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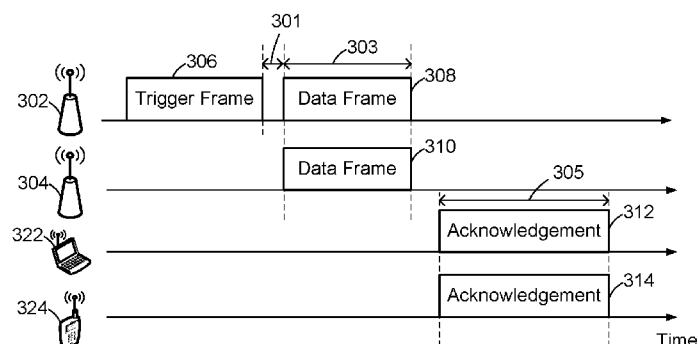


FIG. 3A

(57) **Abstract:** This disclosure describes systems, methods, and devices related to simultaneous downlink transmission coordination. A device may identify device information received from a first device. The device may determine an access point trigger frame, the access point trigger frame comprising an indication for a simultaneous transmission, and one or more frequency allocations to be used by the first device during the simultaneous transmission. The device may cause to send the access point trigger frame to the first device. The device may cause to send one or more data frames to a station device using at least one of the one or more frequency allocations.



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SIMULTANEOUS DOWNLINK TRANSMISSION COORDINATION

CROSS-REFERENCE TO RELATED APPLICATION(S)

[0001] This application claims benefit of U.S. Provisional Application No. 62/440,543
5 filed December 30, 2016, and U.S. Provisional Application No. 62/440,530 filed December
30, 2016, both disclosures of which are incorporated herein by reference as if set forth in full.

TECHNICAL FIELD

[0002] This disclosure generally relates to systems, methods, and devices for wireless
communications and, more particularly, simultaneous downlink transmission coordination.

BACKGROUND

[0003] Wireless devices are becoming widely prevalent and are increasingly requesting
access to wireless channels. Efficient use of the resources of a wireless local area network
(WLAN) is important to provide bandwidth and acceptable response times to the users of the
WLAN.

BRIEF DESCRIPTION OF THE DRAWINGS

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

[0005] FIG. 2 depicts an illustrative schematic diagram of scheduled transmissions
20 between an access point and two devices using a trigger frame, in accordance with one or
more example embodiments of the present disclosure.

[0006] FIG. 3A depicts an illustrative schematic diagram of a simultaneous downlink
transmission coordination system, in accordance with one or more example embodiments of
the present disclosure.

25 [0007] FIG. 3B depicts an illustrative schematic diagram for simultaneous multicast and
broadcast transmission coordination, in accordance with one or more example embodiments
of the present disclosure.

[0008] FIG. 4 depicts an illustrative schematic diagram for simultaneous multicast and
broadcast transmission coordination, in accordance with one or more example embodiments
30 of the present disclosure.

[0009] FIG. 5 depicts an illustrative schematic diagram of a simultaneous downlink transmission coordination system, in accordance with one or more example embodiments of the present disclosure.

[0010] FIGs. 6A-6B depict illustrative schematic diagrams of a simultaneous downlink transmission coordination system, in accordance with one or more example embodiments of the present disclosure.

[0011] FIG. 7 depicts an illustrative schematic diagram of a simultaneous downlink transmission coordination system, in accordance with one or more example embodiments of the present disclosure.

10 [0012] FIG. 8 depicts an illustrative schematic diagram of a simultaneous downlink transmission coordination system, in accordance with one or more example embodiments of the present disclosure.

[0013] FIG. 9A illustrates a flow diagram of an illustrative process for a simultaneous downlink transmission coordination system, in accordance with one or more embodiments of the present disclosure.

[0014] FIG. 9B illustrates a flow diagram of an illustrative process for a simultaneous downlink transmission coordination system, in accordance with one or more example embodiments of the present disclosure.

[0015] FIG. 10 illustrates a functional diagram of an example communication station that may be suitable for use as a user device, in accordance with one or more example embodiments of the present disclosure.

[0016] FIG. 11 illustrates 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.

25 **DETAILED DESCRIPTION**

[0017] Example embodiments described herein provide certain systems, methods, and devices for providing signaling information to Wi-Fi devices in various Wi-Fi networks, including, but not limited to, IEEE 802.11ax (referred to as HE or HEW).

[0018] The following description and the drawings sufficiently illustrate specific
30 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.

[0019] During communication between two devices, one or more frames may be sent and received.

[0020] IEEE 802.11ax has introduced a trigger frame to solicit simultaneous uplink transmission in one basic service set (BSS), for example, from an access point (AP) to one or more station devices (STAs). The trigger frame may allow the APs solicited by the trigger frame to perform time synchronization and frequency synchronization so that the simultaneous uplink transmissions do not interfere with each other. In a Wi-Fi environment, there is usually more than one AP in the neighborhood. However, the communication is typically one to many or many to one, within one BSS. For example, an AP can communicate in the downlink direction with one or more STAs that are associated with that AP, and these one or more STAs can communicate with the AP in the uplink direction. Different APs belonging to different BSSs communicating with their STAs usually perform channel access at different times from each other to avoid interference. However, these APs do not participate in simultaneous uplink transmissions with each other. It is not possible for two APs to synchronize with each other in order to simultaneously transmit to one or more STAs such that the transmissions can be properly decoded by the receiving device. Consequently, the system performance may not be optimized for orthogonal frequency-division multiple access (OFDMA) or multiuser (MU) multiple-input multiple-output (MIMO) schemes with multiple APs and multiple STAs.

[0021] Example embodiments of the present disclosure relate to systems, methods, and devices for simultaneous downlink transmission coordination.

[0022] In one embodiment, a simultaneous downlink transmission coordination system may facilitate the use of a coordination frame (hereinafter referred to as a trigger frame) to coordinate simultaneous downlink transmissions between one or more APs in one or more BSSs. The trigger frame may trigger simultaneous transmissions from different APs in the downlink direction with one or more STAs.

[0023] In one embodiment, a simultaneous downlink transmission coordination system may facilitate a device (e.g., an AP) to send a trigger frame to another device (e.g., another AP). The trigger frame may contain information associated with coordinating simultaneous transmissions between each device and one or more STAs. The information may include synchronization of downlink data to one or more STAs. This may lead to many-to-many communication in the downlink and/or the uplink directions.

[0024] 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 detail below. Example embodiments will now be described with reference to the accompanying figures.

[0025] FIG. 1 is a diagram illustrating an example network environment, in accordance with one or more example embodiments of the present disclosure. Wireless network 100 may include one or more user devices 120 and one or more access point(s) (AP) 102, which may communicate in accordance with IEEE 802.11 communication standards, including IEEE 802.11ax. The user device(s) 120 may be mobile devices that are non-stationary (e.g., not having fixed locations) or may be stationary devices.

[0026] 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. 10 and/or the example machine/system of FIG. 11.

[0027] One or more illustrative user device(s) 120 and/or AP 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 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 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 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.

[0028] 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 can 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 can 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 can 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.).

[0029] The user device(s) 120 and/or AP 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.

[0030] Any of the user device(s) 120 (e.g., user devices 124, 126, 128), and AP 102 may
5 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 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
10 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
15 (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
20 mediums, satellite communication mediums, or any combination thereof.

[0031] Any of the user device(s) 120 (e.g., user devices 124, 126, 128) and AP 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 102. Some non-limiting
25 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
30 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 102.

[0032] Any of the user device(s) 120 (e.g., user devices 124, 126, 128), and AP 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 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 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 102 may be configured to perform any given directional reception from one or more defined receive sectors.

[0033] 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 102 may be configured to use all or a subset of its one or more communications antennas to perform MIMO beamforming.

[0034] Any of the user devices 120 (e.g., user devices 124, 126, 128), and AP 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 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.

[0035] When an AP (e.g., AP 102) establishes communication with one or more user devices 120 (e.g., user devices 124, 126, and/or 128), the AP 102 may communicate in a downlink direction and the user devices 120 may communicate with the AP 102 in an uplink

direction by sending frames in either direction. The user devices 120 may also communicate peer-to-peer or directly with each other with or without the AP 102. The data frames may be preceded by one or more preambles that may be part of one or more headers. These preambles may be used to allow a device (e.g., AP 102 and/or user devices 120) to detect a new incoming data frame from another device. A preamble may be a signal used in network communications to synchronize transmission timing between two or more devices (e.g., between the APs and user devices).

[0036] A trigger frame 104 may be carried using a preamble, along with other signaling, such as resource allocation, to coordinate the uplink OFDMA operation. A trigger frame is a frame that contains a preamble and other fields that may be sent from an AP informing all user devices serviced by the AP that channel access is available. With OFDMA, the AP may transmit a trigger frame for various reasons, such as allocating resources. User devices may use the allocated resource (e.g., 2 MHz of spectrum in a particular portion of the channel) to transmit their data back to the AP.

[0037] STAs are typically located at different distances from an AP. Distances may be associated with actual measurement of distance to the AP or by use of received signal strength indicator (RSSI) or signal to noise ratio (SNR) measurement to classify the proximity of an STA to an AP. For example, if an STA has a certain level of RSSI and/or SNR compared a predetermined threshold, the STA may be classified as proximate to the AP. Similarly, a distance between the STA and the AP may be compared to a threshold when classifying an STA to be proximate or not proximate. It should be understood that determining how to classify a device to be proximate (close) or not proximate (far) may be based on implementation. When an AP sends a trigger frame, due to propagation delay, the trigger frame may not arrive at each STA at the same time. Once an STA receives the trigger frame, it is required to give a response after a certain time delay (e.g., short inter-frame space (SIFS)). Simultaneous transmissions from the STAs to the AP may be considered simultaneous because the propagation delay is not very large. The AP may consider the uplink transmissions received from these STAs to be simultaneous transmissions and may decode them as such. Since signals travel at the speed of light, the propagation delays associated with devices that are at different distances from the AP may be considered negligible so that the AP considers any simultaneous uplink transmissions as being received approximately at the same time. In order for an AP to successfully differentiate between the simultaneous transmissions received from multiple STAs, the AP and the STAs may have employed frequency differentiation using OFDMA or spatial differentiation using MU-

MIMO, or any other mechanism to differentiate and minimize interference between simultaneous transmissions.

[0038] FIG. 2 depicts an illustrative schematic diagram of scheduled transmissions between an access point and two devices using a trigger frame.

5 [0039] Referring to FIG. 2, an AP 202 may be communicating with two user devices (e.g., STA 222 and STA 224). The AP may send a trigger frame 206 that may be received by STA 222 and STA 224.

[0040] IEEE 802.11ax has introduced the trigger frame to solicit simultaneous uplink transmissions in one basic service set (BSS). The trigger frame (e.g., trigger frame 206) may
10 allow STAs solicited by the trigger frame to have time synchronization and frequency synchronization so that the simultaneous uplink transmissions (e.g., data frames 208 and 210) do not interfere with each other. The AP 202 may respond with an acknowledgment 212 for each or both of the data frames (e.g., data frames 208 and 210) received. As a result, OFDMA or MU-MIMO uplink transmission can be done through a trigger frame to increase system
15 throughput. However, for the Wi-Fi transmission, there is usually more than one AP in the neighborhood of STA 222 and STA 222. Different APs usually do channel access at different times to avoid interference. As a result, the system performance cannot be optimized using a simultaneous transmission with an OFDMA or an MU-MIMO scheme. It is understood that the above descriptions are for purposes of illustration and are not meant to
20 be limiting.

[0041] FIG. 3A depicts an illustrative schematic diagram of a simultaneous downlink transmission coordination system, in accordance with one or more example embodiments of the present disclosure.

[0042] Referring to FIG. 3A, there is shown two APs (e.g., AP 302 and AP 304) that may
25 calibrate or coordinate their transmissions in order to simultaneously transmit to their respective STAs (e.g., STA 322 and STA 324).

[0043] In one embodiment, a simultaneous downlink transmission coordination system may determine a trigger frame (e.g., trigger frame 306) that can trigger simultaneous transmissions from different APs during downlink transmissions. For example, AP 302 may
30 determine a trigger frame 306 to send to AP 304 in order to trigger AP 304 to perform simultaneous transmissions with AP 302. Based on the trigger frame 306, the AP 302 and the AP 304 may calibrate their response time. Based on information included in the trigger frame 306, both AP 302 and AP 304 can simultaneously transmit to their respective STAs. In this example, AP 302 can send data frame 308 to STA 322 and AP 304 can simultaneously

send data frame 310 to STA 324. The simultaneous downlink transmission coordination system may facilitate that the STA 322 and the STA 324 are able to receive the data frames 308 and 310, respectively, and properly decode each of these data frames even though both data frames were sent simultaneously by AP 302 and AP 304.

5 [0044] In one embodiment, the transmission (e.g., data frame 308 and/or data frame 310) may be sent after a channel access time delay 301. The channel access time delay 301 may be an inter-frame spacing between the trigger frame and the solicited simultaneous transmission of short inter-frame space (SIFS).

[0045] In one embodiment, the trigger frame 306 may indicate the duration (e.g., duration 10 303) of the simultaneous downlink transmission and the duration (e.g., duration 305) of the simultaneous uplink acknowledgement.

[0046] In one embodiment, the trigger frame 306 may indicate that the content of the common physical preamble should be used by the solicited APs.

[0047] In one embodiment, the trigger frame 306 may indicate the format of a frame 15 (e.g., a PLCP protocol data unit (PPDU)) of the simultaneous downlink transmission (e.g., data frames 308 and 310) and the simultaneous uplink transmission (e.g., acknowledgment frames 312 and 314).

[0048] This mechanism may require some coordination between APs, either over-the-air or through a distribution system (DS), where a background controller controls all of the APs.

20 [0049] In one embodiment, the AP that sends the trigger frame to solicit one or more other APs to perform simultaneous transmission may need to know some information associated with the neighboring APs and STAs it will trigger. The information may include one or more of the buffer status of neighboring APs and STAs, mapping of STAs in the region close to the AP or in the region where frequency selection is needed (far region), level 25 of interference between the STAs and the APs (precise or coarse). In this case, the AP that sends the trigger frame may send frequency allocations (or other resource allocations) and may classify, for example, that a certain frequency is to be used with STAs that were reported to be mapped in the region close to the solicited AP. The trigger frame may also indicate various frequencies to be used by the solicited AP when communicating with STAs that are 30 in a region that is classified as far from the solicited AP. The solicited AP may then use that frequency allocation to transmit to its STAs.

[0050] In one embodiment, the AP sending the trigger frame, may collect information from other APs. The information may be exchanged by sending and receiving messages between the APs. The information may be associated with the STAs and/or the APs that are

serving the STAs. The information may include identification of the STAs, the distances of the STAs to their serving APs, the signal strengths of the STAs to their serving APs, or any other information that may determine the location and signal strength of the STAs.

