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(54) **Title:** ENHANCED WAKE-UP SIGNALING FOR WIRELESS COMMUNICATIONS



FIG. 2

(57) **Abstract:** This disclosure describes systems, methods, and devices related to enhanced wake-up frame transmissions. A device may determine a wake-up frame addressed to a group of station devices and formatted for low-power receivers of the station devices. The device may send the wake-up frame, and the device may send a group-addressed transmission to the group of station devices formatted for respective primary connectivity radios.

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ENHANCED WAKE-UP SIGNALING FOR WIRELESS COMMUNICATIONS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 62/552,197, filed August 30, 2017, the disclosure of which is incorporated by reference as if set forth in full.

TECHNICAL FIELD

[0002] This disclosure generally relates to systems and methods for wireless communications and, more particularly, to device wake-up signaling for power control.

BACKGROUND

[0003] Wireless devices are becoming widely prevalent and are increasingly requesting access to wireless channels. The growing density of wireless deployments require increased network and spectrum availability. Wireless devices may communicate over a next generation 60 GHz (NG60) network, an enhanced directional multi-gigabit (EDMG) network, and/or any other network.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] FIG. 1 is a network diagram illustrating an example network environment, in accordance with one or more example embodiments of the present disclosure.

[0005] FIG. 2 illustrates a portion of wake-up frame format, in accordance with one or more example embodiments of the present disclosure.

[0006] FIG. 3A depicts a flow diagram of an illustrative process for enhanced wake-up signaling, in accordance with one or more example embodiments of the present disclosure.

[0007] FIG. 3B depicts a flow diagram of an illustrative process for enhanced wake-up signaling, in accordance with one or more example embodiments of the present disclosure.

[0008] FIG. 4 shows a functional diagram of an exemplary communication station that may be suitable for use as a user device, in accordance with one or more example embodiments of the present disclosure.

[0009] FIG. 5 is a block diagram of an example machine upon which any of one or more techniques (e.g., methods) may be performed, in accordance with one or more example embodiments of the present disclosure.

DETAILED DESCRIPTION

[0010] Example embodiments described herein provide certain systems, methods, and devices for enhanced device wake-up signaling in wireless communications. The following description and the drawings sufficiently illustrate specific embodiments to enable those skilled in the art to practice them. Other embodiments may incorporate structural, logical, electrical, process, and other changes. Portions and features of some embodiments may be included in, or substituted for, those of other embodiments. Embodiments set forth in the claims encompass all available equivalents of those claims.

[0011] The use of a Low Power Wake Up Receiver (LP-WURx) may be a technique to enable ultra-low power operation for Wi-Fi device. For example, an LP-WURx may use less power than a primary connectivity radio (PCR). A device may conserve power (e.g., battery power) by limiting the time that the PCR is acting. However, to still receive some data when the PCR is inactive, a device may use an active LP-WURx.

[0012] The LP-WURx of a device may not be able to receive the same packets as a PCR, so when an LP-WURx is active and a PCR is inactive at a device, the device may be limited in the types of packets the device may receive. One way to allow devices to stay in a low-power mode until packets formatted for a PCR are to be transmitted to a device is to use a wake-up packet (e.g., wake-up frame).

[0013] A device may have a minimum radio configuration (e.g., using the LP-WURx) which may receive a wake-up packet from a peer device, and the device may stay in a low-power mode until receiving the wake-up packet. When a station (STA) device receives a wake-up packet addressed to the STA, the STA may wake up the STA's PCR and may facilitate communication with an access point (AP) to start a specific protocol, like power-saving mode (PSM) or unscheduled automatic power save delivery (U-APSD), to retrieve data from an AP. This procedure may be executed when an AP has an individually addressed packet to be sent to an individual STA through a PCR.

[0014] Some wake-up packets may not allow for addressing to a group of STAs. For example, for an AP to wake up multiple STAs, a wake-up packet may be sent to each STA individually, requiring multiple wake-up packet transmissions. Otherwise, STAs may remain in low-power modes until a scheduled time (e.g., according to a beacon interval) when STAs may activate their respective PCR to receive transmissions which the LP-WURx may not receive.

[0015] Instead of using a multicast wake-up packet, a device may send a beacon at a defined time, meaning the STAs may have to turn on their respective PCRs to receive the beacon. Because an STA may activate a PCR to receive a beacon only to determine that there is no buffered traffic for the STA, then the activation of the PCR may be a waste of resources of the STA.

[0016] In some PCR operations, an AP may send a group-addressed transmission to a group of STAs. Using a beacon, the AP may set bit 0 of a delivery traffic indication message (DTIM) bitmap of a DTIM beacon to 1 to indicate that there may be buffered group-addressed traffic at the AP intended for the group of STAs. The AP may send the group-addressed transmission through channel access after sending a DTIM beacon. The STA may identify bit 0 of the DTIM bitmap, and if the bit 0 is set to a value of 1, then the STA may keep its PCR active to wait for a subsequent group-addressed transmission from the AP, and the STA may not need to notify the AP that the STA's PCR is active (e.g., awake). This way, an STA may activate a PCR at an expected beacon arrival time to receive a beacon, and then may determine based on the DTIM bitmap if there is buffered traffic at the AP for which the STA may need its PCR active.

[0017] A default behavior when an STA receives an individually addressed wake-up packet may be to wake up a PCR and initiate a transmission to an AP to start a specific protocol like PSM or U-APSD to retrieve data from AP. This procedure may work when an AP has an individually addressed packet to be sent to an individual STA through the STA's PCR. However, when an AP has a group-addressed transmission, (e.g., for a specific multicast group, an AP may be likely to send a wake-up frame with an address field equal to a specific group ID, then all the STAs addressed by the group ID may follow the same behavior and initiate a transmission to AP to start a specific protocol to retrieve data from AP). For a STA to know that it is addressed by a specific group ID, an AP may need to indicate to the STA which group ID to which the STA belongs through a negotiation procedure which uses the STA's PCR.

[0018] An STA may have no way of recognizing that it has no need to initiate a transmission to an AP and to retrieve packets for a specific group-addressed transmission. This may result in a waste of a communication medium and/or inefficient device operation.

[0019] An AP may not know which STA is in a multicast group associated with a multicast service and multicast address. Thus, an AP may not assign a group ID properly to an STA that joins a multicast group.

[0020] It may therefore be beneficial to facilitate multicast wake-up packet transmissions to multiple STAs in a group.

[0021] Example embodiments of the present disclosure relate to systems, methods, and devices for enhanced wake-up signaling for wireless communications.

[0022] A group-addressed transmission may also be called multicast transmission or broadcast transmission. These terms may all mean that a transmission addresses a potential group of STAs rather than just one STA.

[0023] In one or more embodiments, a wake-up packet may include an address field such as a receiver identifier (RXID) field which may be identified by a receiving STA to determine if the wake-up packet is addressed to the STA. The address field may include a group identifier which may be used to identify a group of STAs including or not including the receiving STA. The address field may be a paged identifier field or may be referred to by another name. The address field may be added to an existing wake-up frame format (e.g., as defined in an IEEE 802.11 standard). The use of an address field may allow an AP to assign a group ID to multiple STAs and to send a wake-up frame with a group ID in the address field.

[0024] In one or more embodiments, the address field of a wake-up frame may indicate that the AP needs to send a group-addressed transmission to multiple STAs requiring the use of the STAs respective PCRs. The indication may be represented by one or more bits in a wake-up frame, and may be embedded in a group ID indicated in the address field. The embedded information may be indicated by an AP when the AP and STA negotiate a wake-up receiver (WUR) operation using a PCR (e.g., before sending a wake-up packet). Such an indication may not require an additional bit in a wake-up frame.

[0025] In one or more embodiments, advantages of enhanced wake-up signaling may include that the STA may receive additional information in a wake-up frame which the STA may use to determine that the STA does not need to activate a PCR to initiate a transmission to an AP or retrieve packets for a particular group-addressed transmission. Therefore, an STA may implement a legacy operation for receiving group-addressed traffic, and may improve operational efficiency.

[0026] In one or more embodiments, advantage of enhanced wake-up signaling may include allowing an AP to indicate a group ID with relevant multicast group information for each associated STA without needing to determine whether an STA is in a specific multicast group. Each STA may decide whether to react to a specific group ID by evaluating the associated multicast group information in a wake-up frame.

[0027] The above descriptions are for purposes of illustration and are not meant to be limiting. Numerous other examples, configurations, processes, etc., may exist, some of which are described in greater detail below. Example embodiments will now be described with reference to the accompanying figures.

[0028] FIG. 1 is a network diagram illustrating an example network environment 100, according to some example embodiments of the present disclosure. Wireless network 100 may include one or more user devices 120 and one or more access points(s) (AP) 102, which may communicate in accordance with IEEE 802.11 communication standards. The user device(s) 120 may be mobile devices that are non-stationary (e.g., not having fixed locations) or may be stationary devices.

[0029] In some embodiments, the user devices 120 and the AP 102 may include one or more computer systems similar to that of the functional diagram of FIG. 4 and/or the example machine/system of FIG. 5.

[0030] One or more illustrative user device(s) 120 and/or AP(s) 102 may be operable by one or more user(s) 110. It should be noted that any addressable unit may be a station (STA). An STA may take on multiple distinct characteristics, each of which shape its function. For example, a single addressable unit might simultaneously be a portable STA, a quality-of-service (QoS) STA, a dependent STA, and a hidden STA. The one or more illustrative user device(s) 120 and the AP(s) 102 may be STAs. The one or more illustrative user device(s) 120 and/or AP(s) 102 may operate as a personal basic service set (PBSS) control point/access point (PCP/AP). The user device(s) 120 (e.g., 124, 126, or 128) and/or AP(s) 102 may include any suitable processor-driven device including, but not limited to, a mobile device or a non-mobile, e.g., a static, device. For example, user device(s) 120 and/or AP(s) 102 may include, a user equipment (UE), a station (STA), an access point (AP), a software enabled AP (SoftAP), a personal computer (PC), a wearable wireless device (e.g., bracelet, watch, glasses, ring, etc.), a desktop computer, a mobile computer, a laptop computer, an ultrabook™ computer, a notebook computer, a tablet computer, a server computer, a handheld computer, a handheld device, an internet of things (IoT) device, a sensor device, a PDA device, a handheld PDA device, an on-board device, an off-board device, a hybrid device (e.g., combining cellular phone functionalities with PDA device functionalities), a consumer device, a vehicular device, a non-vehicular device, a mobile or portable device, a non-mobile or non-portable device, a mobile phone, a cellular telephone, a PCS device, a PDA device which incorporates a wireless communication device, a mobile or portable GPS device, a DVB device, a relatively small

computing device, a non-desktop computer, a "carry small live large" (CSLL) device, an ultra mobile device (UMD), an ultra mobile PC (UMPC), a mobile internet device (MID), an "origami" device or computing device, a device that supports dynamically composable computing (DCC), a context-aware device, a video device, an audio device, an A/V device, a set-top-box (STB), a blu-ray disc (BD) player, a BD recorder, a digital video disc (DVD) player, a high definition (HD) DVD player, a DVD recorder, a HD DVD recorder, a personal video recorder (PVR), a broadcast HD receiver, a video source, an audio source, a video sink, an audio sink, a stereo tuner, a broadcast radio receiver, a flat panel display, a personal media player (PMP), a digital video camera (DVC), a digital audio player, a speaker, an audio receiver, an audio amplifier, a gaming device, a data source, a data sink, a digital still camera (DSC), a media player, a smartphone, a television, a music player, or the like. Other devices, including smart devices such as lamps, climate control, car components, household components, appliances, etc. may also be included in this list.

