

CERTIFICATE OF TRANSLATION ACCURACY

I am a professional translator, reviewer, and coordinator specializing in translating Korean, Japanese and Chinese to English and vice versa.

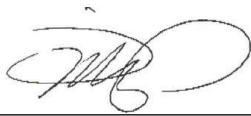
I served as Chief Examiner of the certified court interpreter test for the State of California and as a contract translator and interpreter for various federal agencies through the U.S. Department of State for more than a decade. I served as an instructor at the University of California at Berkeley and the Middlebury Institute of International Studies at Monterey (MIIS) Graduate Program in Translation.

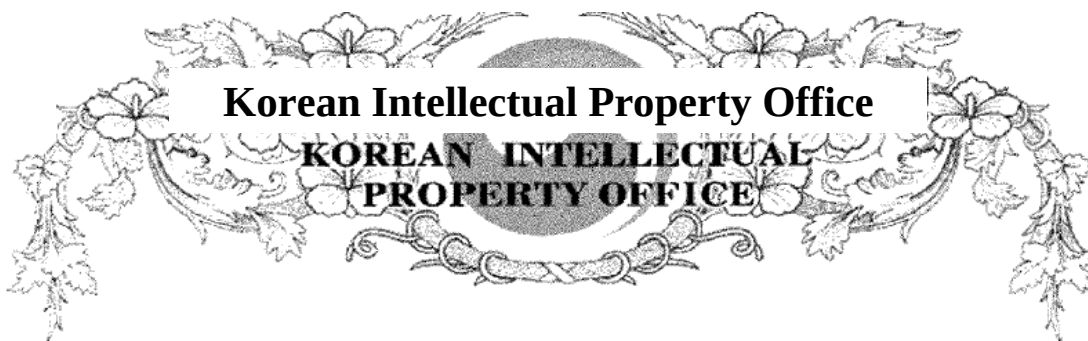
I have more than 30 years of experience translating thousands of technical, legal, and business documents from Korean to English submitted to, among others, Korean judicial authorities, U.S. federal courts, the U.S. International Trade Commission (ITC), and the USPTO Patent Trial and Appeal Board (PTAB).

I certify that I translated the following document from Korean into the English language. I also certify that this is a true, correct, and complete translation of the corresponding source text to the best of my knowledge and ability.

I certify under penalty of perjury that the foregoing is true and correct.

Executed this 29th day of April 2025 in Contra Costa County of the State of California.

By: 
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This is to certify that the following application annexed hereto is a true and correct copy as filed with the Korean Intellectual Property Office (KIPO). *[Korean]*

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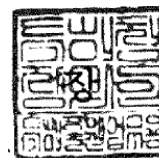
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[English]

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Commissioner of the Korean Intellectual Property Office
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[Bibliography]

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[Title of the Invention in Korean] METHOD, APPARATUS, AND SYSTEM OF EFFICIENT WIDE BANDWIDTH PPDU TRANSMISSIONS IN WIRELESS LANS
[Title of the Invention in English] METHOD, APPARATUS, AND SYSTEM OF EFFICIENT WIDE BANDWIDTH PPDU TRANSMISSIONS IN WIRELESS LANS

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[Application Language]	Korean
[National R&D Project That Supported This Invention]	
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[Ministry Name]	Ministry of Science, ICT and Future Planning
[Name of the Project Manager]	National IT Industry Promotion Agency
[Project Name]	Information and Broadcasting Standards Development Support
[R&D Name]	IEEE802.11 High Efficiency WLAN (HEW) Standard Development

[Contribution Rate]	1/1	
[R&D Conducted by]	WILUS Institute of Standards and Technology Inc.	
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[Purport]	It is hereby submitted to the Commissioner of the Korean Intellectual Property Office (KIPO) as above.	
<i>Agent or Attorney</i>	Kook Il Lim	(signature or seal)

[Fees]		
[Application Filing Fee]	0 page(s)	46,000 KRW
[Additional Appl. Filing Fee]	140 page(s)	0
[Priority Claim Fee]	0 case(s)	0
[Fee for Examination Request]	0 claim(s)	0
[Total]	46,000 KRW	
[Reason for Fee Reduction]	Small Business (70% reduction) [1]	
[Fee after Reduction]	13,800 KRW	

[Description of the Invention]

[Title of the Invention]

METHOD, APPARATUS, AND SYSTEM OF EFFICIENT WIDE BANDWIDTH
PPDU TRANSMISSIONS IN WIRELESS LANS *[in Korean]* {METHOD, APPARATUS, AND
SYSTEM OF EFFICIENT WIDE BANDWIDTH PPDU TRANSMISSIONS IN WIRELESS
LANS} *[in English]*

[Technical Field]

<1> The present invention relates to a wireless communication method, and more particularly, to a method for efficient wideband PPDU transmission.

[Background Technology of the Invention]

<2> In recent years, as mobile devices have become increasingly popular, wireless LAN technologies that can provide fast wireless Internet services to these devices have received a great deal of attention. Wireless LAN technology is a technology that enables mobile devices such as smartphones, smart pads, laptop computers, portable multimedia players, embedded devices, etc., to wirelessly access the Internet in a home or business or in a specific service area based on wireless communication technology at a short distance.

<3> Since the Institute of Electrical and Electronics Engineers (IEEE) 802.11 supported early wireless LAN technologies using the 2.4 GHz frequency, standards for a variety of technologies have been put to practical use or under development. First, IEEE 802.11b supports communication speeds of up to 11 Mbps while using frequencies in the 2.4 GHz band. IEEE 802.11a, which was

commercialized after IEEE 802.11b, uses frequencies in the 5 GHz band rather than the 2.4 GHz band, which reduces the impact of interference compared to frequencies in the 2.4 GHz band, which is significantly more congested, and uses OFDM technology to increase communication speeds up to 54 Mbps. However, IEEE 802.11a has the disadvantage of shorter communication distances compared to IEEE 802.11b. And IEEE 802.11g, like IEEE 802.11b, uses frequencies in the 2.4 GHz band to realize communication speeds of up to 54 Mbps/day and satisfies backward compatibility, so it has received considerable attention, and it has an advantage over IEEE 802.11a in terms of communication distance as well.

<4> IEEE 802.11n is a technical specification designed to overcome the limitations on communication speed that have been noted as a weakness in wireless LANs. IEEE 802.11n aims to increase the speed and reliability of networks and extend the operating distance of wireless networks. More specifically, IEEE 802.11n supports High Throughput (HT) with data rates of up to 540 Mbps or more, and is based on Multiple Inputs and Multiple Outputs (MIMO) technology, which uses multiple antennas at both the transmitter and receiver ends to minimize transmission errors and optimize data rates. The standard can also use a coding scheme that transmits multiple redundant copies of the data to increase data reliability.

<5> As wireless LANs have become more widespread and the applications utilizing them have diversified, a need has arisen for new wireless LAN systems to support higher throughput called VHT (Very High Throughput) than the data rates supported by IEEE 802.11n. Of these, IEEE 802.11ac supports a wide bandwidth (80 MHz to 160 MHz) in the 5 GHz frequency. Although the

IEEE 802.11ac standard is only defined in the 5 GHz band, early 11ac chipsets will also support operation in the 2.4 GHz band for backward compatibility with existing 2.4 GHz band products. In theory, the standard will allow multi-station wireless LAN speeds of at least 1 Gbps and maximum single link speeds of at least 500 Mbps. This is achieved by expanding the wireless interface concept adopted by 802.11n, including wider radio frequency bandwidth (up to 160 MHz), more MIMO spatial streams (up to 8), multi-user MIMO, and higher-density modulation (up to 256 QAM). There is also IEEE 802.11ad, which uses the 60 GHz band to transmit data instead of the existing 2.4 GHz/5GHz band. IEEE 802.11ad is a transmission standard that provides speeds of up to 7 Gbps using beamforming technology, making it suitable for streaming high-bitrate videos, such as large-capacity data or uncompressed HD video, etc.

<6> More recently, as a next-generation wireless LAN standard after 802.11ac and 802.11ad, discussions continue to be held to provide high-efficiency and high-performance wireless LAN communication technology in high-density environments. In other words, in the next-generation wireless LAN environment, high-frequency efficient communication must be provided indoors and outdoors in the presence of high-density stations and access points (APs), and various technologies are required to realize this.

[Specifics of the Invention]

[Problem to Be Solved by the Invention]

<7> It is an object of the present invention to provide high-efficiency/high-performance wireless LAN communications in high-density environments as described above.

[Means to Solve the Problem]

<8> According to an embodiment of the present invention, an apparatus, system, and method of wireless LAN communication for a wireless LAN can be provided.

[Effect of the Invention]

<9> The present invention relates to a wireless communication method, and more particularly, to a method for configuring wireless LAN physical layer header fields that support simultaneous multi-user transmission in indoor and outdoor environments.

[Brief Description of the Drawings]

<10> FIG. 1 is a drawing illustrating a wireless LAN system according to one embodiment of the present invention.

FIG. 2 is a drawing illustrating a wireless LAN system according to another embodiment of the present invention.

FIG. 3 is a block diagram illustrating the configuration of a station according to one embodiment of the present invention.

FIG. 4 is a block diagram illustrating the configuration of an access point according to one embodiment of the present invention.

FIG. 5 illustrates the configuration of L-SIG and RL-SIG and the utilization of the L_LENGTH field according to an embodiment of the present invention.

FIG. 6 illustrates a method for indicating a WLAN PPDU format by utilizing the L_LENGTH field of the L-SIG and RL-SIG parts along with the HE-SIG-A part, according to an

embodiment of the present invention.

FIG. 7 is a diagram illustrating embodiments of additional PPDU formats defined in 11ax, as referenced in FIG. 6.

FIG. 8 illustrates the configuration of the HE-SIG-A field, which changes according to the PPDU format, in accordance with an embodiment of the present invention.

FIG. 9 illustrates the configuration of HE-SIG-B according to an embodiment of the present invention.

FIG. 10 illustrates a method for performing signaling during uplink HE MU PPDU transmission, according to an embodiment of the present invention.

FIG. 11 illustrates conventional methods for transmitting wideband PPDU in relation to an embodiment of the present invention.

FIG. 12 illustrates efficient wideband PPDU transmission methods according to an embodiment of the present invention.

FIG. 13 illustrates methods for transmitting a PPDU using one or two RF modules, taking as an example the non-contiguous, fixed expansion-based wideband PPDU configuration method of FIG. 12(c), according to an embodiment of the present invention.

FIG. 14 illustrates various sequences in which non-contiguous PPDU transmission is applied, according to an embodiment of the present invention.

FIG. 15 illustrates various sequences in which non-contiguous PPDU transmission is applied, according to another embodiment of the present invention.

FIG. 16 illustrates a method for configuring an ACK channel during non-contiguous PPDU

transmission, according to an embodiment of the present invention.

FIG. 17 provides a detailed illustration of the frequency filtering process for the wideband PPDU transmission method of FIG. 13(a), according to an embodiment of the present invention.

FIG. 18 provides a detailed illustration of the frequency filtering process for the wideband PPDU transmission method of FIG. 13(b).

FIG. 19 provides a detailed illustration of the frequency filtering process for the wideband PPDU transmission method of FIG. 13(c).

FIG. 20 illustrates the configuration of HE-SIG-B in an HE MU PPDU transmitted over 80 MHz, according to an embodiment of the present invention.

FIG. 21 illustrates the configuration of HE-SIG-B in an HE MU PPDU transmitted using Full BW MU-MIMO, according to an embodiment of the present invention.

FIG. 22 illustrates the encoding structure and configuration of the HE-SIG-B field according to an embodiment of the present invention.

FIG. 23 illustrates the encoding structure when using HE-SIG-B compression, according to an embodiment of the present invention.

FIG. 24 illustrates the encoding structure when different MCS values are applied to HE-SIG-B content channel 1 and HE-SIG-B content channel 2, according to an embodiment of the present invention.

FIG. 25 is a table illustrating the number of bits in the HE-SIG-B User Specific field, the number of OFDM symbols, and their variations according to factors such as the number of users, MCS index, and DCM usage, according to an embodiment of the present invention.

FIG. 26 illustrates the encoding structure when different MCS values are applied to HE-SIG-B content channel 1 and HE-SIG-B content channel 2, according to an embodiment of the present invention.

FIG. 27 illustrates the configuration of HE-SIG-B when applying a filtering technique that additionally filters adjacent RUs when data is not transmitted on a specific channel, according to an embodiment of the present invention.

FIG. 28 illustrates signaling methods for HE-SIG-B in an HE MU PPDU transmitted in a non-contiguous manner, according to an embodiment of the present invention.

FIG. 29 illustrates preamble and data transmission methods when applying a filtering technique to avoid data transmission on a specific channel, according to an embodiment of the present invention.

FIG. 30 illustrates SIG-B transmission over a sub-20 MHz channel in SIG-B-based non-contiguous PPDU transmission, according to an embodiment of the present invention.

FIG. 31 illustrates methods for configuring HE-SIG-B when transmitting an HE PPDU using a Non-Contiguous, Fixed Extension scheme, according to an embodiment of the present invention.

FIG. 32 illustrates a method for configuring HE-SIG-B when transmitting an HE PPDU using Non-Contiguous OFDMA between a single AP and a single STA, according to an embodiment of the present invention.

FIG. 33 illustrates methods for configuring HE-SIG-B when transmitting an HE PPDU using a Contiguous, Flexible Extension scheme, according to an embodiment of the present invention.

invention.

FIG. 34 illustrates methods for configuring HE-SIG-B when transmitting an HE PPDU using a Non-Contiguous, Flexible Extension scheme, according to an embodiment of the present invention.

FIG. 35 illustrates methods for configuring HE-SIG-A and HE-SIG-B when transmitting an HE PPDU using a Non-Contiguous, Limited Flexible Extension scheme, according to an embodiment of the present invention.

FIG. 36 illustrates methods for configuring various HE PPDU bandwidths when transmitting an HE PPDU using both a Non-Contiguous, Fixed Extension scheme and a Contiguous, Flexible Extension scheme, according to an embodiment of the present invention.

FIG. 37 illustrates methods for configuring various HE PPDU bandwidths when transmitting an HE PPDU using a Non-Contiguous, Limited Flexible Extension scheme, according to an embodiment of the present invention.

FIG. 38 illustrates methods for configuring various HE PPDU bandwidths by combining multiple configurations generated based on HE PPDU bandwidth composition principles, according to an embodiment of the present invention.

FIG. 39 illustrates methods for signaling a non-contiguous channel-based PPDU, according to an embodiment of the present invention.

FIG. 40 illustrates a method for signaling a non-contiguous channel-based PPDU using the BW subfield of SIG-A, according to an embodiment of the present invention.

FIG. 41 illustrates methods for signaling a non-contiguous channel-based PPDU using the

RU allocation subfield of SIG-B, according to an embodiment of the present invention.

FIG. 42 illustrates a method for signaling a non-contiguous channel-based PPDU using the User Specific subfield of SIG-B, according to an embodiment of the present invention.

FIG. 43 illustrates a method for signaling a specific 26 RU positioned at the center when signaling a non-contiguous channel-based PPDU using the User Specific subfield of SIG-B, according to an embodiment of the present invention.

FIG. 44 illustrates a method for extending the Null AID-based signaling described in FIG. 42 to indicate unallocated RUs in contiguous channel-based PPDU transmission, according to an embodiment of the present invention.

FIG. 45 is a drawing illustrating methods of Non-contiguous PPDU BW signaling.

FIG. 46 illustrates an embodiment in which the SIG-B channels are fixed among the SIG-A-only signaling methods described in FIG. 45.

FIG. 47 illustrates an embodiment in which the SIG-B channels are variable, among the SIG-A standalone signaling methods or the SIG-A/B cooperative signaling methods described in FIG. 45.

FIG. 48 illustrates an embodiment in which the SIG-B channels are variable in a P80 configuration among the SIG-A/SIG-B cooperative signaling methods described in FIG. 45.

[Detailed Specifics for Practicing the Invention]

<11> The terms used in this specification have been chosen to be as generic as possible in current

common usage, taking into account their function in the invention, but they may vary according to the intent of a person having ordinary skill in the art of this technical field, custom, or emergence of new technologies, etc. In addition, in certain cases, terms have been chosen at will by the applicant, in which case their meaning will be given in the description of the invention to which they relate. It is therefore intended that the terms used in this specification should be construed based on the actual meaning of the term and the context of the specification as a whole, and not merely as a designation of a term.

<12> Throughout the specification, when a configuration is said to be "connected" to another configuration, this includes not only being "directly connected" but also being "electrically connected" with another constituent element in between. Also, when a configuration is said to "include" a particular constituent element, it is meant to be capable of including additional constituent elements, not to the exclusion of other constituent elements, unless specifically to the contrary. In addition, the limitation of "same or more" or "same or less" with respect to a particular threshold may be appropriately substituted with "more than" or "less than", respectively, depending on the embodiment.

<13> FIG. 1 illustrates a wireless LAN system according to one embodiment of the present invention. A wireless LAN system includes one or more Basic Service Sets (BSS), which represent a set of devices that can communicate with each other by successfully synchronizing. Generally, BSS can be divided into infrastructure BSS (BSS) and independent BSS (IBSS), and FIG. 1 shows

infrastructure BSS.

<14> As illustrated in FIG. 1, infrastructure BSS (BSS1, BSS2) includes or more stations (STA-1, STA-2, STA-3, STA-4, STA-5), access point (PCP/AP-1, PCP/AP- 2) that is a station that provides a distribution service (DS), and a distribution system (DS) that connects multiple access points (PCP/AP-1, PCP/AP- 2).

<15> A station (station, STA) is any device that includes a medium access control (MAC) and a physical layer interface to a wireless medium as defined by the IEEE 802.11 standard, and broadly includes both non-access point (Non-AP) stations as well as access points (APs). Also, the term "terminal" may be used in this specification as a concept that includes both stations and wireless LAN communication devices such as APs. A station for wireless communication includes a processor and a transceiver, and may further include a user interface portion, a display unit, and the like, depending on the embodiment. The processor may generate frames to be transmitted over the wireless network, process frames received over the wireless network, and perform various other processing to control the station. The transceiver is functionally connected to the processor and transmits and receives frames over the wireless network for the station.

<16> An access point (AP) is a discrete entity that provides access to a distribution system (DS) via a wireless medium for stations associated with it. In principle, communication between non-AP stations in an infrastructure is carried out, in principle, via an AP, but direct communication between non-AP stations is also possible if a link is established. In this invention, AP is used as a concept

that includes PCP (Personal BSS Coordination Point), and broadly speaking, it can include all concepts of centralized controller, base station (BS), node-B, base transceiver system (BTS), and/or site controller, etc.

<17> A plurality of infrastructure BSSs may be connected via a distribution system (DS). The plurality of BSSs connected via the distribution system may be referred to as an Extended Service Set (ESS).

<18> FIG. 2 illustrates an independent BSS, which is a wireless LAN system according to another embodiment of the present disclosure. In the embodiment of FIG. 2, portions that are identical or corresponding to the embodiment of FIG. 1 are intended to omit redundant description.

<19> BSS-3 shown in FIG. 2 is an independent BSS and does not include an AP, so none of the stations (STA-6, STA-7) are in the state of being connected to an AP. An independent BSS is not allowed to connect to the distribution system and forms a self-contained network. In an independent BSS, each station (STA-6, STA-7) can be directly connected to each other.

<20> FIG. 3 is a block diagram illustrating the configuration of a station 100 according to one embodiment of the present invention.

<21> As shown, a station 100 according to an embodiment of the present invention may comprise a processor 110, a network interface card (NIC) 120, a user interface portion 140, a display unit 150, and a memory 160.

