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Minneapolis, MN 55402

CONFIRMATION NO. 5591
FILING RECEIPT



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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 62/200,368**

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Title

BANDWIDTH AND SUB-CHANNEL INDICATIONS IN WIRELESS COMMUNICATIONS

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

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PTO/SB/16 (11-08)

Approved for use through 05/31/2015. OMB 0651-0032

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Title of Invention		BANDWIDTH AND SUB-CHANNEL INDICATIONS IN WIRELESS COMMUNICATIONS			
Attorney Docket Number (if applicable)		P87447Z			
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Signature	/Nash M. Zogaib/			Date (YYYY-MM-DD)	2015-08-03
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 a bandwidth and sub-channel indications system. A device may determine a wireless communication channel with a first device in accordance with a wireless communication standard. The device may generate a high efficiency frame in accordance with a high efficiency communication standard the high efficiency frame including, at least in part, one or more high efficiency signal fields. The device may determine one or more indication bits included in at least one of the one or more high efficiency signal fields. The device may cause to send the high efficiency frame to the first device over the wireless communication channel.

UNITED STATES PATENT APPLICATION

ENTITLED:

**BANDWIDTH AND SUB-CHANNEL INDICATIONS IN WIRELESS
COMMUNICATIONS**

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BANDWIDTH AND SUB-CHANNEL INDICATIONS IN WIRELESS COMMUNICATIONS

TECHNICAL FIELD

[0001] This disclosure generally relates to systems and methods for wireless communications and, more particularly, to a bandwidth and sub-channel indications system 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

[0001] FIG. 1 depicts a network diagram illustrating an example network environment of an illustrative bandwidth and sub-channel indications system, according to one or more example embodiments of the disclosure.

[0002] FIG. 2 depicts an illustrative schematic diagram of a contiguous channel.

[0003] FIG. 3 depicts an illustrative schematic diagram of a non-contiguous channel in a bandwidth and sub-channel indications system, in accordance with one or more example embodiments of the present disclosure.

[0004] FIG. 4 depicts an illustrative schematic diagram of a bandwidth and sub-channel indications system, in accordance with one or more example embodiments of the present disclosure.

[0005] FIG. 5 depicts an illustrative schematic diagram of a bandwidth and sub-channel indications system, in accordance with one or more example embodiments of the present disclosure.

[0006] FIG. 6 depicts a flow diagram of an illustrative process for an illustrative bandwidth and sub-channel indications system, in accordance with one or more embodiments of the disclosure.

[0007] 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.

[0008] FIG. 8 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

[0009] 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.

ABSTRACT/BACKGROUND

[0010] In legacy Wi-Fi systems, a communications channel between two or more devices is contiguous in frequency. However, in recent Wi-Fi systems, non-contiguous channel bonding may be implemented. Within a contiguous 80MHz band, some 20MHz subchannel(s) may be unused due to interference or co-channel usage. The remaining usable 20MHz subchannels may form a contiguous or non-contiguous channel. This may require an indication scheme for signaling the non-contiguous band.

HIGH LEVEL DESCRIPTION OF INVENTION

[0011] Example embodiments of the present disclosure relate to systems, methods, and devices for bandwidth and sub-channel indications. In one embodiment, a user device may occupy multiple 20MHz subchannels; as a result, bandwidth indication of user device allocation may need to be extended for the per-20MHz encoding. For example, the used 20MHz subchannels may be indicated in HE-SIG-A using, e.g., 3 or 7 bits. In another embodiment, the

size of HE-SIG-B common may be reduced after some 20MHz sub-channel is punctured. In one embodiment, sub-channel groups for two parallel HE-SIG-B encoding streams may be introduced. In an another embodiment, the resource unit (RU) allocation pattern may be extended to cover 484- and 996-tone RUs.

FIGURE 1

[0012] FIG. 1 is a network diagram illustrating an example network environment, according to some example embodiments of the present disclosure. Wireless network 100 can 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 (HEW). The user device(s) 120 may be mobile devices that are non-stationary and do not have fixed locations.

Setup of Figure 1

[0013] In some embodiments, the user devices 120 may include one or more computer systems similar to that of the functional diagram of FIG. 7 and/or the example machine/system of FIG. 8.

[0014] 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.

BOILER PLATE

NETWORK(S)

[0015] 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.

ANTENNA(S)

[0016] 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.

[0017] 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.

Walk Through FIG. 1:

Invention: the state of the art. Introduce the concept of multicast. What happens with this invention?

[0018] In one embodiment, and with reference to FIG. 1, an HEW preamble (e.g., preamble 140) may include one or more fields, such as, legacy training fields (e.g., legacy short training (L-STF) field and legacy long training (L-LTF) field), legacy signal field (L-SIG), high efficiency signal (HE-SIG) field, high-efficiency short training field (HE-STF), and high efficiency, long training field (HE-LTF) 142, etc. 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.

[0019] 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).

[0020] In one embodiment, and with reference to FIG. 1, an HEW preamble (e.g., preamble 140) may include at least in part, a high efficiency signal field A (HE-SIG-A), a high efficiency signal field B (HE-SIG-B), a high efficiency short training field, a high efficiency long training field, and a data field that contains the data to be transmitted from one device to another. It is understood that the above acronyms may be different and not to be construed as a limitation as other acronyms may be used for the fields included in an HEW preamble.

FIGURE 2

[0021] FIG. 2 depicts an illustrative schematic diagram of a contiguous channel. It is understood that contiguous channel indicate that there is no gap between the one or more subchannels used for the transmission of data between two devices (e.g., between AP 102 and user device(s) 120).