[0031] As used herein, the term "Internet of Things (IoT) device" is used to refer to any object (e.g., an appliance, a sensor, etc.) that has an addressable interface (e.g., an Internet protocol (IP) address, a Bluetooth identifier (ID), a near-field communication (NFC) ID, etc.) and may transmit information to one or more other devices over a wired or wireless connection. An IoT device may have a passive communication interface, such as a quick response (QR) code, a radio-frequency identification (RFID) tag, an NFC tag, or the like, or an active communication interface, such as a modem, a transceiver, a transmitter-receiver, or the like. An IoT device may have a particular set of attributes (e.g., a device state or status, such as whether the IoT device is on or off, open or closed, idle or active, available for task execution or busy, and so on, a cooling or heating function, an environmental monitoring or recording function, a light-emitting function, a sound-emitting function, etc.) that may be embedded in and/or controlled/monitored by a central processing unit (CPU), microprocessor, ASIC, or the like, and configured for connection to an IoT network such as a local ad-hoc network or the Internet. For example, IoT devices may include, but are not limited to, refrigerators, toasters, ovens, microwaves, freezers, dishwashers, dishes, hand tools, clothes washers, clothes dryers, furnaces, air conditioners, thermostats, televisions, light fixtures, vacuum cleaners, sprinklers, electricity meters, gas meters, etc., so long as the devices are equipped with an addressable communications interface for communicating with the IoT network. IoT devices may also include cell phones, desktop computers, laptop computers, tablet computers, personal digital assistants (PDAs), etc. Accordingly, the IoT network may be comprised of a combination of

"legacy" Internet-accessible devices (e.g., laptop or desktop computers, cell phones, etc.) in addition to devices that do not typically have Internet-connectivity (e.g., dishwashers, etc.).

[0032] The user device(s) 120 and/or AP(s) 102 may also include mesh stations in, for example, a mesh network, in accordance with one or more IEEE 802.11 standards and/or 3GPP standards.

[0033] Any of the user device(s) 120 (e.g., user devices 124, 126, 128), and AP(s) 102 may be configured to communicate with each other via one or more communications networks 130 and/or 135 wirelessly or wired. The user device(s) 120 may also communicate peer-to-peer or directly with each other with or without the AP(s) 102. Any of the communications networks 130 and/or 135 may include, but not limited to, any one of a combination of different types of suitable communications networks such as, for example, broadcasting networks, cable networks, public networks (e.g., the Internet), private networks, wireless networks, cellular networks, or any other suitable private and/or public networks. Further, any of the communications networks 130 and/or 135 may have any suitable communication range associated therewith and may include, for example, global networks (e.g., the Internet), metropolitan area networks (MANs), wide area networks (WANs), local area networks (LANs), or personal area networks (PANs). In addition, any of the communications networks 130 and/or 135 may include any type of medium over which network traffic may be carried including, but not limited to, coaxial cable, twisted-pair wire, optical fiber, a hybrid fiber coaxial (HFC) medium, microwave terrestrial transceivers, radio frequency communication mediums, white space communication mediums, ultra-high frequency communication mediums, satellite communication mediums, or any combination thereof.

[0034] Any of the user device(s) 120 (e.g., user devices 124, 126, 128) and AP(s) 102 may include one or more communications antennas. The one or more communications antennas may be any suitable type of antennas corresponding to the communications protocols used by the user device(s) 120 (e.g., user devices 124, 126 and 128), and AP(s) 102. Some non-limiting examples of suitable communications antennas include Wi-Fi antennas, Institute of Electrical and Electronics Engineers (IEEE) 802.11 family of standards compatible antennas, directional antennas, non-directional antennas, dipole antennas, folded dipole antennas, patch antennas, multiple-input multiple-output (MIMO) antennas, omnidirectional antennas, quasi-omnidirectional antennas, or the like. The one or more communications antennas may be communicatively coupled to a radio component to transmit and/or receive signals, such as communications signals to and/or from the user devices 120 and/or AP(s) 102.

[0035] Any of the user device(s) 120 (e.g., user devices 124, 126, 128), and AP(s) 102 may be configured to perform directional transmission and/or directional reception in conjunction with wirelessly communicating in a wireless network. Any of the user device(s) 120 (e.g., user devices 124, 126, 128), and AP(s) 102 may be configured to perform such directional transmission and/or reception using a set of multiple antenna arrays (e.g., DMG antenna arrays or the like). Each of the multiple antenna arrays may be used for transmission and/or reception in a particular respective direction or range of directions. Any of the user device(s) 120 (e.g., user devices 124, 126, 128), and AP(s) 102 may be configured to perform any given directional transmission towards one or more defined transmit sectors. Any of the user device(s) 120 (e.g., user devices 124, 126, 128), and AP(s) 102 may be configured to perform any given directional reception from one or more defined receive sectors.

[0036] MIMO beamforming in a wireless network may be accomplished using RF beamforming and/or digital beamforming. In some embodiments, in performing a given MIMO transmission, user devices 120 and/or AP(s) 102 may be configured to use all or a subset of its one or more communications antennas to perform MIMO beamforming.

[0037] Any of the user devices 120 (e.g., user devices 124, 126, 128), and AP(s) 102 may include any suitable radio and/or transceiver for transmitting and/or receiving radio frequency (RF) signals in the bandwidth and/or channels corresponding to the communications protocols utilized by any of the user device(s) 120 and AP(s) 102 to communicate with each other. The radio components may include hardware and/or software to modulate and/or demodulate communications signals according to pre-established transmission protocols. The radio components may further have hardware and/or software instructions to communicate via one or more Wi-Fi and/or Wi-Fi direct protocols, as standardized by the Institute of Electrical and Electronics Engineers (IEEE) 802.11 standards. In certain example embodiments, the radio component, in cooperation with the communications antennas, may be configured to communicate via 2.4 GHz channels (e.g., 802.11b, 802.11g, 802.11n, 802.11ax), 5 GHz channels (e.g., 802.11n, 802.11ac, 802.11ax), or 60 GHz channels (e.g., 802.11ad). In some embodiments, non-Wi-Fi protocols may be used for communications between devices, such as Bluetooth, dedicated short-range communication (DSRC), Ultra-High Frequency (UHF) (e.g. IEEE 802.11af, IEEE 802.22), white band frequency (e.g., white spaces), or other packetized radio communications. The radio component may include any known receiver and baseband suitable for communicating via the communications protocols. The radio component may

further include a low noise amplifier (LNA), additional signal amplifiers, an analog-to-digital (A/D) converter, one or more buffers, and digital baseband.

[0038] In one or more embodiments, the one or more user devices 120 may operate in an ultra-low power mode to conserve power. During this time, the LP-WUR 146 (e.g., an LP-WURx) of a user device 120 may be active while a main radio 144 (e.g., a PCR) may be inactive. Because the LP-WUR 146 may operate in a lower power state than the main radio 144, power may be conserved on the user device 120.

[0039] The use of the LP-WUR 146 may reduce the delay caused by using a low-power mode. For example, when implementing a low-power mode in which the main radio 144 is deactivated for a period of time, and then activates for a short period of time, power may be conserved, but sometimes at the cost of a delay in sending/receiving transmissions because of the interval during which the main radio 144 may be deactivated. To reduce this delay problem of a power save mode, the LP-WUR 146 also may be implemented on a device with the main radio 144 so that, for example, a device may receive transmissions while the main radio 144 is deactivated. The wake-up packet 140 may be sent/received using a lower data rate and modulation than the data packet 138 so that, for example, a lower-power radio such as the LP-WUR 146 may receive the wake-up packet.

[0040] In one or more embodiments, the main radio 142 of AP 102 may communicate with the one or more user devices 120. For example, the main radio 142 of AP 102 may communicate one or more data packets (e.g., data packet 138) with the one or more user device(s) 120. The data packet 138 may be sent in a group-addressed transmission, for example, to devices that are associated with a group address. The data packet 138 may also include one or more indications of STA group identifiers to be used in a wake-up packet.

[0041] In one or more embodiments, an AP 102 may send, in a multicast transmission, one or more wake-up packets 140 to one or more user device(s) 120 whose LP-WURs 146 will be on during an agreed time period. The wake-up packet 140 may indicate to a user device 120 to activate a higher power mode, which may include activating the main radio 144 on the user device 120.

[0042] In one or more embodiments, an AP 102 may include a main radio 142 (e.g., an 802.11 radio), and the user device(s) 120 may include a main radio 144 and an LP-WUR 146. The LP-WUR 146 may receive the wake-up packet 140 from the AP 102, and may send a signal which causes the main radio 144 to activate. Once the main radio 144 is active, the user device(s) 120 may be able to receive 802.11 transmissions from the AP 102.

[0043] It is understood that the above descriptions are for purposes of illustration and are not meant to be limiting.

[0044] FIG. 2 illustrates a portion 200 of wake-up frame format, in accordance with one or more example embodiments of the present disclosure.

[0045] In one or more embodiments, a wake-up frame (e.g., wake-up packet 140 of FIG. 1) may include multiple components. For example, a wake-up frame may include a medium access control (MAC) header, which may include multiple fields (e.g., other fields 202, RXID/Address field 204, other fields 206). A wake-up frame may include a variable-length frame body which may include information specific to a type of frame. A wake-up frame also may include a frame check sequence (FCS), which may include a cyclic redundancy check bit. The RXID/Address field 204 may include an identifier for the wake-up frame, and the identifier may depend on the type of wake-up frame (e.g., WUR beacon, WUR wake-up frame, WUR discovery frame, WUR vendor specific frame). The identifier may identify one or more receiving STAs (e.g., a group of STAs).

[0046] In one or more embodiments, the wake-up frame may include an indication in the RXID/Address field 204 to indicate (e.g., using a bit) that the frame is sent due to a need of an AP (e.g., AP 102 of FIG. 1) to send a group-addressed transmission to be received using a PCR (e.g., main radio 144 of FIG. 1). The indication may be provided by one bit in the wake-up frame, and may indicate that the frame is sent due to an intention of the AP to send a group-addressed transmission (e.g., group addressed traffic) to be received by a PCR after the transmission of the wake-up frame. The indication may be a group identifier which identifies all STAs associated with the AP, in which case a broadcast identifier may be used.

[0047] In one or more embodiments, the AP may not expect an STA addressed by the wake-up frame to initiate a transmission through a PCR to the AP after the STA wakes up its PCR.

[0048] In one or more embodiments, the AP may need to send a group-addressed transmission after a time duration has passed, starting from an end of a transmitted wake-up frame. The time duration may be larger than a maximum time required to wake up a PCR among all the STAs that may receive the wake-up frame. This way, the AP may allow all group-addressed STAs enough time to activate their respective PCRs to receive group-addressed transmissions.

[0049] In one or more embodiments, a group-addressed transmission may be a beacon. The AP may need to send a wake-up frame before a time duration of the next target beacon

transmission time (TBTT). The time duration may be larger than a maximum time required to wake up the respective PCRs among all the STAs that may receive the wake-up frame. The indication for a beacon may be a separate bit in the wake-up frame. One reason to send the wake-up frame before the next beacon transmission is to conserve power at the STAs. For example, STAs may be aware of a time that a next beacon is to be sent by the AP, so the STAs may activate their respective PCRs to receive the beacon. Because activating the PCR requires additional power, some power at the STAs may be conserved by the AP sending a wake-up packet which may be received by a lower-power radio (e.g., LP-WUR 146 of FIG. 1). Because the wake-up packet may indicate whether a particular STA is intended to receive traffic from the AP, an STA may determine based on the RXID/Address field 204 whether or not to activate a PCR.

[0050] In one or more embodiments, the indication may be embedded in a group identifier indicated in an RXID field of the wake-up frame. An AP may associate a multicast address, a multicast service indication, or multicast group indication with an indicated group identifier when the AP and an STA negotiate WUR operations through a PCR. The group identifier in a wake-up frame may indicate that the AP has buffered group-addressed traffic for the associated multicast group. The indicated group identifier through a PCR may be a WRU mode element, which may be in a WUR action frame. An STA may determine whether the group identifier is relevant if the STA is in the multicast group. The AP may send related group-addressed transmissions for the multicast group after the wake-up frame is sent with the group identifier in the RXID field. The AP may need to send the group-addressed transmission after a time duration has passed, starting from the end of a transmitted wake-up frame, where the time duration may be larger than a maximum time required to wake up a PCR among all the STAs that may receive the wake-up frame. The AP may not expect the addressed STA to initiate transmission through a PCR to the AP after the STA wakes up its PCR.

[0051] In one or more embodiments, an AP may indicate that group-addressed traffic may be buffered, and may communicate this group ID indication during a negotiation before sending the wake-up frame (e.g., negotiations may be performed using a PCR). The indicated group identifier may be included or indicated in a WUR mode element, which may be included in the WUR action frame. The AP may send all group-addressed transmissions after the wake-up frame which includes the group identifier and the RXID/Address field 204.