<22> First, the network interface card 120 is a module for performing wireless LAN connectivity, and performs packet transmission and reception for the station 100. The network interface card 120 may be built into or external to the station 100, and may include at least one network interface card module utilizing different frequency bands, depending on the embodiment. For example, the network interface card may include network interface card modules of different frequency bands, such as 2.4 GHz, 5 GHz, and 60 GHz. According to one embodiment, the station 100 may comprise a network interface card module utilizing a frequency band above 6 GHz and a network interface card module utilizing a frequency band below 6 GHz. Each network interface card module can perform wireless communication with an AP or an external station in accordance with the wireless LAN specifications for the frequency band supported by that network interface card module. The network interface card 120 may operate only one network interface card module at a time or may operate multiple network interface card modules together simultaneously, depending on the performance and requirements of the station 100. When the station 100 includes a plurality of network interface card modules, each of the network interface card modules may be provided in a standalone form or may be integrated into a single chip.

<23> Next, the user interface portion 140 includes various forms of input/output means provided in the station 100. That is, the user interface portion 140 can receive user input using various input means, and the processor 110 can control the station 100 based on the received user input. Further, the user interface portion 140 may utilize various output means to perform outputs based on

instructions from the processor 110.

<24> Next, the display unit 150 outputs an image on a display screen. The display unit 150 may output various display objects, such as content executed by the processor 110 or a user interface based on control instructions of the processor 110. In addition, the memory 160 stores control programs used in the station 100 and various data accordingly. Such control programs may include connection programs required for the station 100 to perform connections with APs or external stations.

<25> The processor 110 of the present invention may execute various instructions or programs, and process data within the station 100. The processor 110 may also control each of the units of the station 100 described above, and may control data transmission and reception between the units. According to an embodiment of the present invention, the processor 110 may execute a program for establishing a connection with an AP stored in the memory 160 and receive a communication setup message transmitted by the AP. Further, the processor 110 may read information about a priority condition of the station 100 included in the communication setup message, and may request access to the AP based on the information about the priority condition of the station 100. Specific embodiments of this will be described later.

<26> The station 100 illustrated in FIG. 3 is a block diagram according to one embodiment of the present invention, wherein the separated blocks represent logically distinct elements of the device. Accordingly, the elements of the device described above may be mounted on a single chip or a

plurality of chips, depending on the design of the device. Furthermore, in an embodiment of the present invention, some components of the station 100, such as the user interface portion 140 and the display unit 150, may be optionally equipped in the station 100.

<27> FIG. 4 is a block diagram illustrating the configuration of an AP 200 according to one embodiment of the present disclosure.

<28> As shown, an AP 200 according to an embodiment of the present invention may comprise a processor 210, a network interface card 220, and a memory 260. With respect to FIG. 4, portions of the configuration of the AP 200 that are identical or equivalent to the configuration of the station 100 of FIG. 3 will be omitted to avoid redundant description.

<29> Referring now to FIG. 4, an AP 200 according to the present disclosure comprises a network interface card 220 for operating a BSS in at least one frequency band. As described above in the embodiment of FIG. 3, the network interface card of the AP 200 may also a plurality of network interface modules utilizing different frequency bands from each other. In other words, the AP 200 according to an embodiment of the present invention may comprise two or more network interface card modules in different frequency bands, such as 2.4 GHz, 5 GHz, and 60 GHz. Preferably, the AP 200 may comprise a network interface card module utilizing a frequency band above 6 GHz and a network interface card module utilizing a frequency band below 6 GHz. Each network interface card module can perform wireless communication with stations in accordance with the wireless LAN specifications for the frequency band supported by that network interface card

module. The network interface card 220 may operate only one network interface card module at a time or may operate multiple network interface card modules together simultaneously, depending on the performance and requirements of the AP 200.

<30> Next, the memory 260 stores control programs used by the AP 200 and various data associated therewith. These control programs may include an access program that manages access to the station. Further, the processor 210 controls each unit of the AP 200 and may control data transmission and reception between the units. According to an embodiment of the present invention, the processor 210 may execute a program for connecting with a station stored in the memory 260 and transmit a communication setting message for one or more stations. The communication setup message may include information about the access priority conditions of each station. Further, the processor 210 performs the connection setting according to the connection request of the station. A specific embodiment of this will be described later.

<32> FIG. 5 illustrates the configuration of L-SIG and RL-SIG and the utilization of the L_LENGTH field, according to an embodiment of the present invention.

<33> FIGS. 5(a)/(b) illustrate the frame formats of 11a/g and 11ax PPDU, respectively, according to an embodiment of the present invention. FIG. 5(c) presents the detailed field structure of L-SIG and RL-SIG, which are commonly used across the aforementioned PPDU formats.

<34> The L-SIG utilizes 64 FFT OFDM (-32 to 0 to 31, a total of 64 subcarriers). In this

configuration, the leftmost 6 subcarriers (-32 to -27) and the rightmost 5 subcarriers (27 to 31) are used as guard carriers, while the central subcarrier (0) is used as a DC carrier. Excluding these $6 + 5 + 1 = 12$ subcarriers, there remain 52 subcarriers, of which 4 subcarriers (-21, -7, 7, 21) are allocated as pilot subcarriers, while the remaining 48 subcarriers are used for data transmission. When employing BPSK modulation with a coding rate of $1/2$ (MCS = BPSK, Rate = $1/2$), a total of 24 bits of information can be transmitted. The configuration of these 24-bit information fields is shown in FIG. 5(c).

<35> L_RATE (4 bits) indicates the MCS (Modulation and Coding Scheme) used for data transmission, representing one of the transmission rates (6/9/12/18/24/36/48/54 Mbps) derived from a combination of modulation schemes (BPSK, QPSK, 16-QAM, 64-QAM) and coding rates ($1/2$, $2/3$, $3/4$). By referring to the L_RATE and L_LENGTH fields, the total length of the PPDU can be determined. An 11ax STA always sets the L_RATE field to the minimum transmission rate of 6 Mbps.

<36> L_LENGTH (12 bits), when combined with the L_RATE field, indicates the length of the PPDU. The interpretation method of this field differs between legacy nodes and 11ax nodes.

<37> When a legacy STA receives the PPDU, the L_RATE field set to 6 Mbps indicates that 3 bytes (24 bits) can be transmitted within one 64-FFT OFDM symbol duration of 4us. Approximating SVC (16 bits) and Tail (6 bits) as one symbol (24 bits), the PPDU length (PPDU_LENGTH) can be calculated as $PPDU_LENGTH = RXTIME = TXTI = (1 + \lceil L_LENGTH/3 \rceil) \times 4 + 20$ (Refer to FIG. 5(d)). In the equation above, the additional 20us accounts for the transmission time of L-STF, L-LTF, and L-SIG. The ceil [x] operation represents the smallest integer greater

than or equal to x . The maximum value of L_LENGTH (12 bits) is 4095, which results in a maximum $PPDU_LENGTH$ of 5.484 ms. However, legacy devices based on the 11a/g standard may consider an L_LENGTH field greater than 2340 bytes as invalid, since such values were not permitted under earlier standards. Considering this limitation, the maximum $PPDU_LENGTH$ is effectively reduced to 3.144 ms.

<38> When an 11ax STA receives the PPDU, the symbol count based on 64-FFT can be obtained by adding 3 bytes (corresponding to SVC/TAIL) to the L_LENGTH field and then dividing by the symbol transmission capacity of 3 bytes per symbol. Multiplying the number of symbols by $4\ \mu s$ (time per symbol) and adding $20\ \mu s$ (corresponding to L-STF, L-LTF, and L-SIG transmission) results in the $PPDU_LENGTH$ or $RXTIME$. $RXTIME(us) = [(L_LENGTH + 3) / 3] \times 4 + 20$. Conversely, an 11ax STA transmitting the PPDU must set as $L_LENGTH = [(TXTIME - 20) / 4] \times 3 - 3$, where $TXTIME$ represents the total transmission time of the 11ax PPDU (refer to FIG. 5(d)).

<39> In the equations above, for an 11ax STA, the L_LENGTH value is always computed as $\text{floor}(L_LENGTH / 3)$ after reception, meaning that three different L_LENGTH values map to the same $PPDU_LENGTH$. For example, the three values $L_LENGTH = \{3k+1, 3k+2, 3(k+1)\}$ all yield the same result $(k+1)$ when applying $\text{floor}(L_LENGTH / 3)$.

<40> In an embodiment of the present invention, the three L_LENGTH values are used to indicate $PPDU_LENGTH$ while performing additional signaling. The values of L_LENGTH in the form of $\{3k+1, 3k+2, 3(k+1)\}$, or combinations of values that represent the same L_LENGTH while also conveying additional information to the 11ax receiving terminal, may be used to indicate the types

of PPDU's applied to the corresponding 11ax PPDU.

<42> FIG. 6 illustrates a method for indicating a WLAN PPDU format using the L_LENGTH field in the L-SIG and RL-SIG parts, along with the HE-SIG-A part, according to an embodiment of the present invention.

<43> As mentioned in FIG. 5, three different L_LENGTH values can be used not only to indicate PPDU_LENGTH but also to perform additional signaling.

<44> First, when L_LENGTH is expressed in the form of $3k+1$, the 11ax PPDU can indicate an HE SU PPDU, an HE Trigger-based PPDU, or an Extension PPDU, which are exchanged between an AP and a single STA. For this purpose, additional signaling is performed using the modulation of two symbols in the HE-SIG-A part. If the PPDU is an HE SU PPDU or an HE Trigger-based PPDU, both symbols of HE-SIG-A are modulated using BPSK. If the PPDU is an Extension PPDU, the two symbols of HE-SIG-A are modulated using BPSK and QBPSK, respectively. The Extension PPDU may be used to indicate PPDU formats supported by future standards beyond 11ax or to define additional PPDU formats within 11ax.

<45> Second, when L_LENGTH is expressed in the form of $3k+2$, the 11ax PPDU can indicate an HE MU PPDU exchanged between an AP and multiple STAs, or an HE Extended Range (ER) SU PPDU or HE ER Trigger-based PPDU exchanged between an AP and an outdoor STA. For this purpose, additional signaling is performed using the modulation of two symbols in the HE-SIG-A part. If the PPDU is an HE MU PPDU, both symbols of HE-SIG-A are modulated using BPSK. If the PPDU is an HE ER SU PPDU or an HE ER Trigger-based UL PPDU, the two symbols of HE-

SIG-A are modulated using BPSK and QBPSK, respectively.

<46> In the case of the HE MU PPDU shown in FIG. 6(c), when exchanged between the AP and multiple STAs, the HE-SIG-B includes scheduling information that allows the multiple STAs to receive the PPDU simultaneously. Additionally, the HE MU PPDU may also be used as a PPDU format for uplink transmission from a single STA to the AP. In this case, as shown in FIG. 6(d), the AID information, which cannot be included in an SU PPDU, may be contained in the HE-SIG-B, and there is the advantage of being able to transmit data over a narrower bandwidth rather than occupying the full bandwidth. In the former case, since the AID information allows identification of the receiver or transmitter of the MU PPDU, it can be utilized to perform spatial reuse operations that take the transmitting and receiving STA into consideration. In the latter case, the RU Allocation field in HE-SIG-B, which contains information about frequency division and the number of spatial streams, may include signaling information that indicates how the total bandwidth (e.g., 20 MHz) is divided, and which specific frequency band within the divided segments is used by the STA to transmit data.

<47> Additionally, the signaling structure of the RU Allocation field may include only signaling information that indicates which part of the bandwidth is used by the STA for data transmission, under the assumption that the information on how the total bandwidth is divided in the frequency domain has already been exchanged and known between the AP and STA.

<48> Additionally, the RU Allocation field may indicate how the total bandwidth is divided in the frequency domain, and the specific data transmission region of each STA may be represented through the User Specific Info fields that follow. In this case, to indicate the actual data region used

by the STA, multiple User Specific Info fields may need to be inserted with the Null AID, as shown in FIG. 27. To reduce such overhead, a signaling method may be applied in which the non-AID portions of the User Specific Info field set to Null AID indicate the region where the actual STA's data is located. Subsequently, a User Specific Info field containing the transmitting STA's allocated AID from the AP may be transmitted. In this configuration, it becomes possible to indicate the RU used for data transmission of the corresponding user with a maximum of only two User Specific Info fields.

<49> The mapping between L_LENGTH field values and PPDU types, as mentioned above, can be modified in order while maintaining the same conceptual meaning.

<51> FIG. 7 is a diagram illustrating embodiments of additional PPDU formats defined in 11ax, as referenced in FIG. 6.

<52> As shown in FIG. 7(a), one embodiment of the additional PPDU formats defined in 11ax is the HE ER MU PPDU (SIG-A/B) format. When $\text{mod}3 = 1$ and the modulation is BPSK or QPSK, the PPDU corresponds to an HE ER MU PPDU format. In this case, HE-SIG-A may be repeated along the time axis, as shown in FIG. 6(d), and additionally, HE-SIG-B may be inserted and also repeated along the time axis. This repetitive transmission of HE-SIG-A and HE-SIG-B along the time axis provides a receiver gain of more than 3 dB, enabling signal reception over longer distances. Unlike the format in FIG. 6(d), this PPDU format offers the advantage of enabling HE-SIG-B signaling, making it applicable for downlink single/multi-user long-range transmission as well as uplink single-user long-range transmission. Furthermore, even in a PPDU transmitted by a single

STA or single AP, the inclusion of HE-SIG-B signaling allows the data transmission portion, based on 256FFT/20MHz, to be transmitted as a narrowband signal. Unlike the SU PPDU format in FIG. 6(d), this format allows the AP to transmit a signal to a single STA (or a STA to transmit to the AP) using only RUs narrower than 20 MHz, such as 26RU, 52RU, or 106RU, thereby concentrating the maximum allowable transmit power in the ISM band into a narrower RU. This enables further extension of transmission range, not only due to the repetition of the HE-SIG-A/B fields in the 64FFT/20MHz region, but also during the data transmission phase in the 256FFT/20MHz region. Additionally, similar to the MU PPDU format shown in FIG. 6(c), this format provides the benefit of enabling the AP to transmit to multiple users while extending the transmission range. For example, in HE-SIG-B, it may be signaled that the 20 MHz channel is divided into 9 segments of 26RU for OFDMA-based transmission, and that 1 RU is allocated to each of two STAs. This enables the full allowed transmit power in the ISM band to be concentrated on the two narrow RUs, thereby increasing the transmission distance as described above.

<53> As shown in FIG. 7(b), one embodiment of the additional PPDU formats defined in 11ax is the HE ER MU PPDU (SIG-A) format. In the case where $\text{mod}3 = 1$ and BPSK or QPSK modulation is used, the format corresponds to an ER HE MU PPDU format, where HE-SIG-A may be repeated along the time axis, as shown in FIG. 6(d), but HE-SIG-B is not transmitted in order to reduce preamble overhead. In this case, the distinction between the HE ER MU PPDU (SIG-A/B) and HE ER MU PPDU (SIG-A) formats is made using a 1-bit indicator included in SIG-A. The repeated transmission of the HE-SIG-A field along the time axis provides a receiver gain exceeding 3 dB,

thereby enabling signal reception over extended distances. This PPDU format may be used for long-range single-user transmission in either the downlink or uplink, similar to the format shown in FIG. 6(d). This format also offers the advantage that even in a PPDU transmitted by a single STA or a single AP, the data transmission portion, based on 256FFT/20MHz, can be sent as a narrowband signal without HE-SIG-B signaling. Unlike the SU PPDU format in FIG. 6(d), this allows a signal sent by an AP to a single STA (or vice versa) to be transmitted using only RUs narrower than 20 MHz (e.g., 26RU, 52RU, or 106RU), thereby concentrating the full allowable transmit power in the ISM band into the narrow RU. This, in turn, extends the transmission range during the data transmission phase in the 256FFT/20MHz region, in addition to the range extension achieved by the repetition of the HE-SIG-A field in the 64FFT/20MHz region. In this case, the RU used may be predefined between the AP and STA within a pre-agreed resource allocation configuration, so that no separate signaling such as HE-SIG-B is required. Furthermore, the RU may be signaled not through HE-SIG-B but through HE-SIG-A, and unlike the various signaling options of HE-SIG-B, a much simpler signaling method may be used (e.g., fixing the configuration to 9 RUs consisting of 26 tones over 20 MHz, and signaling only one of specific positions such as RU 1, 5, or 9).

<54> As shown in FIG. 7(c), one embodiment of the additional PPDU formats defined in 11ax is the HE ER MU PPDU (SIG-A/C) format. When $\text{mod}3 = 1$ and BPSK or QPSK modulation is used, the PPDU corresponds to an ER HE MU PPDU format, in which HE-SIG-A may be repeated along the time axis, as shown in FIG. 6(d). To reduce preamble overhead, HE-SIG-B is not transmitted;

instead, HE-SIG-C is transmitted in the 256FFT/20MHz region. This repeated transmission of the HE-SIG-A field provides a receiver gain exceeding 3 dB, enabling signal reception over extended distances. In this case, the RU from which data is received is predefined between the AP and STA within a resource allocation configuration, allowing the STA to monitor its RU without additional signaling such as HE-SIG-B. In another embodiment, the RU may be signaled through HE-SIG-A instead of HE-SIG-B, using a very simple signaling method—for example, assuming a fixed configuration of 9 RUs composed of 26 tones over 20 MHz, and signaling only one among specific positions such as RU 1, 5, or 9. In this case, HE-SIG-C can transmit various information necessary for the STA to decode the data transmitted in the corresponding RU, such as MCS, number of spatial streams, Transmit Beamforming (TxBF) status, and the type of coding scheme (BCC or LDPC) used.

<55> As shown in FIG. 7(d), one embodiment of the additional PPDU formats defined in 11ax is the HE ER MU PPDU (SIG-C) format. When $\text{mod}3 = 1$ and BPSK or QPSK modulation is used, the format corresponds to an ER HE MU PPDU format. In this case, HE-SIG-A is not repeated along the time axis, and to reduce preamble overhead, HE-SIG-B is not transmitted. Instead, HE-SIG-C is transmitted in the 256FFT/20MHz region. Here, the HE-SIG-A field is not intended for the distant STA receiving the PPDU, but rather enables STAs located near the AP to set their NAV (Network Allocation Vector) using the TXOP duration information included in HE-SIG-A. In this case, the RU for data reception may be predefined between the AP and the receiving STA within a specific resource allocation configuration, such that no additional signaling like HE-SIG-B is

required. The HE-SIG-C may transmit various information required by the STA to decode the data received in the corresponding RU, including the MCS, number of spatial streams, whether TxBF (Transmit Beamforming) is used, and the coding scheme (BCC or LDPC).

<57> FIG. 8 illustrates the configuration of the HE-SIG-A field, which varies depending on the PPDU format, according to an embodiment of the present invention.

<58> The HE-SIG-A field provides PPDU common information necessary for receiving 11ax PPDUs and can be modulated using BPSK ($R=1/2$) over 64FFT with two symbols. The PPDU common information includes parameters such as PPDU Bandwidth, BSS Color, Number_of_HE-LTF, and SIG-B MCS.

<59> For an outdoor STA, the two symbols of HE-SIG-A can be repeated for transmission, and this repeated structure is referred to as RHE-SIG-A. The presence or absence of RHE-SIG-A can be signaled as described in FIG. 6.

<60> Additionally, the HE-SIG-A field has different bit-field structures depending on whether the PPDU format is HE SU PPDU, HE MU PPDU, or HE Trigger-based PPDU.

<61> As shown in FIG. 8(a), when the PPDU format is HE SU PPDU, the HE-SIG-A field includes the following bit fields:

<62> DL/UL indicates the transmission direction of the SU PPDU.

