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Sutherland Asbill & Brennan / ITL
c/o CPA Global
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Minneapolis, MN 55402

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The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 62/244,603**

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Early Publication Request: No

Title

NON-CONTIGUOUS CHANNEL BONDING

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

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Provisional Application for Patent Cover Sheet

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c)

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All Inventors Must Be Listed – Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. — Add

Title of Invention	NON-CONTIGUOUS CHANNEL BONDING
Attorney Docket Number (if applicable)	P91705Z

Correspondence Address

Direct all correspondence to (select one):

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Customer Number	101021

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The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.
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○ Yes, the invention was made by an agency of the United States Government. The U.S. Government agency name is:
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Signature	/Nash M. Zogaib/			Date (YYYY-MM-DD)	2015-10-21
First Name	Nash	Last Name	Zogaib	Registration Number (If appropriate)	68304

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ABSTRACT

This disclosure describes methods, apparatus, and systems related to non-contiguous channel bonding. A device may generate a high efficiency preamble in accordance with a high efficiency communication standard, the high efficiency preamble including, at least in part, one or more legacy signal fields, one or more high efficiency signal fields, and one or more training fields. The device may determine a type of communication over a wireless communication channel with a first device, the wireless communication channel having one or more subchannels. The device may determine one or more available subchannels of the one or more subchannels. The device may determine, based at least in part on the type of communication, a number of clear channel assessments. The device may cause to send the high efficiency preamble using the one or more available subchannels.

UNITED STATES PATENT APPLICATION

ENTITLED:

NON-CONTIGUOUS CHANNEL BONDING

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NON-CONTIGUOUS CHANNEL BONDING

TECHNICAL FIELD

[0001] This disclosure generally relates to systems and methods for wireless communications and, more particularly, to non-contiguous channel bonding in wireless communications.

BACKGROUND

[0002] Wireless devices are becoming widely prevalent and are increasingly requesting access to wireless channels. A next generation WLAN, IEEE 802.11ax or High-Efficiency WLAN (HEW), is under development. HEW utilizes Orthogonal Frequency-Division Multiple Access (OFDMA) in channel allocation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] FIG. 1A depicts a network diagram illustrating an example network environment of an illustrative non-contiguous channel bonding system, according to one or more example embodiments of the disclosure.

[0004] FIG. 1B depict a diagram illustrating throughput degradation in contiguous channel bonding.

[0005] FIG. 1C depicts non-contiguous channel bonding, according to one or more example embodiments of the disclosure.

[0006] FIG. 2 depicts an illustrative schematic diagram of a trigger frame based communication, in accordance with one or more example embodiments of the present disclosure.

[0007] FIGs. 3A-3B depict illustrative schematic diagrams of subchannel decoding in non-contiguous channel bonding.

[0008] FIGs. 4A-4B depict illustrative schematic diagrams of subchannel decoding in non-contiguous channel bonding by adding one CCA, in accordance with one or more example embodiments of the present disclosure.

[0009] FIGs. 5A-5B depict illustrative schematic diagrams of subchannel decoding in non-contiguous channel bonding where the bandwidth is configured to be 160 MHz, in accordance with one or more example embodiments of the present disclosure.

[0010] FIG. 6 depicts a flow diagram of an illustrative process for an illustrative non-contiguous channel bonding system, in accordance with one or more embodiments of the disclosure.

[0011] FIG. 7 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 disclosure.

[0012] FIG. 7 is a block diagram of an example machine upon which any of one or more techniques (e.g., methods) may be performed, in accordance with one or more embodiments of the disclosure.

DETAILED DESCRIPTION

[0013] 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).

[0014] The following description and the drawings sufficiently illustrate specific embodiments to enable those skilled in the art to practice them. Other embodiments may incorporate structural, logical, electrical, process, and other changes. Portions and features of some embodiments may be included in, or substituted for, those of other embodiments. Embodiments set forth in the claims encompass all available equivalents of those claims.

[0015] During communication between two devices, one or more frames may be sent and received. These frames may include one or more fields (or symbols) that may be based on an IEEE 802.11 standard. In a high efficiency communication (e.g., HEW) these one or more fields may be represented by one or more OFDMA symbols.

[0016] Non-contiguous channel bonding may increase throughput when a 20 MHz subband in the middle is occupied. However, this technique may add implementation complexities, for example, per-20 MHz clear channel assessment (CCA). The Fast Fourier Transform (FFT) circuit may not be always turned on for saving power. When it is off, the power measurement for each 20 MHz subband may need to be done in time domain samples for saving power. For example, the receiver may need to down convert each 20 MHz subchannel to baseband around

Direct Current (DC) and conduct low pass filtering. This consumes digital multiplications and power.

[0017] Example embodiments of the present disclosure relate to systems, methods, and devices for non-contiguous channel bonding that facilitates a trigger based and a non-trigger based non-contiguous channel bonding. In the trigger-based case, a device may be instructed to conduct CCA within a limited time. For example, a trigger frame may tell the device to measure the CCA for each 20 MHz subband after the trigger frame within, for example, 4 microseconds. Since FFT may be used the limited time, CCA may be done for each 20 MHz subband. In the non-trigger based case, the device may monitor the channel without instructions.

[0018] FIG. 1A is a network diagram illustrating an example network environment, according to some example embodiments of the present disclosure. Wireless network 100 may include one or more 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 device(s) 120 may be mobile devices that are non-stationary and do not have fixed locations.

[0019] In some embodiments, the user devices 120 and AP 102 may include one or more computer systems similar to that of the functional diagram of FIG. 6 and/or the example machine/system of FIG. 7.

[0020] One or more illustrative user device(s) 120 may be operable by one or more user(s) 110. The user device(s) 120 (e.g., 124, 126, or 128) may include any suitable processor-driven user device including, but not limited to, a desktop user device, a laptop user device, a server, a router, a switch, an access point, a smartphone, a tablet, wearable wireless device (e.g., bracelet, watch, glasses, ring, etc.) and so forth.

[0021] Any of the user device(s) 120 (e.g., user devices 124, 126, 128), and AP 102 may be configured to communicate with each other via one or more communications networks 130 and/or 135 wirelessly or wired. Any of the communications networks 130 and/or 135 may include, but not limited to, any one of a combination of different types of suitable communications networks such as, for example, broadcasting networks, cable networks, public networks (e.g., the Internet), private networks, wireless networks, cellular networks, or any other suitable private and/or public networks. Further, any of the communications networks 130

and/or 135 may have any suitable communication range associated therewith and may include, for example, global networks (e.g., the Internet), metropolitan area networks (MANs), wide area networks (WANs), local area networks (LANs), or personal area networks (PANs). In addition, any of the communications networks 130 and/or 135 may include any type of medium over which network traffic may be carried including, but not limited to, coaxial cable, twisted-pair wire, optical fiber, a hybrid fiber coaxial (HFC) medium, microwave terrestrial transceivers, radio frequency communication mediums, white space communication mediums, ultra-high frequency communication mediums, satellite communication mediums, or any combination thereof.

[0022] Any of the user device(s) 120 (e.g., user devices 124, 126, 128), and AP 102 may include one or more communications antennae. Communications antenna may be any suitable type of antenna corresponding to the communications protocols used by the user device(s) 120 (e.g., user devices 124, 124 and 128), and AP 102. Some non-limiting examples of suitable communications antennas include Wi-Fi antennas, Institute of Electrical and Electronics Engineers (IEEE) 802.11 family of standards compatible antennas, directional antennas, non-directional antennas, dipole antennas, folded dipole antennas, patch antennas, multiple-input multiple-output (MIMO) antennas, or the like. The communications antenna may be communicatively coupled to a radio component to transmit and/or receive signals, such as communications signals to and/or from the user devices 120.

[0023] 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), 5 GHz channels (e.g.

802.11n, 802.11ac), 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.

[0024] Typically, 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 may communicate in the downlink direction by sending data frames. 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 the user device to detect a new incoming data frame from the AP. 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).

[0025] In one embodiment, and with reference to FIG. 1A, an HEW preamble (e.g., preamble 140) may include one or more fields, such as, legacy short training and long training field, a legacy signal field (L-SIG), a high efficiency signal A (HE-SIG-A) field, a high efficiency signal B (HE-SIG-B) field, high efficiency short training and long training fields. It is understood that the above acronyms may be different and not to be construed as a limitation as other acronyms maybe used for the fields included in an HEW preamble.

[0026] FIG. 1B depicts a diagram illustrating throughput degradation in contiguous channel bonding.

[0027] In FIG. 1B, in an 80 MHz channel, a secondary 20 MHz may be busy but the rest 60 MHz may be idle. However, the contiguous channel bonding may only use 20 MHz instead of 60 MHz.

[0028] FIG. 1C depicts non-contiguous channel bonding, according to one or more example embodiments of the disclosure.

[0029] In FIG. 1C, for the non-trigger based case, the number of CCAs may be kept the same as in the legacy 11ac, i.e. CCAs only on primary 20, secondary 20, secondary 40, and secondary

80 MHz. If a secondary subchannel is busy, that subchannel may not be used but the remaining usable subchannels may still be used.

[0030] FIG. 2 depicts an illustrative schematic diagram of a trigger frame based communication, in accordance with one or more example embodiments of the present disclosure.

[0031] In one embodiment, if the CCA is done for a short duration, then it may be done on each 20 MHz subband without burning much power. FFT may be used to separate the signals on each 20 MHz subband. However, if the device monitors the channel for long time, FFT may be turned off and time domain samples are used for CCAs. In this case, the number of CCAs may be limited.