[0051] STAs are typically located at different distances from an AP. Distances may be associated with actual measurement of distance to the AP or by use of received signal strength indicator (RSSI) or signal to noise ratio (SNR) measurement to classify the proximity of an STA to an AP. For example, if an STA has a certain level of RSSI and/or SNR compared a predetermined threshold, the STA may be classified as proximate to the AP. Similarly, a distance between the STA and the AP may be compared to a threshold when classifying an STA to be proximate or not proximate. It should be understood that determining how to classify a device to be proximate (clos) or not proximate (far) may be based on implementation.

[0052] The information may also include the identification of the APs that are solicited to communicate simultaneously, the coverage area of the APs, or the location of the APs (e.g., coordinate or other location identification information). The AP sending the trigger frame may then determine how to assign resources (e.g., frequencies, resource units, subchannels, bands, etc.) based on the collected information. The AP sending the trigger frame may determine based on a certain criteria which frequency should be used by the APs when sending their downlink data and by the STAs when sending their uplink data. For example, the AP may compare a certain value received from the APs to a threshold value. Based on that comparison, the AP may determine the one or more frequency selections that it may send in the trigger frame.

[0053] In one embodiment, the trigger frame may indicate which AP is solicited for transmission. The trigger frame may indicate which subchannel for a solicited AP to transmit. The trigger frame may indicate which group of STAs for a subchannel for a solicited AP to transmit. The AP that sends the trigger frame may transmit simultaneously with the other AP solicited by the trigger frame for transmission. The solicited AP or the AP that transmits the trigger frame may synchronize with the end of the trigger frame to achieve timing synchronization and minimize interference among APs that transmit simultaneously. The inter-frame spacing between the trigger frame and the solicited simultaneous transmission is SIFS. The AP solicited by the AP does CCA including physical carrier or virtual carrier sensing between the inter-frame spacing to determine if it can transmit after being solicited by the trigger frame. The solicited AP or the AP that transmits the trigger frame synchronizes with the clock of the AP that sends the trigger frame to achieve frequency

synchronization and minimize carrier frequency offset and interference among APs that transmit simultaneously. The AP that is solicited can be a soft AP or an ad-hoc STA, for example, an STA that transmits device-to-device transmission to another STA. The trigger frame may indicate the power that will be used by each solicited AP for simultaneous transmission.

[0054] It is understood that the above descriptions are for purposes of illustration and are not meant to be limiting.

[0055] FIG. 3B depicts an illustrative schematic diagram for simultaneous multicast and broadcast transmission coordination, in accordance with one or more example embodiments of the present disclosure.

[0056] Referring to FIG. 3B, there is shown two APs (e.g., AP 352, and AP 354). The AP 352 may send a trigger frame 356 to the AP 354 that would act as a trigger to indicate to the AP 354 to perform simultaneous transmissions of one or more multicast or broadcast frames (e.g., multicast/broadcast frames 358, 360, 362, and 364).

[0057] The trigger frame 356 may indicate a common MAC header 357 for soliciting transmission as shown in FIG. 3B. The trigger frame 356 may indicate the multicast/broadcast address (e.g., receiver address (RA) in the MAC header 354) for the solicited APs to transmit multicast transmission. The trigger frame 356 may indicate a common transmitter address (e.g., TA in MAC header 354) for the solicited APs to transmit multicast transmission. The trigger frame 356 may indicate the data rate for the solicited simultaneous transmissions from different APs. The trigger frame 356 may indicate the same scrambling seed for the solicited simultaneous transmissions from different APs. The trigger frame 356 may indicate a PPDU format for the solicited simultaneous transmissions from different APs. The trigger frame 356 may indicate a coding option for the solicited simultaneous transmissions from different APs. The trigger frame 356 may indicate a packet index for the packets that will be included in multicast/broadcast data that is transmitted by the solicited AP. The trigger frame 356 may indicate the type of control frame for the broadcast transmission from the solicited AP. As a result, each solicited AP may know the format of the frame that should be transmitted (e.g., for broadcast transmission). The trigger frame 356 may indicate the number of times to repeat the same multicast transmission. This may be used to increase the probability that every STA in the neighborhood may receive the transmission. The separation of each multicast/broadcast transmission may be a short inter-frame space (SIFS) (e.g., SIFS 351 and 355). The trigger frame 356 may indicate bandwidth

353 for the multicast/broadcast transmission. It is understood that the above descriptions are for purposes of illustration and are not meant to be limiting.

[0058] FIG. 4 depicts an illustrative schematic diagram for simultaneous multicast and broadcast transmission coordination, in accordance with one or more example embodiments
5 of the present disclosure.

[0059] Referring to FIG. 4, there is shown three APs (e.g., APs 402, 404, and 406) that may be coordinating in order to facilitate a simultaneous multicast/broadcast transmission to three STAs (e.g., STAs 422, 424, and 426).

[0060] In one embodiment, a simultaneous multicast and broadcast transmission
10 coordination system may use a trigger frame that may trigger simultaneous multicast or broadcast transmissions from different APs (e.g., APs 402, 404, and 406). Since different APs send the same multicast or broadcast content simultaneously on the same channel, the signal strength from different APs may be viewed as the same signal and can be combined at the STA. As a result, the interference impact among different APs is minimized.

[0061] In the example of FIG. 4, the AP 402 may send a trigger frame to AP 404 and AP 406. Based on that trigger frame, AP 402, AP 404, and AP 406 may coordinate simultaneous
15 transmissions to the STAs 422, 424, and 426. The APs may transmit multicast/broadcast frames to all of the STAs in the vicinity such that these transmissions are sent simultaneously from all the APs.

[0062] In one embodiment, the AP that sends the trigger may need to know some information associated with the neighboring APs and STAs it will trigger. The information may include one or more of the buffer status of the neighboring APs and STAs, mapping of the STAs in the region close to the AP or in the region where frequency selection is needed, or the level of interference between the STAs and the APs (precise or coarse).
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[0063] In one embodiment, the AP sending the trigger frame may collect information from other APs. The information may be exchanged by sending and receiving messages between the APs. The information may be associated with the STAs and/or the APs that are serving the STAs. The information may include identification of the STAs, the distances of the STAs to their serving APs, signal strengths of the STAs to their serving APs, or any other
25 information that may determine the location and signal strength of the STA. The information may also include identification of the APs that are solicited to communicate simultaneously, the coverage area of the APs, or the location of the APs (e.g., coordinate or other location identification information). The AP sending the trigger frame may then determine how to assign resources (e.g., frequencies, resource units, subchannels, bands, etc.) based on the
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collected information. The AP sending the trigger frame may determine based on a certain criteria which frequency should be used by the APs when sending their downlink data and by the STAs when sending their uplink data. For example, the AP may compare a certain value received from the APs to a threshold value. Based on that comparison, the AP may
5 determine the one or more frequency selections that it may send in the trigger frame.

[0064] It is understood that the above descriptions are for purposes of illustration and are not meant to be limiting.

[0065] FIG. 5 depicts an illustrative schematic diagram of a simultaneous downlink transmission coordination system, in accordance with one or more example embodiments of
10 the present disclosure.

[0066] Referring to FIG. 5, there is shown three APs (e.g., AP1, AP2, and AP3) and six STAs (e.g., STA 551, STA 552, STA 553, STA 554, STA 555, and STA 556). This example shows that STA 551 and STA 554 are served by AP1, STA 552 and STA 555 are served by AP2, and STA 553 and STA 556 are served by AP3. This example also shows that STA 551,
15 STA 552, and STA 553 are in close proximity to AP1, AP2 and AP3, respectively, and that STA 554, STA 555, and STA 556 are not close to their serving APs (e.g., AP1, AP2, and AP3, respectively).

[0067] As explained before, there is no known solution to enable simultaneous transmissions from different APs to have time synchronization and frequency
20 synchronization so that the simultaneous downlink transmissions do not interfere with each other. For example, if AP1 transmits signals to STA 554, and AP2 transmits signals to STA 555, there may be interference between the AP1 and AP2 signals if they were to transmit simultaneously.

[0068] In one embodiment, for an enhanced spectral utilization, if an STA is determined
25 to be close to its servicing AP, the AP may transmit to its close STA since it would be easy for the AP to recognize transmission coming from the close STA since the power level difference (e.g., received signal strength indicator (RSSI), signal to noise ratio (SNR), etc.) alone may be enough to recognize that the signals are coming from the close STA and interference may not be an issue from other STAs, where the signals may have a lower power
30 level.

[0069] Therefore, it would be easy to tell the APs to use the same frequency to communicate with their respective STAs that are close because it is safe to assume that interference is minimal due to the proximity of the STA to the serving AP. However, if the AP is serving a far STA, then interference may impact these communications.

[0070] Control in Wi-Fi is given to individual APs, which perform channel sensing to determine if another AP is transmitting on a channel. In case another AP is transmitting, the AP would back off the channel until the channel is clear. Traditionally, for Wi-Fi APs, different APs cannot coordinate to transmit to different far STAs in a different frequency.

5 Different APs also cannot coordinate to transmit to different close STAs in the same frequency.

[0071] However, with the simultaneous downlink transmission coordination system, APs are capable of simultaneously transmitting without inducing interference with other APs.

[0072] In one embodiment, a simultaneous downlink transmission coordination system
10 may facilitate frequency reuse with minimal interference between neighboring APs. For example, a simultaneous downlink transmission coordination system may comprise one or more processors that may be configured to transmit a trigger frame to one or more APs to indicate how the one or more APs can simultaneously transmit any data they have to one or more STAs that may be associated with these APs. The trigger frame may contain operating
15 frequency indication (in case of OFDMA). For example, one or more APs may use the same frequency to transmit to STAs that are close to the one or more APs.

[0073] The AP that will be sending the trigger frame may collect information from other APs. The information may be exchanged by sending and receiving messages between the APs. The information may be associated with the STAs and/or the APs that are serving the
20 STAs. The information may include the identification of the STAs, the distances of the STAs to their serving APs, the signal strengths of the APs to their serving APs, or any other information that may determine the location and signal strength of the STA. The information may also include the identification of the APs that are solicited to communicate simultaneously, the coverage area of the APs, or the location of the APs (e.g., coordinate or
25 other location identification information). The AP sending the trigger frame may then determine how to assign resources (e.g., frequencies, resource units, subchannels, bands, etc.) based on the collected information. The AP sending the trigger frame may determine based on a certain criteria which frequency should be used by the APs when sending their downlink data and by the STAs when sending their uplink data. For example, the AP may compare a
30 certain value received from the APs to a threshold value. Based on that comparison, the AP may determine the one or more frequency selections that it may send in the trigger frame.

[0074] In the example of FIG. 5, AP1, AP2, and AP3 may receive the trigger frame and may extract from the trigger frame the frequency indication that AP1, AP2, and AP3 use the same frequency, for example, frequency 501, when communicating with close STAs. In this

case, since STA 551, STA 552, and STA 553 are determined to be close to AP1, AP2, and AP3 respectively, frequency 501 may be used by these APs without causing interference with each other.

[0075] In one embodiment, a simultaneous downlink transmission coordination system may comprise one or more processors that may be configured to transmit a trigger frame to one or more APs to indicate the use of different frequencies with STAs that are determined to not be close to the one or more APs but still are serviced by these one or more APs. For example, AP1, AP2, and AP3 may use different frequencies when communicating with STA 554, STA 555, and STA 556, which are determined to not be close to AP1, AP2, and AP3, respectively. For example, the trigger frame may indicate that frequency 502 may be used by AP3, frequency 503 may be used by AP2, and frequency 504 may be used by AP1. Having the one or more APs use different frequencies when communicating simultaneously with their STAs, allows for better spectral usage and efficient bandwidth usage with minimal or no interference.

[0076] It is understood that the above descriptions are for purposes of illustration and are not meant to be limiting.

[0077] FIGs. 6A-6B depicts illustrative schematic diagrams of a simultaneous downlink transmission coordination system, in accordance with one or more example embodiments of the present disclosure.

[0078] Referring to FIG. 6A, there is shown a simulation to demonstrate the gains by using the simultaneous downlink transmission coordination system. FIG. 6A shows seven APs (e.g., AP1, AP2, AP3, AP4, AP5, AP6, and AP7). Each of these APs is shown to be serving one STA. For example, AP1 serves STA 601, AP2 serves STA 602, AP3 serves STA 603, AP4 serves STA 604, AP5 serves STA 605, AP6 serves STA 606, and AP7 serves STA 607. Each of these APs may have a coverage area represented by a hexagon. The STAs are shown to be at the edge of the coverage area of each of their respective serving APs.

[0079] In one embodiment, a simultaneous downlink transmission coordination system may facilitate an AP (e.g., AP1) to send a trigger frame to the other APs (e.g., AP2, AP3, AP4, AP5, AP6, and AP7). The trigger frame may contain indications of frequency usage by these APs. For example, the trigger frame may inform the APs that AP1 will transmit to STA 601 on subchannel 1, AP3 should transmit to STA 603 on subchannel 2, AP5 should transmit to STA 605 on subchannel 2, and AP7 should transmit to STA 607 on subchannel 2. In addition, the trigger frame may indicate that AP2 should transmit to STA 602 on subchannel

3, AP4 should transmit to STA 604 on subchannel 3, and AP6 should transmit to STA 606 on subchannel 3.

[0080] In one embodiment, a simultaneous downlink transmission coordination system may inform the STAs (e.g., STA 601, STA 602, STA 603, STA 604, STA 605, STA 606, and STA 607) to transmit their uplink acknowledgment on one or more subchannels. For example the trigger frame may contain an indication that STA 601 should transmit its acknowledgment to AP1 on subchannel 1, STA 603 should transmit its acknowledgment to AP3 on subchannel 2, STA 605 should transmit its acknowledgment to AP5 on subchannel 2, and STA 607 should transmit this acknowledgment to AP7 on subchannel 2. Further the trigger frame may contain an indication that STA 602 should transmit its acknowledgment to AP2 on subchannel 3, STA 604 should transmit its acknowledgment to AP4 on subchannel 3, and STA 606 should transmit its acknowledgment to AP6 on subchannel 3. It is understood that the above descriptions are for purposes of illustration and are not meant to be limiting.

[0081] Referring to FIG. 6B, there is shown the result of the simulation. The baseline is determined based on the assumption that the seven APs (e.g., AP1, AP2, AP3, AP4, AP5, AP6, and AP7) perform channel access and send high efficiency (HE) single user (SU) PPDU with a request to send (RTS)/clear to send (CTS) mechanism as opposed to using the trigger frame. As can be seen from FIG. 6B, the simulation yielded an approximate 26% increase for the average throughput.

[0082] It is understood that the above descriptions are for purposes of illustration and are not meant to be limiting.

[0083] FIGs. 7 depicts an illustrative schematic diagram of a simultaneous downlink transmission coordination system, in accordance with one or more example embodiments of the present disclosure.

[0084] Referring to FIG. 7, there is shown a simulation to demonstrate the gains by using the simultaneous downlink transmission coordination system. FIG. 7 shows seven APs (e.g., AP1, AP2, AP3, AP4, AP5, AP6, and AP7). Each of these APs is shown to be serving one STA. For example, AP1 serves STA 701, AP2 serves STA 702, AP3 serves STA 703, AP4 serves STA 704, AP5 serves STA 705, AP6 serves STA 706, and AP7 serves STA 707. Each of these APs may have a coverage area represented by a hexagon. The STAs are shown to be close to their respective serving APs.