- <63> Format distinguishes whether the PPDU is an HE SU PPDU or an HE Trigger-based PPDU.
- <64> BSS Color indicates the identifier of the BSS where the PPDU is exchanged.
- <65> Spatial Reuse conveys SINR Margin, TX Power, and other relevant information that can be referenced by STAs intending to perform Spatial Reuse transmission during the transmission of the corresponding PPDU.
- <66> TXOP Duration indicates the TXOP interval that continues after the transmission of the PPDU, allowing surrounding STAs to set NAV (Network Allocation Vector) to defer their transmissions during that period.
- <67> Bandwidth specifies the total bandwidth over which the PPDU is transmitted. This value can indicate one of 20MHz, 40MHz, 80MHz, or 160MHz (including 80+80MHz).
- <68> MCS indicates the MCS value applied to the MPDU in the corresponding PPDU.
- <69> CP+LTF Size represents the combination of the LTF type (1x, 2x, or 4x LTF) used and the Cyclic Prefix (CP) values applied to the subsequent A-MPDU transmission.
- <70> Coding indicates whether BCC or LDPC coding is used and, in the case of LDPC, whether an Extra Symbol was transmitted.
- <71> NSTS indicates the Number of Spatial Time Streams (NSTS) transmitted when the PPDU is transmitted using SU-MIMO.
- <72> STBC specifies whether Space Time Block Coding (STBC) was applied.

- <73> TxBF indicates whether Transmit Beamforming was used.
- <74> DCM specifies whether Dual Carrier Modulation (DCM) was applied, which transmits the same information on two subcarriers to mitigate narrowband interference.
- <75> Packet Extension indicates the level of Packet Extension applied to the corresponding PPDU.
- <76> Beam Change specifies whether Beam Change was applied after L-LTF and before HE-LTF in the PPDU.
- <77> CRC/Tail is used to verify the integrity of the information contained in HE-SIG-A and initialize the BCC decoder.
- <79> As shown in FIG. 8(b), in the case of the HE MU PPDU format, HE-SIG-A includes the following bit fields. Portions that overlap with the description in FIG. 8(a) may not be separately explained.
- <80> DL/UL indicates the transmission direction of the MU PPDU. While it is currently evident that MU PPDU is always set to DL MU and transmitted only in the downlink, exceptions can be considered through the following embodiments:
- <81> First, even in the case of PPDU exchanges between a single AP and STA, HE MU PPDU may be selected if the transmission of the HE-SIG-B field is required, allowing the transmission direction of the PPDU to be specified accordingly. This is because, even in the case of PPDU exchanges between a single AP and STA, data can be selectively transmitted over specific bands

using either Contiguous OFDMA or Non-contiguous OFDMA. For example, if STA1 performs CCA (Clear Channel Assessment) before transmitting an 80MHz PPDU to the AP and determines that only the Secondary 20MHz channel is busy, the conventional method would require transmission only over the Primary 20MHz. However, with the proposed method, PPDU transmission can be performed over the Primary 20MHz and Secondary 40MHz, excluding only the Secondary 20MHz. In this case, Resource Allocation Signaling for the corresponding PPDU necessarily requires the HE-SIG-B field. In this case, even though STA1 is transmitting a PPDU as a single STA, it can use the HE MU PPDU format for transmission and set the DL/UL bit field to UL before transmitting. Further details regarding Non-Contiguous OFDMA will be explained in other figures. Alternatively, when a single STA intends to transmit an uplink PPDU using a specific RU within a 20 MHz channel, it may transmit the PPDU using the HE MU PPDU format, with the DL/UL bit field set to UL. Details regarding narrowband OFDMA transmission by a single STA are further described in other figures.

<82> Second, even in the case of PPDU exchange between a single AP and a single STA, when the transmission of the HE-SIG-B field is required to enable enhanced Spatial Reuse operation, the HE MU PPDU may be selected, and the transmission direction of the PPDU may be indicated accordingly. Unlike the HE SU PPDU, the HE MU PPDU allows the STA AID of the receiver to be indicated in the Per User Information field of the HE-SIG-B. In the case where the HE MU PPDU is used for uplink transmission, it is preferable to indicate the AID of the transmitting STA, not that of the receiving AP. This is because the receiver in the UL PPDU is clearly the AP, and indicating the AID of the transmitting STA allows neighboring OBSS STAs that receive the PPDU

to perform more advanced Spatial Reuse operations. The Spatial Reuse function using an HE UL MU PPDU in which the AID of the transmitting STA is indicated may operate as follows.

<83> For example, suppose BSS A and BSS B exist. If a STA A-1 belonging to BSS A transmits a HE UL MU PPDU, the STAs in BSS B that overhear the transmission can measure the distance to the BSS A AP, the receiver, based on previously received downlink PPDU from the BSS A AP. Based on this information, they can immediately perform Spatial Reuse operations, taking into account the interference impact of the UL PPDU on the receiving AP.

<84> Additionally, when the BSS A AP subsequently transmits a downlink PPDU to STA A-1, the STAs in BSS B can also consider the signal strength previously measured from A-1's uplink HE UL MU PPDU to evaluate the potential interference to the receiving STA and thereby immediately apply Spatial Reuse operations.

<85> In this case, the Spatial Reuse operation is enabled by identifying the BSS Color through HE-SIG-A, and confirming the AID of the receiving or transmitting STA through HE-SIG-B. If the PPDU is determined to be an OBSS (Overlapping BSS) PPDU, and the interference impact on the receiver is below a certain threshold, the Spatial Reuse function can be executed.

<86> In HE MU PPDU, the Bandwidth field can indicate a wider variety of bandwidth options compared to the Bandwidth field in HE SU PPDU.

<87> This is because, in addition to the conventional 20/40/80/160MHz Contiguous bandwidths, additional signaling bits may be required to represent the Non-Contiguous bandwidths as described above.

<88> The SIG-B MCS field indicates the MCS used in HE-SIG-B, and SIG-B can employ a

variable MCS (0 to 5) depending on the amount of information that needs to be signaled.

<89> In HE MU PPDU, the CP+LTF Size field signals only the values used in HE SU PPDU, excluding the combination of $1x_LTF + 0.8us_CP$.

<90> The SIG-B Compression field indicates that a compression mode has been applied to reduce the amount of information when signaling SIG-B. Specifically, when an HE MU PPDU is transmitted as a Full-BW MU-MIMO, frequency-specific resource allocation for each 20MHz sub-channel becomes unnecessary, thereby allowing SIG-B compression. The details regarding SIG-B Compression are further explained in other figures.

<91> The SIG-B Dual MCS field is used when transmitting PPDU of 40MHz or higher, where HE-SIG-B may transmit different information in each Primary 20MHz and Secondary 20MHz sub-channel, and this is referred to as HE-SIG-B Content Channel 1 and Content Channel 2. The HE-SIG-B Content Channel may be determined based on rules other than the Primary/Secondary 20MHz channel configuration between the transmitter and receiver. In this disclosure, it is assumed that information regarding the location of the HE-SIG-B Content Channels has been exchanged in advance between the transmitter and receiver according to an arbitrary rule. In this case, different MCS levels can be applied to each Primary/Secondary 20MHz in order to maintain a similar number of HE-SIG-B symbols. The SIG-B Dual MCS field signals the MCS levels applied to SIG-B for each 20MHz sub-channel. Additionally, in cases where SIG-B Compression is enabled for Full-BW MU-MIMO, the SIG-B Dual MCS field may have a different meaning. Specifically, for Full-BW MU-MIMO, since there is no need to distribute information across Primary/Secondary 20MHz using different MCS levels, the SIG-B Dual MCS field is instead used to indicate the number of

STAs participating in MU-MIMO. This reduces the decoding complexity of SIG-B in subsequent processing.

<92> The SIG-B DCM field indicates whether DCM (Dual Carrier Modulation) has been applied to SIG-B to ensure stable transmission of the SIG-B portion.

<93> The Num of SIG-B Sym field indicates the number of symbols used for transmitting SIG-B.

<95> As illustrated in FIG. 8(c), when the HE Trigger-based PPDU is used, the HE-SIG-A includes the following bit fields. The explanations overlapping with FIGS. 8(a) and 7(b) may not be redundantly described.

<96> The Format field is used to distinguish whether the PPDU is an HE SU PPDU or an HE Trigger-based PPDU. Subsequently, BSS Color, Spatial Reuse, TXOP Duration, and Bandwidth bit fields are transmitted. Since the HE Trigger-based PPDU is a UL PPDU that one or more STAs transmit simultaneously, the SIG-A field is commonly included in all UL PDUs, making it difficult to include individual STA-specific information. Therefore, only the common information of the PPDU can be contained. However, this results in an issue where out of the 52 available bits in the SIG-A portion, approximately 20 bits remain unused. Details on how to compensate for this issue are further explained in other figures.

<98> FIG. 9 illustrates the configuration of HE-SIG-B according to an embodiment of the present

invention.

<99> The HE-SIG-B may be present in an HE MU PPDU and contains information necessary for receiving a Multi-User PPDU. This information is classified into Common Info and User-Specific Info. The detailed configuration of HE-SIG-B is illustrated in FIG. 9(a). The RA (Resource Allocation) information, which contains the OFDMA frequency division allocation information for the corresponding bandwidth, is included, along with a CRC/Tail field to ensure integrity. The RA field is 8 bits in length and is structured as shown in FIG. 9(b). By analyzing the RA information, it is possible to determine how many STA-specific information elements are included. The STA-specific information is transmitted in pairs along with the CRC/Tail field. If three STA-specific information elements are transmitted, the CRC/Tail field is separately appended to the first two STA information elements, while the third STA information element has its own CRC/Tail field. The Resource Allocation information may include an x-Null indicator, which signifies that a user is either not allocated in a particular frequency band or allocated but not transmitting user information over the SIG-B transmission channel. The x-Null indicator can have specific bandwidth-based indicators such as 242 Null (20MHz/242SC (subcarriers)), 484 Null (40MHz/484SC), and 996 Null (80MHz/996SC), or it may have a multi-purpose Null indicator. In addition, the Common Info region may include a "C26" signaling bit indicating whether data is transmitted to the central 26RU within PPDU bandwidths of 80 MHz or greater. If the bit is set to 1, it signifies that within the corresponding PPDU of 80 MHz or greater, data is transmitted in the central DC region's 26RU directed to an arbitrary STA, and the User Specific Info for that STA is signaled as illustrated in FIG. 20.

<100> The User (STA) specific information is transmitted as a 21-bit field when the STA is an OFDMA STA, as illustrated in FIG. 9(c)-1, and when the STA is an MU-MIMO STA, the STA-specific information is also conveyed as a 21-bit field, as shown in FIG. 9(c)-2. In the case of an arbitrary MU-MIMO STA, the STA must be able to determine the position and number of its spatial streams among multiple STAs receiving MU-MIMO within the same RU, and this is signaled through the Spatial Configuration Field as shown in FIG. 9(d). Each STA, upon identifying the OFDMA and MIMO configuration via the RA field, determines whether it is scheduled to receive MU-MIMO data within its assigned RU based on the order in which its STA ID is signaled. Accordingly, the STA must interpret the User Specific Info field differently depending on the configuration shown in FIG. 9(c)-1 or FIG. 9(c)-2. Furthermore, if the SIG-B Compression field in FIG. 8(b) is set to 1, this indicates Full Bandwidth MU-MIMO. In such a case, the HE-SIG-B does not include an RA field, and all STAs signaled in the User Specific Info field are assumed to be MU-MIMO STAs. Therefore, interpretation must be carried out based solely on the MU-MIMO User Specific Info field, as shown in FIG. 9(c)-2.

<102> FIG. 10 illustrates a method of performing signaling when transmitting an uplink HE MU PPDU according to one embodiment of the present invention.

<103> As described in FIG. 8(b), the HE MU PPDU may also be used for uplink PPDU transmission by a single STA. In such a case, as shown in FIG. 10(a), the STA transmits its data using a specific RU of 20 MHz or less, concentrating its transmit power within that RU. This allows the STA to achieve extended transmission range, leveraging the benefit of focused power transmission.

<104> However, in this case, based on the HE-SIG-B signaling methods described in FIG. 9, the

signaling method for uplink HE MU PPDU is as follows.

<105> First, the RA field is used to signal the overall bandwidth configuration of the PPDU, and the User Specific Info field employs Null STA AIDs to complete the signaling. For example, if a 20 MHz bandwidth is divided into nine 26RUs using OFDMA, the RA field may be signaled as "00000000" according to FIG. 9(b). The User Specific Info corresponding to the RU used for uplink transmission by the STA includes the necessary PPDU information, while the User Specific Info fields corresponding to all other RUs include Null STA AIDs (see FIG. 10(b)). In this case, if the STA transmits data in the third 26RU, the User Specific Info fields for RUs 1 to 2 and 4 to 9 are transmitted with Null STA AIDs. This method leverages the HE-SIG-B signaling structure originally designed for downlink, which may lead to substantial signaling overhead. To minimize this overhead, it is possible to truncate the User Specific Info fields after the one containing the actual STA information. In the example above, Null STA Specific Info fields for RUs 1 and 2 are transmitted first, followed by the STA Specific Info for RU 3. Subsequent fields for RUs 4 through 9 are omitted. Upon receiving the third STA Specific Info field, the AP can recognize the RU to which the STA's data has been allocated and, therefore, does not require any further STA Specific Info fields. Consequently, the transmitting STA can omit additional Null STA Specific Info fields, reducing unnecessary signaling.

<106> Second, for uplink signaling, one can either utilize the TBD (To Be Determined) area within the Resource Allocation field in FIG. 9(b) or newly define a dedicated Uplink Resource Allocation field. For example, as illustrated in FIG. 10(c), the 20 MHz band may be divided into 26RU, 52RU, 106RU, etc., and signaling indices may be used to indicate which of these RUs is used by the STA for uplink data transmission via the Resource Allocation field. In this case, only a single STA Specific Info field needs to be transmitted, significantly reducing signaling overhead. In FIG. 10(c),

three representative scenarios are explicitly signaled via index values: Division into nine 26RUs, and signaling one of them for transmission; Division into four 52RUs and one 26RU, and signaling one of the 52RUs; and Division into two 106RUs and one 26RU, and signaling one of the 106RUs. These signaling fields can be implemented by using the TBD index space within the downlink RA field structure shown in FIG. 9(b), or by newly defining an uplink-specific RA field, excluding the index values already allocated for downlink.

<107> Third, for uplink signaling, certain bit fields in HE-SIG-A of FIG. 8(b), which are not required in uplink HE MU PPDU transmission, can be repurposed to carry additional signaling. For example, in uplink HE MU PPDU transmission, the following fields can be reused. For the Number of HE-LTF Symbols, this field becomes redundant because its function overlaps with the NSTS (Number of Spatial Time Streams) field inside the User Specific Info portion of HE-SIG-B, thus making separate signaling unnecessary. For the Number of SIG-B Symbols, since a single STA is being signaled, the amount of signaling information is fixed, and the number of required symbols can be predefined. Therefore, explicit indication of the symbol count is unnecessary. These repurposed fields can be used to assist HE-SIG-B's Common Info and User Specific Info signaling and can also support uplink HE MU PPDU-specific signaling. For instance, in HE-SIG-A, one may signal the location of the RU that the STA will use for uplink data transmission within the OFDMA RU configuration indicated by HE-SIG-B's RA field. In this approach, HE-SIG-B's RA field remains unchanged, and only one User Specific Info field needs to be transmitted to complete the signaling process. This method enables a more efficient uplink signaling mechanism with minimal overhead, tailored for single STA uplink transmission within the HE MU PPDU format.

<108> In another embodiment of the present invention, signaling methods are described for the case

where an uplink HE MU PPDU is transmitted not in a narrowband RU smaller than 20 MHz, but across the full bandwidth of 20/40/80/160 (80+80) MHz. In this case, the BW field in FIG. 8(b) indicates the overall bandwidth of the PPDU. The SIG-B Compression field is set to 1, allowing the RA field described in FIG. 9(b) to be omitted. However, unlike the case described in FIG. 9(c), even when the SIG-B Compression field is set to 1, the User Specific Info field must still be interpreted according to the OFDMA-based structure shown in FIG. 9(c)-1, not the MU-MIMO structure in FIG. 9(c)-2.

<110> FIG. 11 illustrates conventional methods for transmitting a wideband PPDU, in relation to an embodiment of the present invention.

<111> FIG. 11(a) illustrates a method of transmitting a Physical Layer Convergence Protocol (PLCP) Protocol Data Unit (PPDU) using an 80MHz bandwidth. Initially, after the previous PPDU transmission on the channel is completed, a STA with data to transmit checks whether the primary channel is idle during the Arbitrary Inter-Frame Spacing (AIFS) period. If the primary channel remains idle during CCA (Clear Channel Assessment), the STA decreases the Backoff Window (BW) value by 1 at each idle slot. If the channel becomes busy at any CCA slot, the STA stops the CCA process and resumes CCA once the channel becomes idle again, starting from the previously paused BW value after AIFS. Once the BW value reaches zero, the STA prepares for transmission. Prior to transmission, the STA performs CCA on the intended subchannels for a duration equal to the PIFS (Point Coordination Function Inter-Frame Space) to determine their availability. FIG. 11(a) illustrates a scenario where CCA detects an ongoing transmission on a secondary 20MHz channel,

causing the STA to use only the primary 20MHz channel for data transmission. In this case, the STA must be capable of Dynamic Bandwidth Operation, allowing it to quickly reconfigure the PPDU based on the available channel bandwidth.

<112> FIG. 11(b) illustrates a scenario in which, during CCA (Clear Channel Assessment), an ongoing transmission is detected on a secondary 20MHz channel, leading the STA to halt its transmission attempt. Instead of transmitting on the available primary 20MHz channel, the STA continues CCA until the entire 80MHz channel becomes idle. Only then does the STA proceed with transmitting an 80MHz PPDU. In this case, the STA is limited to Static Bandwidth Operation, meaning it lacks the capability to dynamically reconfigure the PPDU according to the available channel bandwidth.

<113> As described above, in the existing wideband PPDU transmission methods, when communication is actively occurring in the subchannels within an OBSS (Overlapping Basic Service Set) environment, issues arise where the transmission PPDU bandwidth is reduced (as shown in FIG. 11(a)) or the PPDU transmission is continuously delayed (as shown in FIG. 11(b)).

<115> FIG. 12 illustrates efficient wideband PPDU transmission methods according to an embodiment of the present invention.

<116> FIG. 12(a) depicts a Contiguous, Fixed Extension-based wideband PPDU transmission method, in which the PPDU always occupies contiguous frequency bands. The bandwidth extension follows a fixed expansion sequence, such as 20→40→80→160, restricting flexibility in dynamically adapting bandwidth.

<117> This method is identical to the conventional approach described in FIG. 11 and has the drawback of low spectrum utilization efficiency. The CCA (Clear Channel Assessment) process only reports the first detected busy channel among the primary 20MHz, secondary 20MHz, secondary 40MHz, and secondary 80MHz channels. Since contiguous bandwidth occupation is enforced, the bandwidth cannot be extended beyond the first busy channel, making CCA results for subsequent channels unnecessary.

<118> FIG. 12(b) illustrates a Contiguous, Flexible Extension-based wideband PPDU transmission method, where the PPDU always occupies contiguous frequency bands but allows flexible bandwidth expansion in 20MHz increments, such as 20→40→60→80→100→120→140→160.

<119> In this method, CCA (Clear Channel Assessment) only reports the first detected busy 20MHz channel. Since contiguous bandwidth occupation is enforced, bandwidth expansion beyond the first busy channel is restricted, making CCA results for subsequent channels unnecessary.