[0032] In one embodiment, two cases of CCA operations may be defined: trigger based and non-trigger based. In the trigger-based case, the device may be instructed to conduct CCA within a limited time. For example, a trigger frame may tell the device to measure the CCA for each 20 MHz subband after the trigger frame within, for example, 4 microseconds. The trigger may be a multiuser, multicast trigger a single user, or unicast frame such as request to send (RTS). Since FFT is only used for a limited duration, CCA may be done for each 20 MHz subband. In the example of FIG. 2, Device 2 may need to continue the FFT operation for one symbol after the trigger frame. Depending on the CCA results, the response may not be sent over the primary subchannel. For example, if the primary subchannel is busy but secondary 20 MHz and another 20 MHz subband are clear, the response may be sent over the two subbands. In the non-trigger based case, the device monitors the channel without instructions. Since FFT is preferred not being used for saving power, we want to limit the number of CCAs.

[0033] In one embodiment, for limiting the number of CCAs for IEEE 802.11ac, the less the secondary subchannel is busy, the smaller the bandwidth may be used. In the example in FIG. 1C, the busy 20 MHz secondary subchannel reduces the channel to 20 MHz, and the busy 40 MHz secondary subchannel may reduce the channel to 40 MHz. Therefore, solving the busy 20 MHz secondary provides the most gain. When FFT circuit is turned on, per 20 MHz CCA is feasible. However, in idle mode before receiving the indication for CCA measurement e.g. a trigger frame, the receiver prefers turning the FFT circuit off to save power. In this case, the CCA is usually done on time domain samples by down conversion and low pass filtering. Since these operations consume power, we want to limit the number of CCAs. This also may help the

receiver in decoding the HE preamble because this limits the formats of HE-SIG-B. The HE preamble may be sent over the primary subchannel and the clear subbands (or clear subchannels) passing CCAs. Therefore, the configuration of CCAs may limit the transmission formats of HE preamble such that the receiver may need to decode those formats.

[0034] FIGs. 3A-3B depict illustrative schematic diagrams of subchannel decoding in non-contiguous channel bonding.

[0035] In one embodiment, the CCA complexity may be kept as low as possible. For example, the CCA may be kept the same as in the legacy IEEE 802.11 standard. For example, if the system is configured to be 160 MHz (as in FIG. 3B), the CCA may be done on primary 20 MHz, secondary 20 MHz, secondary 40 MHz, and secondary 80 MHz. If the system is configured to be 80 MHz (as in FIG. 3A), the CCA is only done on primary 20 MHz, secondary 20 MHz, and secondary 40 MHz. The channel bonding may be then among the primary and the secondary subchannels. On the occupied secondary subchannel, the legacy preamble and the high efficiency (HE) preamble may not be sent.

[0036] In one embodiment, the HE-SIG-B field may be divided into two subfields HE-SIG-B1 and HE-SIG-B2 and the two may be sent over adjacent 20 MHz subbands. For a low end receiver that does not combine, the receiver may only decode the primary 40 MHz subchannel or the secondary 40 MHz or half of the secondary 80 MHz to get both HE-SIG-B1 and HE-SIG-B2.

[0037] FIGs. 4A-4B depict illustrative schematic diagrams of subchannel decoding in non-contiguous channel bonding by adding one CCA, in accordance with one or more example embodiments of the present disclosure.

[0038] In one embodiment, if one CCA operation is added on the top of IEEE 802.11ac, the throughput gain may be maximized using the additional CCA. The additional CCA may be applied to half of the largest secondary subchannel. For example, if the maximum bandwidth of the system is 80 MHz, then the largest secondary subchannel is the secondary 40 MHz subchannel. The existing CCA and the proposed CCA operations are illustrated in FIG. 4B. After adding one CCA, the receiver may essentially perform CCA for each 20 MHz subchannel in the 80 MHz channel. In legacy system, if one 20 MHz in the secondary 40 MHz subchannel is occupied, the whole 40 MHz subchannel is not used as shown in FIG. 4A. In contrast, the proposed solution in FIG. 4B can use all remaining 20 MHz subbands. In addition, the

implementation of the proposed scheme is compatible with the legacy. The existing CCA for the secondary 40 MHz subchannel may be reused. One CCA for one of the two 20 MHz subbands in the secondary 40 MHz subchannel is added. The CCA power measurement for the other 20 MHz subband may be simply obtained as:

[0039] $P_{CCA}(2^{\text{nd}}\ 20\text{MHz}) = P_{CCA}(40\ \text{MHz}) - P_{CCA}(1^{\text{st}}\ 20\ \text{MHz})$.

[0040] Namely, the total power of each 20 MHz subband is the power of the 40 MHz secondary channel.

[0041] FIGs. 5A-5A depict illustrative schematic diagrams of subchannel decoding in non-contiguous channel bonding where the bandwidth is configured to be 160 MHz, in accordance with one or more example embodiments of the present disclosure.

[0042] When the maximum system bandwidth is configured to be 160 MHz, one CCA may be added to the largest secondary subchannel, i.e. secondary 80 MHz subchannel as shown in FIG. 5A. The 80 MHz subchannel may be divided into two 40 MHz subbands and each has a CCA as shown in FIG. 5B.

[0043] FIG. 6 illustrates a flow diagram of illustrative process 600 for a non-contiguous channel bonding system in accordance with one or more embodiments of the disclosure.

[0044] At block 602, a device may generate a high efficiency preamble in accordance with a high efficiency communication standard, the high efficiency preamble including, at least in part, one or more legacy signal fields, one or more high efficiency signal fields, and one or more training fields.

[0045] At block 604, the device may determine a type of communication over a wireless communication channel with a first device, the wireless communication channel having one or more subchannels.

[0046] At block 606, the device may determine one or more available subchannels of the one or more subchannels.

[0047] At block 608, the device may determine, based at least in part on the type of communication, a number of clear channel assessments.

[0048] At block 610, the device may cause to send the high efficiency preamble using the one or more available subchannels.

[0049] FIG. 7 shows a functional diagram of an exemplary communication station 700 in accordance with some embodiments. In one embodiment, FIG. 7 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 700 may also be suitable for use as a handheld device, mobile device, cellular telephone, smartphone, tablet, netbook, wireless terminal, laptop computer, wearable computer device, femtocell, High Data Rate (HDR) subscriber station, access point, access terminal, or other personal communication system (PCS) device.

[0050] The communication station 700 may include communications circuitry 702 and a transceiver 710 for transmitting and receiving signals to and from other communication stations using one or more antennas 701. The communications circuitry 702 may include circuitry that can operate the physical layer communications and/or medium 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 700 may also include processing circuitry 706 and memory 708 arranged to perform the operations described herein. In some embodiments, the communications circuitry 702 and the processing circuitry 706 may be configured to perform operations detailed in FIGs. 2, 3A-B, 4A-B, 5A-B, and 6.

[0051] In accordance with some embodiments, the communications circuitry 702 may be arranged to contend for a wireless medium and configure frames or packets for communicating over the wireless medium. The communications circuitry 702 may be arranged to transmit and receive signals. The communications circuitry 702 may also include circuitry for modulation/demodulation, upconversion/downconversion, filtering, amplification, etc. In some embodiments, the processing circuitry 706 of the communication station 700 may include one or more processors. In other embodiments, two or more antennas 701 may be coupled to the communications circuitry 702 arranged for sending and receiving signals. The memory 708 may store information for configuring the processing circuitry 706 to perform operations for configuring and transmitting message frames and performing the various operations described herein. The memory 708 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 708 may include a computer-readable storage device may, read-only memory (ROM), random-access memory (RAM), magnetic disk storage media, optical storage media, flash-memory devices and other storage devices and media.

[0052] In some embodiments, the communication station 700 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.

[0053] In some embodiments, the communication station 700 may include one or more antennas 701. The antennas 701 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.

[0054] In some embodiments, the communication station 700 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.

[0055] Although the communication station 700 is illustrated as having several separate functional elements, two or more of the functional elements may be combined and may be implemented by combinations of software-configured elements, such as processing elements including digital signal processors (DSPs), and/or other hardware elements. For example, some elements may include one or more microprocessors, DSPs, field- programmable gate arrays (FPGAs), application specific integrated circuits (ASICs), radio- frequency integrated circuits

(RFICs) and combinations of various hardware and logic circuitry for performing at least the functions described herein. In some embodiments, the functional elements of the communication station 700 may refer to one or more processes operating on one or more processing elements.

[0056] Certain embodiments may be implemented in one or a combination of hardware, firmware, and software. Other embodiments may also be implemented as instructions stored on a computer-readable storage device, which may be read and executed by at least one processor to perform the operations described herein. A computer-readable storage device may include any non-transitory memory mechanism for storing information in a form readable by a machine (e.g., a computer). For example, a computer-readable storage device may include read-only memory (ROM), random-access memory (RAM), magnetic disk storage media, optical storage media, flash-memory devices, and other storage devices and media. In some embodiments, the communication station 700 may include one or more processors and may be configured with instructions stored on a computer-readable storage device memory.

[0057] FIG. 8 illustrates a block diagram of an example of a machine 800 or system upon which any one or more of the techniques (e.g., methodologies) discussed herein may be performed. In other embodiments, the machine 800 may operate as a standalone device or may be connected (e.g., networked) to other machines. In a networked deployment, the machine 800 may operate in the capacity of a server machine, a client machine, or both in server-client network environments. In an example, the machine 800 may act as a peer machine in peer-to-peer (P2P) (or other distributed) network environments. The machine 800 may be a personal computer (PC), a tablet PC, a set-top box (STB), a personal digital assistant (PDA), a mobile telephone, wearable computer device, a web appliance, a network router, 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.

[0058] 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.

[0059] The machine (e.g., computer system) 800 may include a hardware processor 802 (e.g., a central processing unit (CPU), a graphics processing unit (GPU), a hardware processor core, or any combination thereof), a main memory 804 and a static memory 806, some or all of which may communicate with each other via an interlink (e.g., bus) 808. The machine 800 may further include a power management device 832, a graphics display device 810, an alphanumeric input device 812 (e.g., a keyboard), and a user interface (UI) navigation device 814 (e.g., a mouse). In an example, the graphics display device 810, alphanumeric input device 812, and UI navigation device 814 may be a touch screen display. The machine 800 may additionally include a storage device (i.e., drive unit) 816, a signal generation device 818 (e.g., a speaker), a non-contiguous channel bonding device 819, a network interface device/transceiver 820 coupled to antenna(s) 830, and one or more sensors 828, such as a global positioning system (GPS) sensor, compass, accelerometer, or other sensor. The machine 800 may include an output controller 834, 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, card reader, etc.)).