[0022] In FIG. 2, one or more subchannels may be either primary or secondary subchannels. For example, there is one primary subchannel 210 of about 20 MHz and secondary subchannels 212 (including 3 subchannels of about 20 MHz each).

FIGURE 3

[0023] FIG. 3 depicts an illustrative schematic diagram of a non-contiguous channel in a bandwidth and sub-channel indications system, in accordance with one or more example embodiments of the present disclosure.

[0024] It is understood that non-contiguous channel indicate a subchannel that is not usable within the sequence of subchannels (e.g., primary and secondary subchannels). In the example of FIG. 3, a 20 MHz subchannel may be removed or punctured out (e.g., the third 20MHz subchannel) because the subchannel may be not usable. On the punctured 20MHz subchannel, there may be no data signal being sent but preamble signals such as HE-SIG-A, HE-SIG-B, and HE-STF and HE-LTF may or may not be sent.

[0025] In one embodiment, one or more used 20 MHz subchannels may need to be signaled to the receiving device (e.g., user device 120). In order to indicate that the one or more 20 MHz subchannels are used, an indication may need to be sent to the receiving device. For example,

for signaling the used 20MHz subchannels in a physical layer convergence protocol (PLCP) protocol data unit (PPDU), indication bits may be placed in HE-SIG-A such that the receiving device may be able to determine which 20 MHz subchannels are used. The HE-SIG-A content may be encoded within any 20MHz subchannel and repeated on all used 20MHz subchannels. Since 80MHz may be a mandatory mode of 802.11ax (HEW). The primary 20MHz subchannel may be known by each STA (e.g., user device 120) in the cell and the STAs of the cell listen to the primary subchannel. The transmitter may acquire the primary 20MHz subchannel for each transmission. Therefore, there is may be no need to indicate the presence of the primary 20MHz subchannel. There may be a need for 3 bits to indicate the presence of the other three secondary 20MHz subchannels (e.g., one bit for each). For example, for 160MHz channel, there may be two options if there is only one primary 20MHz subchannel.

[0026] Option 1: 7 bits may be used to indicate the presence of the 7 secondary 20MHz subchannels, respectively. This may incur a significant overhead in HE-SIG-A.

[0027] Option 2: a table may be defined for the most useful channel configurations and assign indices to the configurations. The number of index bits may be less than 7 (e.g. 4 or 5 bits). For example, 4 index bits may indicate 16 configurations of the secondary subchannels.

[0028] In one embodiment, the bandwidth indication field in HE-SIG-A may be desirable to be of the same format for all channel sizes (e.g., 20/40/80/160MHz) since the receiver may not know the bandwidth before decoding HE-SIG-A. Therefore, the bandwidth indication format may remain constant for all channel sizes. For example, 7, 6, 5, or 4 bits may be used for the bandwidth indication field. If 4 bits is used, eight out of the 16 configurations may the same as all the feasible 80MHz subchannel configurations that can be indicated by 3 bits. The eight configurations may be useful for 20/40/80MHz channels. The 160MHz channel may be hard to acquire and the configurations for greater than 80MHz channels may be less useful. Besides the eight configurations for 80MHz, the configuration for full 160MHz may be another useful one that may be included in the 16 configurations. Furthermore, the configurations with one 20MHz subchannel not used out of the whole 160MHz may be also useful.

[0029] Table 1 shows an example of 4-bit indication, where P denotes the primary 20MHz subchannel. Sk denotes the k-th 20MHz subchannel. X denotes a used subchannel in the

configuration. The primary 20MHz subchannel is assumed to be always used in the configuration.

	P	S1	S2	S3	S4	S5	S6	S7	Note
1	x								Primary 20 MHz
2	x	x							Primary 40 MHz
3	x		x						
4	x	x	x						
5	x			X					
6	x	x		X					
7	x		x	X					
8	x	x	x	X					Primary 80 MHz
9	x	x	x	X	x	x	x	x	Primary 160 MHz
10	x		x	X	x	x	x	x	
11	x	x		X	x	x	x	x	
12	x	x	x		x	x	x	x	
13	x	x	x	X		x	x	x	
14	x	x	x	X	x		x	x	
15	x	x	x	X	x	x		x	
16	x	x	X	X	X	x	x		

[0030] In one embodiment, for 160MHz channel, if there are two primary 20MHz subchannels, then the 3-bit design for 80MHz channel may be reused here. The 160MHz channel may be divided into two 80MHz subchannels, each of which has a primary 20MHz subchannel that the receiver may listen to. The bandwidth indication fields of the two primary 20MHz subchannels may be different and independent.

[0031] In one embodiment, the size of HE-SIG-B may be reduced after a puncturing out of subchannel. After some 20MHz subchannel is punctured out (i.e. not used), the indication for resource unit (RU) allocation may be simplified. For example, each 20MHz subchannel may take about 5-8 bits for RU allocation that partitions the frequency bandwidth into RUs and may allocate the RUs to users. If a 20MHz subchannel is not used, then the usable bandwidth may reduce and the number of indication bits for RU allocation may be reduced by about 5-8 bits. The RU allocation bits may be in the common part of HE-SIG-B.

[0032] In some embodiments, there may be no common part in HE-SIG-B. For example, the RU allocation indication may be in the user's specific part. Because the subchannel puncturing may reduce the usable bandwidth, the indication bits for the per-user RU allocation may be reduced accordingly. Each 20MHz subchannel may include about 16 different per-user RU

allocations. Therefore, the number of RU allocations may be reduced by about 16 after one 20MHz subchannel is punctured.