<120> FIG. 12(c) illustrates a Non-Contiguous, Fixed Extension-based wideband PPDU transmission method, where the PPDU can occupy non-contiguous frequency bands, but bandwidth expansion follows a fixed sequence, such as 20→40→80→160.

<121> In this method, CCA must report all detected busy channels among the primary 20MHz, secondary 20MHz, secondary 40MHz, and secondary 80MHz channels. Since non-contiguous bandwidth occupation is allowed, CCA results for all sub-channels are required.

<122> FIG. 12(d) illustrates a Non-Contiguous, Flexible Extension-based wideband PPDU transmission method, where the PPDU can occupy non-contiguous frequency bands and allows flexible bandwidth expansion in 20MHz increments.

<123> In this method, CCA (Clear Channel Assessment) must report all detected busy channels in 20MHz increments. Since non-contiguous bandwidth occupation is allowed, CCA results for all secondary 20MHz channels are required.

<124> FIG. 12(e) illustrates a Non-Contiguous, Limited Flexible Extension-based wideband PPDU transmission method, where the PPDU can occupy non-contiguous frequency bands, and bandwidth expansion in 20MHz increments is permitted; however, certain core channels, including the primary 20MHz, must always be occupied. FIG. 12(e) illustrates a case where the core channel is set to the primary 40MHz.

<125> CCA must report all detected busy channels in 20MHz increments. Since non-contiguous bandwidth occupation is allowed, CCA results for all secondary 20MHz channels are required.

<126> Comparing the five methods above,

<127> the method in FIG. 12(b) allows contiguous wideband PPDU transmission; however, it has the drawback that if OBSS activity exists in any secondary 20MHz channel, wideband PPDU transmission is significantly restricted.

<128> The method in FIG. 12(c) results in non-contiguous PPDU formation but has the advantage that even with OBSS activity in secondary 20MHz and 40MHz channels, wideband PPDU transmission up to 160MHz is still possible. However, this method only allows one instance of non-contiguous frequency allocation within the 160MHz bandwidth.

<129> The method in FIG. 12(d) offers the highest multi-channel utilization, but it comes with a high CCA burden, and in some cases, wideband PPDU transmission may extend across multiple non-contiguous frequency bands, which can be a disadvantage.

<130> In FIGS. 12(c) and 12(d), when a secondary 20MHz channel is detected as busy, the PPDU configuration can adapt to exclude that channel while considering other available frequency bands. However, in such cases, the signaling overhead of HE-SIG-B may become concentrated on the primary 20MHz channel, which is a potential drawback.

<131> The method in FIG. 12(e) exhibits similar performance to that in FIG. 12(d); however, when the core channels are set as a primary 40MHz band, it has the advantage of eliminating the signaling burden on HE-SIG-B.

<133> FIG. 13 illustrates methods for transmitting a PPDU using one or two RF modules based on the non-contiguous, fixed extension-based wideband PPDU configuration method exemplified in FIG. 12(c), according to an embodiment of the present invention.

<134> The methods depicted in FIG. 13 can be applied to all wideband PPDU configuration

methods proposed in FIG. 12.

<135> FIG. 13(a) illustrates a method in which a transmitter equipped with a single RF module supporting up to 160MHz transmits a 160MHz PPDU. If, based on the CCA result, the secondary 40MHz channel is determined to be busy, the wideband PPDU is transmitted using only one RF module over the idle primary 40MHz (a combination of primary 20MHz and secondary 20MHz) and the secondary 80MHz. In this case, the PPDU is an HE MU PPDU, in which data intended for multiple receiving STAs is configured using OFDMA. If the CCA result indicates that the secondary 40MHz channel is busy, the data allocated to STAs assigned to that channel is immediately deferred, and the corresponding channel becomes a filtered channel where no data is transmitted.

<136> This method is much easier to implement than the Dynamic PPDU reconstruction method described in FIG. 11(a). In FIG. 11(a), Dynamic PPDU reconstruction requires modifying the wideband PPDU into a narrowband PPDU immediately before transmission based on CCA results. Since the PPDU must be dynamically reconstructed, the PPDU length must also be adjusted to fit the allocated TXOP duration, making implementation highly complex.

<137> However, the Dynamic PPDU reconstruction method in FIG. 13(a) is relatively simpler to implement because the OFDMA-based PPDU is preconfigured, and only the RUs allocated to busy channels are filtered out, while the remaining RUs are transmitted.

<138> In this case, the overall PPDU configuration follows the spectral mask of a 160MHz channel, and no data is transmitted in channels determined to be busy via filtering. However, signals transmitted in the primary 40MHz channel do not adhere to the 40MHz spectral mask, meaning that

RUs transmitted in sections adjacent to the filtered secondary 40MHz channel could potentially interfere with OBSS signals present in the secondary 40MHz channel. To minimize this interference, adjacent RUs may be additionally filtered before transmission.

<139> FIG. 13(b) illustrates a method in which a transmitter equipped with a single RF module supporting up to 160MHz transmits a 160MHz PPDU, wherein, if the CCA result indicates that the secondary 40MHz channel is busy, the wideband PPDU is transmitted using only one RF module over the idle primary 40MHz (a combination of primary 20MHz and secondary 20MHz) and secondary 80MHz. In this case, the PPDU is an HE MU PPDU, in which data intended for multiple receiving STAs is configured using OFDMA. If the CCA result shows that the secondary 40MHz channel is busy, the data allocated to the STAs assigned to that channel is immediately deferred, and the corresponding channel is designated as a filtered channel, where no data transmission occurs.

<140> Here, the overall PPDU configuration follows the spectral mask of an 80MHz channel, and no data is transmitted in channels determined to be busy via filtering. However, signals transmitted in the primary 20MHz channel do not adhere to the 20MHz spectral mask, meaning that RUs transmitted in sections adjacent to the filtered secondary 20MHz channel may interfere with OBSS signals present in the secondary 20MHz channel. To minimize this interference, the adjacent RUs may be additionally filtered before transmission.

<141> FIG. 13(c) illustrates a method for transmitting a wideband PPDU when the transmitter is equipped with two RF modules, supports up to 80+80MHz, and intends to transmit an 80+80MHz PPDU, wherein, if the CCA result indicates that the secondary 40MHz channel is busy, the wideband PPDU is transmitted using both RF modules over the idle primary 40MHz (combination

of primary 20MHz + secondary 20MHz) and secondary 80MHz. In this case, the PPDU is an HE MU PPDU, constructed using OFDMA, targeting multiple receiving STAs. Based on the CCA result for the secondary 40MHz channel, data allocated to the corresponding receiving STAs is deferred. The first RF module transmits a PPDU over the primary 40MHz channel, which adheres to the 40MHz spectral mask. Simultaneously, the second RF module transmits a PPDU over the secondary 80MHz channel, which adheres to the 80MHz spectral mask. Since this configuration ensures that no interference is introduced into the secondary 40MHz channel, there is no need to filter the transmission of adjacent RUs.

<142> FIG. 13(d) illustrates a method for transmitting a wideband PPDU when the transmitter is equipped with two RF modules, supports 80+80MHz, and intends to transmit an 80+80MHz PPDU, wherein, if the CCA result indicates that the secondary 20MHz channel and the secondary 80MHz channel are busy, the wideband PPDU is transmitted using only one RF module over the idle primary 20MHz + secondary 40MHz. In this case, the second RF module does not need to be activated, and the operation of the first RF module is the same as described in FIG. 11(b). Additionally, since the original first RF module adheres to the 80MHz spectral mask, the PPDU transmitted by the first RF module also maintains a filtered structure, where the secondary 20MHz channel portion is filtered within the 80MHz spectral mask.

<144> FIG. 14 illustrates various sequences in which Non-contiguous PPDU transmission is applied according to an embodiment of the present invention.

<145> FIG. 14(a) depicts a sequence where, prior to DL MU transmission, the AP performs CCA, detects that the secondary 20MHz channel is busy, and then transmits an MU-RTS over the primary

20MHz and secondary 40MHz. Subsequently, the AP receives Simultaneous CTS responses from each STA over the corresponding bands and proceeds with the DL MU PPDU transmission. In this case, the MU-RTS must explicitly specify the bandwidth information, enabling the receiving STAs to transmit CTS responses over the primary 20MHz and secondary 40MHz bands.

<146> FIG. 14(b) illustrates a sequence in which, prior to DL MU transmission, the AP performs CCA and detects that the primary 80MHz channel is idle, thereby transmitting an MU-RTS over the primary 80MHz band. However, upon receiving Simultaneous CTS responses from the STAs, the AP fails to receive a signal from the secondary 20MHz band. As a result, the DL MU PPDU is transmitted over the primary 20MHz and secondary 40MHz bands. In this case, both the MU-RTS and DL MU PPDU must explicitly indicate their respective bandwidths, with the MU-RTS specifying a primary 80MHz bandwidth, while the DL MU PPDU specifies a primary 20MHz and secondary 40MHz bandwidth. The bandwidth information can be explicitly signaled either through the BW field in the HE-SIG-A field, as described in FIG. 8, or through the RA field in HE-SIG-B, as described in FIG. 9.

<147> FIG. 14(c) illustrates a sequence in which, for UL MU transmission, the AP performs CCA and detects that the secondary 20MHz channel is busy. Consequently, the AP signals the Trigger frame over the primary 20MHz and secondary 40MHz bands, and subsequently, each STA transmits an UL MU PPDU within these designated bands. In this scenario, the Trigger frame must specify the bandwidth information to ensure that the receiving STAs transmit UL MU PPDU within the primary 20MHz and secondary 40MHz bands. Furthermore, no transmitting STAs should be allocated within the secondary 20MHz band due to its busy status.

<148> FIG. 14(d) illustrates a sequence in which, for UL MU transmission, the AP performs CCA and detects that the primary 80MHz channel is idle, wherein, the AP transmits a Trigger frame over

the primary 80MHz band, and subsequently, each STA transmits an UL MU PPDU within the assigned bands. This illustrates a situation where one or more STAs, having been allocated an UL RU in the secondary 20MHz channel upon receiving the Trigger, do not use the secondary 20MHz channel due to detecting that the channel is busy or because a NAV has been set.

<150> FIG. 15 illustrates various sequences in which non-contiguous PPDU transmission is applied according to another embodiment of the present invention.

<151> FIG. 15(a) illustrates a sequence in which, prior to DL MU transmission, the AP performs a CCA, detects that the lower 20MHz portion of the secondary 40MHz channel is busy, transmits an MU-RTS over the primary 40MHz and secondary 40MHz, and subsequently receives simultaneous CTS responses from the respective STAs over the designated bands before transmitting the DL MU PPDU. In this case, the MU-RTS must specify BW information to ensure that the receiving STAs can send CTS over the primary 40MHz and secondary 40MHz. However, this also depicts a situation where one or more STAs instructed to send CTS over the secondary 40MHz detect that the channel is busy or that a NAV has been set, thereby refraining from transmitting CTS in the secondary 40MHz. The AP then compares the bandwidth over which the MU-RTS was transmitted and the bandwidth over which the CTS responses were received, ensuring that the DL MU PPDU is transmitted only in the common bandwidth.

<152> FIG. 15(b) illustrates a sequence in which, prior to DL MU transmission, the AP performs a CCA, detects that the primary 80MHz channel is idle, transmits an MU-RTS over the primary 80MHz, and subsequently receives simultaneous CTS responses from the STAs. However, when the CTS responses are received, no signal is received from the secondary 40MHz channel, leading

the AP to transmit the DL MU PPDU over the primary 40MHz and secondary 40MHz instead. In this case, the MU-RTS and the DL MU PPDU must each specify BW information for the primary 80MHz and the primary 40MHz + secondary 40MHz, respectively. The BW information can be explicitly signaled through the BW field in the HE-SIG-A, as described in FIG. 8, or through the RA field in the HE-SIG-B, as described in FIG. 9.

<153> FIG. 15(c) illustrates a sequence in which, for UL MU transmission, the AP performs a CCA, detects that the secondary 20MHz channel is busy, transmits a Trigger signaling the primary 40MHz and secondary 40MHz, and subsequently receives UL MU PPDU from the respective STAs over the designated bands. In this case, the Trigger must specify BW information to ensure that the receiving STAs can transmit UL MU PPDU over the primary 40MHz and secondary 40MHz. Additionally, no transmitting STAs should be allocated within the secondary 20MHz channel. This also depicts a situation where one or more STAs instructed to transmit UL PPDU over the secondary 20MHz detect that the channel is busy or that a NAV has been set, thereby refraining from transmitting UL PPDU over the secondary 20MHz. In this case, the AP receives UL MU PPDU over the same or a narrower bandwidth than the bandwidth over which the Trigger was transmitted.

<154> FIG. 15(d) illustrates a sequence in which, for UL MU transmission, the AP performs a CCA, detects that the primary 80MHz channel is idle, transmits a Trigger over the primary 80MHz, and subsequently receives UL MU PPDU from the respective STAs over the designated bands. However, this also depicts a situation where one or more STAs that were allocated UL resources in the secondary 20MHz channel detect that the channel is busy or that a NAV has been set, thereby refraining from using the secondary 20MHz channel.

<156> FIG. 16 illustrates a method for setting an acknowledgment channel during non-contiguous PPDU transmission according to an embodiment of the present invention.

<157> FIG. 16(a) shows a case where a DL MU PPDU is transmitted using a contiguous PPDU bandwidth, and the corresponding multi-user acknowledgment is received in the form of an UL MU transmission. In this case, each STA that received data from the DL MU PPDU obtains information on the uplink acknowledgment (or data) transmission RU from either a separate Trigger frame MPDU included in the received A-MPDU or from the UL MU Response field in the header of a specific MPDU within the A-MPDU, and performs UL MU data transmission in the corresponding RU. FIG. 16(d) presents an example index structure for signaling the corresponding uplink RU allocation. The RU Allocation field is composed of 8 bits in total. The first bit performs signaling for the Primary/Secondary 80 MHz, and the following 7 bits indicate which RU within the 80 MHz band has been allocated. In this case, there is no issue even if each STA is instructed to transmit UL Ack using any arbitrary RU within the 80 MHz band occupied by the DL MU PPDU.

<158> However, as shown in FIG. 16(b), when a DL MU PPDU is transmitted using a non-contiguous PPDU bandwidth and the corresponding multi-user acknowledgment is received via UL MU, problems may arise due to the above RU Allocation signaling. If, as shown in FIG. 16(b), the acknowledgment channels for the DL MU PPDU are signaled through RU Allocation without specific constraints, it is possible that acknowledgments or data may be transmitted even in frequency bands that were not occupied by the DL MU PPDU, potentially causing collisions with OBSS. As described in FIGS. 14 to 15, the determination of a non-contiguous PPDU transmission may be made right before transmission based on the results of multi-channel CCA. Therefore,

reflecting this in real-time by reconfiguring the RU Allocation fields within the Trigger Frame or the UL MU Response field of each A-MPDU in the DL MU PPDU may not be feasible due to insufficient timing margin.

<159> To resolve the aforementioned issue, the present invention proposes a method in which constraints are imposed on the configuration of the uplink RU used for transmitting responses, based on the downlink RU configuration of the DL MU PPDU.

<160> When transmitting a DL MU PPDU, the AP must ensure that for any data transmitted in a given RU, the corresponding uplink Ack is received within the same 20 MHz band that contains that RU. Accordingly, RU Allocation signaling within the DL MU PPDU must instruct the uplink Ack transmission within that 20 MHz band. In the case where data is transmitted over 40 MHz or 80 MHz RUs using DL MU-MIMO, the AP must signal uplink Ack reception within the same 40 MHz or 80 MHz band. This is because for MU-MIMO, it is not feasible to construct a non-contiguous bandwidth PPDU by transmitting only a portion of the 40 MHz band. Thus, when MU-MIMO is used, it is permissible to designate Ack channels freely within the bandwidth occupied by the downlink data.

<161> Referring to the example of FIG. 16(c), when a non-contiguous bandwidth DL MU PPDU is transmitted by combining a Primary 40MHz and a Secondary 40MHz, signaling must be performed so that the Ack channel for data transmitted in the lower 20MHz band is received within the lower 20MHz band. In the case of the upper 40MHz band, if the corresponding band is used only for MU-MIMO, the Ack channel must be received within the upper 40MHz band. If the corresponding band is used for OFDMA, the Ack channel must be signaled to be received within the 20MHz band that includes the respective RU.

<163> FIG. 17 provides a detailed illustration of the frequency filtering aspects of the wideband PPDU transmission method described in FIG. 13(a) according to an embodiment of the present invention.

<164> FIG. 13(a) illustrates a scenario where a transmitter equipped with a single RF module, capable of supporting 160MHz, detects through CCA that the secondary 40MHz channel is busy and subsequently transmits a wideband PPDU using only one RF module over the idle primary 40MHz (a combination of primary 20MHz and secondary 20MHz) and secondary 80MHz. As described in FIG. 13(a), while filtering the secondary 40MHz channel, it is also possible to apply additional filtering to adjacent resource units (RUs) within the primary 20MHz channel. Initially, the centrally located 26RB within the primary 80MHz band is prioritized for filtering. Furthermore, if the additional adjacent transmission is likely to interfere with the OBSS transmission occurring within the secondary 40MHz, further filtering may be applied. The decision regarding additional RU filtering may be based on various factors, including the transmission power of the transmitting STA, the maximum transmission power allowed for each frequency band, and the received signal strength of the OBSS transmission.

<165> In this case, based on the result of the filtered secondary 40MHz CCA, the following operations may be performed. First, if a legacy PPDU using 64FFT/20MHz is detected in the secondary 40MHz, then, as described above, not only the 40MHz band but also the central 26 tones may be additionally filtered. Second, if a HE PPDU using 256FFT/20MHz is detected in the secondary 40MHz, the filtering of the central 26 tones may be determined based on the band occupied by the detected HE PPDU. If the detected HE PPDU is located at a frequency-domain

distance greater than a certain threshold from the central 26 tones, it is not necessary to filter the central 26 tones. If the distance is less than or equal to the threshold, the central 26 tones may be filtered. Third, if neither a legacy nor HE PPDU is detected in the secondary 40MHz and only an arbitrary wireless signal is detected, the filtering of the central 26 tones may be determined based on the bandwidth occupied by the detected signal. If the edge of the bandwidth occupied by the signal is at a distance greater than a certain threshold from the central 26 tones in the frequency domain, filtering of the central 26 tones is not necessary.

<167> FIG. 18 illustrates in detail the frequency filtering aspect of the method for transmitting a wideband PPDU as described in FIG. 13(b) according to an embodiment of the present invention.

<168> FIG. 13(b) illustrates a case where a transmitter equipped with a single RF module, supporting 160MHz, detects through CCA that the secondary 40MHz channel is busy and transmits a wideband PPDU using only one RF module over the idle primary 40MHz (a combination of primary 20MHz and secondary 20MHz) and secondary 80MHz. In this case, as described in FIG. 13(b), while filtering the secondary 40MHz channel, it is also possible to further filter adjacent resource units (RUs) in the primary 20MHz channel. Thus, in the primary 20MHz channel, narrowband RUs can be allocated in the adjacent region of the secondary 20MHz channel to minimize resource wastage.