[0060] The storage device 816 may include a machine readable medium 822 on which is stored one or more sets of data structures or instructions 824 (e.g., software) embodying or utilized by any one or more of the techniques or functions described herein. The instructions 824 may also reside, completely or at least partially, within the main memory 804, within the static memory 806, or within the hardware processor 802 during execution thereof by the machine 800. In an example, one or any combination of the hardware processor 802, the main memory 804, the static memory 806, or the storage device 816 may constitute machine-readable media.

[0061] The non-contiguous channel bonding device 819 may be carry out or perform any of the operations and processes (e.g., process 600) described and shown above. For example, the non-contiguous channel bonding device 819 may be configured to facilitate a trigger based and a non-trigger based non-contiguous channel bonding. In the trigger-based case, a device may be instructed to conduct CCA within a limited time. For example, a trigger frame may tell the device to measure the CCA for each 20 MHz subband after the trigger frame within, for example, 4 microseconds. Since FFT may be used the limited time, CCA may be done for each 20 MHz subband. In the non-trigger based case, the device may monitor the channel without instructions.

[0062] While the machine-readable medium 822 is illustrated as a single medium, the term "machine-readable medium" may include a single medium or multiple media (e.g., a centralized or distributed database, and/or associated caches and servers) configured to store the one or more instructions 824.

[0063] Various embodiments may be implemented fully or partially in software and/or firmware. This software and/or firmware may take the form of instructions contained in or on a non-transitory computer-readable storage medium. Those instructions may then be read and executed by one or more processors to enable performance of the operations described herein. The instructions may be in any suitable form, such as but not limited to source code, compiled code, interpreted code, executable code, static code, dynamic code, and the like. Such a computer-readable medium may include any tangible non-transitory medium for storing information in a form readable by one or more computers, such as but not limited to read only

memory (ROM); random access memory (RAM); magnetic disk storage media; optical storage media; a flash memory, etc.

[0064] The term "machine-readable medium" may include any medium that is capable of storing, encoding, or carrying instructions for execution by the machine 800 and that cause the machine 800 to perform any one or more of the techniques of the present disclosure, or that is capable of storing, encoding, or carrying data structures used by or associated with such instructions. Non-limiting machine-readable medium examples may include solid-state memories and optical and magnetic media. In an example, a massed machine-readable medium includes a machine-readable medium with a plurality of particles having resting mass. Specific examples of massed machine-readable media may include non-volatile memory, such as semiconductor memory devices (e.g., Electrically Programmable Read-Only Memory (EPROM), or Electrically Erasable Programmable Read-Only Memory (EEPROM)) and flash memory devices; magnetic disks, such as internal hard disks and removable disks; magneto-optical disks; and CD-ROM and DVD- ROM disks.

[0065] The instructions 824 may further be transmitted or received over a communications network 826 using a transmission medium via the network interface device/transceiver 820 utilizing any one of a number of transfer protocols (e.g., frame relay, internet protocol (IP), transmission control protocol (TCP), user datagram protocol (UDP), hypertext transfer protocol (HTTP), etc.). Example communications networks may include a local area network (LAN), a wide area network (WAN), a packet data network (e.g., the Internet), mobile telephone networks (e.g., cellular networks), Plain Old Telephone (POTS) networks, wireless data networks (e.g., Institute of Electrical and Electronics Engineers (IEEE) 802.11 family of standards known as Wi-Fi®, IEEE 802.16 family of standards known as WiMax®), IEEE 802.15.4 family of standards, and peer-to-peer (P2P) networks, among others. In an example, the network interface device/transceiver 820 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 826. In an example, the network interface device/transceiver 820 may include a plurality of antennas to wirelessly communicate using at least one of single-input multiple-output (SIMO), multiple-input multiple-output (MIMO), or multiple-input single-output (MISO) techniques. The term "transmission

medium" shall be taken to include any intangible medium that is capable of storing, encoding, or carrying instructions for execution by the machine 800 and includes digital or analog communications signals or other intangible media to facilitate communication of such software. The operations and processes (e.g., processes 500 and 550) 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.

[0066] The word "exemplary" is used herein to mean "serving as an example, instance, or illustration." Any embodiment described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments. The terms "computing device", "user device", "communication station", "station", "handheld device", "mobile device", "wireless device" and "user equipment" (UE) as used herein refers to a wireless communication device such as a cellular telephone, smartphone, tablet, netbook, wireless terminal, laptop computer, a femtocell, High Data Rate (HDR) subscriber station, access point, printer, point of sale device, access terminal, or other personal communication system (PCS) device. The device may be either mobile or stationary.

[0067] 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.

[0068] 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, 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.

[0069] 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.

[0070] Some embodiments may be used in conjunction with one way and/or two-way radio communication systems, cellular radio-telephone communication systems, a mobile phone, a cellular telephone, a wireless telephone, a Personal Communication Systems (PCS) device, a PDA device which incorporates a wireless communication device, a mobile or portable Global Positioning System (GPS) device, a device which incorporates a GPS receiver or transceiver or chip, a device which incorporates an RFID element or chip, a Multiple Input Multiple Output (MIMO) transceiver or device, a Single Input Multiple Output (SIMO) transceiver or device, a Multiple Input Single Output (MISO) transceiver or device, a device having one or more internal antennas and/or external antennas, Digital Video Broadcast (DVB) devices or systems, multi-standard radio devices or systems, a wired or wireless handheld device, e.g., a Smartphone, a Wireless Application Protocol (WAP) device, or the like.

[0071] Some embodiments may be used in conjunction with one or more types of wireless communication signals and/or systems following one or more wireless communication protocols,

for example, Radio Frequency (RF), Infra Red (IR), Frequency-Division Multiplexing (FDM), Orthogonal FDM (OFDM), Time-Division Multiplexing (TDM), Time-Division Multiple Access (TDMA), Extended TDMA (E-TDMA), General Packet Radio Service (GPRS), extended GPRS, Code-Division Multiple Access (CDMA), Wideband CDMA (WCDMA), CDMA 2000, single-carrier CDMA, multi-carrier CDMA, Multi-Carrier Modulation (MDM), Discrete Multi-Tone (DMT), Bluetooth®, Global Positioning System (GPS), Wi-Fi, Wi-Max, ZigBeeTM, Ultra-Wideband (UWB), Global System for Mobile communication (GSM), 2G, 2.5G, 3G, 3.5G, 4G, Fifth Generation (5G) mobile networks, 3GPP, Long Term Evolution (LTE), LTE advanced, Enhanced Data rates for GSM Evolution (EDGE), or the like. Other embodiments may be used in various other devices, systems, and/or networks.

[0072] According to example embodiments of the disclosure, there may be a device. The device may include at least one memory that stores computer-executable instructions, and at least one processor of the one or more processors configured to access the at least one memory, wherein the at least one processor of the one or more processors is configured to execute the computer-executable instructions to standard, the high efficiency preamble including, at least in part, one or more legacy signal fields, one or more high efficiency signal fields, and one or more training fields. The at least one processor of the one or more processors may be configured to execute the computer-executable instructions to determine a type of communication over a wireless communication channel with a first device, the wireless communication channel having one or more subchannels. The at least one processor of the one or more processors may be configured to execute the computer-executable instructions to determine one or more available subchannels of the one or more subchannels. The at least one processor of the one or more processors may be configured to execute the computer-executable instructions to determine, based at least in part on the type of communication, a number of clear channel assessments. The at least one processor of the one or more processors may be configured to execute the computer-executable instructions to cause to send the high efficiency preamble using the one or more available subchannels.

[0073] The implementations may include one or more of the following features. The one or more high efficiency signal fields may include at least one of a high efficiency signal A (HE-SIG-A) field and a high efficiency signal B (HE-SIG-B) field. The type of communication may include at least one of a trigger frame based communication or a non-trigger frame based communication.

The number of clear channel assessments may be based at least in part of a size of the subchannel. The one or more subchannels may include at least one of a primary sub-channel and one or more secondary sub-channels. The device may further include a transceiver configured to transmit and receive wireless signals. The device may further include an antenna coupled to the transceiver.

[0074] In example embodiments of the disclosure, there may be a non-transitory computer-readable medium. The non-transitory computer-readable medium may store computer-executable instructions which when executed by one or more processors result in performing operations comprising determining a wireless communication channel with a first device having one or more subchannels, generating a high efficiency preamble in accordance with a high efficiency communication standard, the high efficiency preamble including, at least in part, one or more legacy signal fields, one or more high efficiency signal fields, and one or more training fields, determining a type of communication over the wireless communication channel, determining one or more available subchannels of the one or more subchannels, determining, based at least in part on the type of communication, a number of clear channel assessments, and causing to send the high efficiency preamble using the one or more available subchannels.

[0075] Implementations may include one or more of the following features. The type of communication may include at least one of a trigger frame based communication or a non-trigger frame based communication. The number of clear channel assessments is based at least in part of a size of the subchannel. The one or more subchannels include at least one of a primary sub-channel and one or more secondary sub-channels. The one or more high efficiency signal fields include at least one of a high efficiency signal A (HE-SIG-A) field and a high efficiency signal B (HE-SIG-B) field.

[0076] Implementations may include one or more of the following features. In example embodiments of the disclosure, there may be a method. The method may include determining a wireless communication channel with a first device having one or more subchannels, generating a high efficiency preamble in accordance with a high efficiency communication standard, the high efficiency preamble including, at least in part, one or more legacy signal fields, one or more high efficiency signal fields, and one or more training fields, determining a type of communication over the wireless communication channel, determining one or more available subchannels of the one or

more subchannels, determining, based at least in part on the type of communication, a number of clear channel assessments, and causing to send the high efficiency preamble using the one or more available subchannels.