[0052] In one or more embodiments, the indication of group-addressed traffic may be embedded in the group ID indicated in the RXID/Address field 204. As a result, when an STA

receives a wake-up packet with the group ID, the STA may determine that an AP may have buffered group-addressed traffic for STAs associated with the group ID. Because the STA should be aware of its group ID from previous negotiations with the AP, the STA may identify the group ID and recognize whether the group-addressed traffic is addressed for the STA or for another group of STAs not including the STA.

[0053] In one or more embodiments, enhanced wake-up signaling may be used to indicate to an STA to check for a next beacon if an STA is associated with a group ID included in the RXID/Address field 204 of a wake-up packet.

[0054] In one or more embodiments, an AP may associate a beacon transmission with an indicated group identifier when the AP and an STA negotiate a WUR operation using a PCR. The indicated group identifier may be included in a WUR mode element in a WUR action frame. The AP may indicate that an STA should listen for a beacon if the STA is addressed by the wake-up frame. The next beacon may be the beacon scheduled for the next TBTT after the STA wakes up its PCR. The AP may need to send a wake-up frame before a time duration of the next TBTT, where the time duration may be larger than a maximum time required to wake up a PCR among all the STAs that may receive the wake-up frame. The group identifier may be a specific group identifier (e.g., group 1) in an RXID field of the wake-up frame.

[0055] In one or more embodiments, the group identifier may not have any associated information, so the STA may initiate a transmission to the AP to retrieve data from the AP.

[0056] It is understood that the above descriptions are for purposes of illustration and are not meant to be limiting.

[0057] FIG. 3A illustrates a flow diagram of an illustrative process 300 for enhanced wake-up signaling, in accordance with one or more embodiments of the disclosure.

[0058] At block 302, one or more processors of a device (e.g., AP 102 of FIG. 1) may determine a multicast wake-up frame (e.g., wake-up packet 140 of FIG. 1). The multicast wake-up frame may include an address field (e.g., RXID/Address field 204) identifying a group of STAs (e.g., user devices 120 of FIG. 1), which may include a first STA, and the multicast wake-up frame may further include an indication that group addressed traffic is to be sent to the PCRs of the group of STAs. The group of STAs may include all STAs associated with the device or a subset of all STAs associated with the device, and the address field may include a broadcast identifier. The address field may include a group identifier negotiated between the device and the group of STAs, and the group identifier may indicate that the device has group addressed traffic buffered for the group of STAs. The device also may send another frame including a

wake-up receiver mode element indicating a group identifier associated with the group of STAs so that the group of STAs is aware of the group identifier when the STAs receive the wake-up frame. The other frame may be a beacon or another type of frame. The address field may include an indication that the first STA should activate the primary connectivity radio at a time of a next beacon associated with a beacon interval (e.g., a DTIM beacon and a DTIM beacon interval). The multicast wake-up frame may be sent with a lower data rate than frames sent to a device PCR, for example.

[0059] At block 304, the one or more processors of the device may cause the device to send the multicast wake-up frame. The multicast wake-up frame may be sent using a lower data rate and/or modulation than frames sent to a device PCR, and may be sent while the addressed STAs are in a low-power mode with PCRs inactive.

[0060] At block 306, the one or more processors of the device may cause the device to send a group-addressed frame (e.g., data packet 138 of FIG. 1) to the STAs associated with the group identifier in the address field. The group-addressed frame may be sent after a time has passed after sending the wake-up frame to allow group-addressed STAs to activate their respective PCRs. The group-addressed frame may be sent with a higher data rate and/or modulation than the wake-up frame, and may be sent before a next beacon so that the group-addressed STAs may not need to wait for another beacon to activate their PCRs to receive a frame intended for a PCR.

[0061] It is understood that the above descriptions are for purposes of illustration and are not meant to be limiting.

[0062] FIG. 3B illustrates a flow diagram of an illustrative process 350 for enhanced wake-up signaling, in accordance with one or more embodiments of the disclosure.

[0063] At block 352, one or more processors of a receiving device (e.g., user device(s) 120 of FIG. 1) may identify a multicast wake-up frame (e.g., wake-up packet 140 of FIG. 1). The multicast wake-up frame may include an address field identifying a group of STAs including the receiving device, and further including an indication that group addressed traffic is to be sent to PCRs of the group of STAs. The group of STAs may include all STAs associated with an AP from which the multicast wake-up frame was received, and the address field may include a broadcast identifier, or the group of STAs may include a subset of all the STAs associated with the AP. The receiving device may receive one or more additional multicast wake-up frames which may include an address field with a group identifier associated with the receiving device or not associated with the receiving device. The group identifier of the address field may have

been negotiated between the receiving device and the AP, and may indicate that the AP has traffic buffered for the group of STAs. The group identifier may be included in a wake-up receiver mode element of a frame (e.g., a beacon), and may indicate that the receiving device should activate a PCR at a time of a next beacon to be sent by the AP.

[0064] At block 354, the one or more processors of the receiving device may determine an indication that the receiving device is associated with the group of STAs identified in the address field of the multicast wake-up frame. The group of STAs may include all STAs associated with an AP, or may include a subset of STAs associated with the AP. If the receiving device determines that the group identifier in the address field is associated with the receiving device, then the STA may recognize that AP has group-buffered traffic for the receiving device.

[0065] At block 356, the one or more processors of the receiving device may initiate a PCR (e.g., main radio 144 of FIG. 1) on the receiving device. The receiving device may receive the multicast wake-up frame with an LP-WURx while the PCR may be deactivated. The receiving device may activate the PCR and deactivate the LP-WURx.

[0066] At block 358, the one or more processors of the receiving device may identify a frame received by a PCR of the receiving device from the AP. The frame may be sent by the AP after a time to allow for the receiving device to activate the PCR.

[0067] It is understood that the above descriptions are for purposes of illustration and are not meant to be limiting.

[0068] FIG. 4 shows a functional diagram of an exemplary communication station 400 in accordance with some embodiments. In one embodiment, FIG. 4 illustrates a functional block diagram of a communication station that may be suitable for use as an AP 102 (FIG. 1) or a user device 120 (FIG. 1) in accordance with some embodiments. The communication station 400 may also be suitable for use as a handheld device, a mobile device, a cellular telephone, a smartphone, a tablet, a netbook, a wireless terminal, a laptop computer, a wearable computer device, a femtocell, a high data rate (HDR) subscriber station, an access point, an access terminal, or other personal communication system (PCS) device.

[0069] The communication station 400 may include communications circuitry 402 and a transceiver 410 for transmitting and receiving signals to and from other communication stations using one or more antennas 401. The transceiver 410 may be a device comprising both a transmitter and a receiver that are combined and share common circuitry (e.g., communication circuitry 402). The communications circuitry 402 may include amplifiers, filters, mixers, analog to digital and/or digital to analog converters. The transceiver 410 may transmit and

receive analog or digital signals. The transceiver 410 may allow reception of signals during transmission periods. This mode is known as full-duplex, and may require the transmitter and receiver to operate on different frequencies to minimize interference between the transmitted signal and the received signal. The transceiver 410 may operate in a half-duplex mode, where the transceiver 410 may transmit or receive signals in one direction at a time.

[0070] The communications circuitry 402 may include circuitry that may operate the physical layer (PHY) communications and/or media access control (MAC) communications for controlling access to the wireless medium, and/or any other communications layers for transmitting and receiving signals. The communication station 400 may also include processing circuitry 406 and memory 408 arranged to perform the operations described herein. In some embodiments, the communications circuitry 402 and the processing circuitry 406 may be configured to perform operations detailed in FIGs. 2, 3A, and 3B.

[0071] In accordance with some embodiments, the communications circuitry 402 may be arranged to contend for a wireless medium and configure frames or packets for communicating over the wireless medium. The communications circuitry 402 may be arranged to transmit and receive signals. The communications circuitry 402 may also include circuitry for modulation/demodulation, upconversion/downconversion, filtering, amplification, etc. In some embodiments, the processing circuitry 406 of the communication station 400 may include one or more processors. In other embodiments, two or more antennas 401 may be coupled to the communications circuitry 402 arranged for sending and receiving signals. The memory 408 may store information for configuring the processing circuitry 406 to perform operations for configuring and transmitting message frames and performing the various operations described herein. The memory 408 may include any type of memory, including non-transitory memory, for storing information in a form readable by a machine (e.g., a computer). For example, the memory 408 may include a computer-readable storage device, read-only memory (ROM), random-access memory (RAM), magnetic disk storage media, optical storage media, flash-memory devices and other storage devices and media.

[0072] In some embodiments, the communication station 400 may be part of a portable wireless communication device, such as a personal digital assistant (PDA), a laptop or portable computer with wireless communication capability, a web tablet, a wireless telephone, a smartphone, a wireless headset, a pager, an instant messaging device, a digital camera, an access point, a television, a medical device (e.g., a heart rate monitor, a blood pressure monitor,

etc.), a wearable computer device, or another device that may receive and/or transmit information wirelessly.

[0073] In some embodiments, the communication station 400 may include one or more antennas 401. The antennas 401 may include one or more directional or omnidirectional antennas, including, for example, dipole antennas, monopole antennas, patch antennas, loop antennas, microstrip antennas, or other types of antennas suitable for transmission of RF signals. In some embodiments, instead of two or more antennas, a single antenna with multiple apertures may be used. In these embodiments, each aperture may be considered a separate antenna. In some multiple-input multiple-output (MIMO) embodiments, the antennas may be effectively separated for spatial diversity and the different channel characteristics that may result between each of the antennas and the antennas of a transmitting station.

[0074] In some embodiments, the communication station 400 may include one or more of a keyboard, a display, a non-volatile memory port, multiple antennas, a graphics processor, an application processor, speakers, and other mobile device elements. The display may be an LCD screen including a touch screen.

[0075] Although the communication station 400 is illustrated as having several separate functional elements, two or more of the functional elements may be combined and may be implemented by combinations of software-configured elements, such as processing elements including digital signal processors (DSPs), and/or other hardware elements. For example, some elements may include one or more microprocessors, DSPs, field-programmable gate arrays (FPGAs), application specific integrated circuits (ASICs), radio-frequency integrated circuits (RFICs) and combinations of various hardware and logic circuitry for performing at least the functions described herein. In some embodiments, the functional elements of the communication station 400 may refer to one or more processes operating on one or more processing elements.

[0076] Certain embodiments may be implemented in one or a combination of hardware, firmware, and software. Other embodiments may also be implemented as instructions stored on a computer-readable storage device, which may be read and executed by at least one processor to perform the operations described herein. A computer-readable storage device may include any non-transitory memory mechanism for storing information in a form readable by a machine (e.g., a computer). For example, a computer-readable storage device may include read-only memory (ROM), random-access memory (RAM), magnetic disk storage media, optical storage media, flash-memory devices, and other storage devices and media. In some

embodiments, the communication station 400 may include one or more processors and may be configured with instructions stored on a computer-readable storage device.

[0077] FIG. 5 illustrates a block diagram of an example of a machine 500 or system upon which any one or more of the techniques (e.g., methodologies) discussed herein may be performed. In other embodiments, the machine 500 may operate as a standalone device or may be connected (e.g., networked) to other machines. In a networked deployment, the machine 500 may operate in the capacity of a server machine, a client machine, or both in server-client network environments. In an example, the machine 500 may act as a peer machine in peer-to-peer (P2P) (or other distributed) network environments. The machine 500 may be a personal computer (PC), a tablet PC, a set-top box (STB), a personal digital assistant (PDA), a mobile telephone, a wearable computer device, a web appliance, a network router, a switch or bridge, or any machine capable of executing instructions (sequential or otherwise) that specify actions to be taken by that machine, such as a base station. Further, while only a single machine is illustrated, the term "machine" shall also be taken to include any collection of machines that individually or jointly execute a set (or multiple sets) of instructions to perform any one or more of the methodologies discussed herein, such as cloud computing, software as a service (SaaS), or other computer cluster configurations.

[0078] Examples, as described herein, may include or may operate on logic or a number of components, modules, or mechanisms. Modules are tangible entities (e.g., hardware) capable of performing specified operations when operating. A module includes hardware. In an example, the hardware may be specifically configured to carry out a specific operation (e.g., hardwired). In another example, the hardware may include configurable execution units (e.g., transistors, circuits, etc.) and a computer readable medium containing instructions where the instructions configure the execution units to carry out a specific operation when in operation. The configuring may occur under the direction of the executions units or a loading mechanism. Accordingly, the execution units are communicatively coupled to the computer-readable medium when the device is operating. In this example, the execution units may be a member of more than one module. For example, under operation, the execution units may be configured by a first set of instructions to implement a first module at one point in time and reconfigured by a second set of instructions to implement a second module at a second point in time.