<169> In this case, based on the result from the CCA of the filtered secondary 20MHz, the following operations may be performed. First, if a legacy PPDU using 64FFT/20MHz is detected

in the corresponding secondary 20MHz, not only the 20MHz band but also the central 26-tone and adjacent RUs may be additionally filtered as mentioned above. Second, if an HE PPDU using 256FFT/20MHz is detected in the corresponding secondary 40MHz, whether or not to filter the central 26-tone and adjacent RUs may be further determined according to the bandwidth occupied by the detected HE PPDU. If the detected HE PPDU is spaced more than a predetermined frequency distance away from the central 26-tone, there is no need to filter the central 26-tone and adjacent RUs. If the detected HE PPDU is within a predetermined frequency distance from the central 26-tone, the central 26-tone or the central 26-tone and adjacent RUs may be filtered. Third, if neither legacy nor HE PPDU is detected in the corresponding secondary 40MHz and only an arbitrary wireless signal is detected, whether or not to filter the central 26-tone may be determined based on the bandwidth occupied by the detected signal. If the edge of the frequency occupied by the signal is located farther than a predetermined distance from the central 26-tone in the frequency axis, there is no need to filter the central 26-tone and adjacent RUs.

<171> FIG. 19 illustrates the frequency filtering process in the transmission of a wideband PPDU according to the method depicted in FIG. 13(c).

<172> FIG. 13(c) illustrates a scenario where a transmitter equipped with two RF modules supports 80+80MHz transmission, wherein, if the CCA result indicates that the secondary 40MHz channel is busy, the wideband PPDU is transmitted using two RF modules over the idle primary 40MHz (a combination of primary 20MHz and secondary 20MHz) and secondary 80MHz. In this case, as described in FIG. 13(c), the secondary 40MHz channel is filtered out. However, since transmission

in the primary 40MHz channel follows the 40MHz spectral mask, additional filtering for adjacent RUs in the primary 40MHz channel is not required. Nevertheless, in this case, half of the centrally allocated 26RB within the primary 80MHz band must also be filtered. The signaling of this 26RB can be delivered through HE-SIG-B, as described in FIG. 20. However, as the RU is not used, the signaling information is not transmitted.

<174> FIG. 20 illustrates the configuration of HE-SIG-B in an HE MU PPDU transmitted over an 80MHz bandwidth according to an embodiment of the present invention.

<175> As shown in FIG. 20(a), when an 80MHz PPDU is transmitted, the L-STF, L-LTF, L-SIG, RL-SIG, and HE-SIG-A fields contain the same information, which is transmitted in the first 20MHz ('A' band) and identically repeated across the second ('B' band), third ('C' band), and fourth ('D' band) 20MHz bands. In contrast, for HE-SIG-B, the information transmitted in the first 20MHz and the second 20MHz may differ, whereas the information transmitted in the first 20MHz and third 20MHz, as well as in the second 20MHz and fourth 20MHz, remains identical. In this case, the HE-SIG-B information transmitted in each 20MHz band must contain the information necessary for the STAs receiving the MPDUs in that respective 20MHz band.

<176> Consequently, a receiving STA must simultaneously decode the HE-SIG-B transmitted over at least the first 20MHz and the second 20MHz bands to quickly determine whether its STA-specific information is included.

<177> FIG. 20(b) illustrates the detailed configuration of HE-SIG-B (A, C) transmitted in the 1st 20MHz (A) and 3rd 20MHz (C) bands. The RA_A || RA_C information, which contains OFDMA

frequency division allocation details for each A and C 20MHz band, is transmitted along with an additional CRC/Tail field for integrity verification. Each RA field is composed of 8 bits, structured as shown in FIG. 9(b). By analyzing this RA information, the number of STA-specific information elements included can be determined, and the STA-specific information is grouped in pairs, with each pair appended with a CRC/Tail. FIG. 20(b) depicts a case where an even number of STAs are allocated in both the A and C bands. In this scenario, the STA-specific information allocated to the A band (A1 to An) is grouped into pairs, each pair being appended with a CRC/Tail, and similarly, the STA-specific information allocated to the C band (C1 to Cn) is grouped into pairs, each pair appended with a CRC/Tail.

<178> Additionally, FIG. 20(b) also illustrates the detailed configuration of HE-SIG-B (B, D) transmitted in the 2nd 20MHz (B) and 4th 20MHz (D) bands. The detailed structure follows the same principles as HE-SIG-B (A, C).

<179> When transmitting an 80MHz OFDMA PPDU, as shown in FIG. 20(a), a 26RB (Resource Block) consisting of 26 subcarriers is positioned in the center frequency region. Since this 26RB resource cannot be clearly assigned to either the A, C bands or the B, D bands, it can be signaled in at least one or both of HE-SIG-B (A, C) and HE-SIG-B (B, D), as shown in FIG. 11(b). In the present invention, based on the RA_A and RA_C, as well as RA_B and RA_D information, a method is proposed in which the signaling always takes place in a predetermined HE-SIG-B channel, specifically the 1st 20MHz channel when both exist. Furthermore, the presence may be signaled through signaling other than the aforementioned RA information, and in this case as well, a method is proposed in which it is always located in a predetermined HE-SIG-B channel, specifically the 1st 20MHz channel. When transmitting a 160MHz or 80+80MHz OFDMA PPDU, one 26RB is

positioned in the center frequency region for each 80MHz band. In the present invention, based on the RA_A and RA_C as well as RA_B and RA_D information, if it is possible for both to exist, a method is proposed in which the central 26RB corresponding to the 1st 80MHz band is always located in the 1st 20MHz channel, and the central 26RB corresponding to the 2nd 80MHz band is always located in the 2nd 20MHz channel, each being predetermined HE-SIG-B channels. Furthermore, the presence may be signaled through signaling other than the aforementioned RA information, and in this case as well, a method is proposed in which it is always individually located in predetermined HE-SIG-B channels, specifically the 1st 20MHz channel and the 2nd 20MHz channel.

<181> FIG. 21 illustrates the configuration of HE-SIG-B in an HE MU PPDU transmitted as Full BW MU-MIMO according to an embodiment of the present invention.

<182> As shown in FIG. 21(a), when transmitted as Full BW MU-MIMO in an 80MHz bandwidth, the frequency RA (Resource Allocation) information in HE-SIG-B is omitted since it is not required. Instead, the information for STAs receiving MU-MIMO across the full bandwidth is divided and transmitted in the 1st 20MHz and 2nd 20MHz. Furthermore, the information transmitted in the 1st 20MHz and 3rd 20MHz, as well as in the 2nd 20MHz and 4th 20MHz, remains identical. In this case, the receiving STA must simultaneously decode HE-SIG-B received in at least the 1st 20MHz and 2nd 20MHz to quickly determine whether its STA-specific information is included.

<183> FIG. 21(b) illustrates a method, according to an embodiment of the present invention, in which the information in the SIG-B Dual MCS field of HE-SIG-A is reinterpreted as the number n of total STAs receiving the Full BW MU-MIMO PPDU. The original SIG-B Dual MCS field is used to indicate the MCS applied to the second channel when different MCS values are used for the

1st and 2nd HE-SIG-B channels. However, in the case of Full BW MU-MIMO, both 1/2 channels distribute user information evenly, eliminating the need for different MCS values. Therefore, as described in FIG. 8, when the SIG-B Compression mode is enabled in HE-SIG-A for Full BW MU-MIMO, the SIG-B Dual MCS field is repurposed to signal the number of receiving STAs in Full BW MU-MIMO.

<184> FIG. 21(c) illustrates the detailed configuration of HE-SIG-B (A_1), which is transmitted in the 1st 20MHz (A) and 3rd 20MHz (C) bands, and HE-SIG-B (A_2), which is transmitted in the 2nd 20MHz (B) and 4th 20MHz (D) bands. Based on the information of #_of_STA(n) included in HE-SIG-A, the number of STA-specific information fields included in each HE-SIG-B channel is determined by evenly dividing n. For example, if n is an even number, the STA-specific information is uniformly distributed as $n/2$ per HE-SIG-B channel, whereas if n is an odd number, one additional STA-specific information field is included in HE-SIG-B (A_1). In this case, the method of decoding the information of a total of n STAs is interpreted in such a manner that the first SIG-B channel is received from left to right, and then the second SIG-B channel is also received from left to right, as illustrated in FIG. 20(c). This means that even if the information from A1 to An is transmitted through different channels, it is logically interpreted in sequential order.

<186> FIG. 22 illustrates the encoding structure and composition of the HE-SIG-B field according to an embodiment of the present invention.

<187> The HE MU PPDU includes the HE-SIG-B field in its preamble, and the HE-SIG-B field contains the necessary information for interpreting the HE MU PPDU. FIG. 22(a) depicts the

encoding structure of the HE-SIG-B field according to an embodiment of the present invention. Referring to FIG. 22(a), the HE-SIG-B field is divided into Common and User-specific blocks. Additionally, the common block and user-specific blocks are separated in the bit domain and encoded based on 20 MHz units. The Common field contains information necessary for all receiving stations to decode the PPDU, including RU allocation, which provides details on RU arrangement and the number of users in MU-MIMO. The User-specific field contains information specific to each receiving station that is not included in the common field. The user-specific fields are arranged in the order of users assigned based on the RU allocation information in the common field. User-specific information includes STAID; NSTS (Number of Spatial Streams), TxBF (Transmit Beamforming), MCS (Modulation and Coding Scheme), DCM (Dual Sub-Carrier Modulation), and Coding (Use of LDPC) for a single user assigned to an RU; If multiple users are assigned to an RU, the user-specific field includes Spatial Configuration Fields, MCS, DCM, and Coding. The Common field forms a single BCC block, while the user-specific field forms a BCC block for every two users, and the last block may consist of a single BCC block for one user. Each BCC block includes CRC and Tail bits. Additionally, at the end of the HE-SIG-B field, padding is appended according to the OFDM symbol boundary.

<188> FIG. 22(b) illustrates the structure of the HE-SIG-B field when utilizing a bandwidth of 40 MHz or greater according to an embodiment of the present invention. Referring to FIG. 22(b), the HE-SIG-B field may be composed of two content channels (HE-SIG-B content channel 1 and HE-SIG-B content channel 2) in units of 20 MHz. In the FIG., each rectangle represents a 20 MHz sub-band, and the numbers 1 and 2 respectively contain different information. In 40 MHz, 80 MHz, and

160 MHz bandwidths, the HE-SIG-B field follows a repeating pattern of 1 and 2, as shown in the FIG. Each 20 MHz HE-SIG-B field includes both common and user-specific fields for the RU utilizing the respective 20 MHz band. Since HE-SIG-B can contain up to two different content types within each 20 MHz band, decoding these two HE-SIG-B content channels allows the reception of complete MU PPDU configuration information for the full bandwidth.

<190> FIG. 23 illustrates the encoding structure when HE-SIG-B compression is used according to an embodiment of the present invention.

<191> Referring to FIG. 23, in order to reduce the overhead of HE-SIG-B, the Common block of HE-SIG-B mentioned in FIG. 22 may be omitted, and this omission can be indicated by a subfield in HE-SIG-A. For example, if HE-SIG-A indicates compression, the Common block of HE-SIG-B is omitted, and instead of the missing Common block RU allocation information, it can be predetermined that the system will operate in full BW MIMO mode. In such cases, when transmitting a PPDU with a bandwidth greater than 20 MHz, the HE-SIG-B content channels become two, and the per-user information in the User-specific field can be split equitably between HE-SIG-B content channel 1 and HE-SIG-B content channel 2. As one embodiment, the per-user information for ceiling ($k/2$) users may be placed in HE-SIG-B content channel 1, while the remaining users' per-user information may be placed in HE-SIG-B content channel 2. If the total number of users, k , is an odd number, HE-SIG-B content channel 1 will contain one more per-user information entry than HE-SIG-B content channel 2.

<193> FIG. 24 illustrates the encoding structure when different MCS values are used for HE-SIG-B content channel 1 and HE-SIG-B content channel 2 according to an embodiment of the present invention.

<194> According to an embodiment of the present invention, the MCS of the HE-SIG-B field is not fixed but can be adjusted to reduce the overhead of HE-SIG-B. For example, a higher MCS index can be used within the range where the receiver can correctly decode HE-SIG-B. Additionally, the acknowledgment history of transmitted frames can be referenced for MCS determination.

<195> Referring to FIG. 24, different MCS values may be used for HE-SIG-B content channel 1 and HE-SIG-B content channel 2. The structure and content of each HE-SIG-B can be referenced from FIG. 22. When using HE-SIG-B compression mode, the Common block, which signals the number of per-user information entries included in HE-SIG-B content channels 1 and 2, is omitted, so the per-user information can be evenly split between HE-SIG-B content channel 1 and HE-SIG-B content channel 2, as described in FIG. 23. However, if, as in the embodiment of FIG. 23, ceiling $(k/2)$ per-user information entries out of a total of k users are included in HE-SIG-B content channel 1, and, as shown in FIG. 24, different MCS values are applied to each HE-SIG-B content channel while using a lower MCS for HE-SIG-B content channel 1, a situation may arise where the total number of OFDM symbols for HE-SIG-B becomes larger compared to when one additional per-user information entry is included in HE-SIG-B content channel 2.

<197> FIG. 25 is a table illustrating the number of bits in the HE-SIG-B User-Specific field and the required number of OFDM symbols according to the number of users, MCS index, and whether DCM is used, according to an embodiment of the present invention.

<198> Referring to FIG. 25, each per-user information entry may require 21 bits, and considering the CRC and tail bits included every two per-user entries, the total number of bits required for 1 to 8 per-user entries may be 31, 52, 83, 104, 135, 156, 187, and 208, respectively. FIG. 25 also shows the number of coded bits required per per-user information entry and the corresponding number of required OFDM symbols depending on the MCS index and whether DCM is used. For example, referring to FIGS. 24 and 25, in a case where HE-SIG-B compression mode is used, MCS 0 is used for HE-SIG-B content channel 1 without DCM, MCS 3 is used for HE-SIG-B content channel 2 without DCM, and the total number of users is 5, HE-SIG-B content channel 1 and 2 would respectively contain 3 and 2 per-user information entries. In this case, the required number of OFDM symbols for HE-SIG-B content channel 1 and content channel 2 would be 4 and 1, respectively, resulting in a total of 4 OFDM symbols required for HE-SIG-B. If, instead, HE-SIG-B content channel 1 and 2 had included 2 and 3 per-user information entries, respectively, then the required number of OFDM symbols for HE-SIG-B content channel 1 and content channel 2 would be 2 and 1, respectively, resulting in a total of 2 OFDM symbols required for HE-SIG-B. That is, when the total number of users is odd, if HE-SIG-B content channel 1 contains one additional per-user information entry, the total number of OFDM symbols required for transmitting HE-SIG-B increases.

<199> Furthermore, according to an embodiment of the present invention, regardless of whether

the HE-SIG-B compression mode is used, if increasing the MCS does not reduce the number of OFDM symbols, only the lowest MCS may be used within the range where the number of OFDM symbols does not increase, to achieve more robust transmission. For example, referring to FIG. 25, when three per-user information entries need to be represented in one HE-SIG-B content channel without using DCM, using MCS 2 does not reduce the number of OFDM symbols compared to using MCS 1, and using MCS 4 or MCS 5 does not reduce the number of OFDM symbols compared to using MCS 3. Therefore, MCS 1, 4, and 5 may not be used. Although FIG. 33 provides an example showing the number of bits and OFDM symbols required for per-user information, the present invention is not limited thereto. The same principle may be applied even when HE-SIG-B compression is not used and the Common block is included in HE-SIG-B. In other words, if using a higher MCS does not reduce the number of OFDM symbols, a higher MCS may not be used.

<200> Furthermore, according to an embodiment of the present invention, regardless of whether the HE-SIG-B compression mode is used, DCM may be employed if its use does not increase the number of OFDM symbols, thereby enabling more robust transmission. For example, when using MCS 3 and representing one or two per-user information entries in a single HE-SIG-B content channel, the required number of OFDM symbols remains the same at one, regardless of whether DCM is used. In such a case, DCM may be utilized for more robust transmission. Although the figures provide examples showing the number of bits and OFDM symbols required for per-user information, the present invention is not limited thereto. The same principle may be applied even when HE-SIG-B compression is not used and the Common block is included in HE-SIG-B. In other words, if using DCM does not increase the number of OFDM symbols, DCM may be employed.

<201> Furthermore, according to an embodiment of the present invention, when using the HE-SIG-B compression mode, it is possible to implicitly signal the number of users in the HE MU PPDU via HE-SIG-A. When HE-SIG-B compression mode is not used, the RU allocation is indicated in the Common block of HE-SIG-B, allowing the number of users to be determined. However, when using HE-SIG-B compression mode, the Common block of HE-SIG-B is omitted, making it necessary to indicate the number of users. Since HE-SIG-A explicitly signals the MCS, number of symbols, and DCM usage for HE-SIG-B, the number of users can be implicitly determined based on this information. In one embodiment, referring to FIG. 25, given the explicitly signaled MCS, number of symbols, and DCM usage, the minimum possible number of users can be determined. For example, if HE-SIG-B does not use DCM, uses MCS 0, and has four symbols, referring to FIG. 25, the possible number of users is 3 or 4, and it may be predetermined to use 3. In another embodiment, referring to FIG. 25, given the explicitly signaled MCS, number of symbols, and DCM usage, the maximum possible number of users can be determined. For example, if HE-SIG-B does not use DCM, uses MCS 0, and has four symbols, referring to FIG. 25, the possible number of users is 3 or 4, and it may be predetermined to use 4. Particularly, when HE-SIG-B uses DCM and MCS 0, the number of users can be determined exactly based on the number of symbols. Additionally, if it is difficult for the HE MU PPDU transmitter to match the number of users determined by the two implicit signaling methods mentioned above, dummy information may be inserted into some of the Per User information fields of HE-SIG-B. For example, the Per User information of an unused AID may be inserted, or the Per User information of an already-present AID may be duplicated. By implicitly signaling the number of users in HE-SIG-A as described in

the present invention, if HE-SIG-A contains a dedicated user count field, this field may be repurposed for other uses or reserved for future use.

<202> Furthermore, according to an embodiment of the present invention, since the combination of HE-SIG-B MCS, number of symbols, and DCM usage in the HE-SIG-A field is limited, if the receiver decodes HE-SIG-A and an impossible combination of HE-SIG-B MCS, number of symbols, and DCM usage appears, it can be determined that an error occurred in the transmission of HE-SIG-A. For example, referring to FIG. 25, when using the HE-SIG-B compression mode, if the MCS of HE-SIG-B is 0 and DCM is not used, the possible number of symbols is 2, 4, 6, 8, etc. However, if the receiver decodes HE-SIG-A and finds that it indicates HE-SIG-B with MCS 0, no DCM, and 5 symbols, it can be determined that an error has occurred. Although the case of using HE-SIG-B compression mode is provided as an example, the present invention is not limited thereto and can also be applied when HE-SIG-B compression mode is not used. In this case, the Bandwidth field of HE-SIG-A may also be referenced in making the determination. When HE-SIG-B compression mode is not used, the HE-SIG-B Common block exists, so the number of bits or symbols may differ from those in FIG. 25, and the number of users may exceed 8, but the same principle can be applied.

<204> FIG. 26 is a diagram illustrating an encoding structure when different MCS values are used for HE-SIG-B content channel 1 and HE-SIG-B content channel 2 according to an embodiment of the present invention.

<205> Referring to FIG. 26, in an embodiment to address the issue mentioned in FIGS. 24 and 25,

where the total number of users is an odd number, causing an odd number of Per User information entries to be included in HE-SIG-B content channel 1 and thereby increasing the total number of OFDM symbols required for HE-SIG-B, it is possible to allocate the Per User information of $\text{ceiling}(k/2)$ users among the total k users to the HE-SIG-B content channel that employs a high MCS, while including the remaining Per User information in the HE-SIG-B content channel that uses a low MCS. If the total number of users can be signaled through HE-SIG-A, the number of Per User information entries included in each HE-SIG-B content channel can be determined according to the MCS signaling for each HE-SIG-B content channel.