[0077] 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.

[0078] 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.

[0079] 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.

[0080] 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.

[0081] 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, comprising:

at least one memory that stores computer-executable instructions; and

at least one processor configured to access the at least one memory, wherein the at least one processor is configured to execute the computer-executable instructions to:

generate a high efficiency preamble in accordance with a high efficiency communication standard, the high efficiency preamble including, at least in part, one or more legacy signal fields, one or more high efficiency signal fields, and one or more training fields;

determine a type of communication over a wireless communication channel with a first device, the wireless communication channel having one or more subchannels;

determine one or more available subchannels of the one or more subchannels;

determine, based at least in part on the type of communication, a number of clear channel assessments; and

cause to send the high efficiency preamble using the one or more available subchannels.

2. The device of claim 1, wherein the one or more high efficiency signal fields include at least one of a high efficiency signal A (HE-SIG-A) field and a high efficiency signal B (HE-SIG-B) field.

3. The device of claim 1, wherein the type of communication includes at least one of a trigger frame based communication or a non-trigger frame based communication.

4. The device of claim 1, wherein the number of clear channel assessments is based at least in part of a size of the subchannel.

5. The device of claim 1, wherein the one or more subchannels include at least one of a primary sub-channel and one or more secondary sub-channels.

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

7. The device of claim 6, further comprising an antenna coupled to the transceiver.

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

determining a wireless communication channel with a first device having one or more subchannels;

generating a high efficiency preamble in accordance with a high efficiency communication standard, the high efficiency preamble including, at least in part, one or more legacy signal fields, one or more high efficiency signal fields, and one or more training fields;

determining a type of communication over the wireless communication channel;

determining one or more available subchannels of the one or more subchannels;

determining, based at least in part on the type of communication, a number of clear channel assessments; and

causing to send the high efficiency preamble using the one or more available subchannels.

9. The non-transitory computer-readable medium of claim 8, wherein the type of communication includes at least one of a trigger frame based communication or a non-trigger frame based communication.

10. The non-transitory computer-readable medium of claim 8, wherein the number of clear channel assessments is based at least in part of a size of the subchannel.

11. The non-transitory computer-readable medium of claim 8, wherein the one or more subchannels include at least one of a primary sub-channel and one or more secondary sub-channels.

12. The non-transitory computer-readable medium of claim 8, wherein the one or more high efficiency signal fields include at least one of a high efficiency signal A (HE-SIG-A) field and a high efficiency signal B (HE-SIG-B) field.

13. A method comprising:

determining a wireless communication channel with a first device having one or more subchannels;

generating a high efficiency preamble in accordance with a high efficiency communication standard, the high efficiency preamble including, at least in part, one or more legacy signal fields, one or more high efficiency signal fields, and one or more training fields;

determining a type of communication over the wireless communication channel;

determining one or more available subchannels of the one or more subchannels;

determining, based at least in part on the type of communication, a number of clear channel assessments; and

causing to send the high efficiency preamble using the one or more available subchannels.

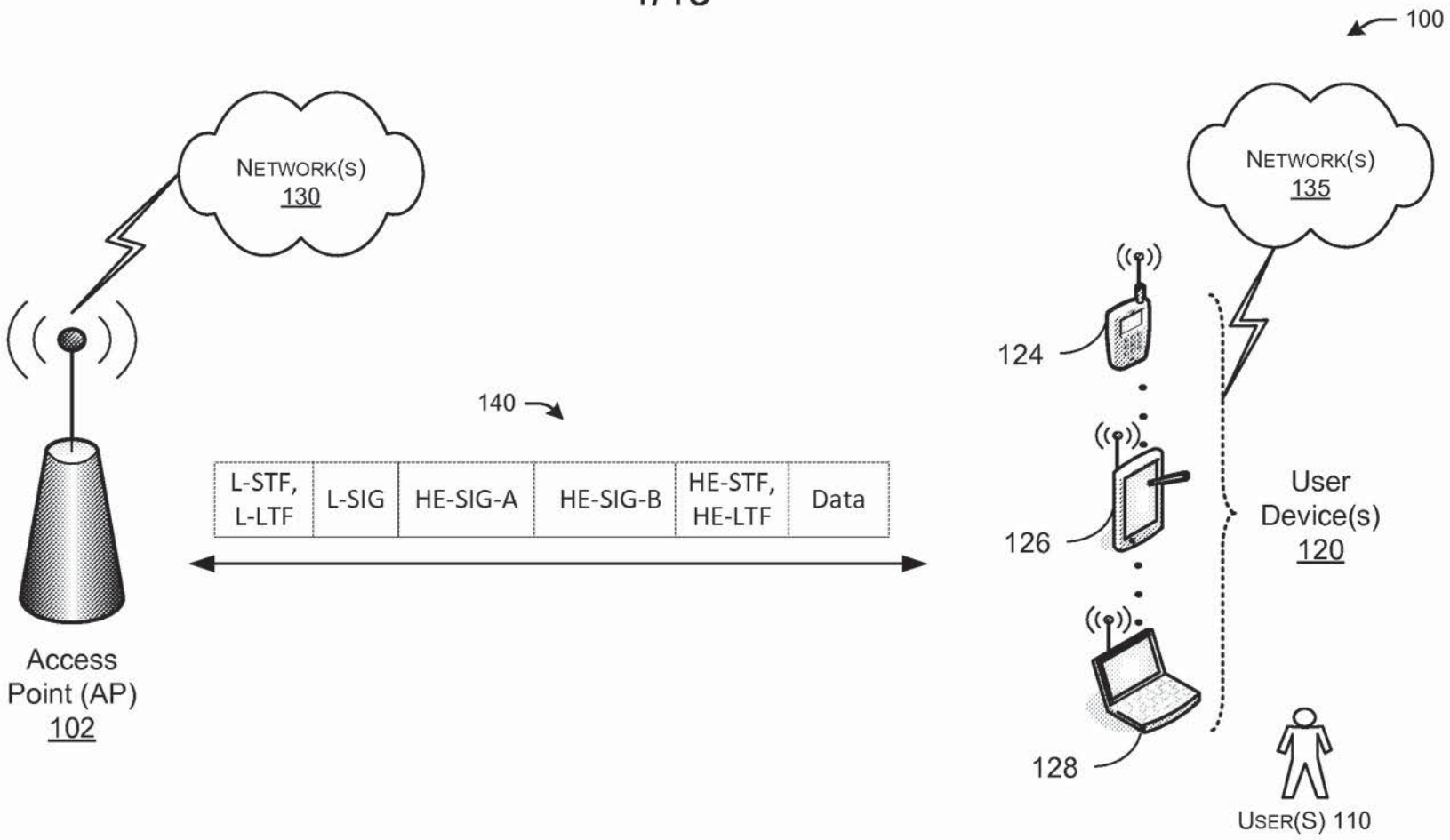

100
NETWORK(S)
130
NETWORK(S)
135
140
L-STF, L-LTF
L-SIG
HE-SIG-A
HE-SIG-B
HE-STF, HE-LTF
Data
124
126
128
User Device(s)
120
Access Point (AP)
102
USER(S) 110

FIG. 1A

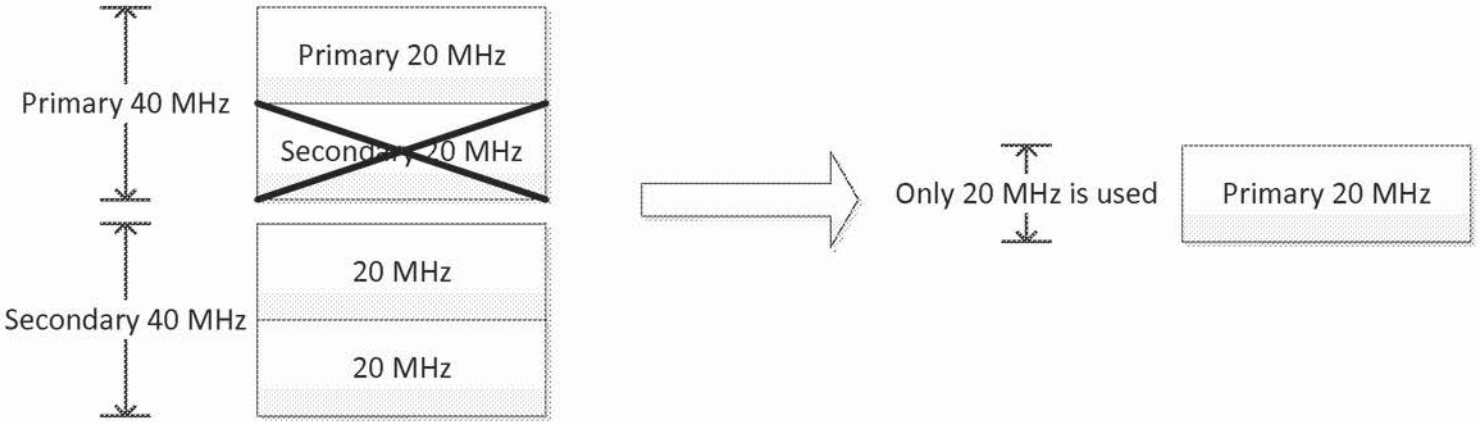

Primary 40 MHz
Secondary 40 MHz
Primary 20 MHz
Secondary 20 MHz
20 MHz
20 MHz
Only 20 MHz is used
Primary 20 MHz