[0085] In one embodiment, a simultaneous downlink transmission coordination system may facilitate an AP (e.g., AP1) to send a trigger frame to the other APs (e.g., AP2, AP3, AP4, AP5, AP6, and AP7). The trigger frame may contain indications of frequency usage by

these APs. For example, the trigger frame may inform the APs to transmit using the same frequency because of the proximity of the STAs to their serving APs.

[0086] For example, an AP may collect information from other APs. The information may be exchanged by sending and receiving messages between the APs. The information may be associated with the STAs and/or the APs that are serving the STAs. The information may include identification of the STAs, the distances of the STAs to their serving APs, the signal strengths of the APs to their serving APs, or any other information that may determine the location and signal strength of the STA. The information may also include the identification of the APs that are solicited to communicate simultaneously, the coverage area of the APs, or the location of the APs (e.g., coordinate or other location identification information). The AP sending the trigger frame may then determine how to assign resources (e.g., frequencies, resource units, subchannels, bands, etc.) based on the collected information. The AP sending the trigger frame may determine based on a certain criteria which frequency should be used by the APs when sending their downlink data and by the STAs when sending their uplink data. For example, the AP may compare a certain value received from the APs to a threshold value. Based on that comparison, the AP may determine the one or more frequency selections that it may send in the trigger frame.

[0087] In one embodiment, a simultaneous downlink transmission coordination system may inform the STAs (e.g., STA 701, STA 702, STA 703, STA 704, STA 705, STA 706, and STA 707) to transmit their uplink acknowledgments on the same frequency. For example, the trigger frame may contain an indication that the STAs should transmit their acknowledgment to their respective AP using a specific frequency. It is understood that the above descriptions are for purposes of illustration and are not meant to be limiting.

[0088] Referring to FIG. 8, there is shown the result of the simulation.. The baseline is determined based on the assumption that the seven APs (e.g., AP1, AP2, AP3, AP4, AP5, AP6, and AP7) perform channel access and send high efficiency (HE) single user (SU) PPDU with a request to send (RTS)/clear to send (CTS) mechanism as opposed to using the trigger frame mechanism. As can be seen from FIG. 8, the simulation yielded an approximate 200% increase for the average throughput.

[0089] It is understood that the above descriptions are for purposes of illustration and are not meant to be limiting.

[0090] FIG. 9A illustrates a flow diagram of an illustrative process for a simultaneous downlink transmission coordination system, in accordance with one or more embodiments of the disclosure.

[0091] At block 902, a device (e.g., the user device(s) 120 and/or the AP 102 of FIG. 1) may identify device information received from a first device. For example, the AP that sends a trigger frame to solicit one or more other APs to perform simultaneous transmissions may need to determine device information associated with the neighboring APs and STAs it will trigger. The device information may include one or more of the buffer status of the neighboring APs and STAs, mapping of STAs in the region close to the AP or in the region where frequency selection is needed (far region), or level of interference between the STAs and the APs (precise or coarse).

[0092] The AP sending the trigger frame may collect information from other APs. The information may be exchanged by sending and receiving messages between the APs. The information may be associated with the STAs and/or the APs that are serving the STAs. The information may include identification of the STAs, the STAs distances to their serving AP, the signal strengths of the STAs to their serving APs, or any other information that may determine the location and signal strength of the STA. The information may also include identification of the APs that are solicited to communicate simultaneously, the coverage area of the APs, or the location of the APs (e.g., coordinate or other location identification information). The AP sending the trigger frame may then determine how to assign resources (e.g., frequencies, resource units, subchannels, bands, etc.) based on the collected information. The AP sending the trigger frame may determine based on a certain criteria which frequency should be used by the APs when sending their downlink data and by the STAs when sending their uplink data. For example, the AP may compare a certain value received from the APs to a threshold value. Based on that comparison, the AP may determine the one or more frequency selections that it may send in the trigger frame.

[0093] At block 904, the device may determine an access point trigger frame, the access point trigger frame comprising an indication for a simultaneous transmission, and one or more frequency allocations to be used by the first device during the simultaneous transmission.

[0094] STAs are typically located at different distances from an AP. When an AP sends a trigger frame, due to propagation delay, the trigger frame may not arrive at each STA at the same time. Once an STA receives the trigger frame, it is required to give a response after a certain time delay (e.g., short inter-frame space (SIFS)). A simultaneous transmission from the STAs to the AP may be considered simultaneous because of the propagation delay not being very large. The AP may consider the uplink transmissions received from these STAs to be simultaneous transmissions and may decode them as such. Since signals travel at the

speed of light, the propagation delays associated with devices that are at different distances from the AP may be considered negligible such that the AP considers any simultaneous uplink transmissions as being received approximately at the same time. In order for an AP to successfully differentiate between the simultaneous transmissions received from multiple STAs, the AP and the STAs may have employed frequency differentiation using OFDMA or spatial differentiation using MU-MIMO, or any other mechanism to differentiate and minimize interference between simultaneous transmissions. The access point trigger frame may indicate to the other APs that receive this trigger frame the duration of the simultaneous downlink transmission (e.g., from an AP to an STA) and the duration of the simultaneous uplink acknowledgement (e.g., from an STA to an AP). The access point trigger frame may indicate the content of the common physical preamble that should be used by the solicited APs. The access point trigger frame may indicate the format of a frame (e.g., a PPDU) of the simultaneous DL transmission and UL simultaneous transmission.

[0095] At block 906, the device may cause to send the access point trigger frame to the first device. For example, the device that sends the trigger frame may send frequency allocations (or other resource allocations) and may classify, for example, that a certain frequency is to be used with STAs that were reported to be mapped in the region close (proximate) to the solicited AP. The trigger frame may also indicate various frequencies to be used by the solicited AP when communicating with STAs that are in a region that is classified as far (not proximate) from the solicited AP. The solicited AP may then use those frequency allocations to transmit to its STAs.

[0096] For example, for enhanced spectral utilization, if an STA is determined to be close to its servicing AP, the AP may transmit to its close STA since it would be easy for the AP to recognize transmission coming from the close STA since the power level difference (e.g., received signal strength indicator (RSSI), signal to noise ratio (SNR), etc.) alone may be enough to recognize that the signals are coming from the close STA and interference may be not an issue from other STAs, where the signals may have a lower power level. Therefore, it would be easy to tell the APs to use the same frequency to communicate with their respective STAs that are close because it is safe to assume that interference is minimal due to the proximity of the STA to the serving AP. However, if the AP is serving a far STA, then interference may impact these communications. The trigger frame may indicate which frequency to use when an AP communicates with an STA that is not close. Having different frequencies when communicating simultaneously with STAs, allows for better spectral usage and efficient bandwidth usage with minimal or no interference.

[0097] At block 908, the device may cause to send one or more data frames to a station device using at least one of the one or more frequency allocations. For example, the device may use a specific frequency based on the indication in the trigger frame. The device would send its data frames to an STA that is associated with that AP using that specific frequency.

5 The data frames may be sent simultaneously with other APs that are sending their data frames to their respective STAs.

[0098] The data frames may also be multicast or broadcast frames. In this case, the trigger frame may indicate a common MAC header for soliciting transmission. The trigger frame may indicate the multicast/broadcast address (e.g., receiver address (RA) in the MAC header) for the solicited APs to transmit multicast transmissions. The trigger frame may indicate a common transmitter address (e.g., TA in the MAC header) for the solicited APs to transmit multicast transmissions. The trigger frame may indicate the data rate for the solicited simultaneous transmissions from different APs. The trigger frame may indicate the same scrambling seed for the solicited simultaneous transmissions from different APs. The trigger frame may indicate a PPDU format for the solicited simultaneous transmissions from different APs. The trigger frame may indicate a coding option for the solicited simultaneous transmissions from different APs. The trigger frame may indicate a packet index for the packets that will be included in multicast/broadcast data that is transmitted by the solicited AP. The trigger frame may indicate the type of control frame for the broadcast transmission from the solicited AP. As a result, each solicited AP may know the format of the frame that should be transmitted (e.g., for broadcast transmission). The trigger frame may indicate the number of times to repeat the same multicast transmission. This may be used to increase the probability that every STA in the neighborhood may receive the transmission. The separation of each multicast/broadcast transmission may be SIFS. The trigger frame may indicate bandwidth for the multicast/broadcast transmission. It is understood that the above descriptions are for purposes of illustration and are not meant to be limiting.

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[0099] FIG. 9B illustrates a flow diagram of an illustrative process 950 for a simultaneous downlink transmission coordination system, in accordance with one or more example embodiments of the present disclosure.

30 [00100] At block 952, a device (e.g., the user device(s) 120 and/or the AP 102 of FIG. 1) may identify an access point trigger frame received from a device. STAs are typically located at different distances from an AP. When an AP sends a trigger frame, due to propagation delay, the trigger frame may not arrive at each STA at the same time. Once an STA receives the trigger frame, it is required to give a response after a certain time delay

(e.g., short inter-frame space (SIFS). A simultaneous transmission from the STAs to the AP may be considered simultaneous because of the propagation delay not being very large. The AP may consider the uplink transmissions received from these STAs to be simultaneous transmissions and may decode them as such. Since signals travel at the speed of light, the propagation delays associated with devices that are at different distances from the AP may be considered negligible such that the AP considers any simultaneous uplink transmissions as being received approximately at the same time. In order for an AP to successfully differentiate between the simultaneous transmissions received from multiple STAs, the AP and the STAs may have employed frequency differentiation using OFDMA or spatial differentiation using MU-MIMO, or any other mechanism to differentiate and minimize interference between simultaneous transmissions. The access point trigger frame may indicate to the other APs that receive this trigger frame, the duration of the simultaneous downlink transmission (e.g., from an AP to an STA) and the duration of the simultaneous uplink acknowledgement (e.g., from an STA to an AP). The access point trigger frame may indicate the content of the common physical preamble that should be used by the solicited APs. The access point trigger frame may indicate the format of a frame (e.g., a PPDU) of the simultaneous downlink transmission and the simultaneous uplink transmission. The AP that sends a trigger frame to solicit one or more other APs to perform simultaneous transmissions may need to know some information associated with the neighboring APs and the STAs it will trigger. The information may include one or more of the buffer status of the neighboring APs and STAs, mapping of the STAs in the region close to the AP or in the region where frequency selection is needed (far region), or level of interference between the STAs and the APs (precise or coarse). The information may be exchanged by sending and receiving messages between the APs. The information may be associated with the STAs and/or the APs that are serving the STAs. The information may include identification of the STAs, the distances of the STAs to their serving APs, the signal strengths of the STAs to their serving APs, or any other information that may determine the location and signal strength of the STA. The information may also include identification of the APs that are solicited to communicate simultaneously, the coverage area of the APs, or the location of the APs (e.g., coordinate or other location identification information). The AP sending the trigger frame may then determine how to assign resources (e.g., frequencies, resource units, subchannels, bands, etc.) based on the collected information. The AP sending the trigger frame may determine based on a certain criteria which frequency should be used by the APs when sending their downlink data and by the STAs when sending their uplink data. For example,

the AP may compare a certain value received from the APs to a threshold value. Based on that comparison, the AP may determine the one or more frequency selections that it may send in the trigger frame.

[00101] The data frames may also be multicast or broadcast frames. In this case, the trigger frame may indicate a common MAC header for soliciting transmission. The trigger frame may indicate the multicast/broadcast address (e.g., receiver address (RA) in the MAC header) for the solicited APs to transmit multicast transmissions. The trigger frame may indicate a common transmitter address (e.g., TA in the MAC header) for the solicited APs to transmit multicast transmissions. The trigger frame may indicate the data rate for the solicited simultaneous transmissions from different APs. The trigger frame may indicate the same scrambling seed for the solicited simultaneous transmissions from different APs. The trigger frame may indicate a PPDU format for the solicited simultaneous transmissions from different APs. The trigger frame may indicate a coding option for the solicited simultaneous transmissions from different APs. The trigger frame may indicate a packet index for the packets that will be included in multicast/broadcast data that is transmitted by the solicited AP. The trigger frame may indicate the type of control frame for the broadcast transmission from the solicited AP. As a result, each solicited AP may know the format of the frame that should be transmitted (e.g., for broadcast transmission). The trigger frame may indicate the number of times to repeat the same multicast transmission. This may be used to increase the probability that every STA in the neighborhood may receive the transmission. The separation of each multicast/broadcast transmission may be SIFS. The trigger frame may indicate bandwidth for the multicast/broadcast transmission.

[00102] At block 954, the device may identify a first frequency to use during communication with one or more first station devices. For example, the device may use a specific frequency based on the indication in the trigger frame. The device would send its data frames to an STA that is associated with that AP using that specific frequency. The data frames may be sent simultaneously with other APs that are sending their data frames to their respective STAs. For example, the trigger frame may indicate a first frequency to be used with some station devices.

[00103] At block 956, the device may identify a second frequency to use during communication with one or more second station devices. The trigger frame may also indicate other frequencies to use with other station devices.

[00104] At block 958, the device may cause to send a first frame to the one or more first station devices using the first frequency. For example, the trigger frame may indicate to an

AP that frames should be sent to certain station devices using a first frequency that may be determined based on the proximity of the station devices to the AP. For example, the AP may use that first frequency with close or proximate STAs.

[00105] At block 960, the device may cause to send a second frame to the one or more
5 second station devices using the second frequency. For example, the trigger frame may indicate to an AP that frames should be sent to certain station devices using a second frequency (or other frequencies) that may be determined based on the proximity of the station devices to the AP. For example, the AP may use that second frequency with non-proximate STAs. It should be understood that other frequencies may also be used with non-proximate
10 STAs in order to minimize interference with other APs that may be simultaneously transmitting based at least in part on the trigger frame soliciting those APs to participate in simultaneous transmissions.

[00106] It is understood that the above descriptions are for purposes of illustration and are not meant to be limiting.

[00107] FIG. 10 shows a functional diagram of an exemplary communication station 1000
15 in accordance with some embodiments. In one embodiment, FIG. 10 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 1000 may also be suitable for use as a handheld device, a mobile device, a cellular
20 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.

[00108] The communication station 1000 may include communications circuitry 1002 and a transceiver 1010 for transmitting and receiving signals to and from other communication
25 stations using one or more antennas 1001. The communications circuitry 1002 may include circuitry that can 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 1000 may also include processing circuitry 1006 and memory 1008 arranged to
30 perform the operations described herein. In some embodiments, the communications circuitry 1002 and the processing circuitry 1006 may be configured to perform operations detailed in FIGs. 1, 2, 3A-B, 4, 5, 6A-B, 7A-7B, 8, 9A-B.