<206> In another embodiment, among the total k users, $\text{ceiling}(k/2)$ Per User information entries are included in HE-SIG-B content channel 1, while the remaining Per User information entries are included in HE-SIG-B content channel 2. In this case, if different MCS values are applied to each HE-SIG-B content channel, it is possible to apply a higher MCS to HE-SIG-B content channel 1 and a lower MCS to HE-SIG-B content channel 2.

<207> In yet another embodiment, HE-SIG-B compression and the application of different MCS values to the two HE-SIG-B content channels may not be performed together.

<209> FIG. 27 illustrates the configuration of HE-SIG-B when, according to an embodiment of the present invention, a filtering technique is applied to exclude a specific channel from data transmission while additionally filtering adjacent RUs.

<210> When transmitting an 80MHz PPDU, if the secondary 20MHz channel is busy, it is excluded, and while filtering the secondary 20MHz channel, adjacent RUs in the primary 20MHz channel (e.g., RU allocated to STA_An) are also additionally filtered. The resulting HE-SIG-B configuration in this case is shown in FIG. 27(b).

<211> At this time, the Common Info for the remaining A, C, and D bands is transmitted, followed by the STA information. If An RU is filtered and the corresponding STA information is deleted, it may cause confusion in receiving the subsequent STA information. To address this issue, a Null STA ID is inserted in the STA information field corresponding to RU An to indicate that the respective band has been filtered. The Null STA ID may either specify a particular STA ID or insert an STA ID that has not been assigned to any STA within the given BSS.

<213> FIG. 28 illustrates signaling methods of HE-SIG-B in a non-contiguous HE MU PPDU transmission according to an embodiment of the present invention.

<214> In the signaling method of HE-SIG-B described in FIG. 20, for non-contiguous transmission, the RA field of HE-SIG-B may indicate the filtered channel by marking the Null field of RA as defined in FIG. 9(b), thereby signaling that data is not transmitted on the respective channel.

<215> In this case, the Null information may either include bandwidth information of the nullified channel (e.g., 242, 484, 996) or be general Null information without specifying bandwidth. If the Null information includes bandwidth information, it can be determined whether the signaling of the 26RB has been additionally removed due to the non-contiguous transmission.

<216> As shown in FIG. 28(a), when S40A (C-band) is busy and does not transmit, the 1st and 2nd HE-SIG-B channels are signaled as illustrated in FIG. 20(b). In this case, by signaling the 242 Null in the 1st HE-SIG-B, the receiving STA can recognize that only the S40A band within the S40 band of the PPDU is nullified, which further indicates that the central 26RB is transmitted. Through this, it can be understood that additional central 26RB-related information is included in the predesignated 26RB transmission channel, specifically in the 1st HE-SIG-B.

<217> Additionally, as shown in FIG. 28(c), when S40 (C and D bands) is busy and no transmission occurs, the 1st and 2nd HE-SIG-B channels signal accordingly, as illustrated in FIG. 20(d). In this case, since 484 Null is signaled in both the 1st and 2nd HE-SIG-B, the receiving STA can recognize that the entire S40 band of the PPDU has been nullified, which further indicates that the central 26RB is also not transmitted. Through this, it can be identified that the central 26RB-related information is not transmitted in the 1st HE-SIG-B, which was pre-designated as the 26RB transmission channel.

<219> FIG. 29 illustrates methods for transmitting preambles and data when applying a filtering technique that prevents data transmission in specific channels, according to an embodiment of the present invention.

<220> FIG. 29(a) illustrates a case where an 80MHz PPDU is transmitted while the S40B (D-band) channel is busy, resulting in no data transmission in that channel.

<221> As shown above, when the CCA detects a busy channel, no signal is transmitted in that channel, including not only the data portion but also the preamble, spanning from the L-Part to the HE-STF/LTF.

<222> This has the advantage of avoiding interference with ongoing OBSS signals in the affected channel. Additionally, in wideband PPDU transmission, the transmission power is distributed across the full bandwidth, causing the per-channel transmission power to be lower compared to narrowband PPDU transmission. However, as shown in FIG. 29(a), by not transmitting in a specific channel, the transmission power is redistributed across the remaining channels, improving the PPDU reception rate.

<223> However, this approach may present the following issues. First, if the S20MHz channel is busy, the signaling burden of HE-SIG-B may concentrate on the P20MHz channel. However, this issue can be mitigated by using the PPDU configuration method described in FIG. 12(e). Second, since HE-STF exhibits a repeating pattern in the time domain when transmitted across the entire 80MHz bandwidth, if it is not transmitted in the busy channel(s), it becomes difficult to maintain the expected time-domain repetition pattern when received over the full bandwidth.

<224> To address these issues, as shown in FIG. 28(b), while the data portion is not transmitted in busy channels, the preamble portion may still be transmitted. FIG. 29(b) illustrates a case where a 160MHz PPDU is transmitted while the S40 (C and D bands), S80A (E band), S80B (F band), and S80D (H band) channels are busy, resulting in no data transmission in those channels. In this case, the preamble portion, including the L-Part and HE-STF/LTF, is still transmitted in the busy channels to resolve the issues discussed in FIG. 28(a). However, in this case, there is a disadvantage

that the transmission of the preamble portion may interfere with signals already being transmitted in OBSS. Nevertheless, in wideband PPDU transmission, since the transmission power is distributed across the full bandwidth, the level of interference to OBSS may not be significant.

<225> Furthermore, to minimize the issues described in FIGS. 29(a) and 29(b), as shown in FIG. 29(c), the HE-STF/LTF (or only HE-STF), which is most critical for reception in the preamble portion, may be transmitted across the full bandwidth even in busy channels. In this approach, transmissions of portions that do not require full-band reception, such as the L-Part, HE-SIG-A/B, and data sections, are restricted, while only the HE-STF/LTF portion, which requires full-band reception, is transmitted. This method minimizes interference with signals already being transmitted in OBSS while ensuring that the necessary preamble components are received properly.

<227> FIG. 30 illustrates the SIG-B transmission in the secondary 20MHz channel in the SIG-B-based non-contiguous PPDU transmission according to an embodiment of the present invention.

<228> As previously described, in 11ax DL MU PPDU, the SIG-B of P20 and S20 deliver different information simultaneously, and each of the corresponding information is repeated in the entire PPDU bandwidth in the form of 1/2/1/2 on a 40MHz basis.

<229> In this case, when using the SIG-B-based signaling schemes (FIGS. 41 to 42) in non-contiguous channel-based PPDU signaling, a problem occurs in that signaling cannot be properly performed if both the SIG-B channels of P20 and S20 mentioned above are not transmitted.

<230> In the case where the S20(B) and S40A(C) bands are busy and data is transmitted only in the P20(A) and S40B (D) bands as shown in FIG. 30, if the SIG-B of S20 is not transmitted, there

may be a problem in receiving the signaling information of the S40B (D) channel. That is, when the bandwidth is set to P80 in HE-SIG-A, all STAs will start receiving the SIG-B of at least P20 and S20, and in this case, if the signaling of S20 is absent, the signaling information of the S40B (D) channel may not be received.

<231> To address this, the following methods can be used.

<232> First, in non-contiguous channel-based PPDU transmission, the preamble can be transmitted over the entire bandwidth. The preamble portion may include the L-Part to the HE-STF/LTF sections. In this case, since the HE-STF can be transmitted over the entire bandwidth, there is an advantage that the receiving STAs can perform AGC over the entire bandwidth. Furthermore, since the full-band preamble is always transmitted, flexible channel bonding options can be adopted without the burden of signaling.

<233> Second, in non-contiguous channel-based PPDU transmission, only channel bonding options that enforce the transmission of both the P20 and S20 bands may be adopted. In this case, transmission up to P40 is always guaranteed, thereby maintaining the structure of SIG-B signaling, but there is a disadvantage in that the channel bonding options for non-contiguous channel-based PPDU transmission become restricted.

<234> Third, in non-contiguous channel-based PPDU transmission, even if data is not transmitted over the S20 band, the preamble portion up to HE-SIG-B may still be transmitted. However, this applies only in cases where data is not transmitted over the S20 channel, but data is transmitted in other bands for which the S20 SIG-B is responsible for signaling. If data is not transmitted over the S20 channel, and none of the bands where the S20 SIG-B is responsible for signaling have data

transmission, then transmission of SIG-B on the S20 channel is not necessary.

<236> FIG. 31 illustrates methods for configuring HE-SIG-B when transmitting an HE PPDU using a Non-Contiguous, Fixed Extension scheme according to an embodiment of the present invention.

<237> FIG. 31(a) depicts a scenario where an HE MU PPDU is transmitted over the entire 80MHz bandwidth while excluding the Secondary 20MHz band, utilizing only the Primary 20MHz and Secondary 40MHz channels. In this case, the BW bit field in HE-SIG-A signals the bandwidth in the form of P20+S40, and HE-SIG-B, which contains the information for (A, C, D) bands, is repeatedly transmitted over each available 20MHz channel. This approach reallocates the role of HE-SIG-B in the Secondary 20MHz band to the Primary 20MHz channel since the Secondary 20MHz channel is unavailable.

<238> FIG. 31(b) illustrates a scenario where an HE MU PPDU is transmitted over the entire 160MHz bandwidth while excluding the Secondary 20MHz band, utilizing only the Primary 20MHz, Secondary 40MHz, and Secondary 80MHz channels. In this case, the BW bit field in HE-SIG-A signals the bandwidth in the form of P20+S40+S80, and HE-SIG-B (A, C, D, E, F, G, H), containing information for the (A, C, D, E, F, G, H) bands, is repeatedly transmitted over each available 20MHz channel. This approach reallocates the role of HE-SIG-B in the Secondary 20MHz band to the Primary 20MHz channel since the Secondary 20MHz channel is unavailable.

<239> FIG. 31(c) illustrates a scenario where an HE MU PPDU is transmitted over the entire 160MHz bandwidth while excluding both the Secondary 20MHz and Secondary 40MHz bands, utilizing only the Primary 20MHz and Secondary 80MHz channels. In this case, the BW bit field in HE-SIG-A signals the bandwidth in the form of P20+S80, and HE-SIG-B, containing information for the (A, E, F, G, H) bands, is repeatedly transmitted over each available 20MHz channel. This approach reallocates the role of HE-SIG-B in the Secondary 20MHz band to the Primary 20MHz channel since the Secondary 20MHz channel is unavailable.

<240> FIG. 31(d) illustrates a scenario where an HE MU PPDU is transmitted over the entire 160MHz bandwidth while excluding the Secondary 40MHz band, utilizing only the Primary 40MHz and Secondary 80MHz channels. In this case, the BW bit field in HE-SIG-A signals the bandwidth in the form of P40+S80, and HE-SIG-B contains information for the (A, E, G) bands and the (B, F, H) bands separately. These are transmitted alternately as HE-SIG-B (A, E, G) and HE-SIG-B (B, F, H) over each Primary 20MHz channel, each Secondary 20MHz channel, and every subsequent 20MHz channel in an alternating manner. Unlike FIGS. 17(a), (b), and (c), in this case, the Secondary 20MHz channel is available, so the role of HE-SIG-B is not reallocated to the Primary 20MHz channel.

<241> Such variable configurations of HE-SIG-B can all be recognized through the BW field in HE-SIG-A. In this case, the BW field in HE-SIG-A signals one of the following configurations: P20, P40, P80, P160 (80+80), P20+S40, P20+S40+S80, P20+S80, or P40+S80.

<243> FIG. 32 illustrates a method for configuring HE-SIG-B when transmitting an HE PPDU using Non-Contiguous OFDMA between a single AP and a single STA according to an embodiment of the present invention.

<244> FIG. 32(a) shows a scenario where the STA transmits an HE MU PPDU over the entire 80MHz bandwidth while excluding the Secondary 20MHz band, utilizing only the Primary 20MHz and Secondary 40MHz channels. In this case, since the HE-SIG-A field defined for conventional HE SU PPDU transmission is not suitable for signaling Non-Contiguous PPDU transmission, the transmission follows the HE MU PPDU format to include HE-SIG-B. The BW bit field in HE-SIG-A signals the bandwidth in the form of P20+S40, and HE-SIG-B carries HE-SIG-B (SU Info), which contains the SU Data information for the (A, C, D) bands, repeating this information over each available 20MHz channel.

<245> Since the BW configuration of 20+40 has already been signaled in HE-SIG-A, the Common Info portion of HE-SIG-B is no longer necessary. Additionally, only a single SU Info portion of the STA-specific part of HE-SIG-B is required. Accordingly, HE-SIG-A must indicate that HE-SIG-B is in a Compression mode where Common Info is omitted. Such variable configurations of HE-SIG-B can be recognized through the BW field and the SIG-B Compression field in HE-SIG-A. In this case, the BW field in HE-SIG-A signals one of the following configurations: P20, P40, P80, P160 (80+80), P20+S40, P20+S40+S80, P20+S80, or P40+S80. Meanwhile, the SIG-B Compression field signals the Single STA HE MU transmission. In this case, the AID field of the SU info may insert the AID of the transmitting STA instead of the AID of the receiving AP. This is because, by setting the DL/UL subfield of the HE MU PPDU to UL, the AP can interpret the AID

in SIG-B as the AID of the transmitting STA, rather than its own AID, when the BSS Color in SIG-A matches its own BSS Color and the DL/UL subfield is set to UL. The same effect can also be achieved even when an AID assigned in consideration of the STA, rather than the STA's own AID, is inserted.

<247> FIG. 33 illustrates a method for configuring HE-SIG-B when transmitting an HE PPDU using the Contiguous, Flexible Extension approach according to an embodiment of the present invention.

<248> FIG. 33(a) depicts a scenario where an HE MU PPDU is transmitted over the entire 80MHz bandwidth while excluding the Secondary 40A MHz band, utilizing only the Primary 20MHz and Secondary 40B MHz channels. In this case, the BW bit field in HE-SIG-A signals the bandwidth in the form of P60, and HE-SIG-B includes HE-SIG-B (A) carrying information for the (A) band and HE-SIG-B (B, D) carrying information for the (B, D) bands, alternating their transmission across each 20MHz channel.

<249> FIG. 33(b) depicts a scenario where an HE MU PPDU is transmitted over the entire 160MHz bandwidth while utilizing the Primary 80MHz and Secondary 80A MHz channels. In this case, the BW bit field in HE-SIG-A signals the bandwidth in the form of P100, and HE-SIG-B includes HE-SIG-B (A, C, E), which contains information for the (A, C, E) bands, and HE-SIG-B (B, D), which contains information for the (B, D) bands, alternating their transmission across each 20MHz channel.

<250> FIG. 33(c) illustrates a scenario in which an HE MU PPDU is transmitted over the entire

160MHz bandwidth while utilizing the Primary 80MHz, Secondary 80A MHz, and Secondary 80B MHz channels. In this case, the BW bit field in HE-SIG-A signals the bandwidth in the form of P120, and HE-SIG-B includes HE-SIG-B (A, C, E), which contains information for the (A, C, E) bands, and HE-SIG-B (B, D, F), which contains information for the (B, D, F) bands, alternating their transmission across each 20MHz channel.

<251> FIG. 33(d) illustrates a scenario in which an HE MU PPDU is transmitted over the entire 160MHz bandwidth while utilizing the Primary 80MHz, Secondary 80A MHz, Secondary 80B MHz, and Secondary 80C MHz channels. In this case, the BW bit field in HE-SIG-A signals the bandwidth in the form of P140, and HE-SIG-B includes HE-SIG-B (A, C, E, G), which contains information for the (A, C, E, G) bands, and HE-SIG-B (B, D, F), which contains information for the (B, D, F) bands, alternating their transmission across each 20MHz channel.

<252> The variable configurations of HE-SIG-B as described above can all be recognized through the BW field in HE-SIG-A. In this case, the BW field in HE-SIG-A signals one of P20, P40, P80, P160 (80+80), P60, P100, P120, or P140.

<254> FIG. 34 illustrates a method for configuring HE-SIG-B when transmitting an HE PPDU structured using the Non-Contiguous, Flexible Extension approach according to an embodiment of the present invention.

<255> FIG. 34(a) depicts a scenario where an HE MU PPDU is transmitted over the entire 160MHz bandwidth, utilizing only the Primary 20MHz and Secondary 40AMHz channels. In this case, the BW bit field of HE-SIG-A signals all the utilized 20MHz channels in a bitmap format as shown in

FIG. 29(e), and HE-SIG-B (A, C), HE-SIG-B containing information for the (A, C) bands, is repeatedly transmitted in an alternating pattern across each 20MHz channel.

<256> FIG. 34(b) illustrates the transmission of an HE MU PPDU over the entire 160MHz bandwidth while using only the Primary 20MHz and Secondary 40MHz channels. Here, the BW bit field of HE-SIG-A signals all the utilized 20MHz channels in a bitmap format as shown in FIG. 29(e), and HE-SIG-B (A, D), HE-SIG-B containing information for the (A, D) bands, is transmitted in an alternating pattern across each 20MHz channel.

<257> FIG. 34(c) shows an HE MU PPDU transmission over the entire 160MHz bandwidth while utilizing the Primary 20MHz, Secondary 40MHz, and Secondary 80MHz channels. In this case, the BW bit field of HE-SIG-A signals all the utilized 20MHz channels in a bitmap format as shown in FIG. 29(e), and HE-SIG-B (A, C, E), HE-SIG-B containing information for the (A, C, E) bands, is transmitted in an alternating pattern across each 20MHz channel.

<258> FIG. 34(d) illustrates the transmission of an HE MU PPDU over the entire 160MHz bandwidth while utilizing only the Primary 20MHz, Secondary 40MHz, and Secondary 80MHz channels. In this case, the BW bit field of HE-SIG-A signals all the utilized 20MHz channels in a bitmap format as shown in FIG. 29(e), and HE-SIG-B (A, C, F), HE-SIG-B containing information for the (A, C, F) bands, is transmitted in an alternating pattern across each 20MHz channel.

<259> The variable configuration of HE-SIG-B, as described above, can be recognized through the BW bitmap field of HE-SIG-A. In this case, the BW bitmap field of HE-SIG-A signals the possible combinations of S20, S40A, S40B, S80A, S80B, S80C, and S80D.

<261> FIG. 35 illustrates a method for configuring HE-SIG-A and HE-SIG-B when transmitting an HE PPDU using the Non-Contiguous, Limited Flexible Extension scheme according to an embodiment of the present invention.

<262> In the Limited Flexible Extension scheme, specific frequency bands that must always be transmitted, including the Primary 20MHz band, are designated as Core Channels. In this FIG., the Core Channels are defined as the Primary 40MHz, which consists of the Primary 20MHz combined with the Secondary 20MHz. However, since these Core Channels are designated to prevent an excessive signaling burden on HE-SIG-B, they may be modified if the signaling burden of HE-SIG-B is not significantly increased.

<263> FIG. 35(a) illustrates a case where an HE MU PPDU is transmitted over a total bandwidth of 160MHz while using only the Primary 40MHz and the Secondary 40MHz channels. In this case, the BW bit field of HE-SIG-A signals 160MHz, and the 1st HE-SIG-B carries information for the (A, C) bands as HE-SIG-B (A, C, 996Null, 996Null), while the 2nd HE-SIG-B carries information for the (B) band as HE-SIG-B (B, 242Null, 996Null, 996Null). These HE-SIG-Bs are transmitted alternately across available 20MHz channels.

<264> FIG. 35(b) illustrates a case where an HE MU PPDU is transmitted over a total bandwidth of 160MHz while using only the Primary 40MHz and the Secondary 40MHz channels. In this case, the BW bit field of HE-SIG-A signals 160MHz, and the 1st HE-SIG-B carries information for the (A) band as HE-SIG-B (A, 242Null, 996Null, 996Null), while the 2nd HE-SIG-B carries information for the (B, D) bands as HE-SIG-B (B, D, 996Null, 996Null). These HE-SIG-Bs are transmitted alternately across available 20MHz channels.