FIG. 1B

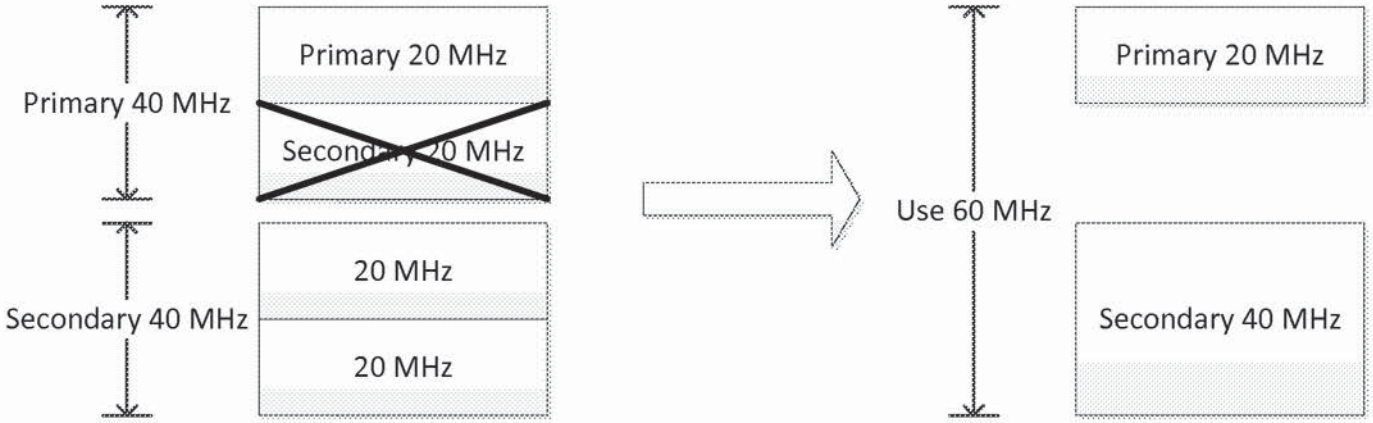

Primary 40 MHz
Primary 20 MHz
Secondary 20 MHz
Secondary 40 MHz
20 MHz
20 MHz
Use 60 MHz
Primary 20 MHz
Secondary 40 MHz

FIG. 1C

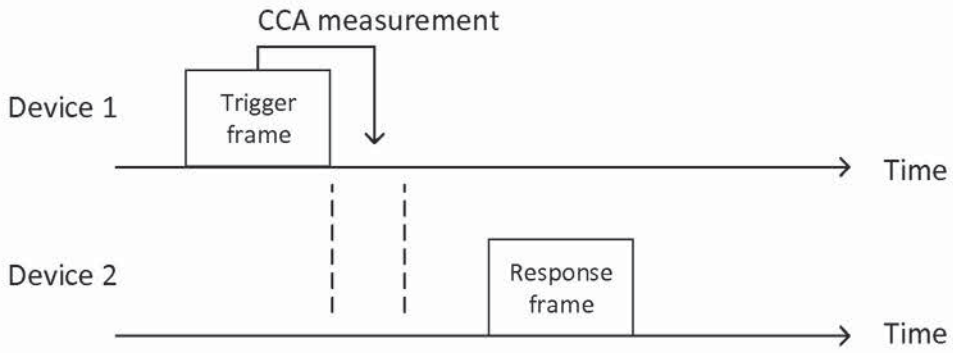
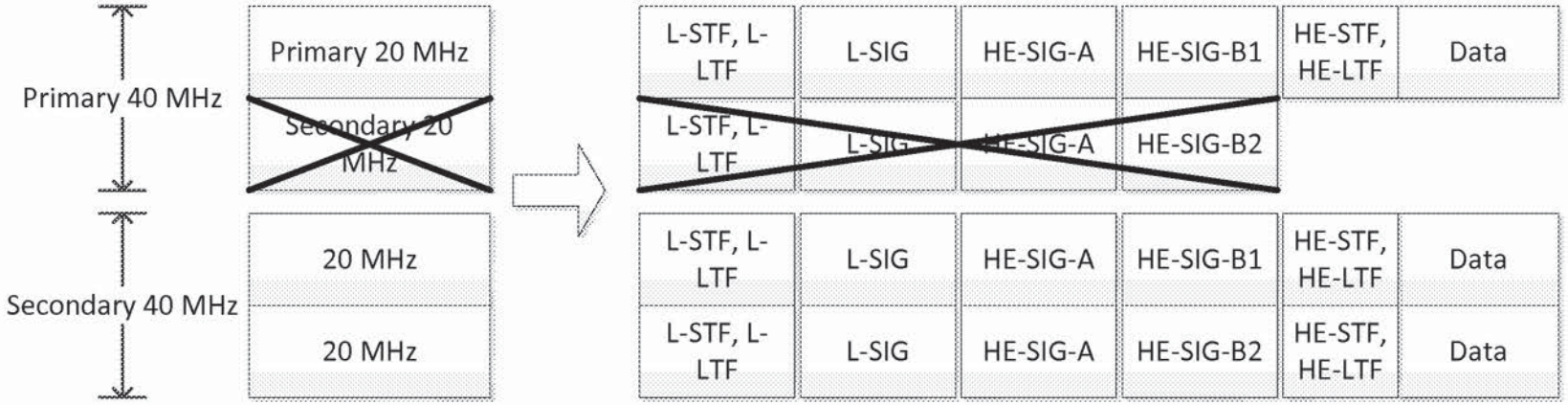

CCA measurement
Device 1
Trigger frame
Time
Device 2
Response frame
Time

FIG. 2


Primary 40 MHz
Secondary 40 MHz
Primary 20 MHz
Secondary 20 MHz
20 MHz
20 MHz
L-STF, L-LTF
L-SIG
HE-SIG-A
HE-SIG-B1
HE-SIG-B2
HE-STF, HE-LTF
Data

(a)

FIG. 3A

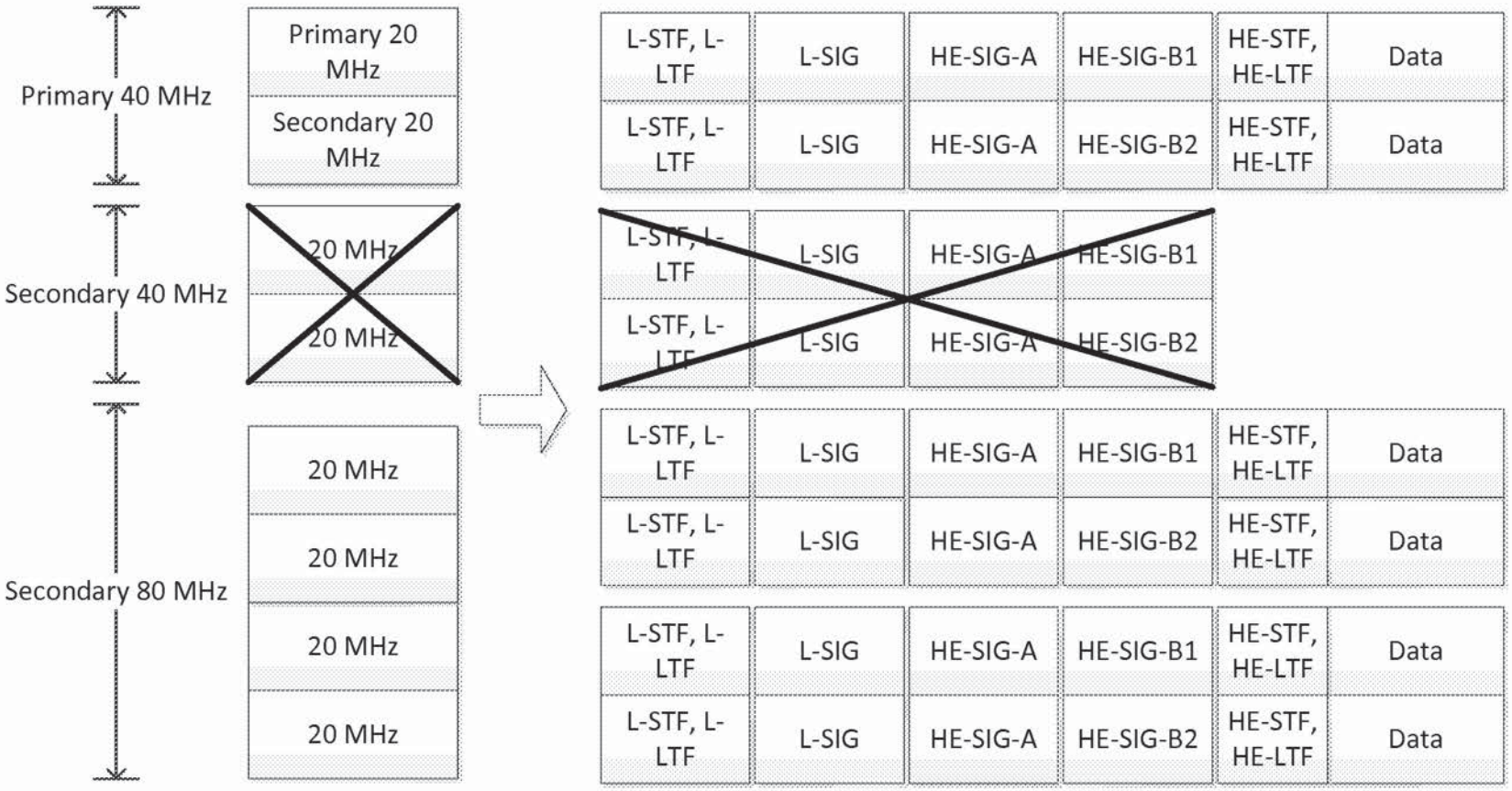
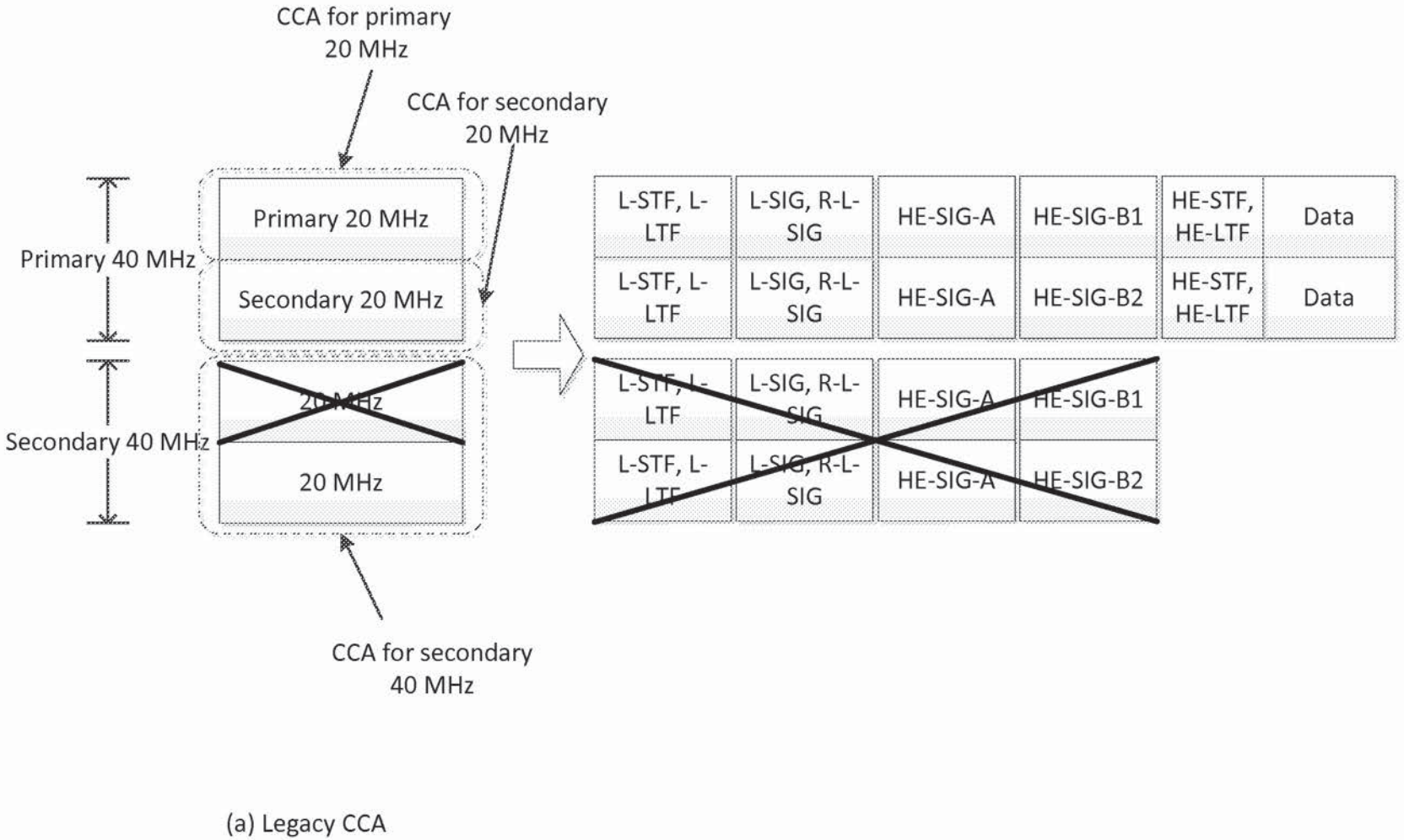