[0079] The machine (e.g., computer system) 500 may include a hardware processor 502 (e.g., a central processing unit (CPU), a graphics processing unit (GPU), a hardware

processor core, or any combination thereof), a main memory 504 and a static memory 506, some or all of which may communicate with each other via an interlink (e.g., bus) 508. The machine 500 may further include a power management device 532, a graphics display device 510, an alphanumeric input device 512 (e.g., a keyboard), and a user interface (UI) navigation device 514 (e.g., a mouse). In an example, the graphics display device 510, alphanumeric input device 512, and UI navigation device 514 may be a touch screen display. The machine 500 may additionally include a storage device (i.e., drive unit) 516, a signal generation device 518 (e.g., a speaker), an enhanced wake-up device 519, a network interface device/transceiver 520 coupled to antenna(s) 530, and one or more sensors 528, such as a global positioning system (GPS) sensor, a compass, an accelerometer, or other sensor. The machine 500 may include an output controller 534, such as a serial (e.g., universal serial bus (USB), parallel, or other wired or wireless (e.g., infrared (IR), near field communication (NFC), etc.) connection to communicate with or control one or more peripheral devices (e.g., a printer, a card reader, etc.)).

[0080] The storage device 516 may include a machine readable medium 522 on which is stored one or more sets of data structures or instructions 524 (e.g., software) embodying or utilized by any one or more of the techniques or functions described herein. The instructions 524 may also reside, completely or at least partially, within the main memory 504, within the static memory 506, or within the hardware processor 502 during execution thereof by the machine 500. In an example, one or any combination of the hardware processor 502, the main memory 504, the static memory 506, or the storage device 516 may constitute machine-readable media.

[0081] The enhanced wake-up device 519 may carry out or perform any of the operations and processes (e.g., the process 300 of FIG. 3A, and the process 350 of FIG. 3B) described and shown above.

[0082] In one or more embodiments, the enhanced wake-up device 519 may determine a wake-up frame comprising an address field identifying a group of station devices comprising a first station device, and comprising an indication of group addressed traffic associated with a primary connectivity radio (PCR) of the first station device; cause to send the wake-up frame to the group of station devices; and cause to send a group addressed frame after a time to allow the first station device to activate the PCR.

[0083] In one or more embodiments, the enhanced wake-up device 519 may perform operations including identifying, at a first station device, a wake-up frame received by a wake-

up receiver of the first station device from an access point device, the wake-up frame comprising an address field identifying a group of station devices comprising the first station device and comprising an indication of group addressed traffic associated with a primary connectivity radio (PCR) of the first station device; determining that the first station device is associated with the group of station devices; causing to activate the PCR of the first station device; and identifying a group addressed frame received by the PCR from the access point device.

[0084] In one or more embodiments, the enhanced wake-up device 519 may perform a method including determining, by processing circuitry of a device, a wake-up frame comprising an address field identifying a group of station devices comprising a first station device, and further comprising an indication of group addressed traffic associated with a primary connectivity radio (PCR) of the first station device; causing to send, by the processing circuitry, the wake-up frame to the group of station; and causing to send, by the processing circuitry, a group addressed frame after a time to allow the first station device to activate the PCR.

[0085] It is understood that the above are only a subset of what the enhanced wake-up device 519 may be configured to perform and that other functions included throughout this disclosure may also be performed by the enhanced wake-up device 519.

[0086] While the machine-readable medium 522 is illustrated as a single medium, the term "machine-readable medium" may include a single medium or multiple media (e.g., a centralized or distributed database, and/or associated caches and servers) configured to store the one or more instructions 524.

[0087] Various embodiments may be implemented fully or partially in software and/or firmware. This software and/or firmware may take the form of instructions contained in or on a non-transitory computer-readable storage medium. Those instructions may then be read and executed by one or more processors to enable performance of the operations described herein. The instructions may be in any suitable form, such as but not limited to source code, compiled code, interpreted code, executable code, static code, dynamic code, and the like. Such a computer-readable medium may include any tangible non-transitory medium for storing information in a form readable by one or more computers, such as but not limited to read only memory (ROM); random access memory (RAM); magnetic disk storage media; optical storage media; a flash memory, etc.

[0088] The term "machine-readable medium" may include any medium that is capable of storing, encoding, or carrying instructions for execution by the machine 500 and that cause the machine 500 to perform any one or more of the techniques of the present disclosure, or that is capable of storing, encoding, or carrying data structures used by or associated with such instructions. Non-limiting machine-readable medium examples may include solid-state memories and optical and magnetic media. In an example, a massed machine-readable medium includes a machine-readable medium with a plurality of particles having resting mass. Specific examples of massed machine-readable media may include non-volatile memory, such as semiconductor memory devices (e.g., electrically programmable read-only memory (EPROM), or electrically erasable programmable read-only memory (EEPROM)) and flash memory devices; magnetic disks, such as internal hard disks and removable disks; magneto-optical disks; and CD-ROM and DVD- ROM disks.

[0089] The instructions 524 may further be transmitted or received over a communications network 526 using a transmission medium via the network interface device/transceiver 520 utilizing any one of a number of transfer protocols (e.g., frame relay, internet protocol (IP), transmission control protocol (TCP), user datagram protocol (UDP), hypertext transfer protocol (HTTP), etc.). Example communications networks may include a local area network (LAN), a wide area network (WAN), a packet data network (e.g., the Internet), mobile telephone networks (e.g., cellular networks), plain old telephone (POTS) networks, wireless data networks (e.g., Institute of Electrical and Electronics Engineers (IEEE) 802.11 family of standards known as Wi-Fi®, IEEE 802.16 family of standards known as WiMax®), IEEE 802.15.4 family of standards, and peer-to-peer (P2P) networks, among others. In an example, the network interface device/transceiver 520 may include one or more physical jacks (e.g., Ethernet, coaxial, or phone jacks) or one or more antennas to connect to the communications network 526. In an example, the network interface device/transceiver 520 may include a plurality of antennas to wirelessly communicate using at least one of single-input multiple-output (SIMO), multiple-input multiple-output (MIMO), or multiple-input single-output (MISO) techniques. The term "transmission medium" shall be taken to include any intangible medium that is capable of storing, encoding, or carrying instructions for execution by the machine 500 and includes digital or analog communications signals or other intangible media to facilitate communication of such software. The operations and processes described and shown above may be carried out or performed in any suitable order as desired in various implementations. Additionally, in certain implementations, at least a portion of the operations

may be carried out in parallel. Furthermore, in certain implementations, less than or more than the operations described may be performed.

[0090] The word "exemplary" is used herein to mean "serving as an example, instance, or illustration." Any embodiment described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments. The terms "computing device," "user device," "communication station," "station," "handheld device," "mobile device," "wireless device" and "user equipment" (UE) as used herein refers to a wireless communication device such as a cellular telephone, a smartphone, a tablet, a netbook, a wireless terminal, a laptop computer, a femtocell, a high data rate (HDR) subscriber station, an access point, a printer, a point of sale device, an access terminal, or other personal communication system (PCS) device. The device may be either mobile or stationary.

[0091] As used within this document, the term "communicate" is intended to include transmitting, or receiving, or both transmitting and receiving. This may be particularly useful in claims when describing the organization of data that is being transmitted by one device and received by another, but only the functionality of one of those devices is required to infringe the claim. Similarly, the bidirectional exchange of data between two devices (both devices transmit and receive during the exchange) may be described as "communicating," when only the functionality of one of those devices is being claimed. The term "communicating" as used herein with respect to a wireless communication signal includes transmitting the wireless communication signal and/or receiving the wireless communication signal. For example, a wireless communication unit, which is capable of communicating a wireless communication signal, may include a wireless transmitter to transmit the wireless communication signal to at least one other wireless communication unit, and/or a wireless communication receiver to receive the wireless communication signal from at least one other wireless communication unit.

[0092] As used herein, unless otherwise specified, the use of the ordinal adjectives "first," "second," "third," etc., to describe a common object, merely indicates that different instances of like objects are being referred to and are not intended to imply that the objects so described must be in a given sequence, either temporally, spatially, in ranking, or in any other manner.

[0093] The term "access point" (AP) as used herein may be a fixed station. An access point may also be referred to as an access node, a base station, an evolved node B (eNodeB), or some other similar terminology known in the art. An access terminal may also be called a mobile station, user equipment (UE), a wireless communication device, or some other similar terminology known in the art. Embodiments disclosed herein generally pertain to wireless

networks. Some embodiments may relate to wireless networks that operate in accordance with one of the IEEE 802.11 standards.

[0094] Some embodiments may be used in conjunction with various devices and systems, for example, a personal computer (PC), a desktop computer, a mobile computer, a laptop computer, a notebook computer, a tablet computer, a server computer, a handheld computer, a handheld device, a personal digital assistant (PDA) device, a handheld PDA device, an on-board device, an off-board device, a hybrid device, a vehicular device, a non-vehicular device, a mobile or portable device, a consumer device, a non-mobile or non-portable device, a wireless communication station, a wireless communication device, a wireless access point (AP), a wired or wireless router, a wired or wireless modem, a video device, an audio device, an audio-video (A/V) device, a wired or wireless network, a wireless area network, a wireless video area network (WVAN), a local area network (LAN), a wireless LAN (WLAN), a personal area network (PAN), a wireless PAN (WPAN), and the like.

[0095] Some embodiments may be used in conjunction with one way and/or two-way radio communication systems, cellular radio-telephone communication systems, a mobile phone, a cellular telephone, a wireless telephone, a personal communication system (PCS) device, a PDA device which incorporates a wireless communication device, a mobile or portable global positioning system (GPS) device, a device which incorporates a GPS receiver or transceiver or chip, a device which incorporates an RFID element or chip, a multiple-input multiple-output (MIMO) transceiver or device, a single input multiple output (SIMO) transceiver or device, a multiple-input single-output (MISO) transceiver or device, a device having one or more internal antennas and/or external antennas, digital video broadcast (DVB) devices or systems, multi-standard radio devices or systems, a wired or wireless handheld device, e.g., a smartphone, a wireless application protocol (WAP) device, or the like.

[0096] Some embodiments may be used in conjunction with one or more types of wireless communication signals and/or systems following one or more wireless communication protocols, for example, radio frequency (RF), infrared (IR), frequency-division multiplexing (FDM), orthogonal FDM (OFDM), time-division multiplexing (TDM), time-division multiple access (TDMA), extended TDMA (E-TDMA), general packet radio service (GPRS), extended GPRS, code-division multiple access (CDMA), wideband CDMA (WCDMA), CDMA 2000, single-carrier CDMA, multi-carrier CDMA, multi-carrier modulation (MDM), discrete multi-tone (DMT), Bluetooth®, global positioning system (GPS), Wi-Fi, Wi-Max, ZigBee, ultra-wideband (UWB), global system for mobile communications (GSM), 2G, 2.5G, 3G, 3.5G, 4G,

fifth generation (5G) mobile networks, 3GPP, long term evolution (LTE), LTE advanced, enhanced data rates for GSM Evolution (EDGE), or the like. Other embodiments may be used in various other devices, systems, and/or networks.

[0097] Example 1 may include a device, the device comprising memory and processing circuitry configured to: determine a wake-up frame comprising an address field identifying a group of station devices comprising a first station device, and comprising an indication of group addressed traffic associated with a primary connectivity radio (PCR) of the first station device; cause to send the wake-up frame to the group of station devices; and cause to send a group addressed frame after a time to allow the first station device to activate the PCR.

[0098] Example 2 may include the device of example 1 and/or some other example herein, wherein the group of station devices comprises all station devices associated with the device and wherein the address field comprises a broadcast identifier.

[0099] Example 3 may include the device of example 1 and/or some other example herein, wherein the group of station devices comprises a subset of all station devices associated with the device.

[0100] Example 4 may include the device of example 1 and/or some other example herein, wherein the address field comprises a group identifier negotiated between the device and the group of station devices, wherein the group identifier indicates that the device has the group addressed traffic buffered for the group of station devices.

[0101] Example 5 may include the device of example 1 and/or some other example herein, wherein the memory and processing circuitry are further configured to cause to send a second frame comprising a wake-up receiver mode element indicating a group identifier associated with the group of station devices, wherein the address field comprises the group identifier.