<265> FIG. 35(c) illustrates a case where an HE MU PPDU is transmitted over a total bandwidth of 160MHz while using only the Primary 20MHz channel. In this case, the BW bit field of HE-SIG-A signals 160MHz, and the 1st HE-SIG-B carries information for the (A) band as HE-SIG-B (A, 242Null, 996Null, 996Null). Since the signaling burden on HE-SIG-B does not increase in this scenario, PPDU transmission is possible without occupying the core channels.

<266> FIG. 35(d) illustrates a case where an HE MU PPDU is transmitted over a total bandwidth of 160MHz while using only the Primary 40MHz, Secondary 40MHz, and Secondary 80MHz channels. In this case, the BW bit field of HE-SIG-A signals 160MHz, and the 1st HE-SIG-B carries information for the (A, C) bands as HE-SIG-B (A, C, 242Null, 484Null), while the 2nd HE-SIG-B carries information for the (B, F) bands as HE-SIG-B (B, 242N, F, 484Null). These HE-SIG-Bs are transmitted alternately across available 20MHz channels.

<268> FIG. 36 illustrates, according to an embodiment of the present invention, a method for configuring various HE PPDU bandwidth configurations when transmitting a PPDU using both a Non-Contiguous, Fixed Extension approach and a Contiguous, Flexible Extension approach.

<269> FIG. 36(a) shows all of the PPDU bandwidth options supported by the Non-Contiguous, Fixed Extension method, including the four PPDU BW options of conventional 11ac and the four new PPDU BW options presented in FIG. 20.

<270> P160, P80, P20+P40, P20+S40+S80, P20, P20+S80, P40, and P40+S80, totaling eight options, can be represented. To signal these configurations, the BW field in HE-SIG-A consists of 3 bits.

<271> FIG. 36(b) includes the four existing PPDU BW options of 11ac and the four new PPDU BW options described in FIG. 33, representing all PPDU BW options supported in the Contiguous, Flexible Extension method.

<272> P160, P80+S80A+S80B+S80C, P80+S80A+S80B, P80+S80A, P80, P20+S40, P20+S40B, P40+S40B, P40+S40B+S80A, P40+S40B+S80A+S80B, P40+S40B+S80A+S80B+S80C, P40+S40B+S80, P20, P40, P40+S80A, P40+S80A+S80B, P40+S80A+S80B+S80C, and P40+S80, totaling 18 options, can be represented. To signal these configurations, the BW field in HE-SIG-A consists of 5 bits.

<273> Additionally, the method in FIG. 27(a) has the disadvantage that, as shown in FIG. 31, for PPDU BW configurations where transmission does not occur in the secondary 20MHz channel, the signaling burden of HE-SIG-B is increased on the primary 20MHz channel. To offset this, PPDU options that do not use the secondary 20MHz channel can be excluded from the BW options in FIG. 36(a). In this case, a total of five options, P160, P80, P20, P40, and P40+S80, can be represented. To signal these configurations, the BW field in HE-SIG-A consists of 3 bits.

<274> Additionally, the method in FIG. 27(b) has the disadvantage that, as shown in FIG. 33, for PPDU BW configurations where transmission does not occur in the secondary 20MHz channel, the signaling burden of HE-SIG-B is increased on the primary 20MHz channel. To offset this, PPDU options that do not use the secondary 20MHz channel can be excluded from the BW options in FIG. 36(b). In this case, a total of 16 options, P160, P80+S80A+S80B+S80C, P80+S80A+S80B, P80+S80A, P80, P40+S40B, P40+S40B+S80A, P40+S40B+S80A+S80B, P40+S40B+S80A+S80B+S80C, P40+S40B+S80, P20, P40, P40+S80A, P40+S80A+S80B,

P40+S80A+S80B+S80C, and P40+S80, can be represented. To signal these configurations, the BW field in HE-SIG-A consists of 4 bits.

<276> FIG. 37 illustrates a method for configuring various HE PPDU BWs when transmitting a PPDU using the Non-Contiguous, Limited Flexible Extension method according to an embodiment of the present invention.

<277> FIG. 37(a) illustrates the PPDU BW options that can be represented using HE-SIG-B Null signaling, as described in FIGS. 12 and 26, in a PPDU with BW = 80MHz.

<278> FIG. 37(b) illustrates the PPDU BW options that can be represented using HE-SIG-B Null signaling, as described in FIGS. 12 and 26, in a PPDU with BW = 160MHz. In this case, the portion corresponding to P80MHz (denoted as Variable) may include the PPDU configurations shown in FIG. 28(a). However, in the case of the last option in FIG. 37(a), which transmits only P20, it is appropriate to combine it only with configurations that do not increase the HE-SIG-B signaling burden in FIG. 37(b) (e.g., S80A, S80C, S80A+S80C). In other cases, combinations with options that maintain core channels without increasing the HE-SIG-B signaling burden are possible.

<279> In FIG. 37, the presence or absence of the central 26RB in each 80MHz segment depends on the selected PPDU BW option. This can be signaled and recognized according to the method described in FIG. 28. However, since the PPDU BW options are diverse and calculating the presence or absence of the central 26RB for each case may be complex, it can be explicitly signaled through HE-SIG-A or other fields.

<281> FIG. 38 illustrates a method of combining various HE PPDU BWs by integrating the combinations generated based on the principles of HE PPDU BW configuration according to an embodiment of the present invention.

<282> FIG. 38(a) illustrates a combination that mixes the method of FIG. 36(a) with the method of FIG. 36(b). In this case, by excluding the overlapping combinations from both methods and adding P20+S40+S80 and P20+S80 from FIG. 36(a) to FIG. 36(b), a total of 20 options can be represented in FIG. 29(a). To signal this, the BW field in HE-SIG-A is configured with a total of 5 bits.

<283> As illustrated in FIG. 38(b), the various BW options generated through the wideband PPDU configuration principles proposed in FIG. 12 may be subject to omission based on additional conditions such as the mandatory inclusion of a secondary 20MHz channel for HE-SIG-B, CCA requirements, and the allowable maximum number of non-contiguous bandwidths.

<284> Additionally, the various BW options generated by the wideband PPDU configuration principles may be implemented as combined BW options through arbitrary combination principles. In this case, the aforementioned additional conditions may be applied after the combination process to eliminate certain BW options.

<286> FIG. 39 illustrates methods for signaling a non-contiguous channel-based PPDU according to an embodiment of the present invention.

<287> As shown in the FIG., an AP intending to transmit an 80MHz DL OFDMA PPDU performs multi-channel CCA, and if the lower 20MHz band of the S40MHz channel is determined to be busy, it nulls the data tones of that channel (i.e., no signal transmission) while transmitting only the tones of the other available channels. The FIG. presents methods for signaling this scenario.

<288> First, the BW subfield of HE-SIG-A can be used to explicitly indicate the non-contiguous channel bandwidth of the entire PPDU. In the illustrated case, the BW subfield transmits the index corresponding to P40+S40A.

<289> Second, the newly defined 242 Null, 484 Null, and 996 Null (or a single Null) indicators can be used in the RU allocation subfield at the front of HE-SIG-B to signal that the corresponding RUs (Resource Units) are null (i.e., no signal transmission).

<290> Third, a newly defined Null STA ID indicator in the STAID field within the User-specific subfield located at the rear of HE-SIG-C can be used to signal that no STA is assigned to receive information in the corresponding RU.

<291> These three methods are discussed in more detail in other figures of the present invention.

<293> FIG. 40 illustrates a method for signaling a non-contiguous channel-based PPDU through the BW subfield of SIG-A according to an embodiment of the present invention.

<294> As described in FIG. 39, the BW subfield of HE-SIG-A explicitly indicates the channels over which the entire PPDU is transmitted. In the example of the PPDU shown in the FIG., it is signaled as P40+S40A.

<295> At this time, in addition to the existing contiguous channel-based PPDU BW options of 20/40/80/160, the BW subfield must also include newly defined BW options according to the non-contiguous channel aggregation technique defined in the present invention.

<296> At this time, it should be noted that, for example, in the case of a PPDU configuration transmitted only in P20, there can be both a contiguous P20 PPDU and a non-contiguous P20 PPDU. A contiguous P20 refers to a PPDU that is initially designed to be transmitted solely within the P20 bandwidth, considering only that bandwidth from the beginning.

<297> A non-contiguous P20, on the other hand, refers to a case where multi-channel CCA is performed to transmit a PPDU such as P80, P160, or P80+S80, and after the CCA results indicate that all secondary channels are busy, those channels are nulled, and transmission occurs only in the P20 channel.

<298> The above two cases share the common characteristic that the actual data is transmitted in the P20 channel. However, since the transmitted data tones, DC tone positions, and configurations differ, it is essential to indicate them separately through distinct signaling.

<300> FIG. 41 illustrates methods for signaling non-contiguous channel-based PPDU through the RU allocation subfield of SIG-B according to an embodiment of the present invention.

- <301> This method signals the nulling status of subchannels through the RU allocation subfield of HE-SIG-B in the scenario described in FIG. 39.
- <302> In this case, the BW subfield of HE-SIG-A indicates only the BW of the entire PPDU originally configured by the AP, thereby specifying the overall data tone and DC tone configuration and positioning.
- <303> The RU allocation subfield of HE-SIG-B is positioned at the beginning of SIG-B and specifies, in at least 20MHz units, how the frequency RUs are divided within the channel and the number of STAs allocated to each RU. At this point, newly defined indices such as 242 Null, 484 Null, 996 Null, or simply Null can be added to the RU allocation index to signal that the corresponding area is nullified and that data tones are not transmitted.
- <304> In a DL MU PPDU format, the HE-SIG-B is transmitted in parallel with separate information over the P20 channel and the S20 channel. The signaling methods under these circumstances are as follows:
- <305> First, as shown in FIG. 41, when the lower 20MHz of the S40MHz channel is nullified, the second RA (RU Allocation) field of the SIG-B for S20, which transmits signaling for the B and D channels, can indicate "242 Null," while the second RA of P20 SIG-B can indicate "242 (Non-Null)." In this case, each SIG-B channel performs independent and explicit signaling, enabling individual signaling of the Null/Non-Null configuration per 20MHz unit.
- <306> Second, in the same example, the second RA field of S20 SIG-B, which transmits signaling for the B and D channels, may indicate "484 Null" instead of "242 Null," while the second RA of P20 SIG-B may indicate "242 (Non-Null)." In this case, the 484 Null in S20 SIG-B performs Null

signaling over a broader area than the original Null. However, the appropriate interpretation of the RA field in P20 SIG-B allows the identification of Non-Null channels.

<307> Third, in the same example, the second RA field of S20 SIG-B, which transmits signaling for the B and D channels, may indicate "Null" instead of a Null value that includes BW information such as 242/484/996, while the second RA of P20 SIG-B may indicate "242 (Non-Null)." In this case, the Null in S20 SIG-B implicitly indicates a bandwidth of only 242 (20MHz). Subsequently, the appropriate interpretation of the RA field in P20 SIG-B allows the identification of Non-Null channels.

<308> As described above, when using the RU allocation field of SIG-B to signal the null regions of a non-contiguous channel-based PPDU, it becomes evident to receiving STAs that the User Specific information corresponding to those RUs is not transmitted at all, as illustrated in the FIG.

<310> FIG. 42 illustrates a method of signaling a non-contiguous channel-based PPDU through the User Specific subfield of SIG-B according to an embodiment of the present invention.

<311> In the scenario of FIG. 39, this method signals that specific data tones have been nulled using the AID subfield within the User Specific subfield of HE-SIG-B.

<312> First, in this case, the BW subfield of HE-SIG-A indicates only the BW of the entire PPDU originally configured by the AP, thereby specifying the overall configuration and location of data tones and DC tones.

<313> Additionally, the RU allocation subfield of HE-SIG-B signals "242 (Non-Null) 1STA" for

the corresponding subchannel. This indicates that a single STA is assigned to a 242RU and that one User Specific subfield will be transmitted subsequently for this STA.

<314> The number of User Specific subfields within HE-SIG-B is determined based on the RU allocation subfield, which specifies the assigned RUs and the number of STAs per RU.

<315> At this time, a Null AID is inserted into the AID field of the User Specific subfield that indicates the STA ID. The Null AID may be an unassigned AID that is available within the BSS but has not yet been allocated to any STA, a reserved AID that has been designated as unused, or an arbitrarily defined specific AID value.

<316> Through this mechanism, no STA will recognize the corresponding RU as an RU it should receive, thereby ensuring that the RU is not received, effectively signaling that the RU has been nulled.

<318> FIG. 43 illustrates a method for signaling a specific Center 26 RU located at the center through the User Specific subfield of SIG-B when signaling a non-contiguous channel-based PPDU according to an embodiment of the present invention.

<319> The method of signaling a non-contiguous channel-based PPDU using the User Specific subfield of SIG-B, as described in FIG. 42, has a drawback in that the STAs receiving the DL OFDMA PPDU cannot fully understand the BW configuration of the PPDU from the initial part of HE-SIG-B. Consequently, it becomes impossible to determine the presence of the Center 26 RU in the middle of an 80MHz PPDU from the beginning of SIG-B. To address this issue, as shown in

the FIG., a STA Specific subfield corresponding to the Center 26 RU must always be inserted into an arbitrary SIG-B channel that signals the Center 26 RU (e.g., the P20 channel). If the Center 26 RU does not exist due to the nulling of other channels, it should be signaled using a Null AID.

<320> If the method described in FIG. 42, which signals the Null AID using an unused reserved AID or a predefined specific AID value, is used, STAs receiving the PPDU may be able to recognize the presence or absence of the Center 26 RU. However, since this recognition is only possible after successfully receiving the User Specific subfield in a different (or the same) SIG-B channel rather than being signaled in the RA field at the beginning of SIG-B, it cannot be reliably ensured to function at all times.

<321> Therefore, when using the Null AID technique in the User Specific field to signal a non-contiguous channel-based PPDU, it may be preferable to always transmit the signaling for the Center 26 RU, regardless of whether actual data transmission occurs.

<323> FIG. 44 illustrates a method of extending the Null AID-based signaling described in FIG. 42 to indicate unallocated RUs in contiguous channel-based PPDU transmission.

<324> In a DL OFDMA PPDU, up to nine RUs exist within a 20 MHz band, each consisting of 26 subcarriers. When transmitting data using these nine RUs but utilizing only eight of them while leaving one RU without data transmission, a method is required to signal this configuration. Similarly, in an 80 MHz PPDU, up to 37 RUs exist, and cases may arise where data is not transmitted in certain RUs, necessitating a signaling method.

<325> To achieve this, the User Specific subfield in HE-SIG-B can insert a Null AID in the User Specific subfield corresponding to the Null RU, indicating that the RU is not transmitted. The Null AID may be an unassigned AID among the range of 1 to 2007, a reserved AID beyond 2007, or a mutually agreed specific Null AID within the range of 1 to 2007.

<326> If the method of using unassigned AIDs is employed, a drawback arises in cases where all AIDs have been allocated to STAs, making it impossible to perform the aforementioned Null RU signaling. Additionally, if the designated AID is in use by a neighboring OBSS with the same BSS Color, the STA of that OBSS may attempt to receive the transmission.

<327> On the other hand, if a reserved AID beyond 2007 or an arbitrarily defined specific Null AID is used, assigning a single AID field allows both the BSS and OBSS to clearly recognize that the corresponding channel is not in use. Moreover, this method ensures signaling remains feasible even when all AIDs within the range of 1 to 2007 have been allocated.

<329> FIG. 45 is a drawing illustrating methods of non-contiguous PPDU B-mode signaling.

<315> An HE MU PPDU may be transmitted using a contiguous PPDU bandwidth of 20/40/80/160 (80+80) MHz. When signaling a bandwidth of 160 MHz PPDU, this may represent a PPDU configuration of 80+80 MHz. In this case, the configuration of 160 MHz or 80+m MHz within a single BSS is static and not dynamically converted. The specific frequency region in the 5 GHz

band is clearly understood by prior information exchange between the AP and the STA. Therefore, even when signaling both 160 MHz contiguous frequency PPDU and 80+80 MHz non-contiguous PPDU as a single mode, there is no ambiguity. The term “non-contiguous PPDU bandwidth” as defined in this figure refers to additional non-contiguous PPDU bandwidth configurations other than the 80+80 MHz configuration.

<331> The HE MU PPDU performs signaling via SIG-A and SIG-B. SIG-A indicates the overall PPDU information including the PPDU bandwidth, while SIG-B transmits information for simultaneous transmission of multiple users.

<332> When designing signaling methods for non-contiguous BW PPDU transmission, the following constraints must be considered:

<333> 1. All non-contiguous BW PPDU options must occupy the primary 20 MHz channel.

<334> 2. In SIG-A, whether or not the second SIG-B information is transmitted must be signaled, or if the second information is transmitted over a channel other than the secondary 20 MHz channel, the specific transmission channel must be indicated. For contiguous PPDU bandwidths excluding 20 MHz PPDU, SIG-B signaling is performed as shown in FIG. 42(a): the first information is transmitted on the primary 20 MHz channel, and the second, different information is transmitted on the secondary 20 MHz channel. In PPDU of 40 MHz bandwidth or higher, these pieces of information are signaled in a repeating pattern of 1/2/1/2/... on a 40 MHz basis. Therefore, in the case of non-contiguous BW PPDU transmission, if the second information is transmitted via a

channel other than the secondary 20 MHz channel, this must be signaled in SIG-A, which precedes the reception of SIG-B.

<335> 3. In SIG-A, the size information of the Common Block in SIG-B must be explicitly signaled or information that allows inference of the size must be signaled. The subfields of SIG-B are divided into a Common Block and a Per User Info portion, as shown in FIG. 45(b). In the case of a contiguous PPDU bandwidth, the length of the Common Block can be clearly identified via the BW field in SIG-A. For example, when BW = 20 MHz, SIG-B transmits only the first information, and the corresponding Common Block of the first information consists of one RU Allocation information and one CRC/Tail. For example, when BW = 80 MHz, SIG-B transmits the first and second different pieces of information over distinct 20 MHz channels. In such a case, each piece of information's Common Block consists of two RU Allocation information elements and one CRC/Tail. If, during the reception of a non-contiguous BW PPDU, the size of the Common Block is unclear prior to the reception of SIG-B, proper reception of the SIG-B Common Block may not be possible. Therefore, even during non-contiguous BW PPDU transmission, SIG-A must explicitly signal the size of the SIG-B Common Block or signal information from which the size can be inferred.

<336> The signaling method for non-contiguous BW PPDU transmission may be implemented in one of the following ways: SIG-A-only signaling, SIG-B-only signaling, or cooperative signaling between SIG-A and SIG-B.

<337> First, in the case of the SIG-A-only signaling method, as illustrated in FIG. 45(b), the BW

subfield of SIG-A is used to include existing contiguous PPDU options, and additionally to explicitly signal non-contiguous PPDU options. This approach has the advantage that overall PPDU information can be rapidly conveyed through SIG-A alone, without additional signaling burden on SIG-B. However, as shown in FIG. 8(b), this method has the drawback that due to the limited number of available bits in SIG-A, it may not be possible to signal a wide variety of non-contiguous PPDU bandwidth options. To address this limitation, among the subfields of the SIG-B field in the HE MU PPDU illustrated in FIG. 8(b), subfields that do not need to be signaled in the case of non-contiguous BW PPDUs can be repurposed to carry BW information. For example, in the case of the Full BW MU-MIMO subfield in FIG. 8(b), when a non-contiguous PPDU BW option is indicated by the BW subfield, it is self-evident that Full BW MU-MIMO is not possible. Therefore, this subfield can be repurposed. This subfield can either be used to signal non-contiguous PPDU BW options or be used for other purposes.