Primary 40 MHz
Secondary 40 MHz
Secondary 80 MHz
Primary 20 MHz
Secondary 20 MHz
20 MHz
20 MHz
20 MHz
20 MHz
20 MHz
L-STF, L-LTF
L-SIG
HE-SIG-A
HE-SIG-B1
HE-SIG-B2
HE-STF, HE-LTF
Data

FIG. 3B



(a) Legacy CCA

FIG. 4A

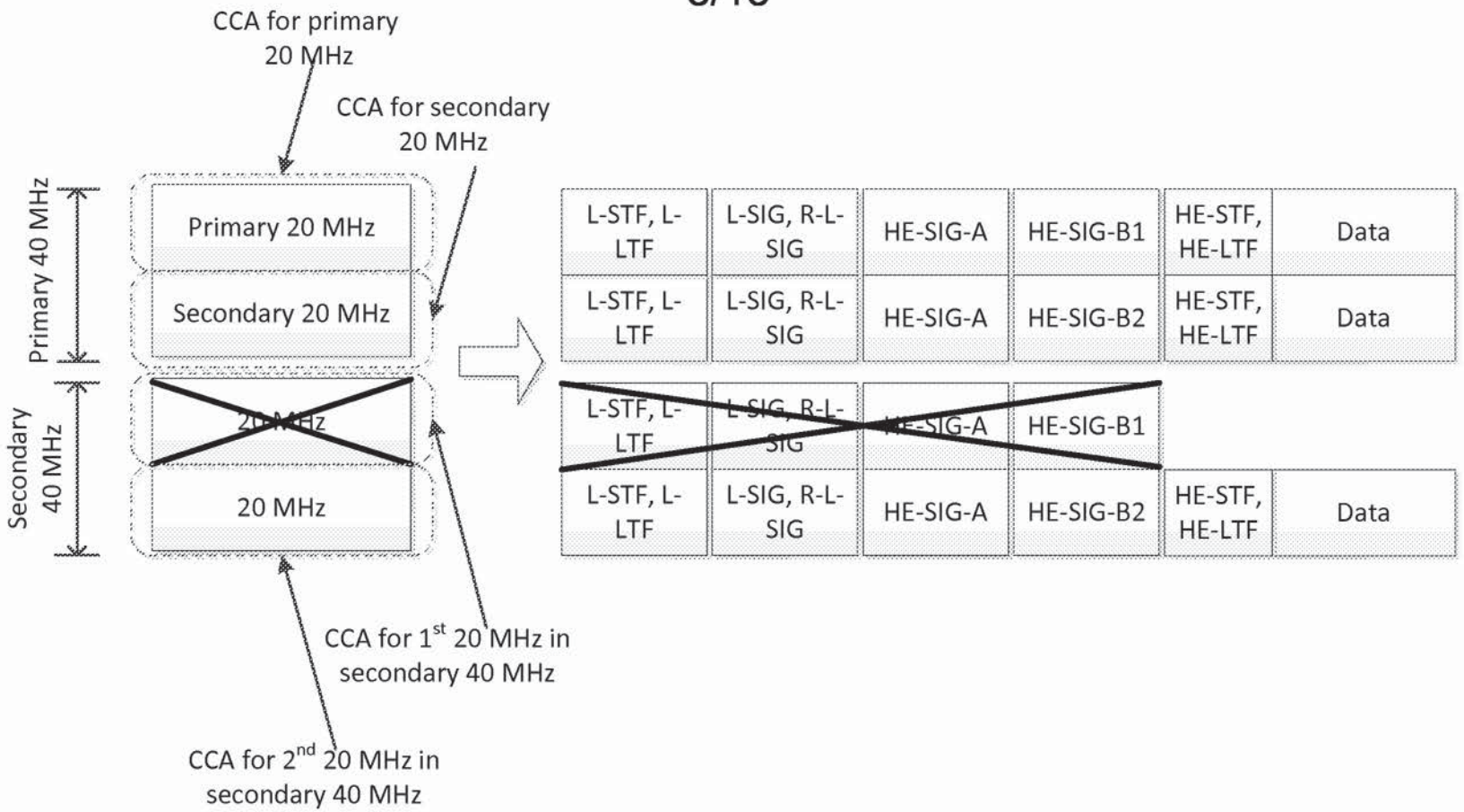
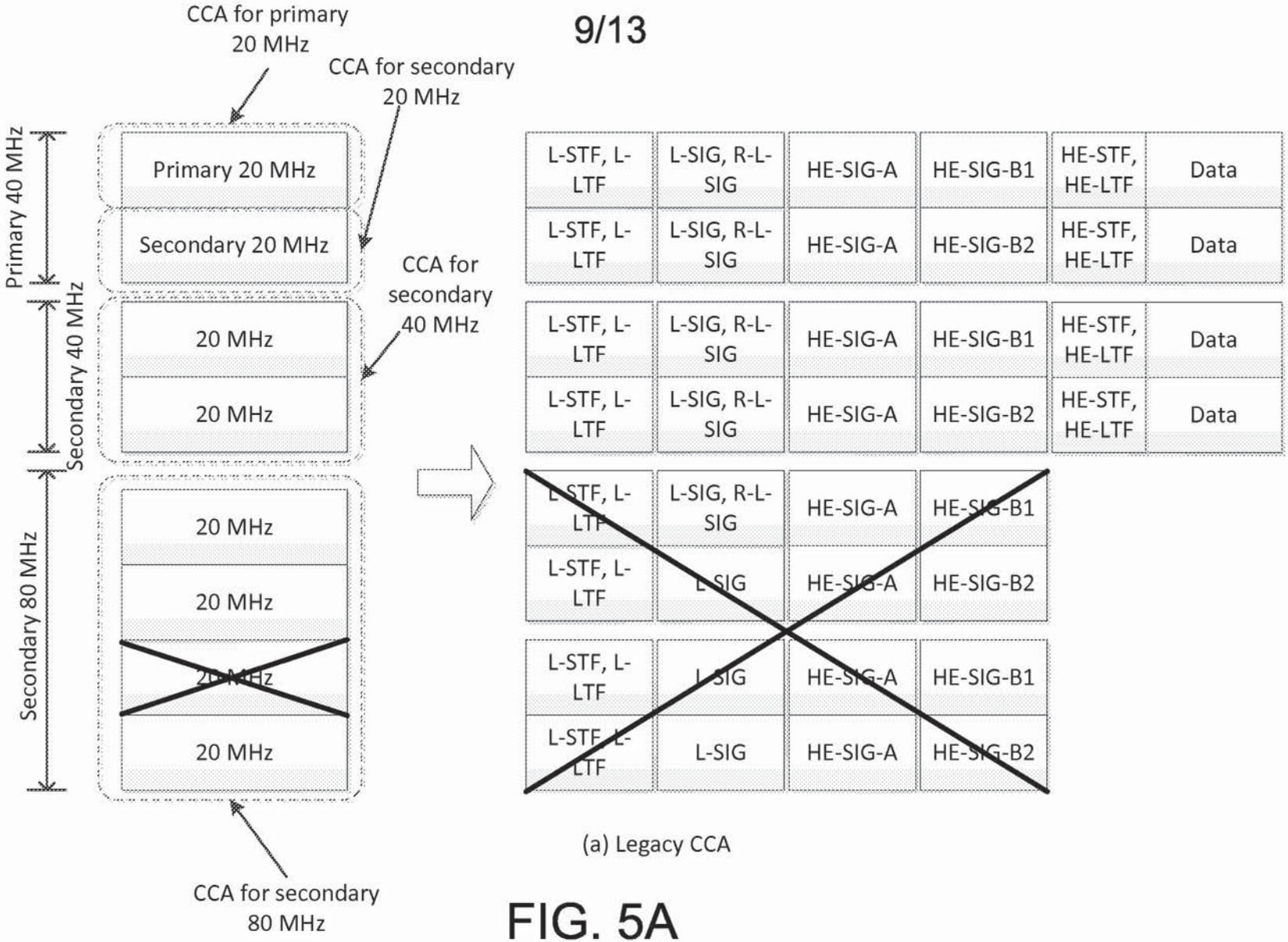
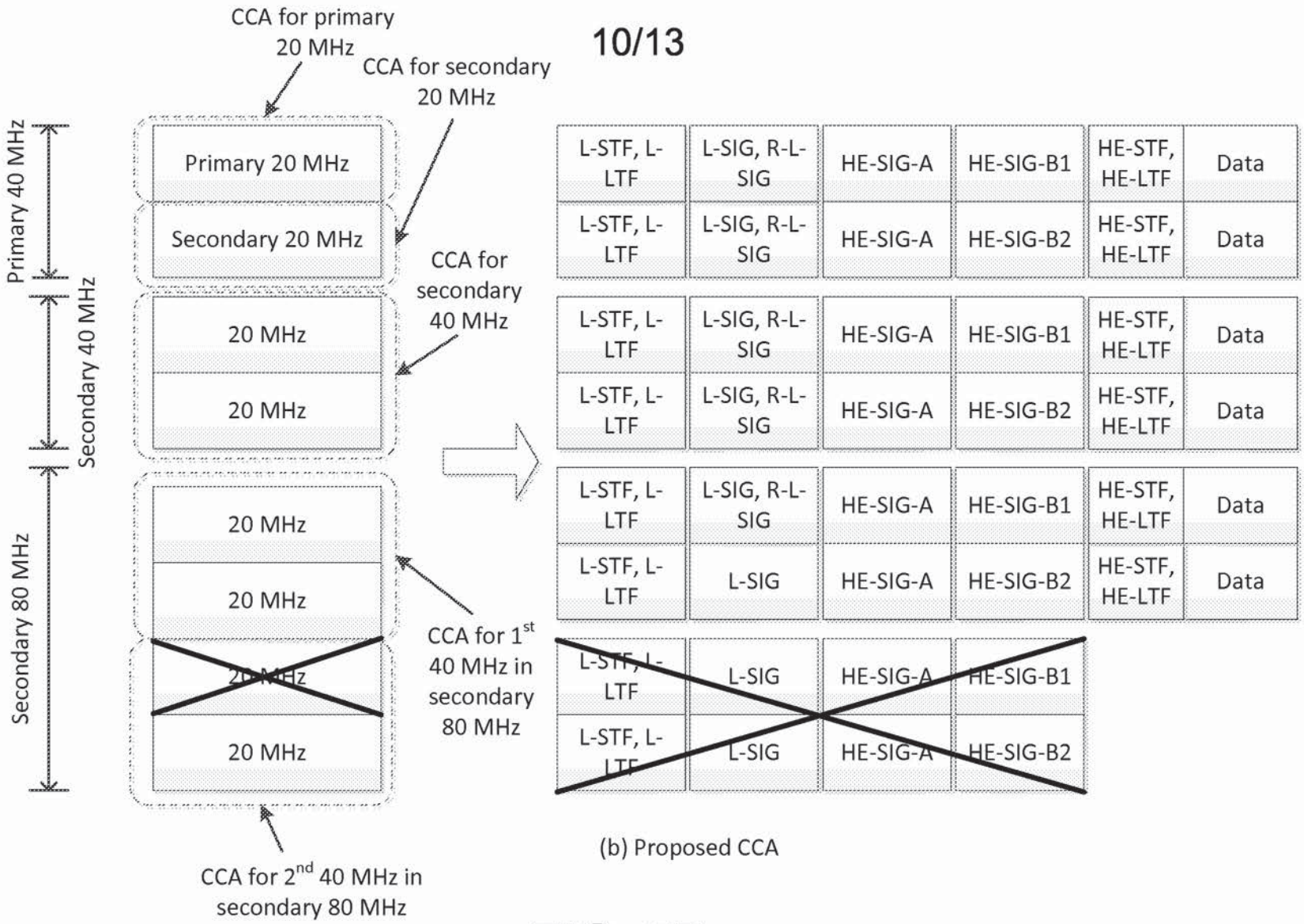