[00109] In accordance with some embodiments, the communications circuitry 1002 may be arranged to contend for a wireless medium and configure frames or packets for communicating over the wireless medium. The communications circuitry 1002 may be arranged to transmit and receive signals. The communications circuitry 1002 may also include circuitry for modulation/demodulation, upconversion/downconversion, filtering, amplification, etc. In some embodiments, the processing circuitry 1006 of the communication station 1000 may include one or more processors. In other embodiments, two or more antennas 1001 may be coupled to the communications circuitry 1002 arranged for sending and receiving signals. The memory 1008 may store information for configuring the processing circuitry 1006 to perform operations for configuring and transmitting message frames and performing the various operations described herein. The memory 1008 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 1008 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.

[00110] In some embodiments, the communication station 1000 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.

[00111] In some embodiments, the communication station 1000 may include one or more antennas 1001. The antennas 1001 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.

[00112] In some embodiments, the communication station 1000 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.

5 [00113] Although the communication station 1000 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
10 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 1000 may refer to one or more processes operating on one or more processing elements.

15 [00114] 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
20 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 1000 may include one or more processors and may be configured with instructions stored on a computer-readable storage
25 device.

[00115] FIG. 11 illustrates a block diagram of an example of a machine 1100 or system upon which any one or more of the techniques (e.g., methodologies) discussed herein may be performed. In other embodiments, the machine 1100 may operate as a standalone device or may be connected (e.g., networked) to other machines. In a networked deployment, the
30 machine 1100 may operate in the capacity of a server machine, a client machine, or both in server-client network environments. In an example, the machine 1100 may act as a peer machine in peer-to-peer (P2P) (or other distributed) network environments. The machine 1100 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.

[00116] 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.

[00117] The machine (e.g., computer system) 1100 may include a hardware processor 1102 (e.g., a central processing unit (CPU), a graphics processing unit (GPU), a hardware processor core, or any combination thereof), a main memory 1104 and a static memory 1106, some or all of which may communicate with each other via an interlink (e.g., bus) 1108. The machine 1100 may further include a power management device 1132, a graphics display device 1110, an alphanumeric input device 1112 (e.g., a keyboard), and a user interface (UI) navigation device 1114 (e.g., a mouse). In an example, the graphics display device 1110, alphanumeric input device 1112, and UI navigation device 1114 may be a touch screen display. The machine 1100 may additionally include a storage device (i.e., drive unit) 1116, a signal generation device 1118 (e.g., a speaker), a simultaneous downlink transmission coordination device 1119, a network interface device/transceiver 1120 coupled to antenna(s) 1130, and one or more sensors 1128, such as a global positioning system (GPS) sensor, a compass, an accelerometer, or other sensor. The machine 1100 may include an output controller 1134, 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.)).

[00118] The storage device 1116 may include a machine readable medium 1122 on which
5 is stored one or more sets of data structures or instructions 1124 (e.g., software) embodying or utilized by any one or more of the techniques or functions described herein. The instructions 1124 may also reside, completely or at least partially, within the main memory 1104, within the static memory 1106, or within the hardware processor 1102 during execution thereof by the machine 1100. In an example, one or any combination of the
10 hardware processor 1102, the main memory 1104, the static memory 1106, or the storage device 1116 may constitute machine-readable media.

[00119] The simultaneous downlink transmission coordination device 1119 may carry out or perform any of the operations and processes (e.g., processes 900 and 950) described and shown above. For example, the simultaneous downlink transmission coordination device
15 1119 may identify device information received from a first device. For example, the AP that sends a trigger frame to solicit one or more other APs to perform simultaneous transmissions may need to know some information associated with the neighboring APs and the STAs it will trigger. The information may include one or more of the buffer status of the neighboring APs and STAs, mapping of the STAs in the region close to the AP or in the region where
20 frequency selection is needed (far region), or level of interference between the STAs and the APs (precise or coarse). The AP sending the trigger frame may collect information from other APs. The information may be exchanged by sending and receiving messages between the APs. The information may be associated with the STAs and/or the APs that are serving the STAs. The information may include identification of the STAs, the distances of the STAs
25 to their serving APs, the signal strengths of the STAs to their serving APs, or any other information that may determine the location and signal strength of the STA. The information may also include the identification of the APs that are solicited to communicate simultaneously, the coverage area of the APs, or the location of the APs (e.g., coordinate or other location identification information). The AP sending the trigger frame may then
30 determine how to assign resources (e.g., frequencies, resource units, subchannels, bands, etc.) based on the collected information. The AP sending the trigger frame may determine based on a certain criteria which frequency should be used by the APs when sending their downlink data and by the STAs when sending their uplink data. For example, the AP may compare a

certain value received from the APs to a threshold value. Based on that comparison, the AP may determine the one or more frequency selections that it may send in the trigger frame.

[00120] The simultaneous downlink transmission coordination device 1119 may determine an access point trigger frame, the access point trigger frame comprising an indication for a simultaneous transmission. STAs are typically located at different distances from an AP. When an AP sends a trigger frame, due to propagation delay, the trigger frame may not arrive at each STA at the same time. Once an STA receives the trigger frame, it is required to give a response after a certain time delay (e.g., short inter-frame space (SIFS)). A simultaneous transmission from the STAs to the AP may be considered simultaneous because of the propagation delay not being very large. The AP may consider the uplink transmissions received from these STAs to be simultaneous transmissions and may decode them as such. Since signals travel at the speed of light, the propagation delays associated with devices that are at different distances from the AP may be considered negligible such that the AP considers any simultaneous uplink transmissions as being received approximately at the same time. In order for an AP to successfully differentiate between the simultaneous transmissions received from multiple STAs, the AP and the STAs may have employed frequency differentiation using OFDMA or spatial differentiation using MU-MIMO, or any other mechanism to differentiate and minimize interference between simultaneous transmissions. The access point trigger frame may indicate to the other APs that receive this trigger frame the duration of the simultaneous downlink transmission (e.g., from an AP to an STA) and the duration of simultaneous uplink acknowledgement (e.g., from an STA to an AP). The access point trigger frame may indicate the content of the common physical preamble that should be used by the solicited APs. The access point trigger frame may indicate the format of a frame (e.g., a PPDU) of the simultaneous downlink transmission and the simultaneous uplink transmission.

[00121] The simultaneous downlink transmission coordination device 1119 may cause to send the access point trigger frame to the first device. For example, the device that sends the trigger frame may send frequency allocations (or other resource allocations) and may classify, for example, that a certain frequency is to be used with STAs that were reported to be mapped in the region close (proximate) to the solicited AP. The trigger frame may also indicate various frequencies to be used by the solicited AP when communicating with STAs that are in a region that is classified as far (not proximate) from the solicited AP. The solicited AP may then use those frequency allocations to transmit to its STAs. For example, for enhanced spectral utilization, if an STA is determined to be close to its servicing AP, the

AP may transmit to its close STA since it would be easy for the AP to recognize transmission coming from the close STA since the power level difference (e.g., received signal strength indicator (RSSI), signal to noise ratio (SNR), etc.) alone may be enough to recognize that the signals are coming from the close STA and interference may be not an issue from other STAs, where the signals may have a lower power level. Therefore, it would be easy to tell the APs to use the same frequency to communicate with their respective STAs that are close because it is safe to assume that interference is minimal due to the proximity of the STA to the serving AP. However, if the AP is serving a far STA, then interference may impact these communications. The trigger frame may indicate which frequency to use when an AP communicates with an STA that is not close. Having different frequencies when communicating simultaneously with STAs allows for better spectral usage and efficient bandwidth usage with minimal or no interference.

[00122] The simultaneous downlink transmission coordination device 1119 may cause to send one or more data frames to a station device using at least one of the one or more frequency allocations. For example, the device may use a specific frequency based on the indication in the trigger frame. The device would send its data frames to an STA that is associated with that AP using that specific frequency. The data frames may be sent simultaneously with other APs that are sending their data frames to their respective STAs.

[00123] The data frames may also be multicast or broadcast frames. In this case, the trigger frame may indicate a common MAC header for soliciting transmission. The trigger frame may indicate the multicast/broadcast address (e.g., receiver address (RA) in the MAC header) for the solicited APs to transmit multicast transmissions. The trigger frame may indicate a common transmitter address (e.g., TA in the MAC header) for the solicited APs to transmit multicast transmissions. The trigger frame may indicate the data rate for the solicited simultaneous transmissions from different APs. The trigger frame may indicate the same scrambling seed for the solicited simultaneous transmissions from different APs. The trigger frame may indicate a PPDU format for the solicited simultaneous transmissions from different APs. The trigger frame may indicate a coding option for the solicited simultaneous transmissions from different APs. The trigger frame may indicate a packet index for the packets that will be included in multicast/broadcast data that is transmitted by the solicited AP. The trigger frame may indicate the type of control frame for the broadcast transmission from the solicited AP. As a result, each solicited AP may know the format of the frame that should be transmitted (e.g., for broadcast transmission). The trigger frame may indicate the number of times to repeat the same multicast transmission. This may be used to increase the

probability that every STA in the neighborhood may receive the transmission. The separation of each multicast/broadcast transmission may be SIFS. The trigger frame may indicate bandwidth for the multicast/broadcast transmission.

[00124] It is understood that the above are only a subset of what the simultaneous
5 downlink transmission coordination device 1119 may be configured to perform and that other functions included throughout this disclosure may also be performed by the simultaneous downlink transmission coordination device 1119.

[00125] While the machine-readable medium 1122 is illustrated as a single medium, the term "machine-readable medium" may include a single medium or multiple media (e.g., a
10 centralized or distributed database, and/or associated caches and servers) configured to store the one or more instructions 1124.

[00126] 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
15 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
20 read only memory (ROM); random access memory (RAM); magnetic disk storage media; optical storage media; a flash memory, etc.

[00127] The term "machine-readable medium" may include any medium that is capable of storing, encoding, or carrying instructions for execution by the machine 1100 and that cause the machine 1100 to perform any one or more of the techniques of the present disclosure, or
25 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
30 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.

[00128] The instructions 1124 may further be transmitted or received over a communications network 1126 using a transmission medium via the network interface device/transceiver 1120 utilizing any one of a number of transfer protocols (e.g., frame relay, internet protocol (IP), transmission control protocol (TCP), user datagram protocol (UDP),
5 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
10 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 1120 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 1126. In an example, the network interface device/transceiver 1120 may include a plurality of antennas to wirelessly communicate using
15 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 1100 and includes digital or analog communications signals or other intangible media to facilitate communication of such
20 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.

[00129] 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
30 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.

[00130] 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.

[00131] 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.

[00132] 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.

[00133] 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.

[00134] Some embodiments may be used in conjunction with one way and/or two-way
5 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
10 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.

[00135] Some embodiments may be used in conjunction with one or more types of
15 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
20 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,
25 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.

[00136] According to example embodiments of the disclosure, there may be a device. The device may include memory and processing circuitry configured to determine device
30 information received from a first device. The processing circuitry may be further configured to determine an access point trigger frame, the access point trigger frame may include an indication for a simultaneous transmission, and one or more frequency allocations to be used by the first device during the simultaneous transmission. The processing circuitry may be

further configured to cause to send the access point trigger frame to the first device. The processing circuitry may be further configured to cause to send one or more data frames to a station device using at least one of the one or more frequency allocations.

[00137] The implementations may include one or more of the following features. The

5 device information comprises at least one of a buffer status of the first device for one or more station devices associated with the first device, a mapping of one or more first station devices associated with the first device in proximate region of the first device, a mapping of one or more second station devices associated with the first device in a non-proximate region of the first device, or a level of interference of the first device. The processing circuitry may be
10 further configured determine the station device is proximate to the device. The processing circuitry may be further configured to determine to use a first frequency during communication with the station device. The processing circuitry may be further configured to determine the station device is not proximate to the device. The processing circuitry may be further configured to determine to use a second frequency during communication with the
15 station device. The processing circuitry may be further configured to indicate in the access point trigger frame that the first device is to use the first frequency with one or more first station devices associated with the first device in a proximate region of the first device. The processing circuitry may be further configured to indicate in the access point trigger frame that the first device is to use a third frequency with one or more second station devices
20 associated with the first device in a non-proximate region of the first device. The second frequency is different from the third frequency. The access point trigger frame further comprises a duration of one or more simultaneous transmissions. The access point trigger frame further comprises a duration of one or more response transmissions, wherein the one or more response transmissions are associated with the one or more simultaneous transmissions.
25 The one or more data frames comprise multicast or broadcast frames. The device may further include a transceiver configured to transmit and receive wireless signals. The device may further include one or more antennas coupled to the transceiver.

[00138] According to example embodiments of the disclosure, there may be a device. The device may include memory and processing circuitry configured to determine an access point
30 trigger frame received from a device. The processing circuitry may be further configured to determine a first frequency to use during communication with one or more first associated station devices. The processing circuitry may be further configured to determine a second frequency to use during communication with one or more second associated station devices. The processing circuitry may be further configured to cause to send a first frame to the one or

more first associated stations devices using the first frequency. The processing circuitry may be further configured to cause to send a second frame to the one or more second associated station devices using the second frequency.

[00139] The implementations may include one or more of the following features. The access point trigger frame comprises a duration of one or more simultaneous transmissions or a duration of one or more response transmissions, wherein the one or more response transmissions are associated with the one or more simultaneous transmissions. The processing circuitry may be further configured to determine the station device is proximate. The processing circuitry may be further configured to determine to use the first frequency during communication with the station device. The processing circuitry may be further configured to determine the station device is not proximate to the device. The processing circuitry may be further configured to determine to use the second frequency during communication with the station device. The processing circuitry may be further configured to cause to send information to the device, wherein the information comprises at least one of a buffer status of one or more associated station devices, a mapping of one or more first associated station devices in proximate region, a mapping of one or more second associated station devices in a non-proximate region, or a level of interference. The device may further include a transceiver configured to transmit and receive wireless signals. The device may further include one or more antennas coupled to the transceiver.

[00140] According to example embodiments of the disclosure, there may be a non-transitory computer-readable medium storing computer-executable instructions which, when executed by a processor, cause the processor to perform operations. The operations may include determining an access point trigger frame received from a device. The operations may include determining a first frequency to use during communication with one or more first associated station devices. The operations may include determining a second frequency to use during communication with one or more second associated station devices. The operations may include causing to send a first frame to the one or more first associated stations devices using the first frequency. The operations may include causing to send a second frame to the one or more second associated station devices using the second frequency.

[00141] The implementations may include one or more of the following features. The access point trigger frame comprises a duration of one or more simultaneous transmissions or a duration of one or more response transmissions, wherein the one or more response transmissions are associated with the one or more simultaneous transmissions. The

operations may further comprise determining the station device is proximate. The operations may include determining to use the first frequency during communication with the station device. The operations may further comprise determining the station device is not proximate to the device. The operations may include determining to use the second frequency during
5 communication with the station device. The operations further comprise causing to send information to the device, wherein the information comprises at least one of a buffer status of one or more associated station devices, a mapping of one or more first associated station devices in proximate region, a mapping of one or more second associated station devices in a non-proximate region, or a level of interference.

10 [00142] According to example embodiments of the disclosure, there may be a non-transitory computer-readable medium storing computer-executable instructions which, when executed by a processor, cause the processor to perform operations. The operations may include determining device information received from a first device. The operations may include determining an access point trigger frame, the access point trigger frame may include
15 an indication for a simultaneous transmission, and one or more frequency allocations to be used by the first device during the simultaneous transmission. The operations may include causing to send the access point trigger frame to the first device. The operations may include causing to send one or more data frames to a station device using at least one of the one or more frequency allocations.

