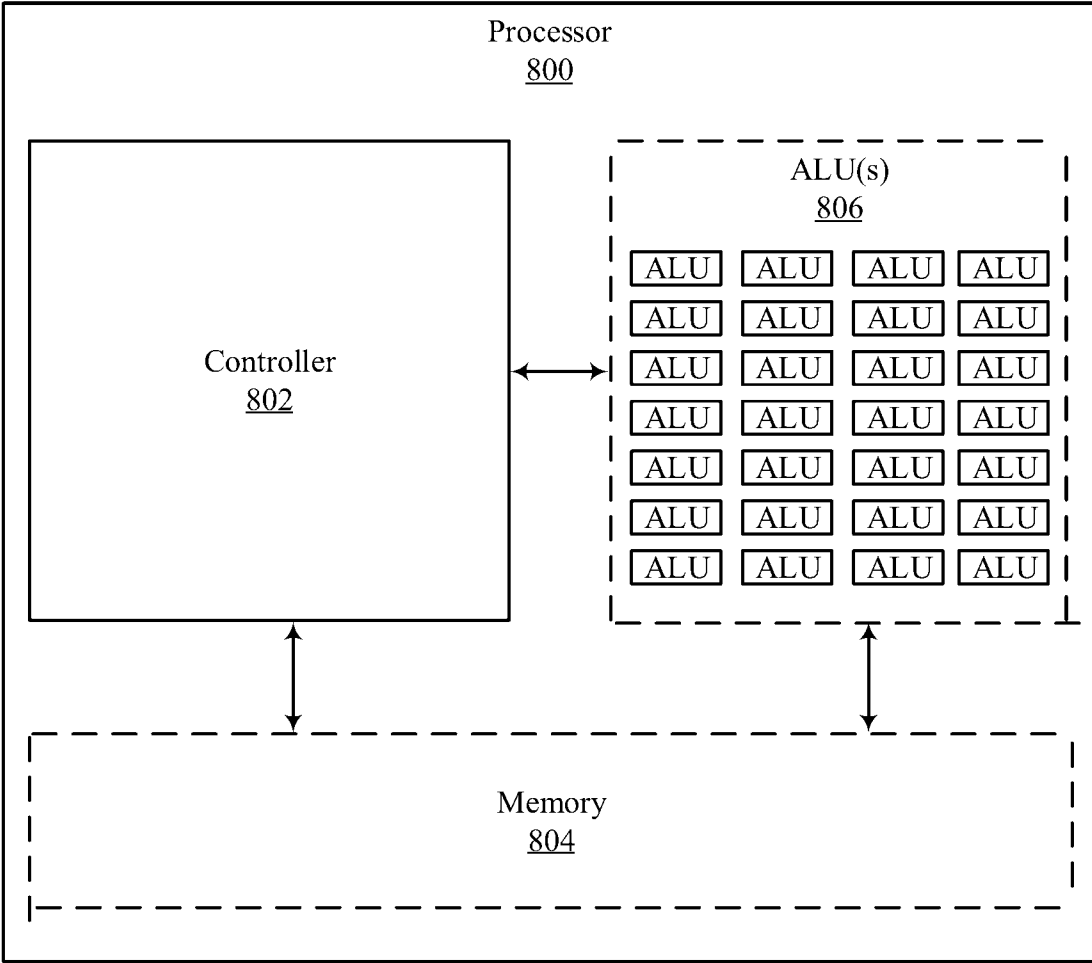


Fig. 8

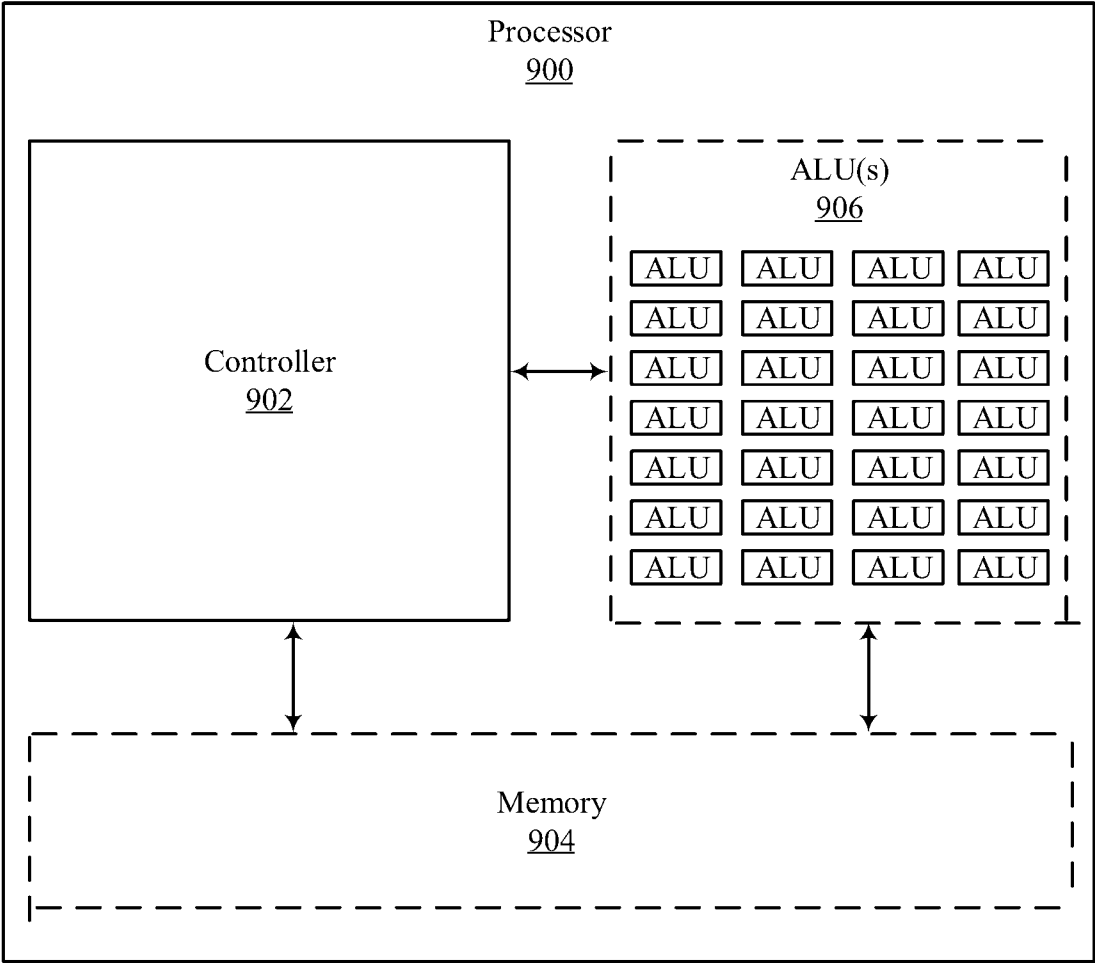


Fig. 9

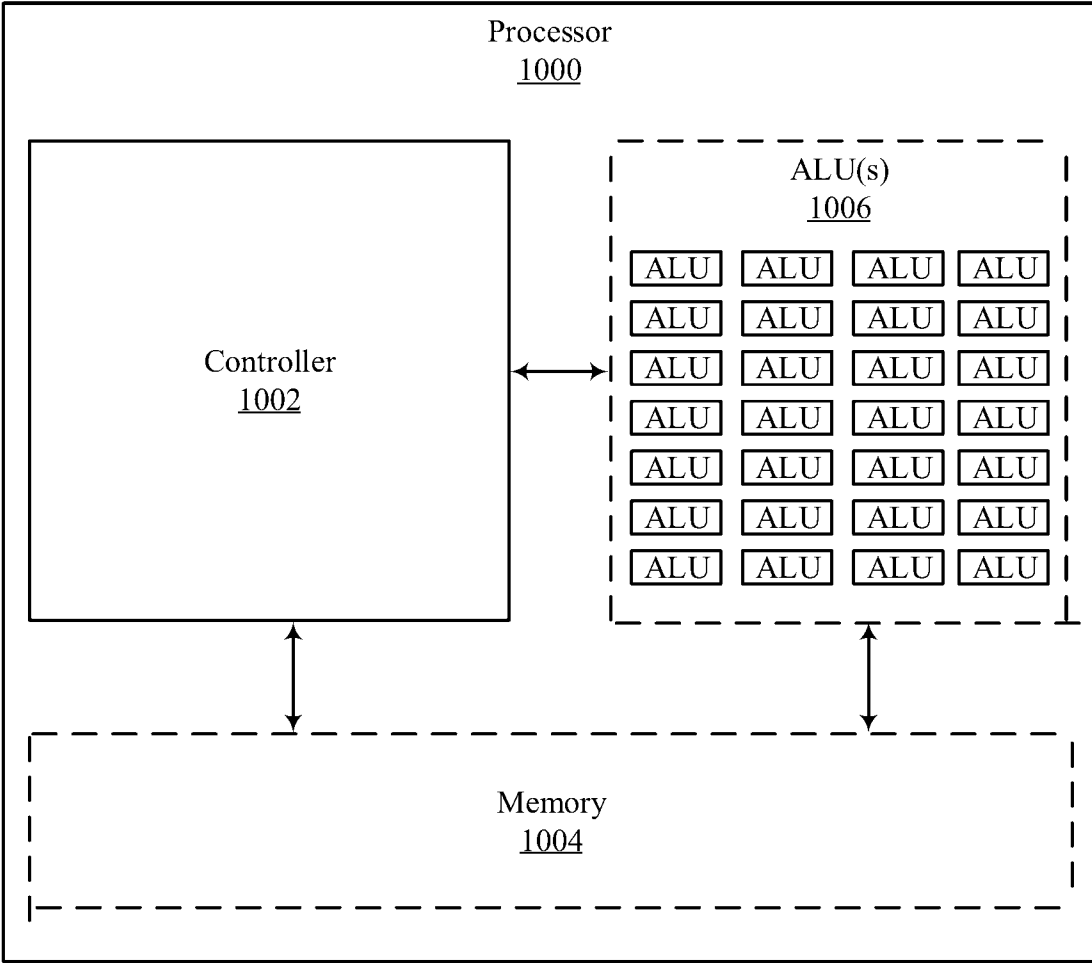


Fig. 10

1100

Transmit, to at least one second device, a first DL transmission to trigger the at least one second device to perform at least one carrier wave transmission to at least one third device, wherein the at least one carrier wave transmission is used to carry at least one UL transmission of the at least one third device