CCA for primary 20 MHz
CCA for secondary 20 MHz
Primary 40 MHz
Secondary 40 MHz
Primary 20 MHz
Secondary 20 MHz
20 MHz
20 MHz
L-STF, L-LTF
L-SIG, R-L-SIG
HE-SIG-A
HE-SIG-B1
HE-SIG-B2
HE-STF, HE-LTF
Data
CCA for 1st 20 MHz in secondary 40 MHz
CCA for 2nd 20 MHz in secondary 40 MHz

FIG. 4B



(a) Legacy CCA

FIG. 5A



(b) Proposed CCA

FIG. 5B

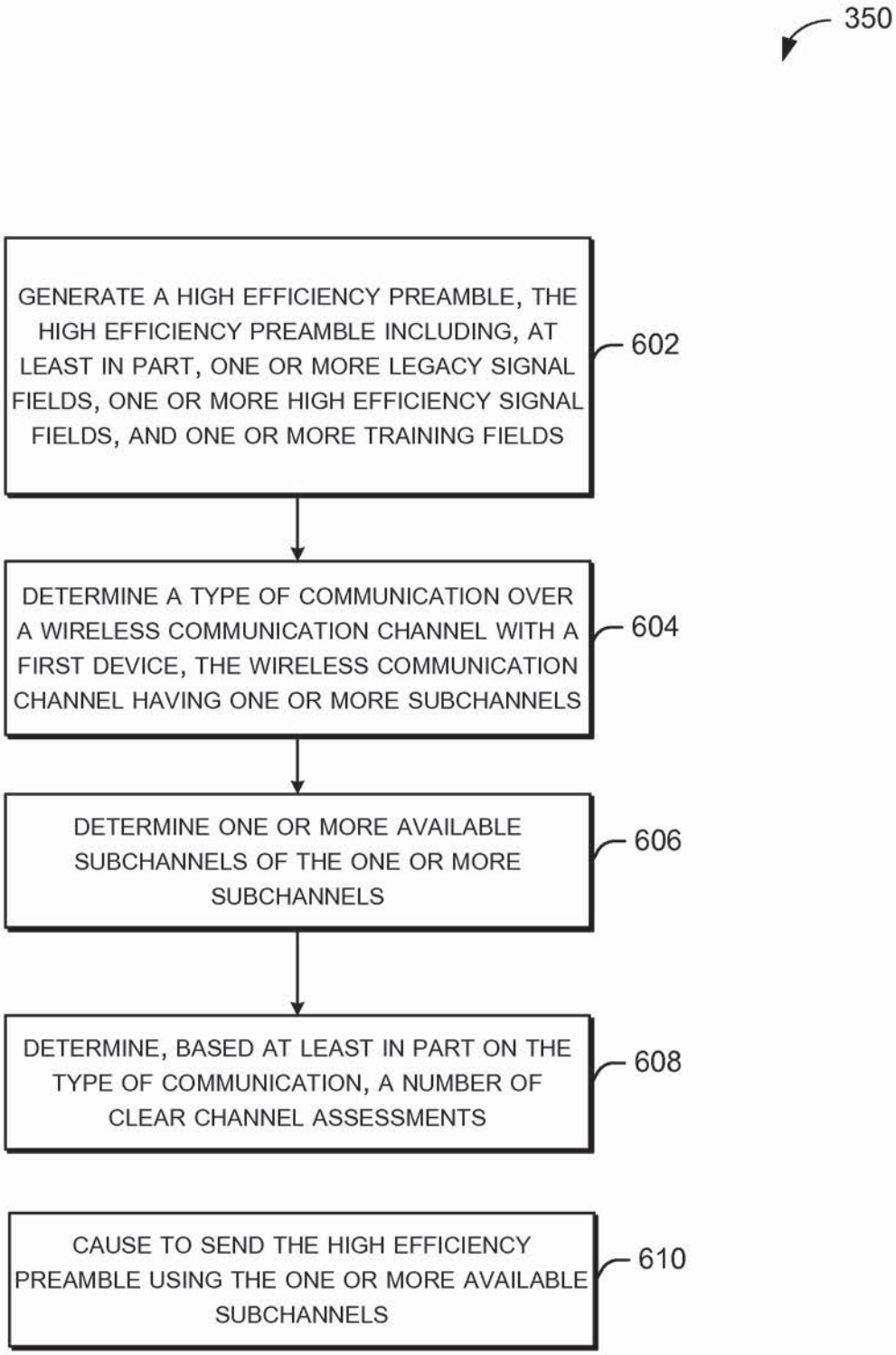

350
GENERATE A HIGH EFFICIENCY PREAMBLE, THE HIGH EFFICIENCY PREAMBLE INCLUDING, AT LEAST IN PART, ONE OR MORE LEGACY SIGNAL FIELDS, ONE OR MORE HIGH EFFICIENCY SIGNAL FIELDS, AND ONE OR MORE TRAINING FIELDS
602
DETERMINE A TYPE OF COMMUNICATION OVER A WIRELESS COMMUNICATION CHANNEL WITH A FIRST DEVICE, THE WIRELESS COMMUNICATION CHANNEL HAVING ONE OR MORE SUBCHANNELS
604
DETERMINE ONE OR MORE AVAILABLE SUBCHANNELS OF THE ONE OR MORE SUBCHANNELS
606
DETERMINE, BASED AT LEAST IN PART ON THE TYPE OF COMMUNICATION, A NUMBER OF CLEAR CHANNEL ASSESSMENTS
608
CAUSE TO SEND THE HIGH EFFICIENCY PREAMBLE USING THE ONE OR MORE AVAILABLE SUBCHANNELS
610