20 [00143] The implementations may include one or more of the following features. The device information comprises at least one of a buffer status of the first device for one or more station devices associated with the first device, a mapping of one or more first station devices associated with the first device in proximate region of the first device, a mapping of one or more second station devices associated with the first device in a non-proximate region of the
25 first device, or a level of interference of the first device. The operations may further comprise determining the station device is proximate to the device. The operations may include determining to use a first frequency during communication with the station device. The operations may further comprise determining the station device is not proximate to the device. The operations may include determining to use a second frequency during
30 communication with the station device. The operations further comprise indicating in the access point trigger frame that the first device is to use the first frequency with one or more first station devices associated with the first device in a proximate region of the first device. The operations further comprise indicating in the access point trigger frame that the first device is to use a third frequency with one or more second station devices associated with the

first device in a non-proximate region of the first device. The second frequency is different from the third frequency. The access point trigger frame further comprises a duration of one or more simultaneous transmissions. The access point trigger frame further comprises a duration of one or more response transmissions, wherein the one or more response transmissions are associated with the one or more simultaneous transmissions. The one or more data frames comprise multicast or broadcast frames.

[00144] According to example embodiments of the disclosure, there may include a method. The method may include determining device information received from a device. The method may include determining an access point trigger frame, the access point trigger frame may include an indication for a simultaneous transmission, and one or more frequency allocations to be used by the device during the simultaneous transmission. The method may include causing to send the access point trigger frame to the device. The method may include causing to send one or more data frames to a station device using at least one of the one or more frequency allocations.

[00145] The implementations may include one or more of the following features. The information comprises at least one of a buffer status of one or more associated station devices, a mapping of one or more first associated station devices in a proximate region, a mapping of one or more second associated station devices in a non-proximate region, or a level of interference. The method may further include determining the station device is proximate to the device. The method may include determining to use a first frequency during communication with the station device. The method may further include determine the station device is not proximate to the device. The method may include determine to use a second frequency during communication with the station device. The method may further include indicating in the access point trigger frame that the first device is to use the first frequency with one or more first station devices associated with the first device in a proximate region of the first device. The method may further include indicating in the access point trigger frame that the first device is to use a third frequency with one or more second station devices associated with the first device in a non-proximate region of the first device. The second frequency is different from the third frequency. The access point trigger frame further comprises a duration of one or more simultaneous transmissions. The access point trigger frame further comprises a duration of one or more response transmissions, wherein the one or more response transmissions are associated with the one or more simultaneous transmissions. The method of claim 18, wherein the one or more data frames comprise multicast or broadcast frames.

[00146] According to example embodiments of the disclosure, there may include a method. The method may include determining an access point trigger frame received from a device. The method may include determining a first frequency to use during communication with one or more first associated station devices. The method may include determining a
5 second frequency to use during communication with one or more second associated station devices. The method may include causing to send a first frame to the one or more first associated stations devices using the first frequency. The method may include causing to send a second frame to the one or more second associated station devices using the second frequency.

10 [00147] The implementations may include one or more of the following features. The access point trigger frame comprises a duration of one or more simultaneous transmissions or a duration of one or more response transmissions, wherein the one or more response transmissions are associated with the one or more simultaneous transmissions. The method may further include determining the station device is proximate. The method may include
15 determining to use the first frequency during communication with the station device. The method may further include determining the station device is not proximate to the device. The method may include determining to use the second frequency during communication with the station device. The method may further include causing to send information to the device, wherein the information comprises at least one of a buffer status of one or more
20 associated station devices, a mapping of one or more first associated station devices in proximate region, a mapping of one or more second associated station devices in a non-proximate region, or a level of interference.

[00148] In example embodiments of the disclosure, there may be an apparatus. The apparatus may include means for determining device information received from a first
25 device. The apparatus may include determining an access point trigger frame, the access point trigger frame may include an indication for a simultaneous transmission, and one or more frequency allocations to be used by the first device during the simultaneous transmission. The apparatus may include causing to send the access point trigger frame to the first device. The apparatus may include causing to send one or more data frames to a station
30 device using at least one of the one or more frequency allocations.

[00149] The implementations may include one or more of the following features. The device information comprises at least one of a buffer status of the first device for one or more station devices associated with the first device, a mapping of one or more first station devices associated with the first device in proximate region of the first device, a mapping of one or

more second station devices associated with the first device in a non-proximate region of the first device, or a level of interference of the first device. The apparatus may further include means for determine the station device is proximate to the device. The apparatus may further include determine to use a first frequency during communication with the station device. The apparatus may further include means for determine the station device is not proximate to the device. The apparatus may further include determine to use a second frequency during communication with the station device. The apparatus may further include means for indicating in the access point trigger frame that the first device is to use the first frequency with one or more first station devices associated with the first device in a proximate region of the first device. The apparatus may further include indicating in the access point trigger frame that the first device is to use a third frequency with one or more second station devices associated with the first device in a non-proximate region of the first device. The second frequency is different from the third frequency. The access point trigger frame further comprises a duration of one or more simultaneous transmissions. The access point trigger frame further comprises a duration of one or more response transmissions, wherein the one or more response transmissions are associated with the one or more simultaneous transmissions. The one or more data frames comprise multicast or broadcast frames.

[00150] In example embodiments of the disclosure, there may be an apparatus. The apparatus may include means for determining an access point trigger frame received from a device. The apparatus may include means for determining a first frequency to use during communication with one or more first associated station devices. The apparatus may include means for determining a second frequency to use during communication with one or more second associated station devices. The apparatus may include means for causing to send a first frame to the one or more first associated stations devices using the first frequency. The apparatus may include means for causing to send a second frame to the one or more second associated station devices using the second frequency.

[00151] The implementations may include one or more of the following features. The access point trigger frame comprises a duration of one or more simultaneous transmissions or a duration of one or more response transmissions, wherein the one or more response transmissions are associated with the one or more simultaneous transmissions. The apparatus may further include means for determining the station device is proximate. The apparatus may include means for determining to use the first frequency during communication with the station device. The apparatus may further include means for determining the station device is not proximate to the device. The apparatus may include means for determining to use the

second frequency during communication with the station device. The apparatus may further include means for cause to send information to the device, wherein the information comprises at least one of a buffer status of one or more associated station devices, a mapping of one or more first associated station devices in proximate region, a mapping of one or more second associated station devices in a non-proximate region, or a level of interference.

[00152] 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.

[00153] 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.

[00154] 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.

[00155] 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.

[00156] 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 memory and processing circuitry configured to:
 - determine device information received from a first device;
 - determine an access point trigger frame, the access point trigger frame comprising an indication for a simultaneous transmission, and one or more frequency allocations to be used by the first device during the simultaneous transmission;
 - cause to send the access point trigger frame to the first device; and
 - cause to send one or more data frames to a station device using at least one of the one or more frequency allocations.
2. The device of claim 1, wherein the device information comprises at least one of a buffer status of the first device for one or more station devices associated with the first device, a mapping of one or more first station devices associated with the first device in proximate region of the first device, a mapping of one or more second station devices associated with the first device in a non-proximate region of the first device, or a level of interference of the first device.
3. The device of claim 1, wherein the processing circuitry is further configured to:
 - determine the station device is proximate to the device; and
 - determine to use a first frequency during communication with the station device.
4. The device of claim 1, wherein the processing circuitry is further configured to:
 - determine the station device is not proximate to the device; and
 - determine to use a second frequency during communication with the station device.
5. The device of claim 3, wherein the processing circuitry is further configured to indicate in the access point trigger frame that the first device is to use the first frequency with one or more first station devices associated with the first device in a proximate region of the first device.

6. The device of claim 4, wherein the processing circuitry is further configured to indicate in the access point trigger frame that the first device is to use a third frequency with one or more second station devices associated with the first device in a non-proximate region of the first device.
7. The device of claim 6, wherein the second frequency is different from the third frequency.
8. The device of claim 1, wherein the access point trigger frame further comprises a duration of one or more simultaneous transmissions.
9. The device of claim 1, wherein the access point trigger frame further comprises a duration of one or more response transmissions, wherein the one or more response transmissions are associated with the one or more simultaneous transmissions.
10. The device of claim 1, wherein the one or more data frames comprise multicast or broadcast frames.
11. The device of claim 1, further comprising a transceiver configured to transmit and receive wireless signals.
12. The device of any one of claims 1-11, further comprising one or more antennas coupled to the transceiver.
13. A non-transitory computer-readable medium storing computer-executable instructions which when executed by one or more processors result in performing operations comprising:
 - determining an access point trigger frame received from a device;
 - determining a first frequency to use during communication with one or more first associated station devices;
 - determining a second frequency to use during communication with one or more second associated station devices;
 - causing to send a first frame to the one or more first associated stations devices using the first frequency; and

causing to send a second frame to the one or more second associated station devices using the second frequency.

14. The non-transitory computer-readable medium of claim 13, wherein the access point trigger frame comprises a duration of one or more simultaneous transmissions or a duration of one or more response transmissions, wherein the one or more response transmissions are associated with the one or more simultaneous transmissions.

15. The non-transitory computer-readable medium of claim 14, wherein the operations further comprise:

- determining the station device is proximate; and
- determining to use the first frequency during communication with the station device

16. The non-transitory computer-readable medium of claim 14 wherein the operations further comprise:

- determining the station device is not proximate to the device; and
- determining to use the second frequency during communication with the station device.

17. The non-transitory computer-readable medium of any one of claims 13-16, wherein the operations further comprise causing to send information to the device, wherein the information comprises at least one of a buffer status of one or more associated station devices, a mapping of one or more first associated station devices in proximate region, a mapping of one or more second associated station devices in a non-proximate region, or a level of interference.

18. A method comprising:

- determining device information received from a device;
- determining an access point trigger frame, the access point trigger frame comprising an indication for a simultaneous transmission, and one or more frequency allocations to be used by the device during the simultaneous transmission;
- causing to send the access point trigger frame to the device; and

causing to send one or more data frames to a station device using at least one of the one or more frequency allocations.

19. The method of claim 18, wherein the information comprises at least one of a buffer status of one or more associated station devices, a mapping of one or more first associated station devices in a proximate region, a mapping of one or more second associated station devices in a non-proximate region, or a level of interference.
20. The method of claim 18, further comprising:
determining the station device is proximate to the device; and
determining to use a first frequency during communication with the station device.
21. The method of claim 18, further comprising:
determine the station device is not proximate to the device; and
determine to use a second frequency during communication with the station device.
22. The method of claim 20, further comprising indicating in the access point trigger frame that the first device is to use the first frequency with one or more first station devices associated with the first device in a proximate region of the first device.
23. The method of claim 21, further comprising indicating in the access point trigger frame that the first device is to use a third frequency with one or more second station devices associated with the first device in a non-proximate region of the first device.
24. The method of claim 23, wherein the second frequency is different from the third frequency.
25. The method of any one of claims 18-24, wherein the access point trigger frame further comprises a duration of one or more simultaneous transmissions.