[0102] Example 6 may include the device of example 1 and/or some other example herein, wherein the group addressed frame is a beacon.

[0103] Example 7 may include the device of example 1 and/or some other example herein, wherein the group addressed frame is a frame indicated in a delivery traffic indication message (DTIM) beacon.

[0104] Example 8 may include the device of example 7 and/or some other example herein, wherein the address field comprises an indication that the first station device should activate the primary connectivity radio at a time of a next DTIM beacon associated with a DTIM beacon interval.

[0105] Example 9 may include the device of example 9 and/or some other example herein, wherein the group of station devices is a first group of station devices, wherein the address field comprises an indication that a second station device of a second group of station devices should maintain a low-power mode at a time of a next beacon associated with a beacon interval.

[0106] Example 10 may include the device of example 1 and/or some other example herein, further comprising a transceiver configured to transmit and receive wireless signals.

[0107] Example 11 may include the device of example 10 and/or some other example herein, further comprising one or more antennas coupled to the transceiver.

[0108] Example 12 may include a non-transitory computer-readable medium storing computer-executable instructions which when executed by one or more processors result in performing operations comprising: identifying, at a first station device, a wake-up frame received by a wake-up receiver of the first station device from an access point device, the wake-up frame comprising an address field identifying a group of station devices comprising the first station device and comprising an indication of group addressed traffic associated with a primary connectivity radio (PCR) of the first station device; determining that the first station device is associated with the group of station devices; causing to activate the PCR of the first station device; and identifying a group addressed frame received by the PCR from the access point device.

[0109] Example 13 may include the non-transitory computer-readable medium of example 12 and/or some other example herein, wherein the group of station devices comprises all station devices associated with the access point device and wherein the address field comprises a broadcast identifier.

[0110] Example 14 may include the non-transitory computer-readable medium of example 12 and/or some other example herein, wherein the group of station devices comprises a subset of all station devices associated with the access point device.

[0111] Example 15 may include the non-transitory computer-readable medium of example 12 and/or some other example herein, wherein the wake-up frame is a first wake-up frame, wherein the address field is a first address field, and wherein the group of station devices is a first group of station devices, the operations further comprising: identifying a second wake-up frame received by the wake-up receiver of the first station device from the access point device, the second wake-up frame comprising a second address field identifying a second group of station devices comprising a second station device, and further comprising an indication of second group addressed traffic associated with a PCR of the second station device; determining

that the first station device is not associated with the second group of station devices; and maintaining a low-power mode wherein the PCR of the first station device is inactive.

[0112] Example 16 may include the non-transitory computer-readable medium of example 12 and/or some other example herein, wherein the address field comprises a group identifier negotiated between the access point device and the group of station devices, wherein the group identifier indicates that the access point device has the group addressed traffic buffered for the group of station devices.

[0113] Example 17 may include the non-transitory computer-readable medium of example 12 and/or some other example herein, the operations further comprising identifying a second frame comprising a wake-up receiver mode element indicating a group identifier associated with the group of station devices, wherein the address field comprises the group identifier.

[0114] Example 18 may include the non-transitory computer-readable medium of example 12 and/or some other example herein, wherein the group addressed frame is a beacon.

[0115] Example 19 may include the non-transitory computer-readable medium of example 12 and/or some other example herein, wherein the group addressed frame is a frame indicated in a delivery traffic indication message (DTIM) beacon.

[0116] Example 20 may include the non-transitory computer-readable medium of example 19 and/or some other example herein, wherein the address field comprises an indication that the first station device should activate the PCR at a time of a next DTIM beacon associated with a DTIM beacon interval.

[0117] Example 21 may include the non-transitory computer-readable medium of example 18 and/or some other example herein, wherein the group of station devices is a first group of station devices, wherein the address field comprises an indication that a second station device of a second group of station devices should maintain a low-power mode at a time of a next beacon associated with a beacon interval.

[0118] Example 22 may include a method comprising: determining, by processing circuitry of a device, a wake-up frame comprising an address field identifying a group of station devices comprising a first station device, and further comprising an indication of group addressed traffic associated with a primary connectivity radio (PCR) of the first station device; causing to send, by the processing circuitry, the wake-up frame to the group of station; and causing to send, by the processing circuitry, a group addressed frame after a time to allow the first station device to activate the PCR.

[0119] Example 23 may include the method of example 22 and/or some other example herein, wherein the group of station devices comprises all station devices associated with the device and wherein the address field comprises a broadcast identifier.

[0120] Example 24 may include the method of example 22 and/or some other example herein, wherein the group of station devices comprises a subset of all station devices associated with the device.

[0121] Example 25 may include the method of example 22 and/or some other example herein, wherein the address field comprises a group identifier negotiated between the device and the group of station devices, wherein the group identifier indicates that the device has the group addressed traffic buffered for the group of station devices.

[0122] An apparatus comprising means for performing a method as claimed in any one of examples 22-25.

[0123] A system, comprising at least one memory device having programmed instruction that, in response to execution cause at least one processor to perform the method of any one of examples 22-25.

[0124] A machine readable medium including code, when executed, to cause a machine to perform the method of any one of examples 22-25

[0125] Example 29 may include a non-transitory computer-readable medium storing computer-executable instructions which when executed by one or more processors result in performing operations comprising: determining a wake-up frame comprising an address field identifying a group of station devices comprising a first station device, and comprising an indication of group addressed traffic associated with a primary connectivity radio (PCR) of the first station device; causing to send the wake-up frame to the group of station devices; and causing to send a group addressed frame after a time to allow the first station device to activate the PCR.

[0126] Example 30 may include the non-transitory computer-readable medium of example 29 and/or some other example herein, wherein the group of station devices comprises all station devices associated with the device and wherein the address field comprises a broadcast identifier.

[0127] Example 31 may include the non-transitory computer-readable medium of example 29 and/or some other example herein, wherein the group of station devices comprises a subset of all station devices associated with the device.

[0128] Example 32 may include the non-transitory computer-readable medium of example 29 and/or some other example herein, wherein the address field comprises a group identifier

negotiated between the device and the group of station devices, wherein the group identifier indicates that the device has the group addressed traffic buffered for the group of station devices.

[0129] Example 33 may include the non-transitory computer-readable medium of example 29 and/or some other example herein, wherein the operations further comprise causing to send a second frame comprising a wake-up receiver mode element indicating a group identifier associated with the group of station devices, wherein the address field comprises the group identifier.

[0130] Example 34 may include the non-transitory computer-readable medium of example 29 and/or some other example herein, wherein the group addressed frame is a beacon.

[0131] Example 35 may include the non-transitory computer-readable medium of example 29 and/or some other example herein, wherein the group addressed frame is a frame indicated in a delivery traffic indication message (DTIM) beacon.

[0132] Example 36 may include the non-transitory computer-readable medium of example 35 and/or some other example herein, wherein the address field comprises an indication that the first station device should activate the primary connectivity radio at a time of a next DTIM beacon associated with a DTIM beacon interval.

[0133] Example 37 may include the non-transitory computer-readable medium of example 29 and/or some other example herein, wherein the group of station devices is a first group of station devices, wherein the address field comprises an indication that a second station device of a second group of station devices should maintain a low-power mode at a time of a next beacon associated with a beacon interval.

[0134] Example 38 may include an apparatus comprising means for: determining, by processing circuitry of a device, a wake-up frame comprising an address field identifying a group of station devices comprising a first station device, and further comprising an indication of group addressed traffic associated with a primary connectivity radio (PCR) of the first station device; causing to send, by the processing circuitry, the wake-up frame to the group of station; and causing to send, by the processing circuitry, a group addressed frame after a time to allow the first station device to activate the PCR.

[0135] Example 39 may include the apparatus of example 38 and/or some other example herein, wherein the group of station devices comprises all station devices associated with the device and wherein the address field comprises a broadcast identifier.

[0136] Example 40 may include the apparatus of example 38 and/or some other example herein, wherein the group of station devices comprises a subset of all station devices associated with the device.

[0137] Example 41 may include the apparatus of example 38 and/or some other example herein, wherein the address field comprises a group identifier negotiated between the device and the group of station devices, wherein the group identifier indicates that the device has the group addressed traffic buffered for the group of station devices.

[0138] Example 42 may include a device, the device comprising memory and processing circuitry configured to: identifying, at a first station device, a wake-up frame received by a wake-up receiver of the first station device from an access point device, the wake-up frame comprising an address field identifying a group of station devices comprising the first station device and comprising an indication of group addressed traffic associated with a primary connectivity radio (PCR) of the first station device; determining that the first station device is associated with the group of station devices; causing to activate the PCR of the first station device; and identifying a group addressed frame received by the PCR from the access point device.

[0139] Example 43 may include the device of example 42 and/or some other example herein, wherein the group of station devices comprises all station devices associated with the access point device and wherein the address field comprises a broadcast identifier.

[0140] Example 44 may include the device of example 42 and/or some other example herein, wherein the group of station devices comprises a subset of all station devices associated with the access point device.

[0141] Example 45 may include the device of example 42 and/or some other example herein, wherein the wake-up frame is a first wake-up frame, wherein the address field is a first address field, and wherein the group of station devices is a first group of station devices, the memory and processing circuitry further configured to: identify a second wake-up frame received by the wake-up receiver of the first station device from the access point device, the second wake-up frame comprising a second address field identifying a second group of station devices comprising a second station device, and further comprising an indication of second group addressed traffic associated with a PCR of the second station device; determine that the first station device is not associated with the second group of station devices; and maintain a low-power mode wherein the PCR of the first station device is inactive.

[0142] Example 46 may include the device of example 42 and/or some other example herein, wherein the address field comprises a group identifier negotiated between the access point device

and the group of station devices, wherein the group identifier indicates that the access point device has the group addressed traffic buffered for the group of station devices.

[0143] Example 47 may include the device of example 42 and/or some other example herein, the memory and processing circuitry further configured to identify a second frame comprising a wake-up receiver mode element indicating a group identifier associated with the group of station devices, wherein the address field comprises the group identifier.

[0144] Example 48 may include the device of example 42 and/or some other example herein, wherein the group addressed frame is a beacon.

[0145] Example 49 may include the device of example 42 and/or some other example herein, wherein the group addressed frame is a frame indicated in a delivery traffic indication message (DTIM) beacon.

[0146] Example 50 may include the device of example 49 and/or some other example herein, wherein the address field comprises an indication that the first station device should activate the PCR at a time of a next DTIM beacon associated with a DTIM beacon interval.

[0147] Example 51 may include the device of example 48 and/or some other example herein, wherein the group of station devices is a first group of station devices, wherein the address field comprises an indication that a second station device of a second group of station devices should maintain a low-power mode at a time of a next beacon associated with a beacon interval.

[0148] Example 52 may include a method comprising: identifying, at a first station device, a wake-up frame received by a wake-up receiver of the first station device from an access point device, the wake-up frame comprising an address field identifying a group of station devices comprising the first station device and comprising an indication of group addressed traffic associated with a primary connectivity radio (PCR) of the first station device; determining that the first station device is associated with the group of station devices; causing to activate the PCR of the first station device; and identifying a group addressed frame received by the PCR from the access point device.

[0149] Example 53 may include the method of example 52 and/or some other example herein, wherein the group of station devices comprises all station devices associated with the access point device and wherein the address field comprises a broadcast identifier.

[0150] Example 54 may include the method of example 52 and/or some other example herein, wherein the group of station devices comprises a subset of all station devices associated with the access point device.

[0151] Example 55 may include the method of example 52 and/or some other example herein, wherein the wake-up frame is a first wake-up frame, wherein the address field is a first address field, and wherein the group of station devices is a first group of station devices, further comprising: identifying a second wake-up frame received by the wake-up receiver of the first station device from the access point device, the second wake-up frame comprising a second address field identifying a second group of station devices comprising a second station device, and further comprising an indication of second group addressed traffic associated with a PCR of the second station device; determining that the first station device is not associated with the second group of station devices; and maintaining a low-power mode wherein the PCR of the first station device is inactive.

[0152] Example 56 may include the method of example 52 and/or some other example herein, wherein the address field comprises a group identifier negotiated between the access point device and the group of station devices, wherein the group identifier indicates that the access point device has the group addressed traffic buffered for the group of station devices.