FIG. 6

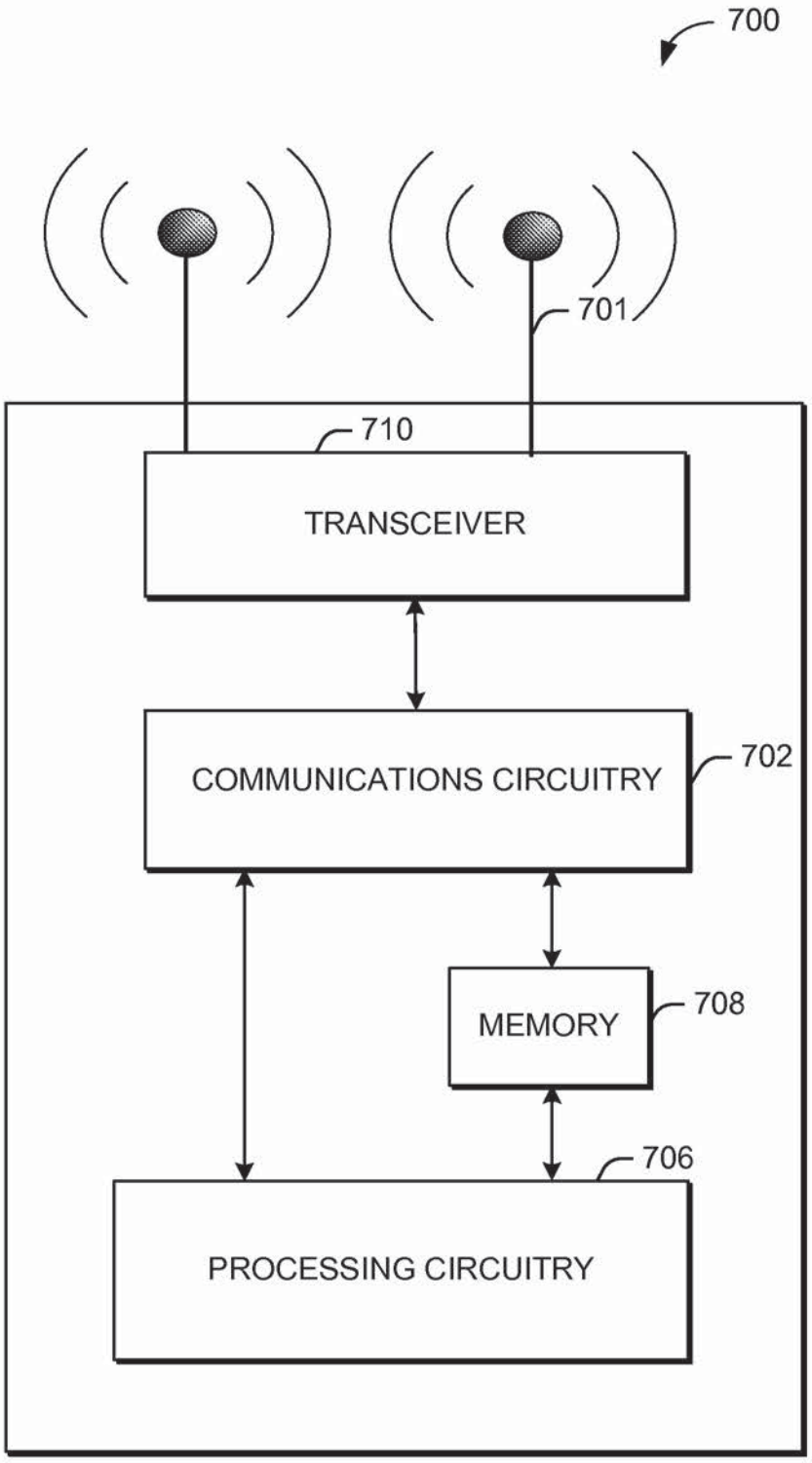

700
701
710
TRANSCEIVER
COMMUNICATIONS CIRCUITRY
702
MEMORY
708
706
PROCESSING CIRCUITRY

FIG. 7

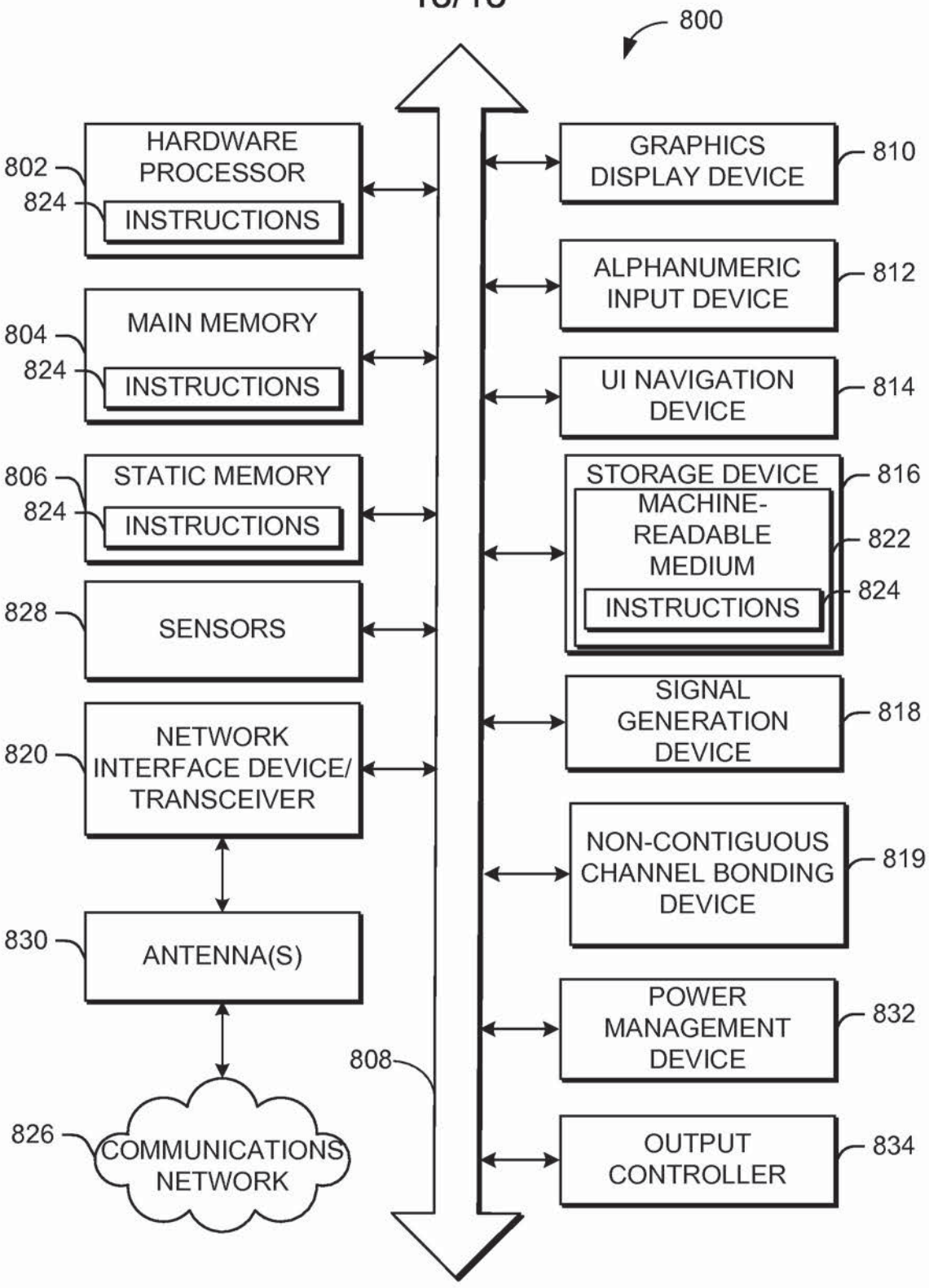

800
HARDWARE PROCESSOR
802
824
INSTRUCTIONS
MAIN MEMORY
804
824
INSTRUCTIONS
STATIC MEMORY
806
824
INSTRUCTIONS
SENSORS
828
NETWORK INTERFACE DEVICE/ TRANSCEIVER
820
ANTENNA(S)
830
COMMUNICATIONS NETWORK
826
808
GRAPHICS DISPLAY DEVICE
810
ALPHANUMERIC INPUT DEVICE
812
UI NAVIGATION DEVICE
814
STORAGE DEVICE
816
MACHINE-READABLE MEDIUM
822
INSTRUCTIONS
824
SIGNAL GENERATION DEVICE
818
NON-CONTIGUOUS CHANNEL BONDING DEVICE
819
POWER MANAGEMENT DEVICE
832
OUTPUT CONTROLLER
834

FIG. 8