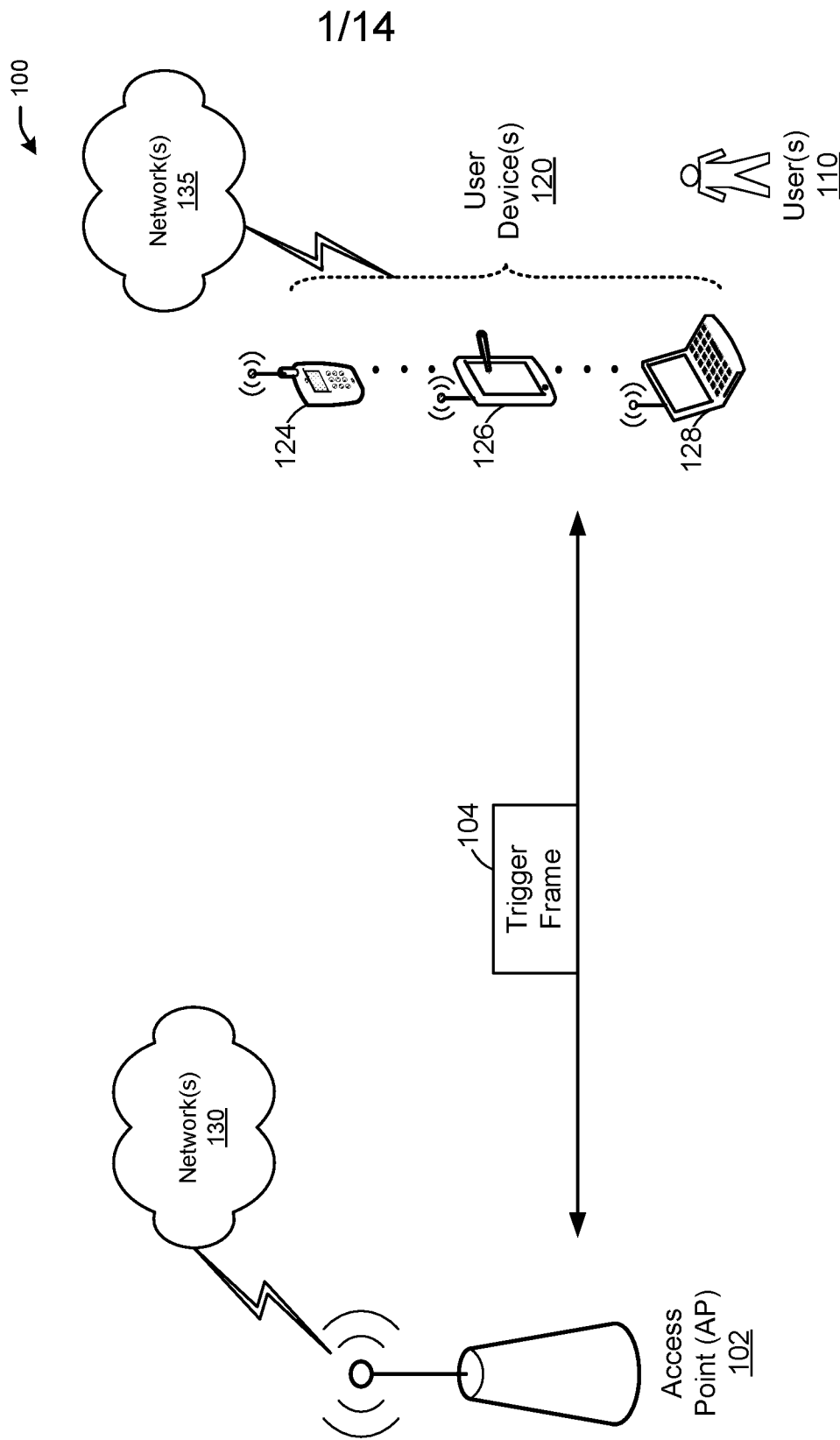


FIG. 1

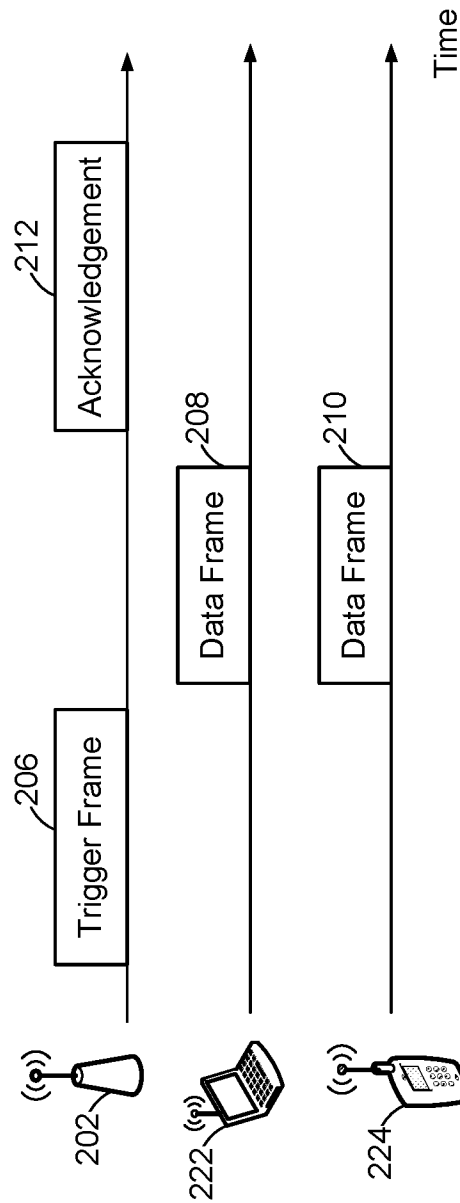


FIG. 2

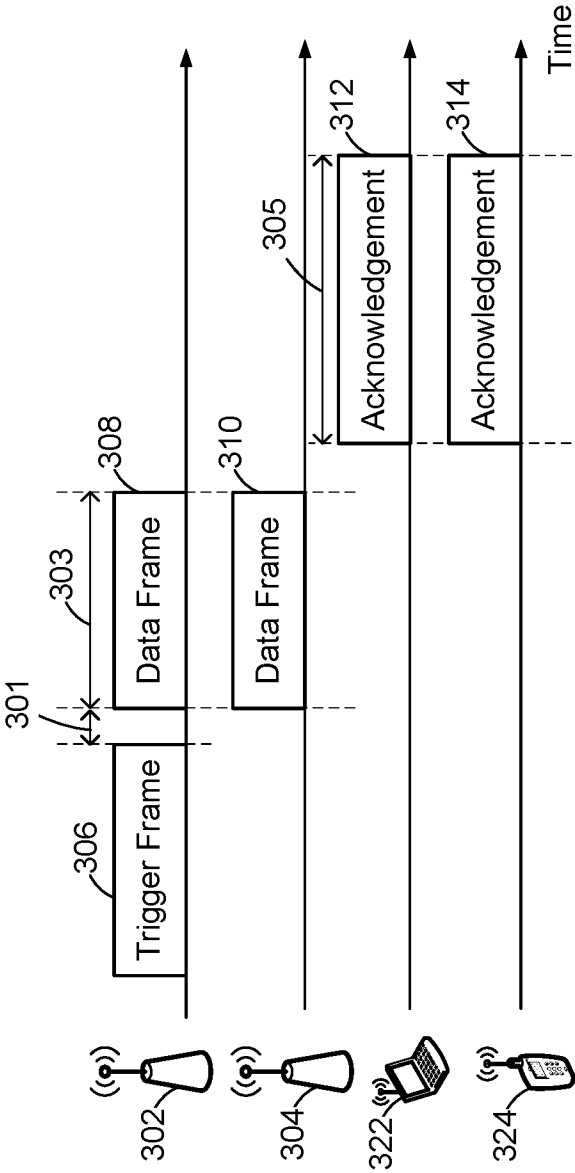


FIG. 3A

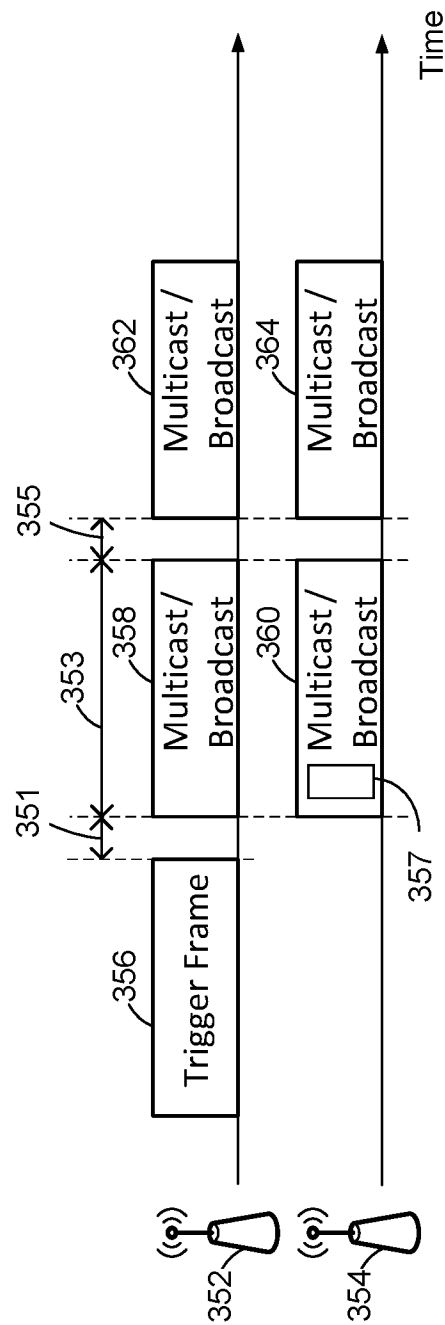


FIG. 3B

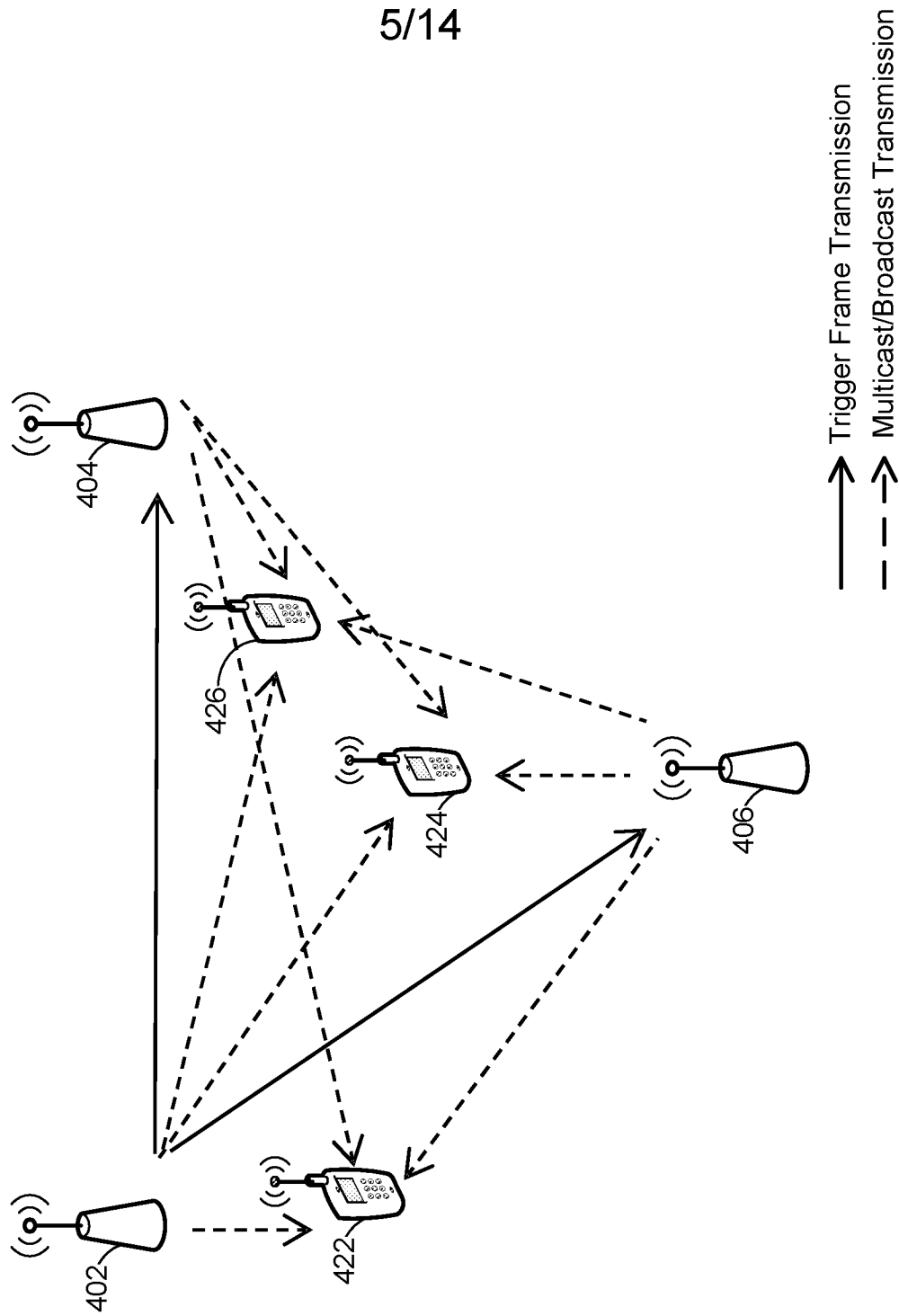


FIG. 4

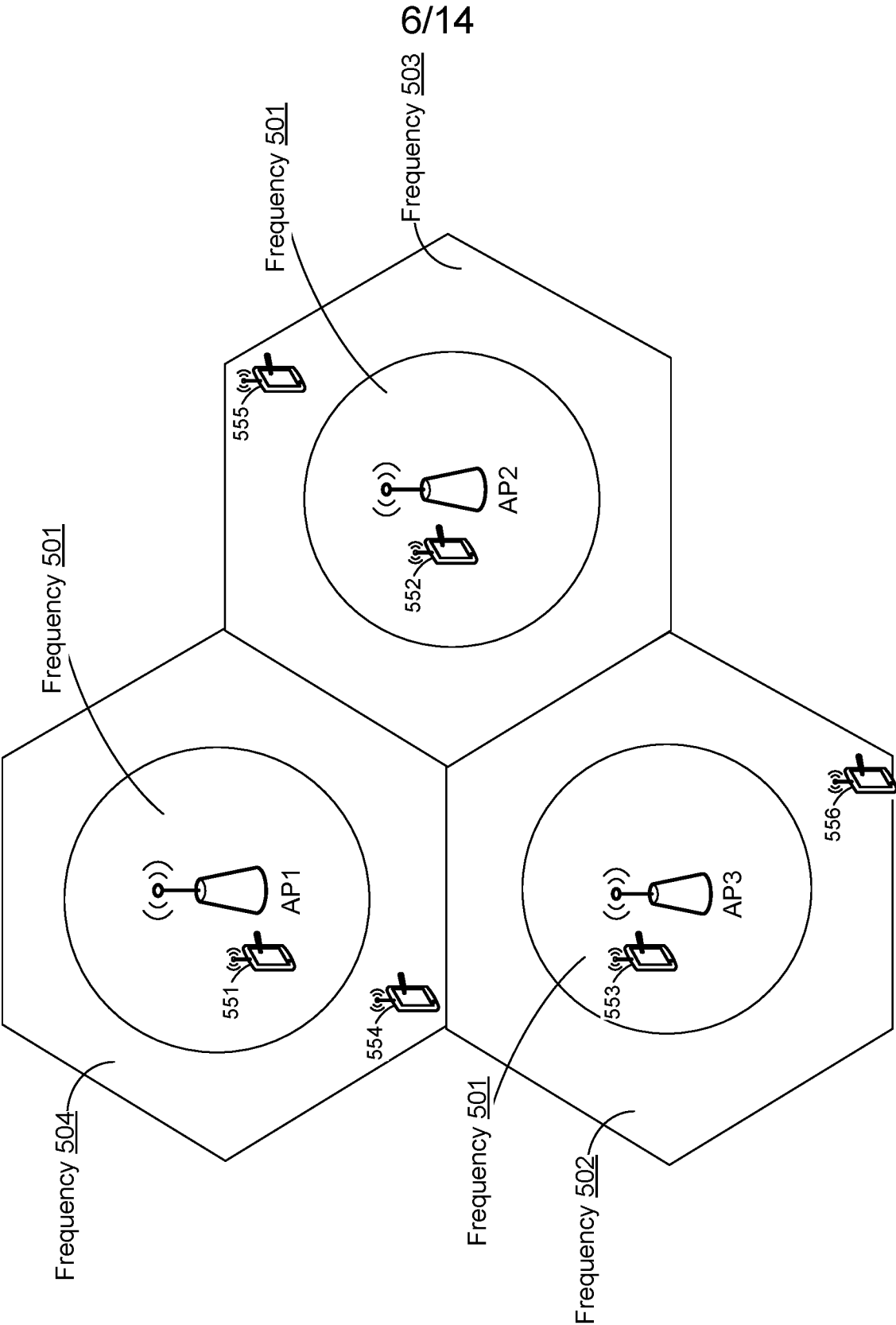


FIG. 5