[0153] Example 57 may include the method of example 52 and/or some other example herein, further comprising identifying a second frame comprising a wake-up receiver mode element indicating a group identifier associated with the group of station devices, wherein the address field comprises the group identifier.

[0154] Example 58 may include the method of example 52 and/or some other example herein, wherein the group addressed frame is a beacon.

[0155] Example 59 may include the method of example 52 and/or some other example herein, wherein the group addressed frame is a frame indicated in a delivery traffic indication message (DTIM) beacon.

[0156] Example 60 may include the method of example 59 and/or some other example herein, wherein the address field comprises an indication that the first station device should activate the PCR at a time of a next DTIM beacon associated with a DTIM beacon interval.

[0157] Example 61 may include the method of example 58 and/or some other example herein, wherein the group of station devices is a first group of station devices, wherein the address field comprises an indication that a second station device of a second group of station devices should maintain a low-power mode at a time of a next beacon associated with a beacon interval.

[0158] Example 62 may include an apparatus comprising means for performing a method as claimed in any one of examples 52-61.

[0159] Example 63 may include a system, comprising at least one memory device having programmed instruction that, in response to execution cause at least one processor to perform the method of any one of examples 52-61.

[0160] Example 64 may include a machine readable medium including code, when executed, to cause a machine to perform the method of any one of examples 52-61.

[0161] Example 65 may include an apparatus comprising means for: identifying, at a first station device, a wake-up frame received by a wake-up receiver of the first station device from an access point device, the wake-up frame comprising an address field identifying a group of station devices comprising the first station device and comprising an indication of group addressed traffic associated with a primary connectivity radio (PCR) of the first station device; determining that the first station device is associated with the group of station devices; causing to activate the PCR of the first station device; and identifying a group addressed frame received by the PCR from the access point device.

[0162] Example 66 may include the method of example 65 and/or some other example herein, wherein the group of station devices comprises all station devices associated with the access point device and wherein the address field comprises a broadcast identifier.

[0163] Example 67 may include the method of example 65 and/or some other example herein, wherein the group of station devices comprises a subset of all station devices associated with the access point device.

[0164] Example 68 may include the method of example 65 and/or some other example herein, wherein the wake-up frame is a first wake-up frame, wherein the address field is a first address field, and wherein the group of station devices is a first group of station devices, further comprising means for: identifying a second wake-up frame received by the wake-up receiver of the first station device from the access point device, the second wake-up frame comprising a second address field identifying a second group of station devices comprising a second station device, and further comprising an indication of second group addressed traffic associated with a PCR of the second station device; determining that the first station device is not associated with the second group of station devices; and maintaining a low-power mode wherein the PCR of the first station device is inactive.

[0165] Example 69 may include the method of example 65 and/or some other example herein, wherein the address field comprises a group identifier negotiated between the access point device and the group of station devices, wherein the group identifier indicates that the access point device has the group addressed traffic buffered for the group of station devices.

[0166] Example 70 may include the method of example 65 and/or some other example herein, further comprising means for identifying a second frame comprising a wake-up receiver mode element indicating a group identifier associated with the group of station devices, wherein the address field comprises the group identifier.

[0167] Example 71 may include the method of example 65 and/or some other example herein, wherein the group addressed frame is a beacon.

[0168] Example 72 may include the method of example 65 and/or some other example herein, wherein the group addressed frame is a frame indicated in a delivery traffic indication message (DTIM) beacon.

[0169] Example 73 may include the method of example 72 and/or some other example herein, wherein the address field comprises an indication that the first station device should activate the PCR at a time of a next DTIM beacon associated with a DTIM beacon interval.

[0170] Example 74 may include the method of example 71 and/or some other example herein, wherein the group of station devices is a first group of station devices, wherein the address field comprises an indication that a second station device of a second group of station devices should maintain a low-power mode at a time of a next beacon associated with a beacon interval.

[0171] Example 75 may include one or more non-transitory computer-readable media comprising instructions to cause an electronic device, upon execution of the instructions by one or more processors of the electronic device, to perform one or more elements of a method described in or related to any of examples 1-74, or any other method or process described herein.

[0172] Example 76 may include an apparatus comprising logic, modules, and/or circuitry to perform one or more elements of a method described in or related to any of examples 1-74, or any other method or process described herein.

[0173] Example 77 may include a method, technique, or process as described in or related to any of examples 1-74, or portions or parts thereof.

[0174] Example 78 may include an apparatus comprising: one or more processors and one or more computer readable media comprising instructions that, when executed by the one or more processors, cause the one or more processors to perform the method, techniques, or process as described in or related to any of examples 1-74, or portions thereof.

[0175] Example 79 may include a method of communicating in a wireless network as shown and described herein.

[0176] Example 80 may include a system for providing wireless communication as shown and described herein.

[0177] Example 81 may include a device for providing wireless communication as shown and described herein.

[0178] Certain aspects of the disclosure are described above with reference to block and flow diagrams of systems, methods, apparatuses, and/or computer program products according to various implementations. It will be understood that one or more blocks of the block diagrams and flow diagrams, and combinations of blocks in the block diagrams and the flow diagrams, respectively, may be implemented by computer-executable program instructions. Likewise, some blocks of the block diagrams and flow diagrams may not necessarily need to be performed in the order presented, or may not necessarily need to be performed at all, according to some implementations.

[0179] These computer-executable program instructions may be loaded onto a special-purpose computer or other particular machine, a processor, or other programmable data processing apparatus to produce a particular machine, such that the instructions that execute on the computer, processor, or other programmable data processing apparatus create means for implementing one or more functions specified in the flow diagram block or blocks. These computer program instructions may also be stored in a computer-readable storage media or memory that may direct a computer or other programmable data processing apparatus to function in a particular manner, such that the instructions stored in the computer-readable storage media produce an article of manufacture including instruction means that implement one or more functions specified in the flow diagram block or blocks. As an example, certain implementations may provide for a computer program product, comprising a computer-readable storage medium having a computer-readable program code or program instructions implemented therein, said computer-readable program code adapted to be executed to implement one or more functions specified in the flow diagram block or blocks. The computer program instructions may also be loaded onto a computer or other programmable data processing apparatus to cause a series of operational elements or steps to be performed on the computer or other programmable apparatus to produce a computer-implemented process such that the instructions that execute on the computer or other programmable apparatus provide elements or steps for implementing the functions specified in the flow diagram block or blocks.

[0180] Accordingly, blocks of the block diagrams and flow diagrams support combinations of means for performing the specified functions, combinations of elements or steps for

performing the specified functions and program instruction means for performing the specified functions. It will also be understood that each block of the block diagrams and flow diagrams, and combinations of blocks in the block diagrams and flow diagrams, may be implemented by special-purpose, hardware-based computer systems that perform the specified functions, elements or steps, or combinations of special-purpose hardware and computer instructions.

[0181] Conditional language, such as, among others, "can," "could," "might," or "may," unless specifically stated otherwise, or otherwise understood within the context as used, is generally intended to convey that certain implementations could include, while other implementations do not include, certain features, elements, and/or operations. Thus, such conditional language is not generally intended to imply that features, elements, and/or operations are in any way required for one or more implementations or that one or more implementations necessarily include logic for deciding, with or without user input or prompting, whether these features, elements, and/or operations are included or are to be performed in any particular implementation.

[0182] Many modifications and other implementations of the disclosure set forth herein will be apparent having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the disclosure is not to be limited to the specific implementations disclosed and that modifications and other implementations are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

CLAIMS

What is claimed is:

1. A device, the device comprising storage and processing circuitry configured to:

determine a wake-up frame comprising an address field and an indication of group addressed traffic, wherein the address field identifies a group of stations devices and wherein the indication of group addressed traffic is associated with a primary connectivity radio (PCR) of a first station device of the group of station devices;

cause to send the wake-up frame to the group of station devices; and

cause to send a group addressed frame after a time to allow the first station device to activate the PCR.

2. The device of claim 1, wherein the group of station devices comprises one or more station devices associated with the device and wherein the address field comprises a broadcast identifier.

3. The device of claim 1, wherein the group of station devices comprises a subset of one or more station devices associated with the device.

4. The device of any of claims 1-3, wherein the address field comprises a group identifier negotiated between the device and the group of station devices, wherein the group identifier indicates that the device has the group addressed traffic buffered for the group of station devices.

5. The device of any of claims 1-4, wherein the storage and processing circuitry are further configured to cause to send a second frame comprising a wake-up receiver mode element indicating a group identifier associated with the group of station devices, wherein the address field comprises the group identifier.

6. The device of any of claims 1-5, wherein the group addressed frame is a beacon.

7. The device of any of claims 1-5, wherein the group addressed frame is a frame indicated in a delivery traffic indication message (DTIM) beacon.

8. The device of claim 7, wherein the address field comprises an indication that the first station device is to activate the PCR at a time of a next DTIM beacon associated with a DTIM beacon interval.

9. The device of claim 1, wherein the group of station devices is a first group of station devices, wherein the address field comprises an indication that a second station device of a second group of station devices is to maintain a low-power mode at a time of a next beacon associated with a beacon interval.

10. The device of claim 1, further comprising a transceiver configured to transmit and receive wireless signals.

11. The device of claim 10, further comprising one or more antennas coupled to the transceiver.

12. A non-transitory computer-readable medium storing computer-executable instructions which when executed by one or more processors result in performing operations comprising:

identifying, at a first station device, a wake-up frame received by a wake-up receiver of the first station device from an access point device, the wake-up frame comprising an address field and an indication of group addressed traffic, wherein the address field identifies a group of stations devices and wherein the indication of group addressed traffic is associated with a primary connectivity radio (PCR) of a first station device of the group of station devices;

determining that the first station device is associated with the group of station devices;

causing to activate the PCR of the first station device; and

identifying a group addressed frame received by the PCR from the access point device.

13. The non-transitory computer-readable medium of claim 12, wherein the group of station devices comprises one or more station devices associated with the access point device and wherein the address field comprises a broadcast identifier.

14. The non-transitory computer-readable medium of claim 12, wherein the group of station devices comprises a subset of one or more station devices associated with the access point device.

15. The non-transitory computer-readable medium of any of claims 12-14, wherein the wake-up frame is a first wake-up frame, wherein the address field is a first address field, and wherein the group of station devices is a first group of station devices, the operations further comprising:

identifying a second wake-up frame received by the wake-up receiver of the first station device from the access point device, the second wake-up frame comprising a second address field identifying a second group of station devices comprising a second station device, and further comprising an indication of second group addressed traffic associated with a PCR of the second station device;

determining that the first station device is not associated with the second group of station devices; and

maintaining a low-power mode wherein the PCR of the first station device is inactive.

16. The non-transitory computer-readable medium of any of claims 12-15, wherein the address field comprises a group identifier negotiated between the access point device and the group of station devices, wherein the group identifier indicates that the access point device has the group addressed traffic buffered for the group of station devices.

17. The non-transitory computer-readable medium of any of claims 12-16, the operations further comprising identifying a second frame comprising a wake-up receiver mode element indicating a group identifier associated with the group of station devices, wherein the address field comprises the group identifier.

18. The non-transitory computer-readable medium of any of claims 12-17, wherein the group addressed frame is a beacon.

19. The non-transitory computer-readable medium of any of claims 12-17, wherein the group addressed frame is a frame indicated in a delivery traffic indication message (DTIM) beacon.

20. The non-transitory computer-readable medium of claim 19, wherein the address field comprises an indication that the first station device is to activate the PCR at a time of a next DTIM beacon associated with a DTIM beacon interval.

21. The non-transitory computer-readable medium of claim 18, wherein the group of station devices is a first group of station devices, wherein the address field comprises an indication that a second station device of a second group of station devices is to maintain a low-power mode at a time of a next beacon associated with a beacon interval.

22. A method, comprising:

determining, by processing circuitry of a device, a wake-up frame comprising an address field and an indication of group addressed traffic, wherein the address field identifies a group of stations devices and wherein the indication of group addressed traffic is associated with a primary connectivity radio (PCR) of a first station device of the group of station devices;

causing to send, by the processing circuitry, the wake-up frame to the group of station devices; and

causing to send, by the processing circuitry, a group addressed frame after a time to allow the first station device to activate the PCR.

23. The method of claim 22, wherein the group of station devices comprises one or more station devices associated with the device and wherein the address field comprises a broadcast identifier.

24. The method of claim 22, wherein the group of station devices comprises a subset of one or more station devices associated with the device.