FIGURE 4

[0033] FIG. 4 depicts an illustrative schematic diagram of a bandwidth and sub-channel indications system, in accordance with one or more example embodiments of the present disclosure.

[0034] In one embodiment, the channel may be divided into two or more subchannel groups. The subchannels of each subchannel group may be contiguous or discontinuous as illustrated above. Each subchannel group may be allocated by one HE-SIG-B stream as shown in FIG. 4 denoted by HE-SIG-B i where $i=1$ or 2 .

[0035] As shown in FIG. 4, HE-SIG-B1 may contain the information (such as resource allocation, user device 120 ID (e.g., STA ID), and modulation encoding scheme (MCS)) for the subchannel group 1 and HE-SIG-B 2 may contain the information for the subchannel group 2. FIG. 4 (a) shows the contiguous subchannel group. This is similar to the contiguous configuration of primary 40 and 80 MHz channels in 802.11n/ac. It is desired that the HE-SIG-B stream and the data resource units (RUs) allocated by the HE-SIG-B stream are within the same frequency subchannel or subchannel group. In the presence of interference, if the data prefers one subchannel group, so does the corresponding HE-SIG-B stream. For FIG. 4 (a), one copy of the HE-SIG-B stream may be in the same subchannel group as the corresponding data but the other copy of HE-SIG-B stream may be in the other subchannel group. In contrast, the HE-SIG-B stream and the corresponding data allocated by the HE-SIG-B stream may be within the same subchannel group in FIG. 4 (b).

FIGURE 5

[0036] FIG. 5 depicts an illustrative schematic diagram of a bandwidth and sub-channel indications system, in accordance with one or more example embodiments of the present disclosure.

[0037] In one embodiment, the indication of RU allocation may be determined by using the example in FIG. 4 (b) for illustration, where subchannel group 1 is interleaved with

subchannel group 2 in frequency. HE-SIG-B 1, which is HE-SIG-B stream 1, may carry the RU allocation information primarily for subchannel group 1. Since there may be two 20 MHz subchannels in each subchannel group, two RU allocation indices may be used for the two 20 MHz subchannels, respectively. Each RU allocation index may take 5-9 bits, e.g., 8 bits as illustrated on the left of FIG. 5. Each RU allocation index may be used for one 20 MHz subchannel.

[0038] In one embodiment, The RU allocation index may specify the allocated RU sizes and locations of the corresponding subchannel. For example, the 20 MHz subchannel may be allocated as a whole piece to a single user for SU mode or multiple users for multi-user user multiple-input multiple-output (MU-MIMO). For another example, the 20 MHz subchannel may be partitioned into smaller RUs and allocated. One such example may be {106-tone RU, 26-tone RU, and two 52-tone RUs}. It should be understood that some RU may not be allocated to any user device 120. For example, the 26-tone RU in the previous example may be not allocated to any user device 120. Namely, the RU allocation pattern may be indicated by the allocation index and the allocation patterns may include full allocation and partial allocation.

[0039] In one embodiment, the RU allocation index in HE-SIG-B i , where $i = 1$ or 2 in the example of FIGs. 4 and 5 may allocate a RU greater than 20 MHz, e.g., 242-tone RU, 484-tone RU and 996-tone RU. In this case, the allocated RU may be the following RU. First, it may have the allocated size e.g. 242-tone. Second, the allocated RU may include the 20 MHz subchannel that RU allocation index may be used for. For the example in FIG. 5, the RU allocation index A is used primarily for the 20 MHz subchannel on the left most of the band. If index A allocates a 242-tone RU, the RU may be the 242-tone RU on the left most of the band. If index A allocates a 484-tone RU, the RU may be the whole 80 MHz band. It is understood that the above is only an example, and other allocation may be possible.

FIGURE 6

[0040] FIG. 6 illustrates a flow diagram of illustrative process 600 for a bandwidth and sub-channel indications system, in accordance with one or more embodiments of the disclosure.

[0041] At block 602, an AP 102 may determine a wireless communication channel with a first device in accordance with a wireless communication standard. At block 604, the AP 102

may generate a high efficiency frame in accordance with a high efficiency communication standard the high efficiency frame including, at least in part, one or more high efficiency signal fields. At block 606, the AP 102 may determine one or more indication bits included in at least one of the one or more high efficiency signal fields. At block 606, the AP 102 may cause to send the high efficiency frame to the first device cause to send the high efficiency frame to the first device over the wireless communication channel.

FIGURE 7 - Boiler

[0042] FIG. 7 shows a functional diagram of an exemplary communication station 800 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 communication station user device 120 (FIG. 1) in accordance with some embodiments. The communication station 800 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.

[0043] The communication station 800 may include communications circuitry 802 and a transceiver 810 for transmitting and receiving signals to and from other communication stations using one or more antennas 801. The communications circuitry 802 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 800 may also include processing circuitry 806 and memory 808 arranged to perform the operations described herein. In some embodiments, the communications circuitry 802 and the processing circuitry 806 may be configured to perform operations detailed in FIGs. 2-6.

BOILER PLATE

[0044] In accordance with some embodiments, the communications circuitry 802 may be arranged to contend for a wireless medium and configure frames or packets for communicating over the wireless medium. The communications circuitry 802 may be arranged to transmit and receive signals. The communications circuitry 802 may also include circuitry for

modulation/demodulation, upconversion/downconversion, filtering, amplification, etc. In some embodiments, the processing circuitry 806 of the communication station 800 may include one or more processors. In other embodiments, two or more antennas 801 may be coupled to the communications circuitry 802 arranged for sending and receiving signals. The memory 808 may store information for configuring the processing circuitry 806 to perform operations for configuring and transmitting message frames and performing the various operations described herein. The memory 808 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 808 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.