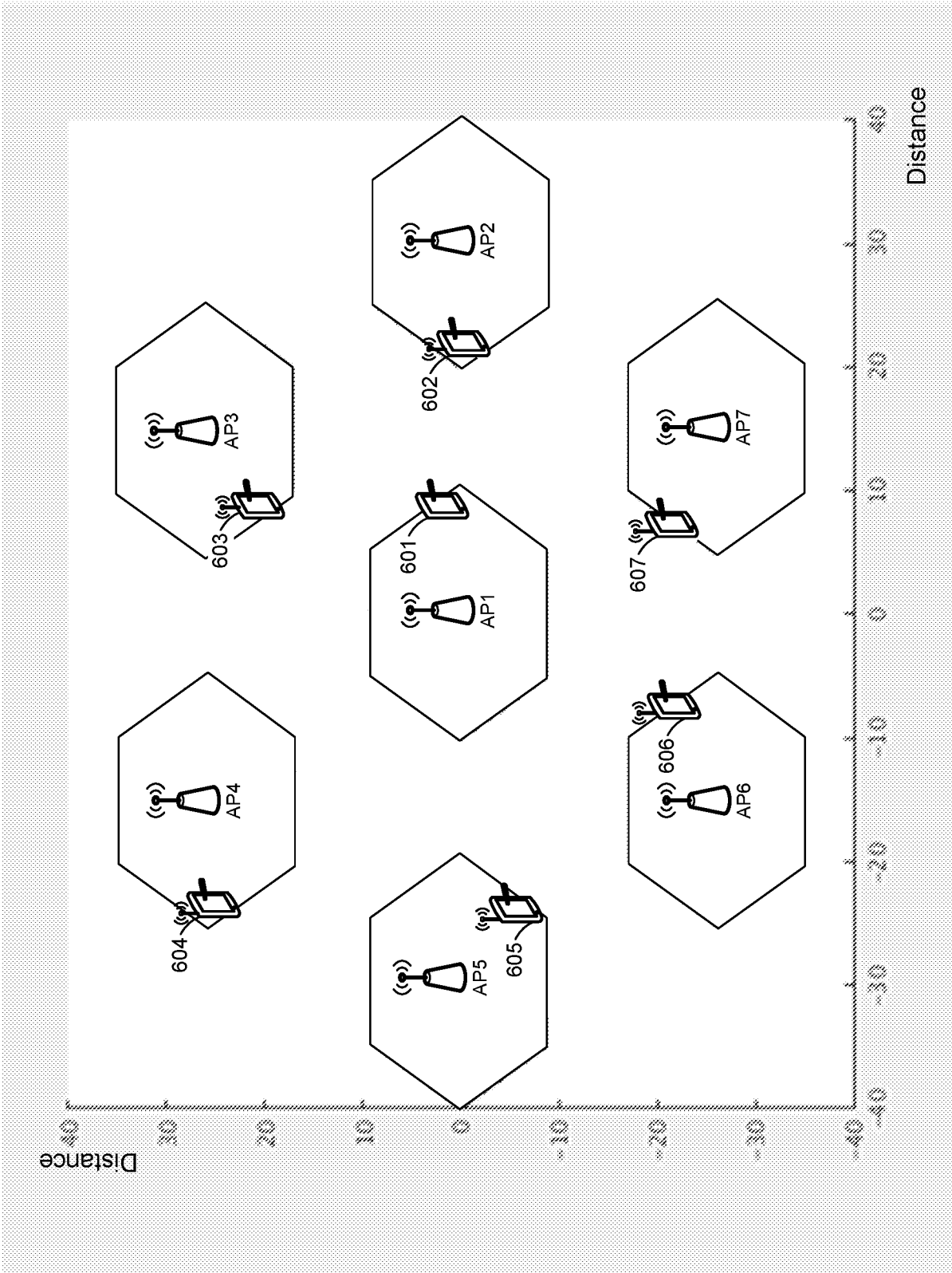


FIG. 6A

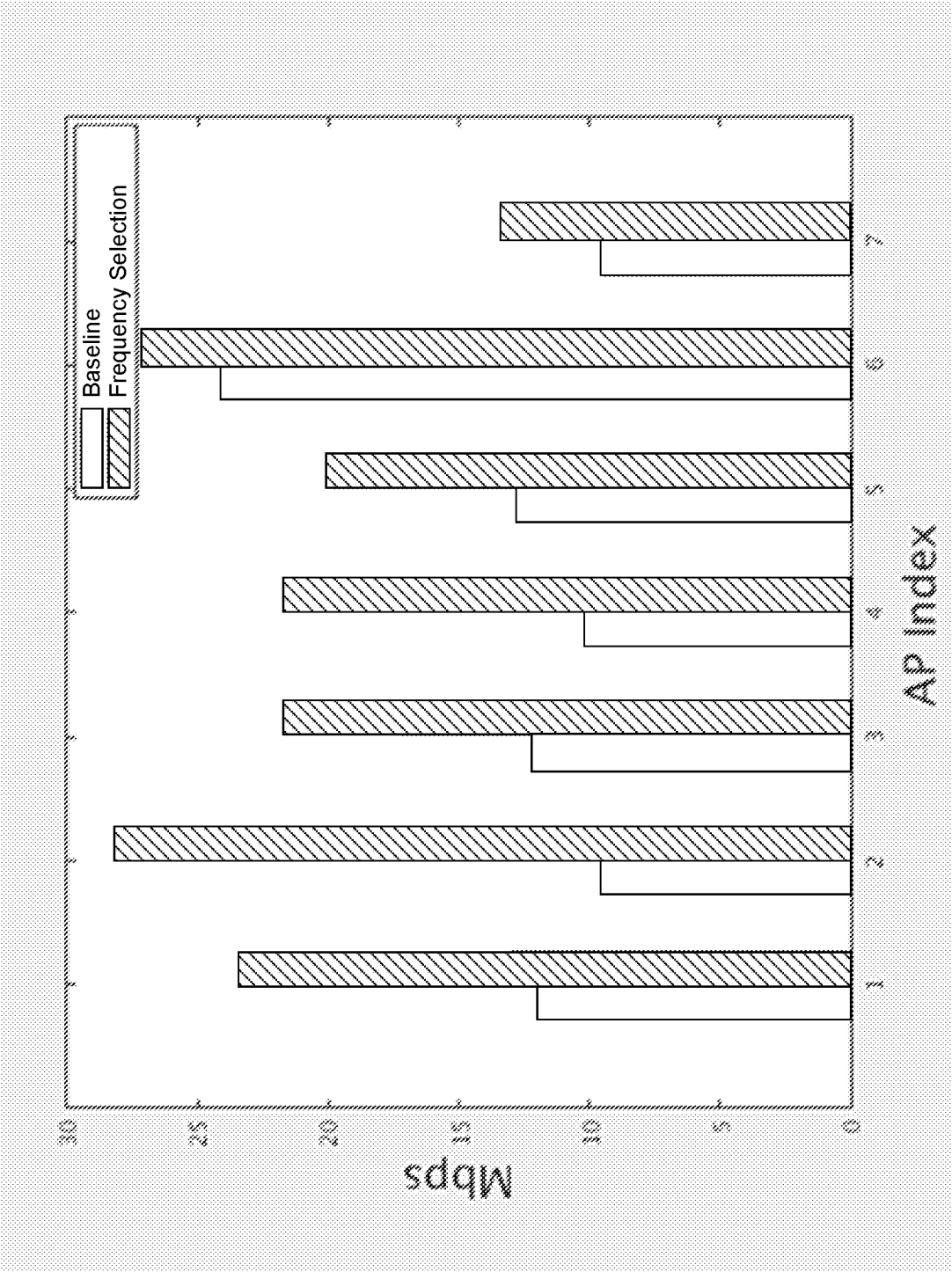


FIG. 6B

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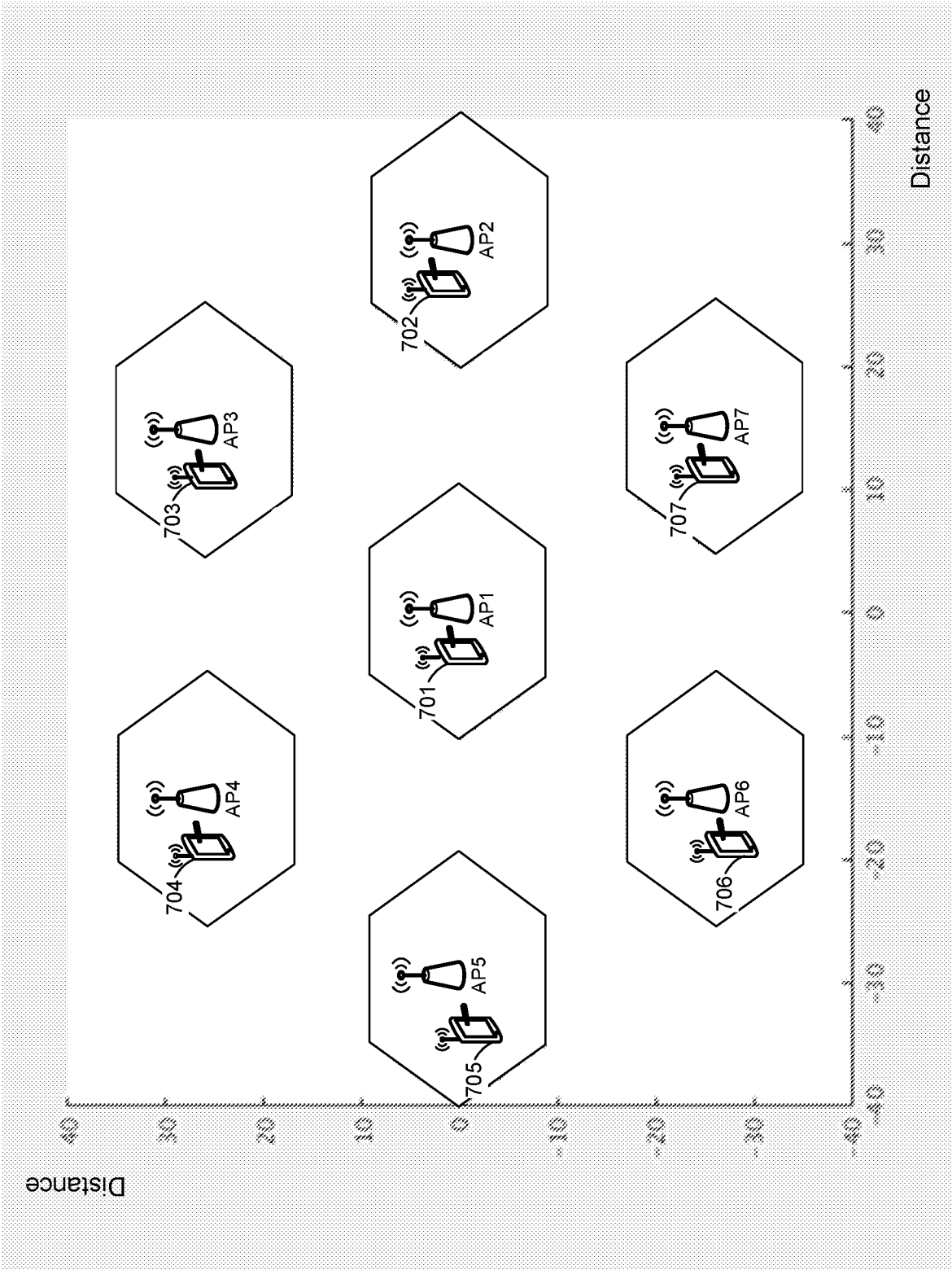


FIG. 7A

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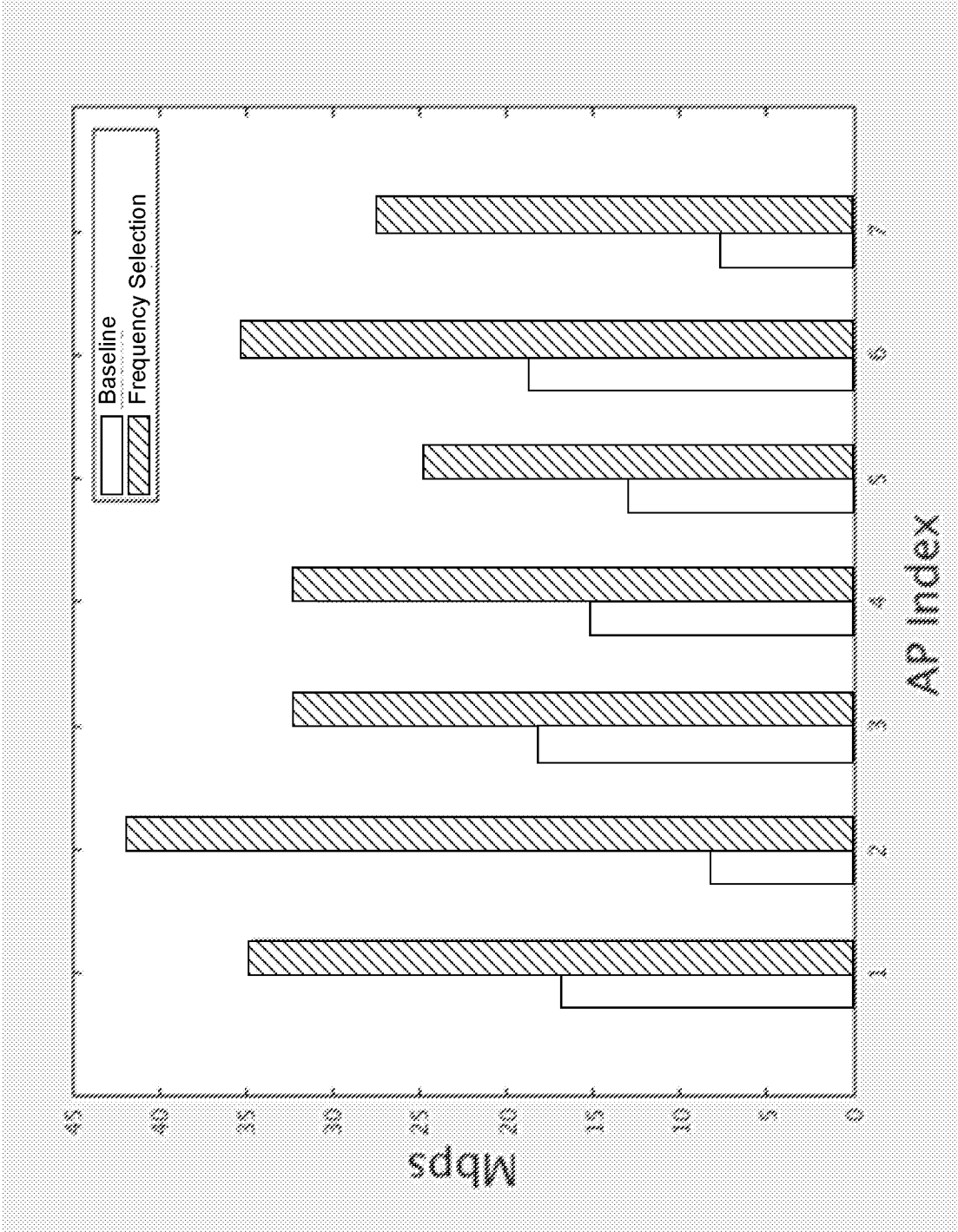