25. The method of any of claims 22-24, wherein the address field comprises a group identifier negotiated between the device and the group of station devices, wherein the group identifier indicates that the device has the group addressed traffic buffered for the group of station devices.

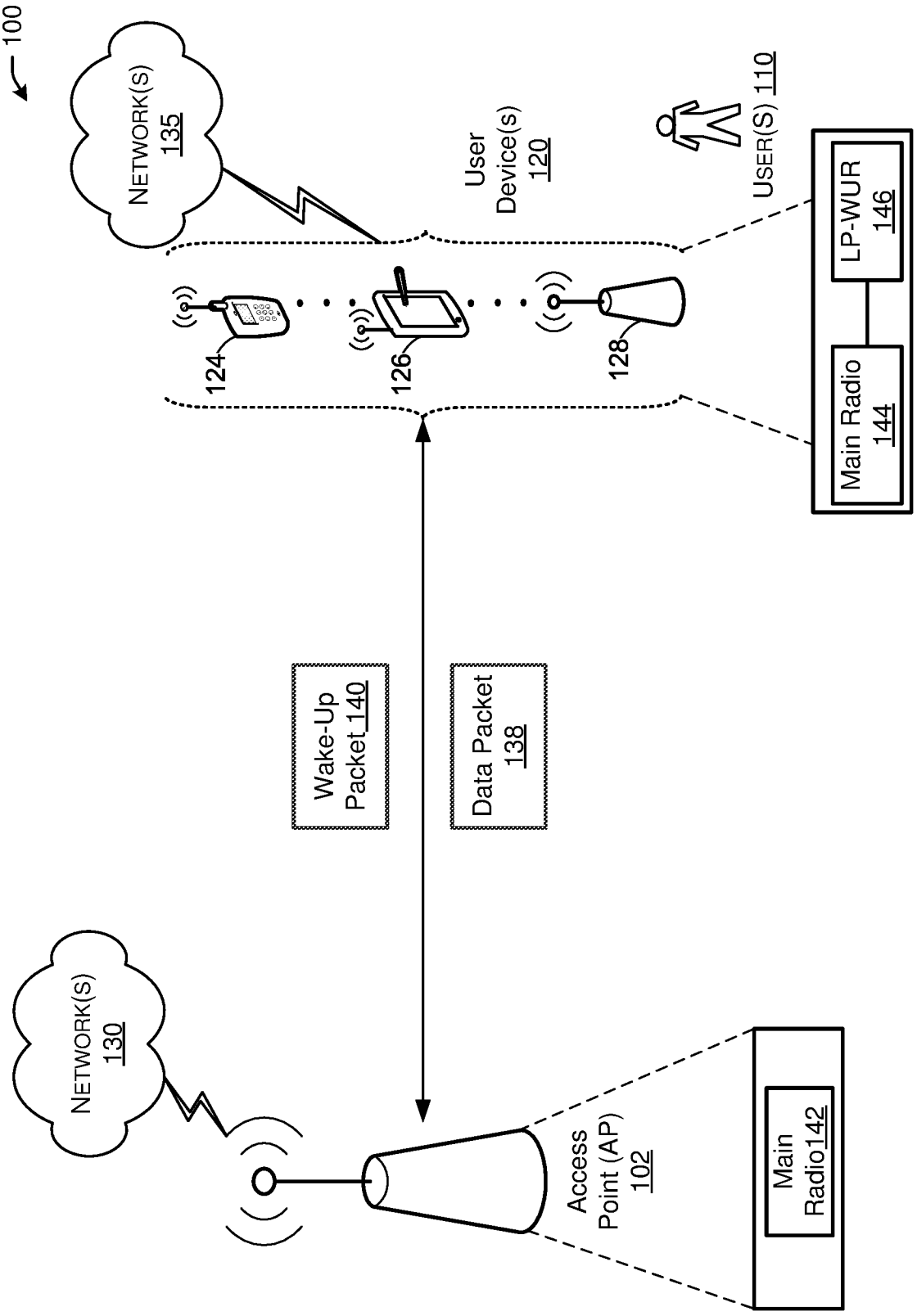

100
NETWORK(S) 135
User Device(s) 120
USER(S) 110
124
126
128
LP-WUR 146
Main Radio 144
Wake-Up Packet 140
Data Packet 138
NETWORK(S) 130
Access Point (AP) 102
Main Radio142

FIG. 1

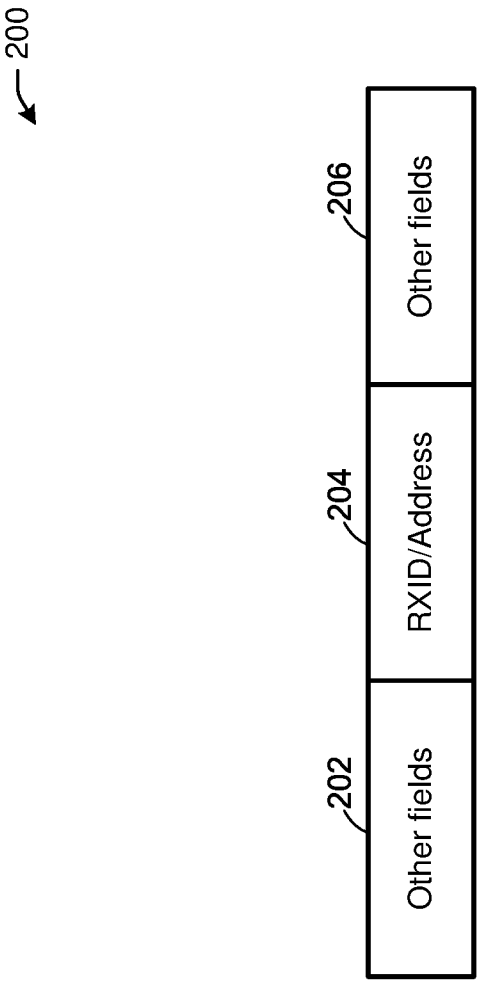


FIG. 2

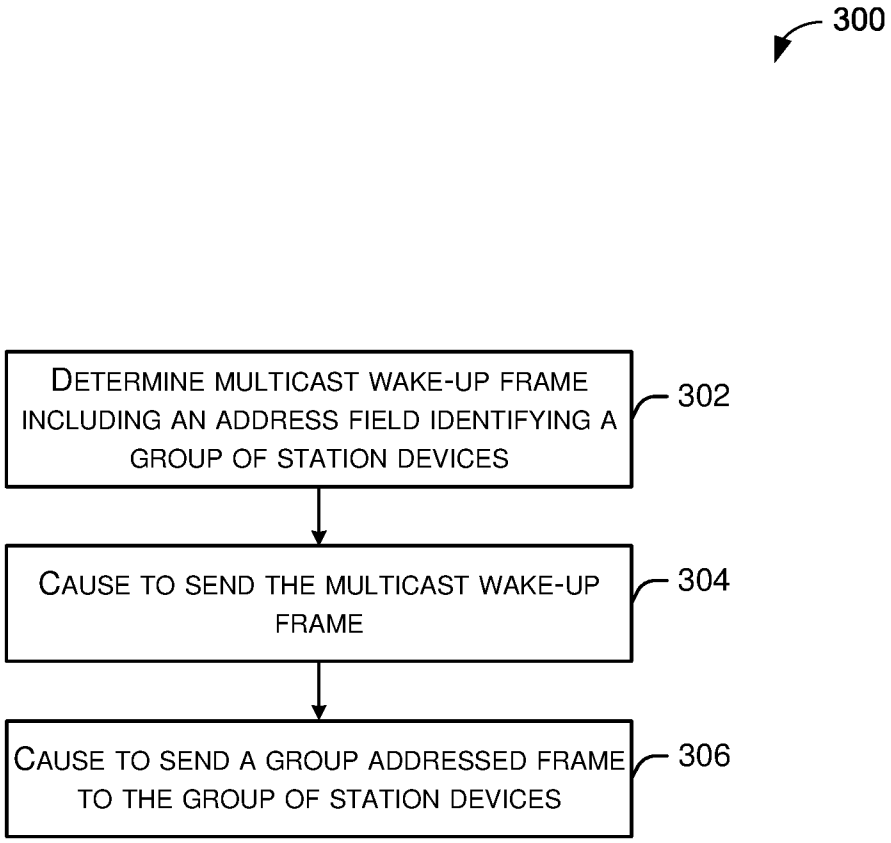

300
DETERMINE MULTICAST WAKE-UP FRAME INCLUDING AN ADDRESS FIELD IDENTIFYING A GROUP OF STATION DEVICES
302
CAUSE TO SEND THE MULTICAST WAKE-UP FRAME
304
CAUSE TO SEND A GROUP ADDRESSED FRAME TO THE GROUP OF STATION DEVICES
306

FIG. 3A

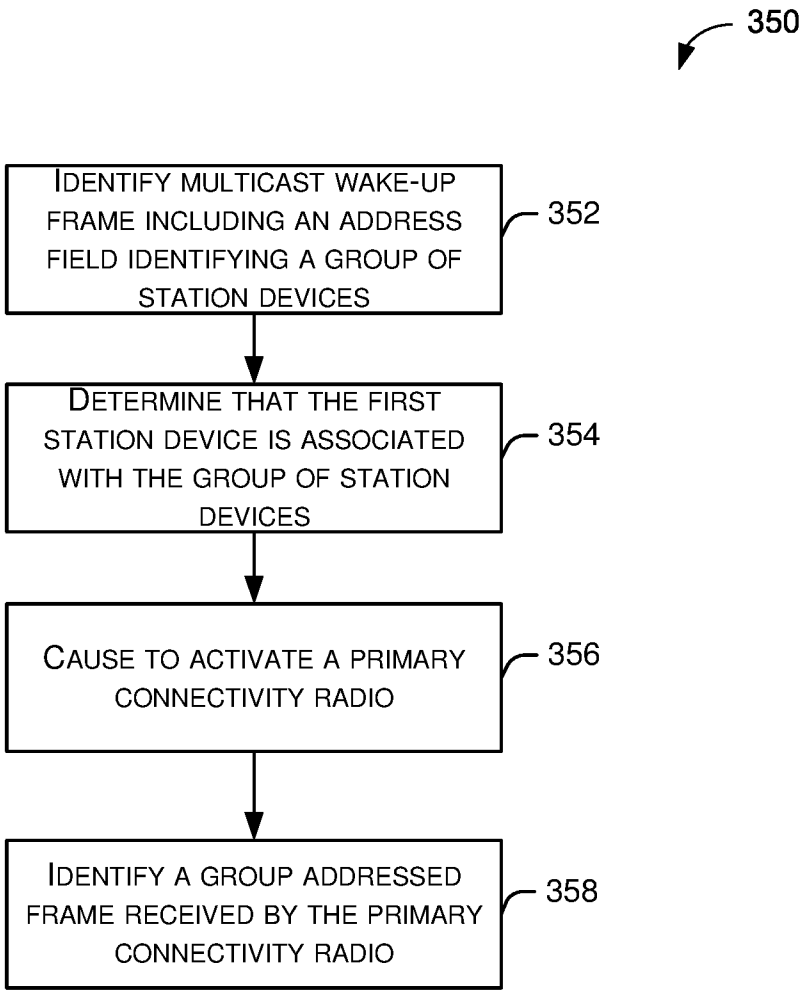

350
IDENTIFY MULTICAST WAKE-UP FRAME INCLUDING AN ADDRESS FIELD IDENTIFYING A GROUP OF STATION DEVICES
352
DETERMINE THAT THE FIRST STATION DEVICE IS ASSOCIATED WITH THE GROUP OF STATION DEVICES
354
CAUSE TO ACTIVATE A PRIMARY CONNECTIVITY RADIO
356
IDENTIFY A GROUP ADDRESSED FRAME RECEIVED BY THE PRIMARY CONNECTIVITY RADIO
358