[0045] In some embodiments, the communication station 800 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.

[0046] In some embodiments, the communication station 800 may include one or more antennas 801. The antennas 801 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.

[0047] In some embodiments, the communication station 800 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.

[0048] Although the communication station 800 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 800 may refer to one or more processes operating on one or more processing elements.

[0049] 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 800 may include one or more processors and may be configured with instructions stored on a computer-readable storage device memory.

FIGURE 8 - Boiler

[0050] FIG. 8 illustrates a block diagram of an example of a machine 900 or system upon which any one or more of the techniques (e.g., methodologies) discussed herein may be performed. In other embodiments, the machine 900 may operate as a standalone device or may be connected (e.g., networked) to other machines. In a networked deployment, the machine 900 may operate in the capacity of a server machine, a client machine, or both in server-client network environments. In an example, the machine 900 may act as a peer machine in peer-to-peer (P2P) (or other distributed) network environments. The machine 900

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.

[0051] 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.

MODULE 919

[0052] The machine (e.g., computer system) 900 may include a hardware processor 902 (e.g., a central processing unit (CPU), a graphics processing unit (GPU), a hardware processor core, or any combination thereof), a main memory 904 and a static memory 906, some or all of which may communicate with each other via an interlink (e.g., bus) 908. The machine 900 may further include a power management device 932, a graphics display device 910, an alphanumeric input device 912 (e.g., a keyboard), and a user interface (UI) navigation device 914 (e.g., a mouse). In an example, the graphics display device 910,

alphanumeric input device 912, and UI navigation device 914 may be a touch screen display. The machine 900 may additionally include a storage device (i.e., drive unit) 916, a signal generation device 918 (e.g., a speaker), a bandwidth and sub-channel indications device 919, a network interface device/transceiver 920 coupled to antenna(s) 930, and one or more sensors 928, such as a global positioning system (GPS) sensor, compass, accelerometer, or other sensor. The machine 900 may include an output controller 934, 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.)).

[0053] The storage device 916 may include a machine readable medium 922 on which is stored one or more sets of data structures or instructions 924 (e.g., software) embodying or utilized by any one or more of the techniques or functions described herein. The instructions 924 may also reside, completely or at least partially, within the main memory 904, within the static memory 906, or within the hardware processor 902 during execution thereof by the machine 900. In an example, one or any combination of the hardware processor 902, the main memory 904, the static memory 906, or the storage device 916 may constitute machine-readable media.

[0054] The bandwidth and sub-channel indications device 919 may be configured to indicate the used 20MHz subchannels in HE-SIG-A using, e.g., 3 or 7 bits. The bandwidth and sub-channel indications device 919 may be configured to reduce the size of HE-SIG-B common after some 20MHz sub-channel is punctured. The bandwidth and sub-channel indications device 919 may be configured to introduce sub-channel groups for two parallel HE-SIG-B encoding streams. The bandwidth and sub-channel indications device 919 may be configured to extend the resource unit (RU) allocation pattern to cover 484- and 996-tone RUs.

Boiler Plate

[0055] While the machine-readable medium 922 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 924.

[0056] The term “machine-readable medium” may include any medium that is capable of storing, encoding, or carrying instructions for execution by the machine 900 and that cause the machine 900 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.

[0057] The instructions 924 may further be transmitted or received over a communications network 926 using a transmission medium via the network interface device/transceiver 920 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 920 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 926. In an example, the network interface device/transceiver 920 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 900 and includes digital or analog communications signals or other intangible media to facilitate communication of such software.

The operations and processes described and shown above may be carried out or performed in any suitable order as desired in various implementations. Additionally, in certain implementations, at least a portion of the operations may be carried out in parallel. Furthermore, in certain implementations, less than or more than the operations described may be performed.

GENERIC TERMS

[0058] 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.

[0059] 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.

[0060] 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.

[0061] 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.

[0062] 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.

[0063] 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, ZigBee™, 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.

[0064] 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.

[0065] 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.

[0066] 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.

[0067] 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.

[0068] 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

1. A device, comprising:
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:
determine a wireless communication channel with a first device in accordance with a wireless communication standard;
generate a high efficiency frame in accordance with a high efficiency communication standard the high efficiency frame including, at least in part, one or more high efficiency signal fields;
determine one or more indication bits included in at least one of the one or more high efficiency signal fields; and
cause to send the high efficiency frame to the first device over the wireless communication channel.
2. The device of claim 1, wherein the wireless communication channel is a non-contiguous channel including one or more sub-channels.
3. The device of claim 2, wherein the one or more sub-channels include a primary sub-channel and one or more secondary sub-channels.
4. The device of claim 1, wherein the one or more high efficiency signal fields include at least one of a high efficiency signal field A (HE-SIG-A) and a high efficiency signal field B (HE-SIG-B).

5. The device of claim 1, wherein the one or more indication bits are associated with a bandwidth of the wireless communication channel.
6. The device of claim 4, wherein the one or more indication bits are included in the HE-SIG-A field.
7. The device of claim 5, wherein the bandwidth of the wireless communication channel includes at least one of a 20 MHz, 40 MHz, 80 MHz, or 160 MHz.
8. The device of claim 1, further comprising:
 - a transceiver configured to transmit and receive wireless signals;
 - an antenna coupled to the transceiver; andone or more processors in communication with the transceiver.
9. A non-transitory computer-readable medium storing computer-executable instructions which, when executed by a processor, cause the processor to perform operations comprising:
 - determining a wireless communication channel with a first device in accordance with a wireless communication standard;
 - generating a high efficiency frame in accordance with a high efficiency communication standard the high efficiency frame including, at least in part, one or more high efficiency signal fields;
 - determining one or more indication bits included in at least one of the one or more high efficiency signal fields; and
 - causing to send the high efficiency frame to the first device over the wireless communication channel.
10. The non-transitory computer-readable medium of claim 9, wherein the wireless communication channel is a non-contiguous channel including one or more sub-channels.