1105

Fig. 11

1200

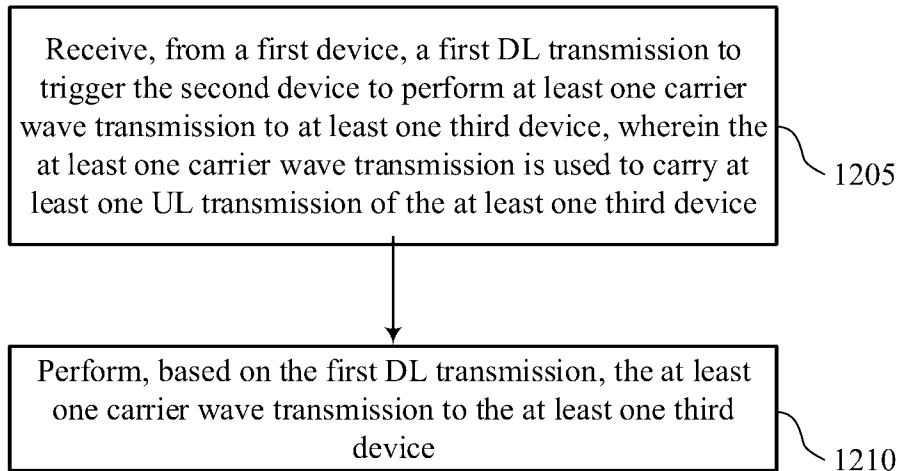


Fig. 12

1300

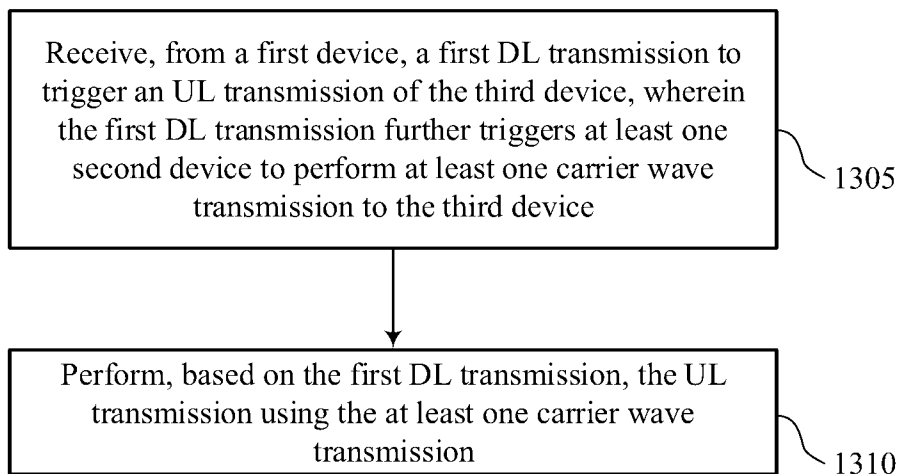


Fig. 13

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2024/070959

A. CLASSIFICATION OF SUBJECT MATTER H04W 72/0453(2023.01)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,CNXTX,ENTXT,DWPI:ambient,A-IOT,IOT,carrier,DL,downlink,UL,uplink,energy,harvest+,indicat+,IAB,intermediate, node,relay,assist+		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2023141393 A1 (QUALCOMM INCORPORATED) 11 May 2023 (2023-05-11) description, paragraphs [0117]-[0139]	1-20
A	CN 116830724 A (BEIJING XIAOMI MOBILE SOFTWARE CO., LTD.) 29 September 2023 (2023-09-29) the whole document	1-20
A	US 2022346022 A1 (NOKIA TECHNOLOGIES OY) 27 October 2022 (2022-10-27) the whole document	1-20
A	VIVO. "Discussion on Ambient IoT" 3GPP TSG RAN Meeting #99 RP-230368, 23 March 2023 (2023-03-23), the whole document	1-20
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents: “A” document defining the general state of the art which is not considered to be of particular relevance “D” document cited by the applicant in the international application “E” earlier application or patent but published on or after the international filing date “L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) “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 “X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone “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 18 September 2024		Date of mailing of the international search report 24 September 2024
Name and mailing address of the ISA/CN CHINA NATIONAL INTELLECTUAL PROPERTY ADMINISTRATION 6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China		Authorized officer CHEN,HongYing Telephone No. (+86) 010-53961636

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2024/070959

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)		Publication date (day/month/year)
US	2023141393	A1	11 May 2023	None		
CN	116830724	A	29 September 2023	None		
US	2022346022	A1	27 October 2022	EP	4084538 A1	02 November 2022