FIG. 3B

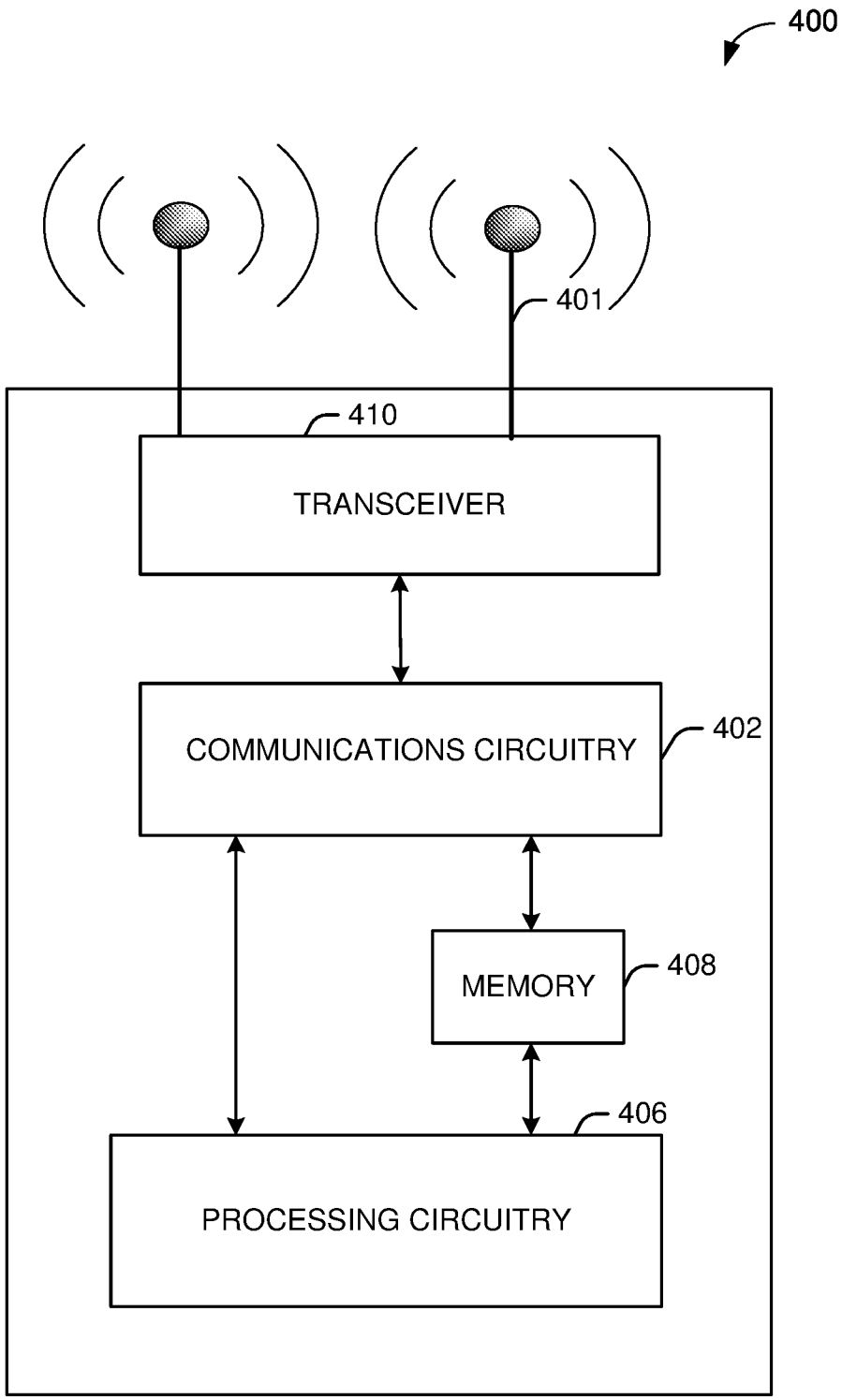

400
401
410
TRANSCEIVER
COMMUNICATIONS CIRCUITRY
402
MEMORY
408
406
PROCESSING CIRCUITRY

FIG. 4

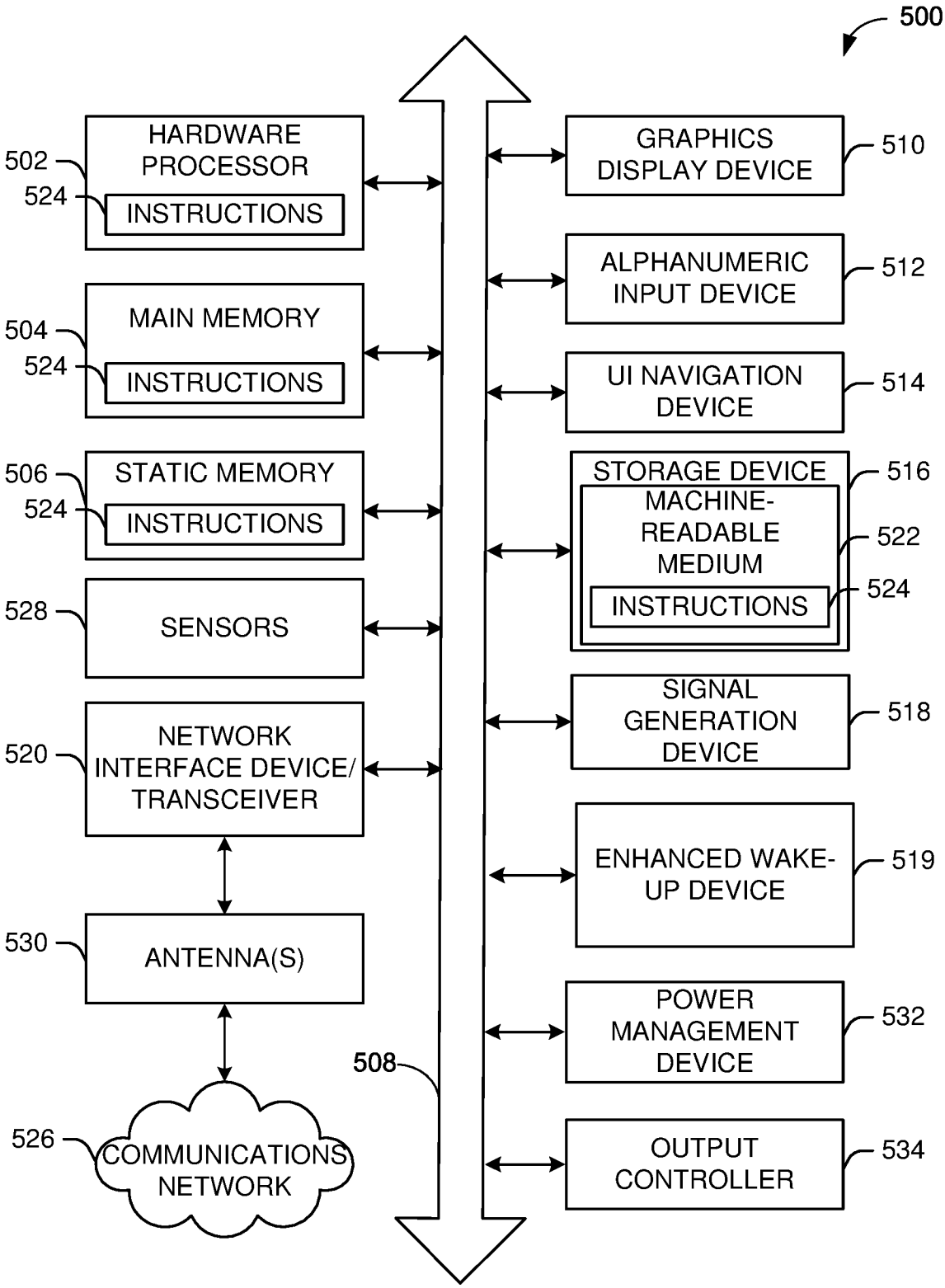

500
HARDWARE PROCESSOR
502
524
INSTRUCTIONS
MAIN MEMORY
504
524
INSTRUCTIONS
STATIC MEMORY
506
524
INSTRUCTIONS
528
SENSORS
NETWORK INTERFACE DEVICE/ TRANSCEIVER
520
530
ANTENNA(S)
526
COMMUNICATIONS NETWORK
508
GRAPHICS DISPLAY DEVICE
510
ALPHANUMERIC INPUT DEVICE
512
UI NAVIGATION DEVICE
514
STORAGE DEVICE
516
MACHINE-READABLE MEDIUM
522
INSTRUCTIONS
524
SIGNAL GENERATION DEVICE
518
ENHANCED WAKE-UP DEVICE
519
POWER MANAGEMENT DEVICE
532
OUTPUT CONTROLLER
534

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2018/039136

A. CLASSIFICATION OF SUBJECT MATTER

H04W 52/02(2009.01)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)
H04W 52/02; H04B 7/04; H04L 27/26; H04W 4/06; H04W 72/12; H04W 8/26; H04W 84/12

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: access point device, station device, wake-up frame, address field, indication of group addressed traffic, primary connectivity radio (PCR)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2017-0111858 A1 (SHAHRNAZ AZIZI et al.) 20 April 2017 See claims 1, 13-14, 21.	1-25
Y	US 2016-0165625 A1 (LG ELECTRONICS INC.) 09 June 2016 See paragraphs [0013], [0048], [0055], [0073], [0083]; claims 13, 19; and figure 2.	1-25
A	US 2015-0358786 A1 (LG ELECTRONICS INC.) 10 December 2015 See paragraphs [0247]-[0250]; and figure 30.	1-25
A	WO 2015-148065 A1 (INTEL IP CORPORATION) 01 October 2015 See paragraphs [0054]-[0055]; and figure 4.	1-25
A	US 2014-0314054 A1 (LG ELECTRONICS INC.) 23 October 2014 See claims 17-26.	1-25

☐ 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
"E" earlier application or patent but published on or after the international filing date
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Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2018/039136

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2017-0111858 A1	20/04/2017	None	
US 2016-0165625 A1	09/06/2016	CN 103563457 A	05/02/2014
		CN 103563457 B	15/02/2017
		EP 2716112 A1	09/04/2014
		EP 2716112 A4	19/11/2014
		EP 2716112 B1	03/02/2016
		EP 2852228 A1	25/03/2015
		EP 2852228 B1	03/01/2018
		ES 2564965 T3	30/03/2016
		JP 2014-515585 A	30/06/2014
		JP 5653565 B2	14/01/2015
		KR 10-1523166 B1	26/05/2015
		KR 10-2014-0037892 A	27/03/2014
		US 2014-0086131 A1	27/03/2014
		US 9237521 B2	12/01/2016
		US 9674783 B2	06/06/2017
		WO 2012-165733 A1	06/12/2012
US 2015-0358786 A1	10/12/2015	KR 10-2015-0138158 A	09/12/2015
		WO 2014-116023 A1	31/07/2014
WO 2015-148065 A1	01/10/2015	TW 201603608 A	16/01/2016
		TW I577211 B	01/04/2017
		US 2015-0282079 A1	01/10/2015
		US 9462549 B2	04/10/2016
US 2014-0314054 A1	23/10/2014	CA 2856489 A1	30/05/2013
		CA 2856489 C	28/02/2017
		CN 103959680 A	30/07/2014
		CN 103959680 B	29/08/2017
		CN 103959681 A	30/07/2014
		CN 103959681 B	09/01/2018
		CN 103988448 A	13/08/2014
		CN 103988448 B	22/02/2017
		EP 2784946 A1	01/10/2014
		EP 2784946 A4	29/07/2015
		EP 2784946 B1	25/07/2018
		EP 2784947 A1	01/10/2014
		EP 2784947 A4	19/08/2015
		EP 2784948 A1	01/10/2014
		EP 2784948 A4	17/12/2014
		EP 2784948 B1	09/11/2016
		ES 2609356 T3	19/04/2017
		JP 2015-502106 A	19/01/2015
		JP 2015-502107 A	19/01/2015
		JP 2015-502108 A	19/01/2015
		JP 5809758 B2	11/11/2015
		JP 5837703 B2	24/12/2015

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2018/039136

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		JP 5873566 B2	01/03/2016
		KR 10-1591212 B1	02/02/2016
		KR 10-1607413 B1	29/03/2016
		KR 10-1607414 B1	11/04/2016
		KR 10-2014-0097158 A	06/08/2014
		KR 10-2014-0097159 A	06/08/2014
		KR 10-2014-0097166 A	06/08/2014
		US 2014-0328238 A1	06/11/2014
		US 2015-0341959 A1	26/11/2015
		US 9456456 B2	27/09/2016
		US 9503976 B2	22/11/2016
		US 9538368 B2	03/01/2017
		WO 2013-077685 A1	30/05/2013
		WO 2013-077690 A1	30/05/2013
		WO 2013-077692 A1	30/05/2013