11. The non-transitory computer-readable medium of claim 10, wherein the wireless communication channel is a non-contiguous channel including one or more sub-channels.
12. The non-transitory computer-readable medium of claim 9, wherein the one or more high efficiency signal fields include at least one of a high efficiency signal field A (HE-SIG-A) and a high efficiency signal field B (HE-SIG-B).
13. The non-transitory computer-readable medium of claim 9, wherein the one or more indication bits are associated with a bandwidth of the wireless communication channel.
14. The non-transitory computer-readable medium of claim 12, wherein the one or more indication bits are included in the HE-SIG-A field.
15. The non-transitory computer-readable medium of claim 13, wherein the bandwidth of the wireless communication channel includes at least one of a 20 MHz, 40 MHz, 80 MHz, or 160 MHz.
16. A method comprising:
 - determining a wireless communication channel with a first device in accordance with a wireless communication standard;
 - generating a high efficiency frame in accordance with a high efficiency communication standard the high efficiency frame including, at least in part, one or more high efficiency signal fields;
 - determining one or more indication bits included in at least one of the one or more high efficiency signal fields; and
 - causing to send the high efficiency frame to the first device over the wireless communication channel.

17. The method of claim 16, wherein the wireless communication channel is a non-contiguous channel including one or more sub-channels.
18. The method of claim 17, wherein the one or more sub-channels include a primary sub-channel and one or more secondary sub-channels.
19. The method of claim 16, wherein the one or more high efficiency signal fields include at least one of a high efficiency signal field A (HE-SIG-A) and a high efficiency signal field B (HE-SIG-B).
20. The method of claim 16, wherein the one or more indication bits are associated with a bandwidth of the wireless communication channel.

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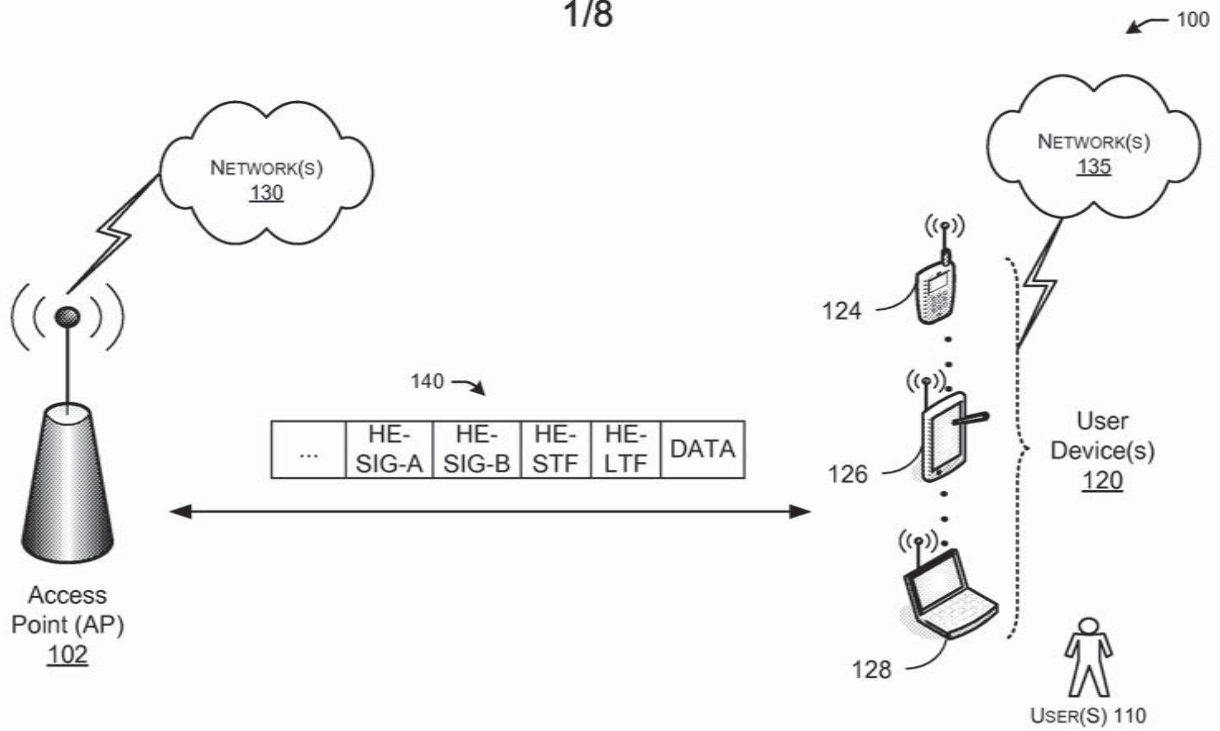