FIG. 8

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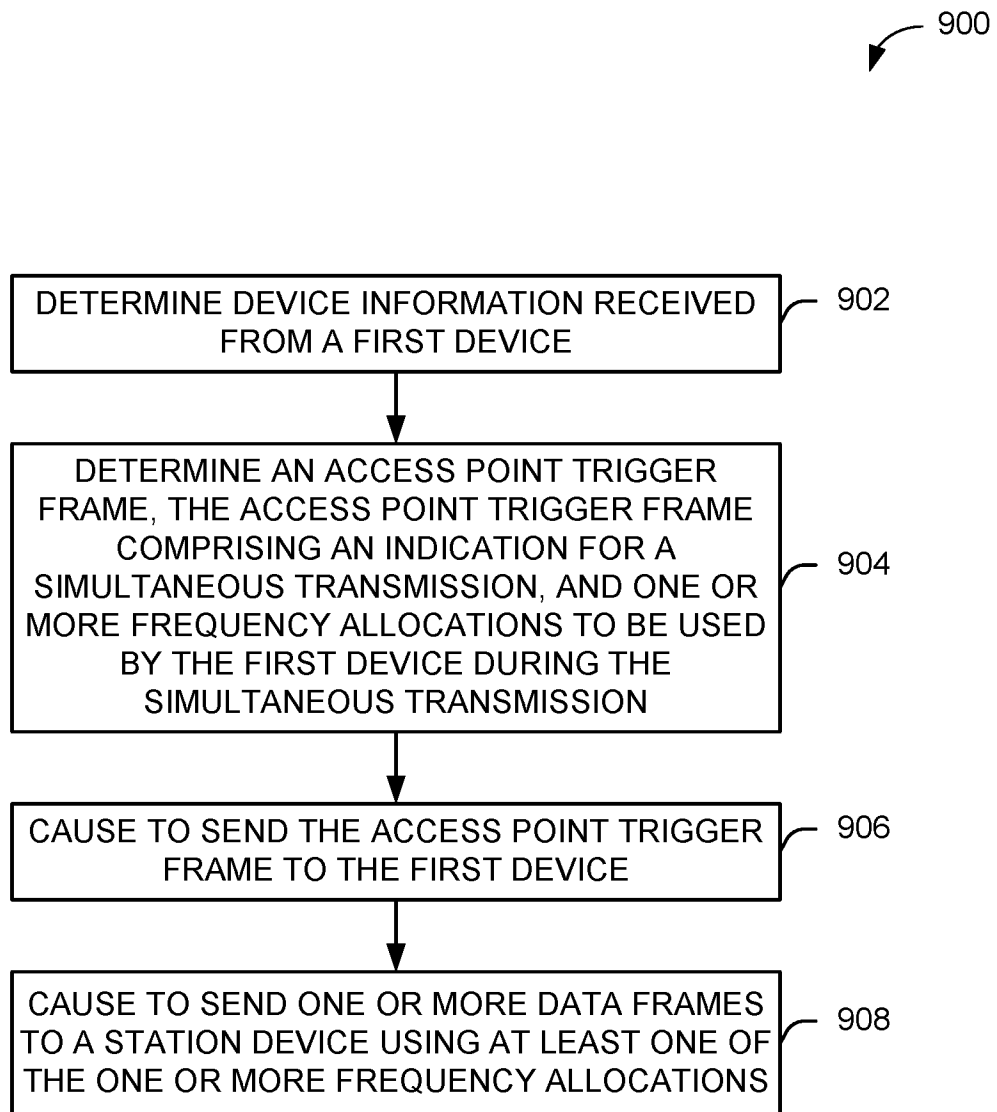


FIG. 9A

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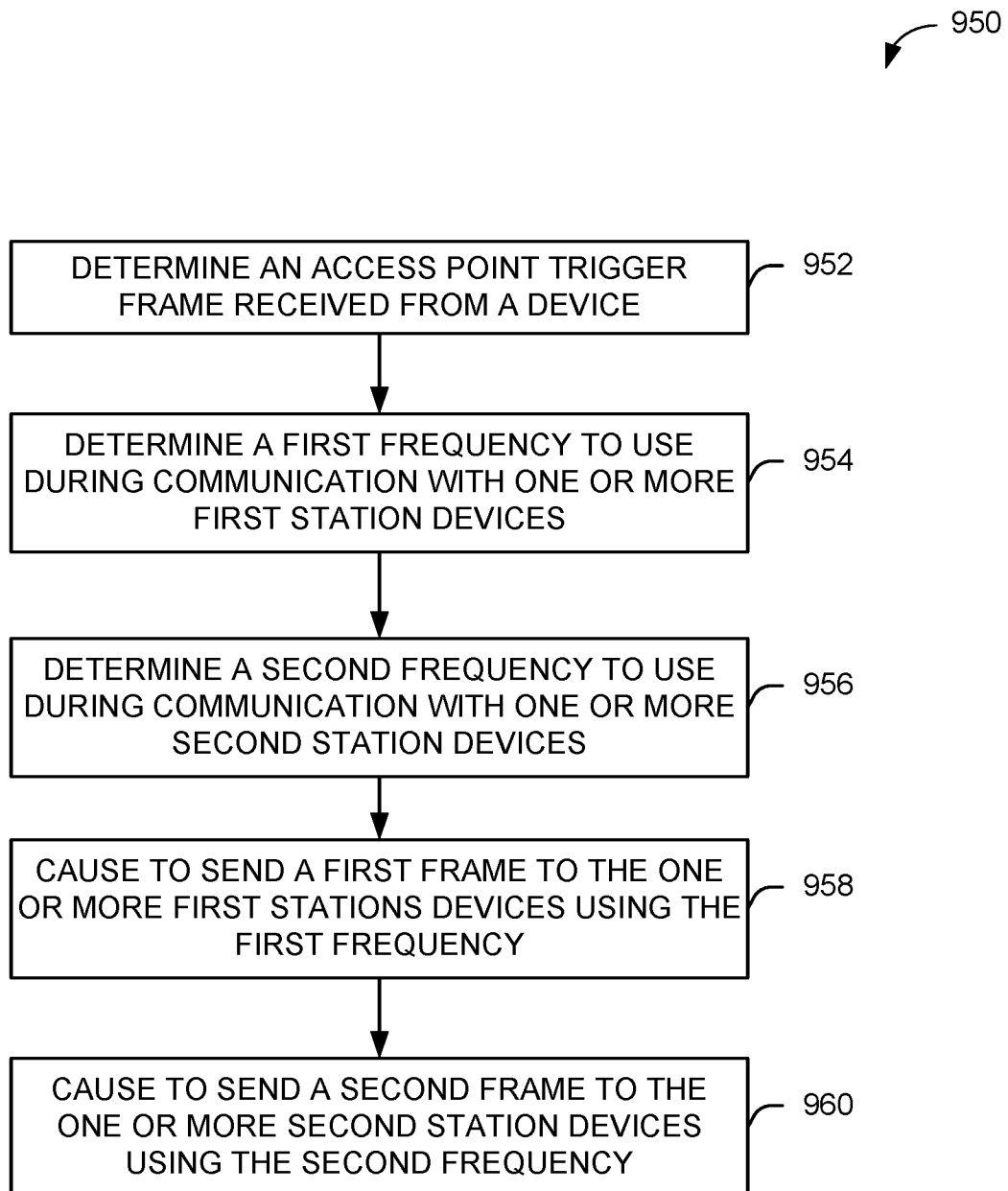


FIG. 9B

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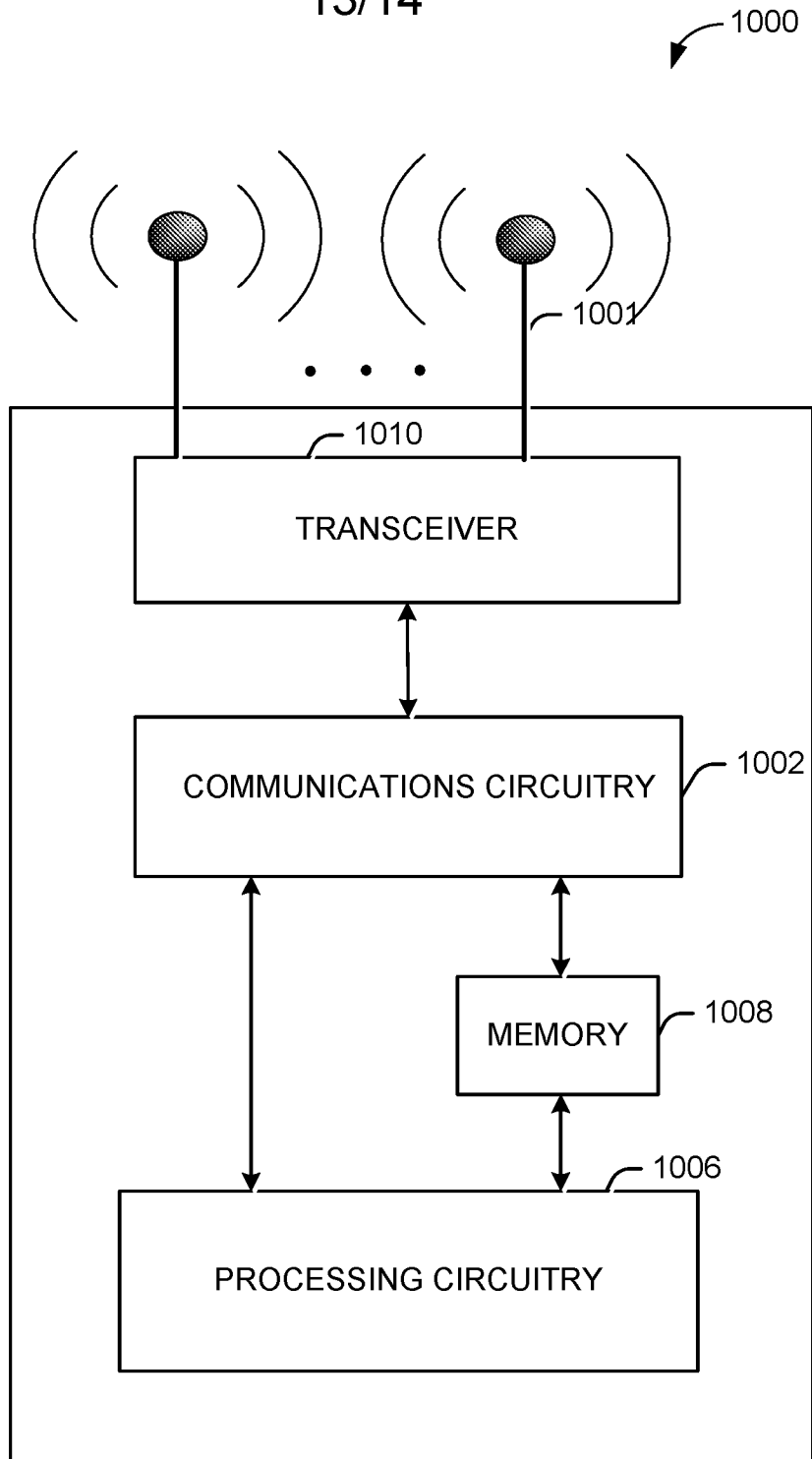


FIG. 10

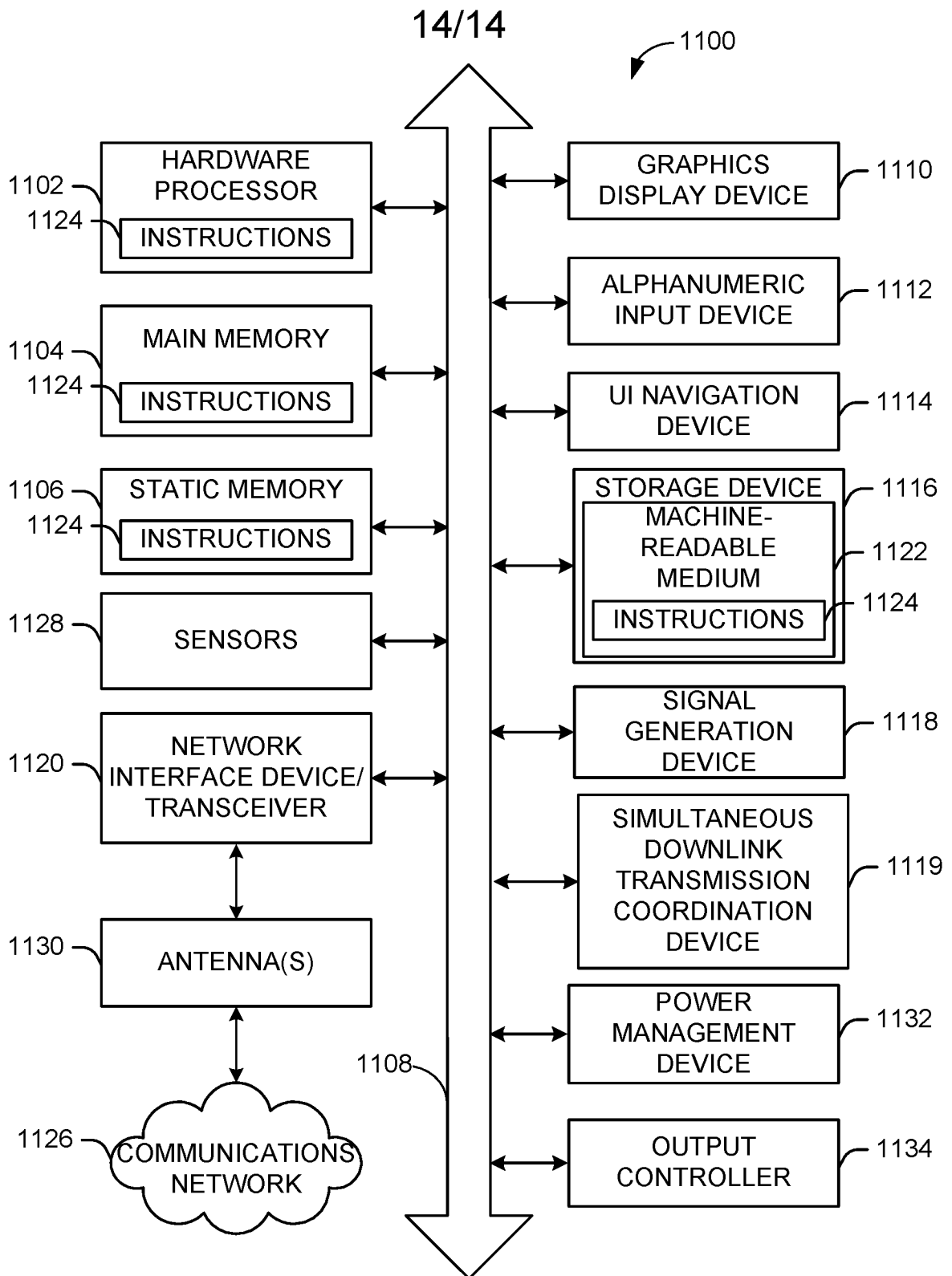


FIG. 11

A. CLASSIFICATION OF SUBJECT MATTER**H04W 72/04(2009.01)i, H04W 84/12(2009.01)i**

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

B. FIELDS SEARCHEDMinimum documentation searched (classification system followed by classification symbols)
H04W 72/04; H04W 72/12; H04L 5/00; H04B 7/26; H04W 28/06; H04B 7/04; H04W 84/12Documentation 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 modelsElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: access point, trigger frame, simultaneous transmission, data frame, frequency allocation, device information, buffer status, proximate**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2016-0360443 A1 (NEWRACOM, INC.) 08 December 2016 See paragraphs [0093]-[0095]; and claim 10.	1-25
A	US 2012-0044925 A1 (DAE WON LEE et al.) 23 February 2012 See paragraphs [0130]-[0131]; and figures 14-15.	1-25
A	US 2016-0316472 A1 (NEWRACOM, INC.) 27 October 2016 See paragraphs [0064]-[0068]; and figure 6.	1-25
A	US 2016-0227565 A1 (INTEL IP CORPORATION) 04 August 2016 See paragraphs [0035]-[0046]; and figures 5a-5b.	1-25
A	US 2015-0063191 A1 (QUALCOMM INCORPORATED) 05 March 2015 See claims 1-12; and figure 7.	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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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

12 January 2018 (12.01.2018)

Date of mailing of the international search report

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Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea



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