FIG. 1

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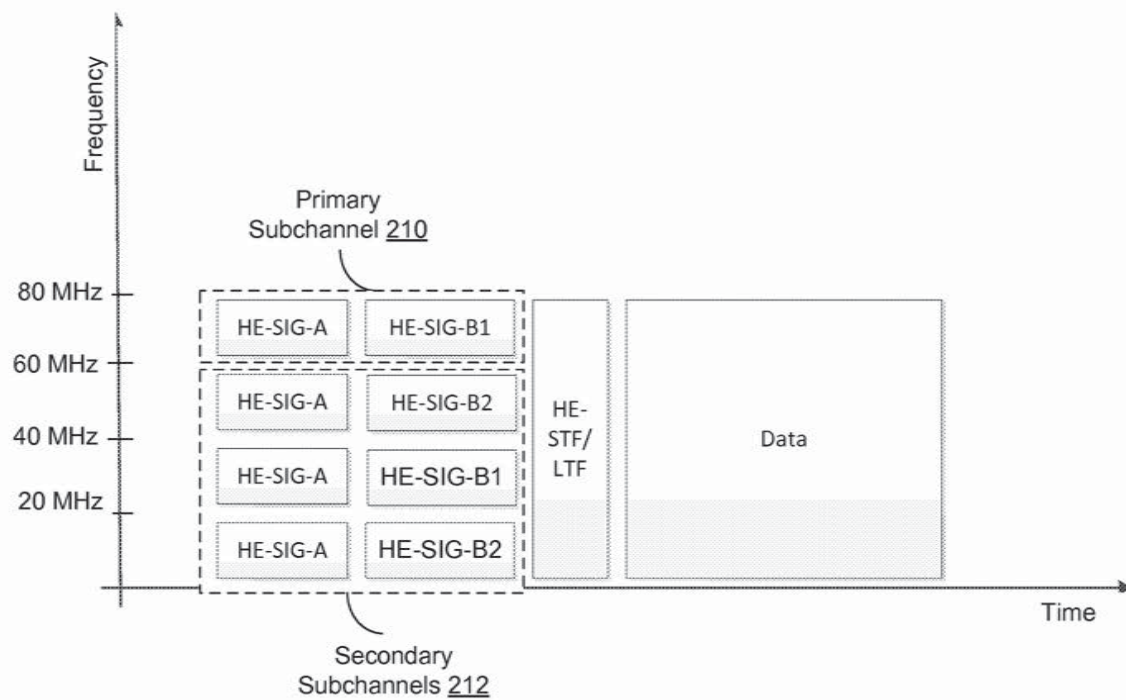


FIG. 2

Title: BANDWIDTH AND SUB-CHANNEL INDICATIONS IN WIRELESS COMMUNICATIONS

Inventor(s): Li et al.

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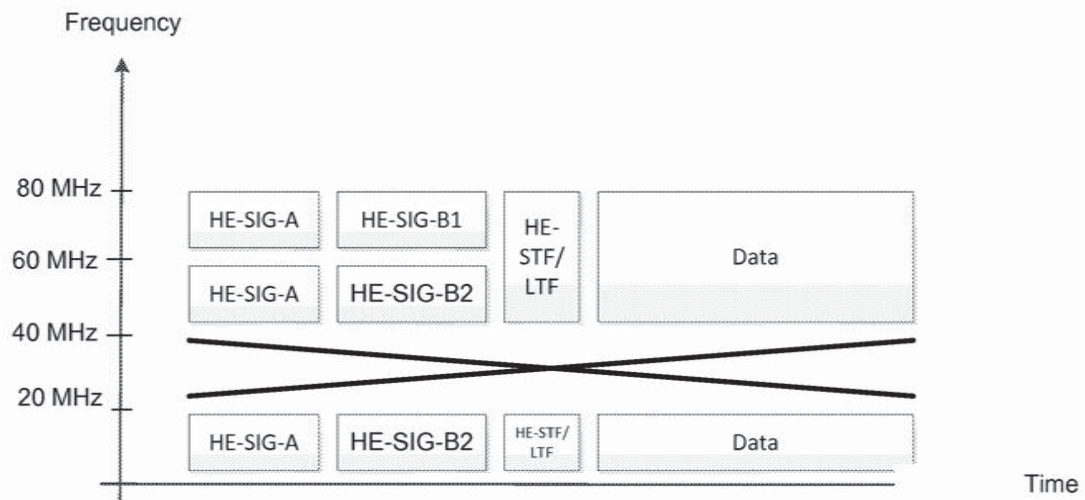


FIG. 3

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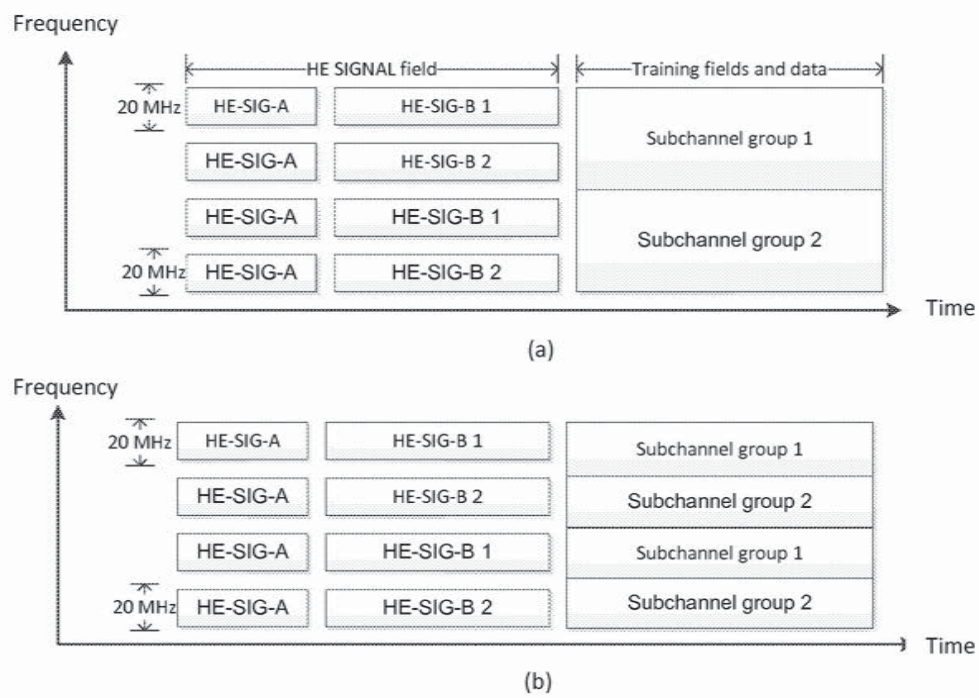


FIG. 4

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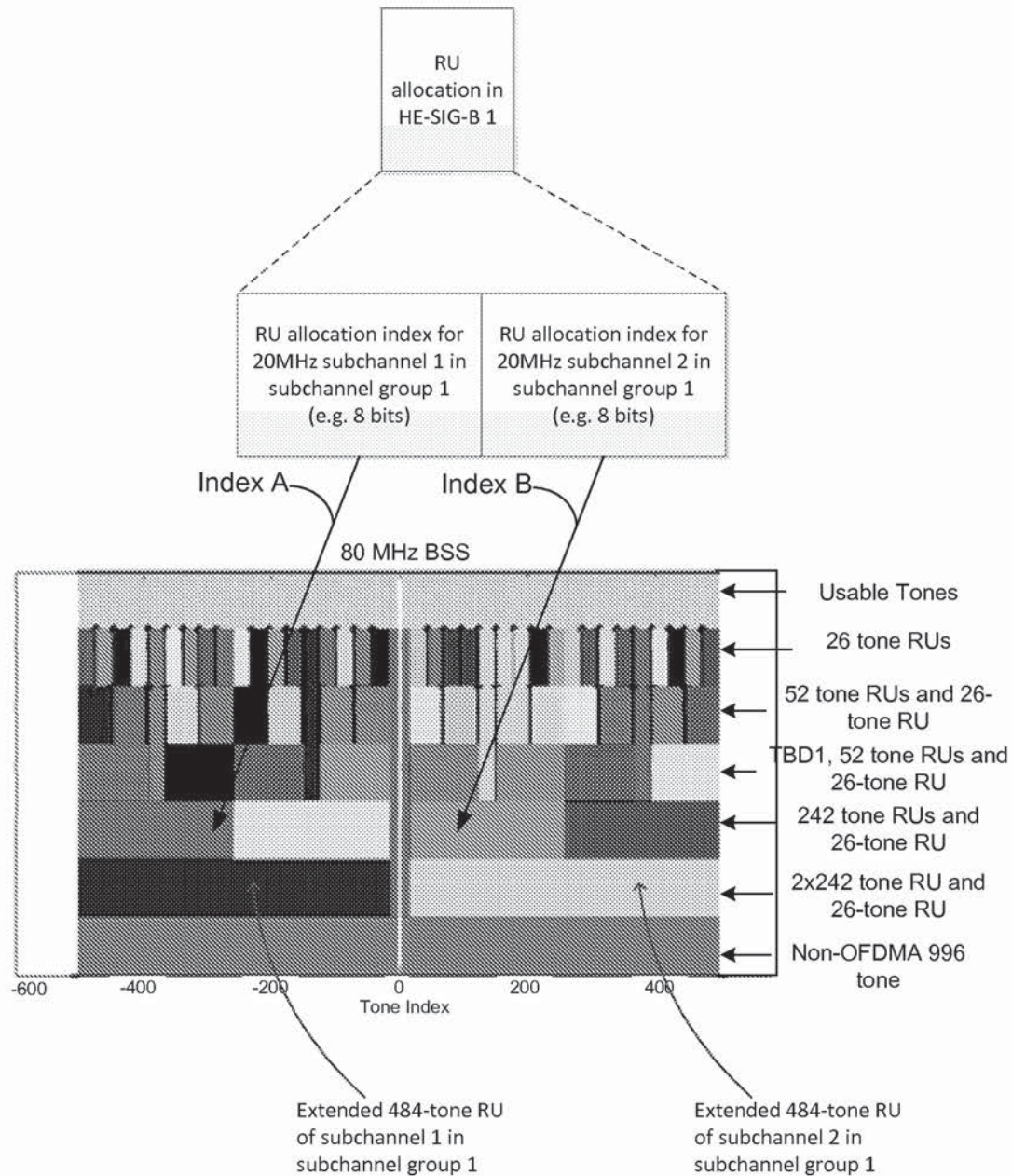


FIG. 5

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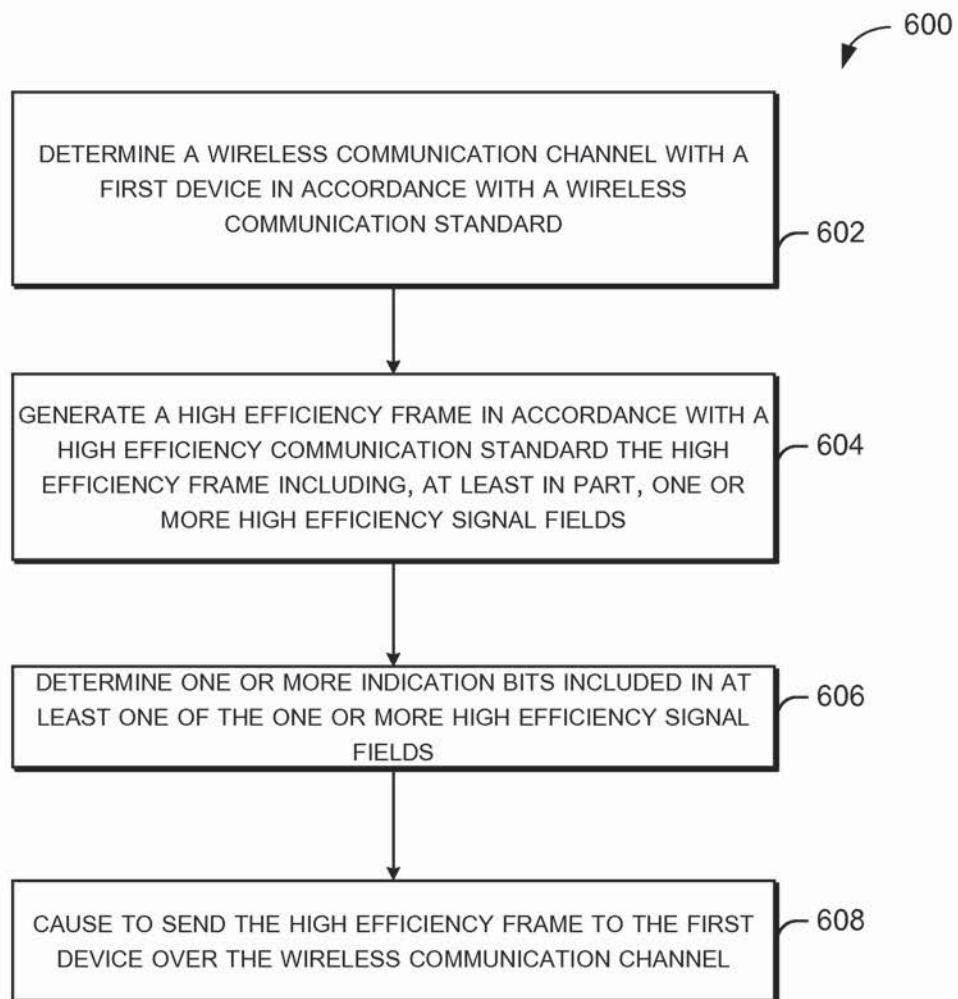


FIG. 6

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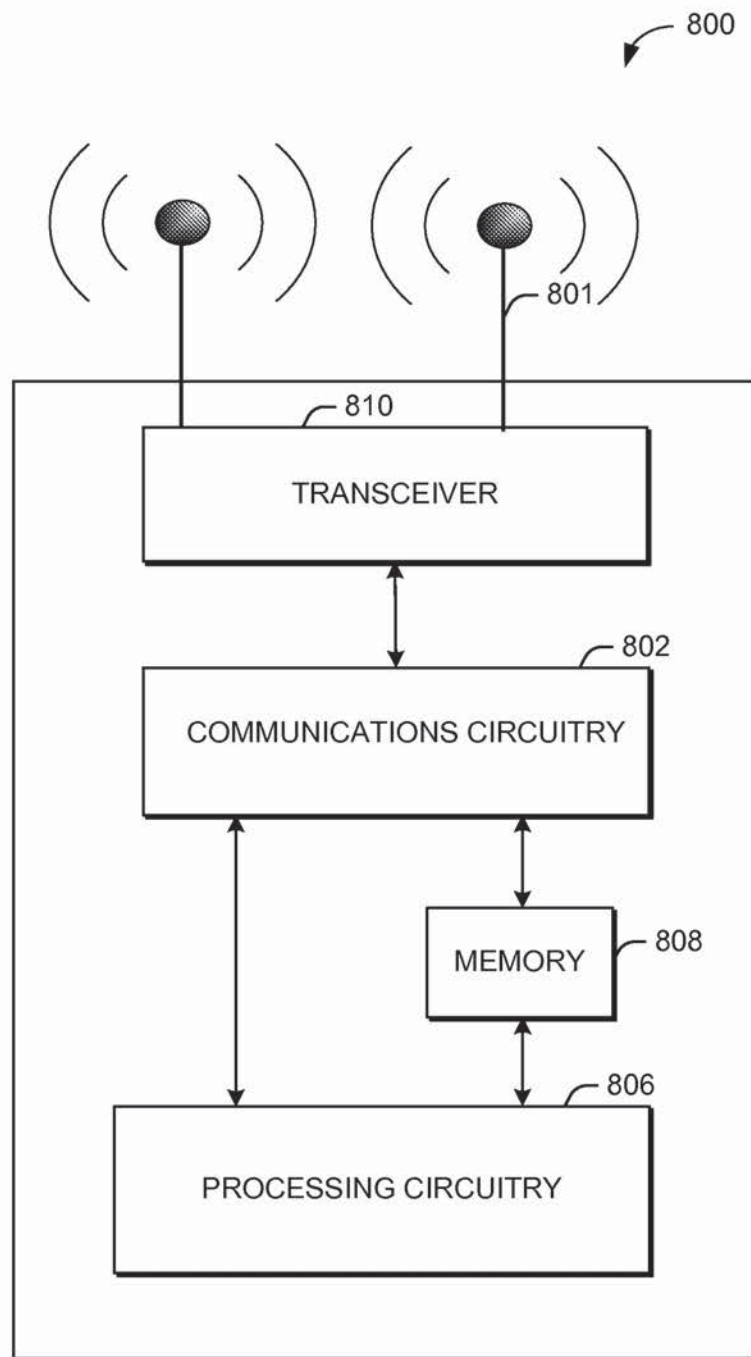


FIG. 7

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