<338> Second, in the case of the SIG-B-only signaling method, SIG-A signals only the existing contiguous PPDU BW options, and as shown in FIG. 45(b), SIG-B signals the information regarding nulled channels either in the Common Block or in the Per User Info Block. This method has the advantage of reducing the signaling overhead in SIG-A. However, it also has the disadvantage that the signaling overhead in SIG-B may increase, or redundant SIG-B information may be transmitted that could have been omitted if the non-contiguous PPDU information had been signaled in advance in SIG-A.

<339> Third, in the cooperative signaling method between SIG-A and SIG-B, a portion of the non-contiguous PPDU bandwidth configuration information is first transmitted via SIG-A, and the

remaining additional information is signaled via SIG-B. The methods for dividing information between SIG-A and SIG-B are as follows:

<340> 1. SIG-A signals the detailed configuration information of the primary 80 MHz PPDU and whether the secondary 80 MHz is to be transmitted. If the transmission of the secondary 80 MHz is indicated in SIG-A, then SIG-B may signal the detailed configuration information of the secondary 80 MHz PPDU.

<341> 2. SIG-A signals the transmission channel information for the second SIG-B information and the size information of the SIG-B Common Block. Using this information, SIG-B can signal the detailed PPDU configuration information.

<342> 3. If non-contiguous BW PPDU transmission always includes a primary 40 MHz, SIG-A can signal the size information of the SIG-B Common Block.

<344> FIG. 46 illustrates an embodiment in which the SIG-B channels are fixed, among the SIG-A-only signaling methods described in FIG. 45.

<345> First, the BW subfield of SIG-A may signal the four existing contiguous PPDU bandwidth options — 20/40/80/160 (80+80) MHz — as shown in FIG. 46(a). Additionally, the BW subfield of SIG-A may signal non-contiguous PPDU bandwidth options as shown in FIGS. 46(b) to 46(e). In this case, as explained in FIG. 45, it is assumed that the channels over which SIG-B information is transmitted are fixed to the primary 40 MHz. This configuration offers the advantage that, when the receiving STA has two decoders to receive SIG-B information, the first decoder can be fixed to P20 and the second decoder can also be fixed to S20. However, if the S20 channel is busy, it

becomes impossible to configure a non-contiguous PPDU, thereby limiting the flexibility of non-contiguous PPDU configurations.

<346> If the total number of bits available for the BW subfield is limited to 3 bits, up to four additional non-contiguous PPDU bandwidth options may be supported. One example configuration is illustrated in FIG. 46(b). Specifically, within the primary 80 MHz band, two configurations (P40+S40A and P40+S40B) are possible. For each of these, two secondary 80 MHz configurations may be added, resulting in a total of four options. These two secondary 80 MHz configurations may be structured as shown in FIG. 46(c).

<347> If the total number of bits in the BW subfield is limited to 4 bits, up to twelve non-contiguous PPDU bandwidth options may be added, and their configuration may be as illustrated in FIG. 46(d). Specifically, starting from two configurations within the primary 80 MHz band (P40+S40A and P40+S40B), each configuration may be extended by six additional secondary 80 MHz configurations, resulting in a total of twelve options. These six secondary 80 MHz configurations for each case may be composed of bandwidth options capable of utilizing at least 40 MHz within the secondary 80 MHz band, as shown in FIG. 46(e).

<349> FIG. 47 illustrates an embodiment in which the SIG-B channels are variable, among the SIG-A-only signaling methods described in FIG. 45.

<350> First, the BW subfield of SIG-A must be able to signal the four existing contiguous PPDU bandwidth options — 20/40/80/160 (80+80) MHz. In total, the BW subfield of SIG-A may signal both contiguous and non-contiguous PPDU bandwidth options in an integrated manner, as shown

in FIGS. 47(a) to 47(d). In this case, as explained in FIG. 45, it is assumed that the channels over which SIG-B information is transmitted are not fixed to the primary 40 MHz. This assumption imposes the constraint that, when the receiving STA is equipped with two decoders for receiving SIG-B information, the first decoder is fixed to P20, while the second decoder must have the capability to switch among S20, S40A, and S40B channels. However, this approach has the advantage of providing greater flexibility in non-contiguous PPDU configuration, since non-contiguous PPDU transmission remains possible even when some of the S20, S40A, or S40B channels are busy.

<351> FIG. 47(a) illustrates a configuration in which the primary 80 MHz channel includes P20, and there is no second SIG-B channel.

<352> FIG. 47(b) illustrates a configuration in which the primary 80 MHz channel includes P40, and the second SIG-B channel exists on S20.

<353> FIG. 47(c) illustrates a configuration in which the primary 80 MHz channel includes P20 and S40A, and the second SIG-B channel exists on S40A. In this case, the receiving STA positions its second decoder on S40A based on the signaling information provided by SIG-A, and receives SIG-B information through P20 and S40A. Originally, in a contiguous PPDU configuration, S40A is the channel that delivers the same first SIG-B information as P20. However, in a non-contiguous PPDU configuration, as in FIG. 47(c), when there is no other second SIG-B channel besides S40A within the primary 80 MHz channel, S40A must deliver second SIG-B information that differs from that of P20. In this case, if the S80 channel is not utilized, the first SIG-B information on P20 delivers information for the P20 channel, and the second SIG-B information on S40A delivers

information for the S40A channel. If the S80 channel is utilized, the first SIG-B information on P20 delivers information for the P20, S80A, and S80C channels, while the second SIG-B information on S40A delivers information for the S40A, S80B, and S80C channels.

<354> FIG. 47(d) illustrates a configuration in which the primary 80 MHz channel includes P20 and S40B, and the second SIG-B channel exists on S40B. In this case, the receiving STA positions its second decoder on S40B based on the signaling information provided by SIG-A, and receives SIG-B information through both P20 and S40B.

<355> If all of the PPDU bandwidth options shown in FIG. 47 are to be signaled in SIG-A, then the BW subfield of SIG-A would require 4 bits. If signaling is to be performed using only 3 bits, then four options must be selected from among the non-contiguous PPDU bandwidth options shown in FIG. 47.

<356> Furthermore, the PPDU bandwidth options illustrated in FIG. 47 can only signal whether or not the S80 is utilized. Therefore, to signal more diverse options regarding S80 usage, such as those illustrated in FIG. 46(e), the P80 PPDU bandwidth options shown in FIG. 47 may be combined with those in FIG. 46(e) to enable signaling of a broader variety of configurations. To explain this in more detail, among all the PPDU BW options shown in FIG. 47, the options of 20, 40, 80, and 160(80+80) are first included, and excluding the cases where the second SIG-B channel does not exist (FIG. 47(a)) or where the second SIG-B channel overlaps with the first SIG-B channel (FIG. 47(c)), the remaining PPDU options can be represented as a combination of the maximum bandwidth of the entire PPDU (80 or 160) and the position of the second SIG-B channel (A or B). Using this method, the PPDU BW options in FIG. 47 can first be signaled in HE-SIG-A with only

3 bits as 20, 40, 80, 160, 80A, 80B, 160A, and 160B. Then, using the Null RU signaling method indicated in FIG. 41 within HE-SIG-B, the nulled channels within the 80MHz or 160MHz band can be additionally indicated.

<358> FIG. 48 illustrates an embodiment in which the SIG-B channels are variable within a P80 configuration, among the SIG-A/SIG-B cooperative signaling methods described in FIG. 45.

<359> First, the BW subfield of SIG-A represents information in the form of (X, Y).

<360> X indicates the location of the second SIG-B channel within the primary 80 MHz channel.

If 2 bits can be allocated for this information, it is possible to indicate any one of the four channels: P20, S20, S40A, or S40B. If only 1 bit can be allocated, it is possible to indicate either S20 or S40B, a total of two channels. In the latter case, even if the SIG-B channel is transmitted only on P20, signaling would indicate that it is also transmitted on S20. In such a scenario, the receiver may attempt to decode the SIG-B information on S20; however, since no signal is actually transmitted on that channel, the decoding will ultimately fail. This behavior does not cause a problem in the case of a PPDU transmission configured solely with P20.

<361> Y indicates the size of the Common Block in SIG-B. If 2 bits can be allocated for this information, the size of the Common Block can be specified to include 1, 2, 3, or 4 RU Allocation subfields. If only 1 bit can be allocated, the Common Block can indicate sizes including only 2 or 4 RU Allocation subfields. In the latter case, unnecessary RU Allocations may be additionally transmitted. However, by inserting Null Indexes into the corresponding RU Allocation information, as described in FIG. 41, the transmission of Per User Info can be suppressed, thereby preventing

additional signaling overhead.

<362> Using the (X, Y) information indicated in the BW subfield of SIG-A as described above, the receiving STA determines, based on X, the channel(s) on which to receive SIG-B within the P80 configuration, and decodes the SIG-B Common Block based on Y. Subsequently, using the information in the RU Allocation subfields within the Common Block, the STA can determine whether any of the channels are additionally nulled. If multiple RU Allocations are present and it is unclear which frequency bands within the maximum 160 MHz bandwidth they correspond to, an additional signaling subfield within the Common Block, called the RU Indication, may be used to identify which channel each RU Allocation refers to. The RU Indication subfield may represent up to eight 20 MHz channels within the maximum 160 MHz bandwidth using a bitmap, and indicate sequentially which channels the subsequent RU Allocation information corresponds to.

<364> As described above, the present invention has been explained using wireless LAN communication as an example. However, the invention is not limited thereto and may be equally applied to other communication systems, including cellular communication. Furthermore, while the methods, devices, and systems of the present invention have been described in relation to specific embodiments, all or part of the components and operations of the invention may be implemented using a computer system with a general-purpose hardware architecture.

<365> The foregoing description of the present invention is provided for illustrative purposes, and the person having ordinary skill in the art will understand that various modifications can be made without departing from the technical spirit or essential characteristics of the invention. Therefore,

the embodiments described above should be interpreted as exemplary rather than limiting. For example, each component described as a single entity may be implemented in a distributed manner, and likewise, components described as being distributed may be implemented in a combined form.

<366> The scope of the present invention is defined by the following claims rather than the foregoing detailed description, and all modifications or variations derived from the meaning and scope of the claims and their equivalents should be construed as falling within the scope of the present invention.

[What is claimed is]

[Claim 1]

A wireless communication method for a terminal,
wherein the method comprises,
receiving a wireless signal of a particular channel;
and using preamble information of the received wireless signal to obtain at least one of
length information of the signal and full-length information of a corresponding data sequence.

[Summary]

[Abstract]

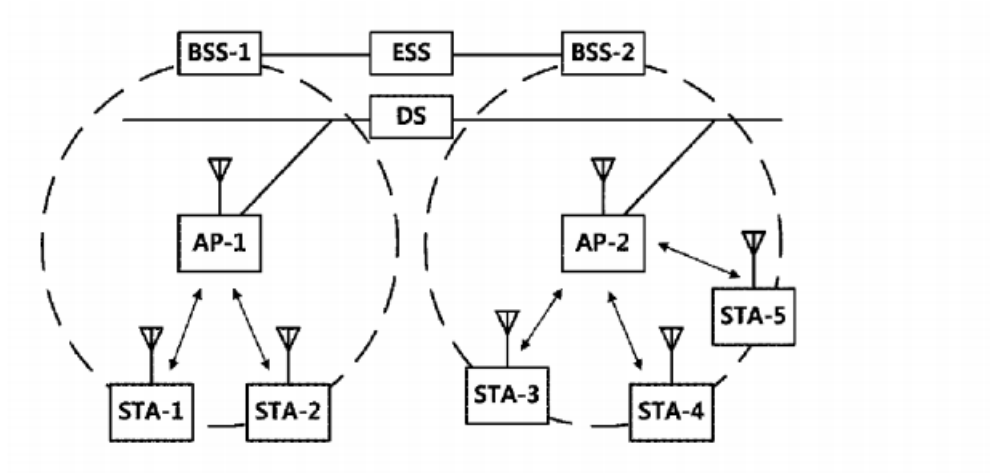
The present invention relates to apparatus, system, and method of wireless LAN communication for wireless LANs. According to an embodiment of the present invention, various methods, apparatuses, and systems for preventing inappropriate operations when BSS color collision occurred are provided.

[Representative Drawings]

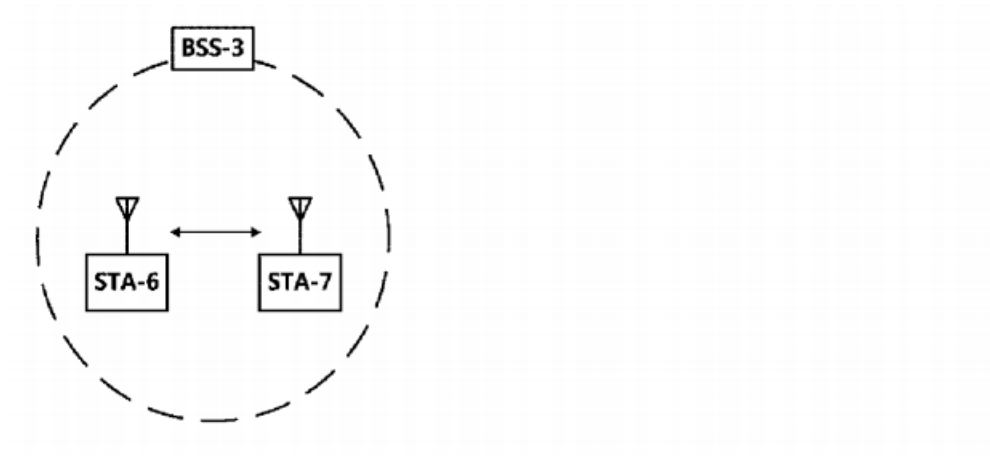
FIG. 12

[Drawings]

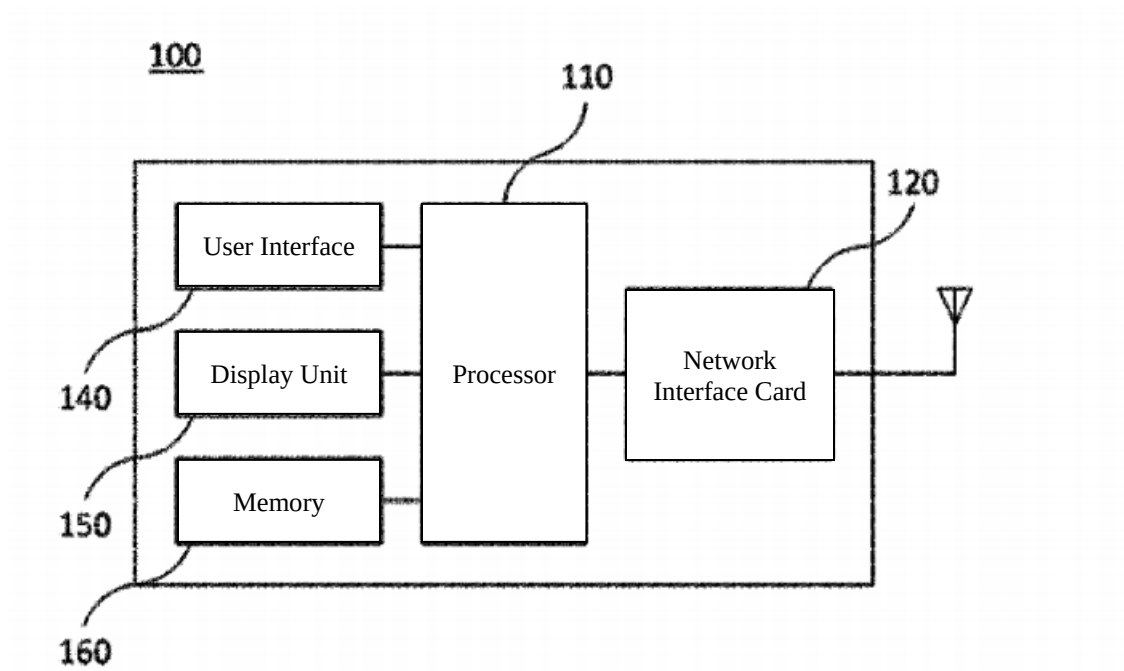
[FIG. 1]



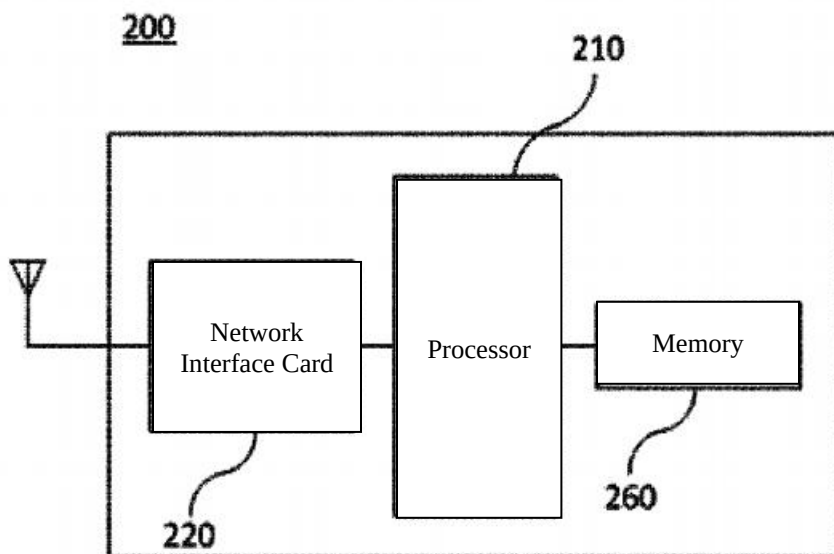
[FIG. 2]



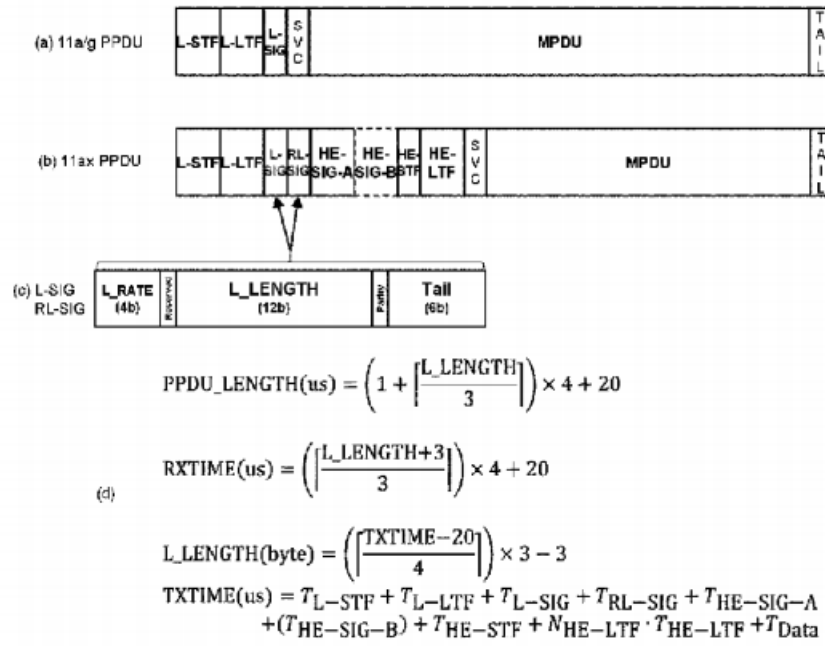
[FIG. 3]



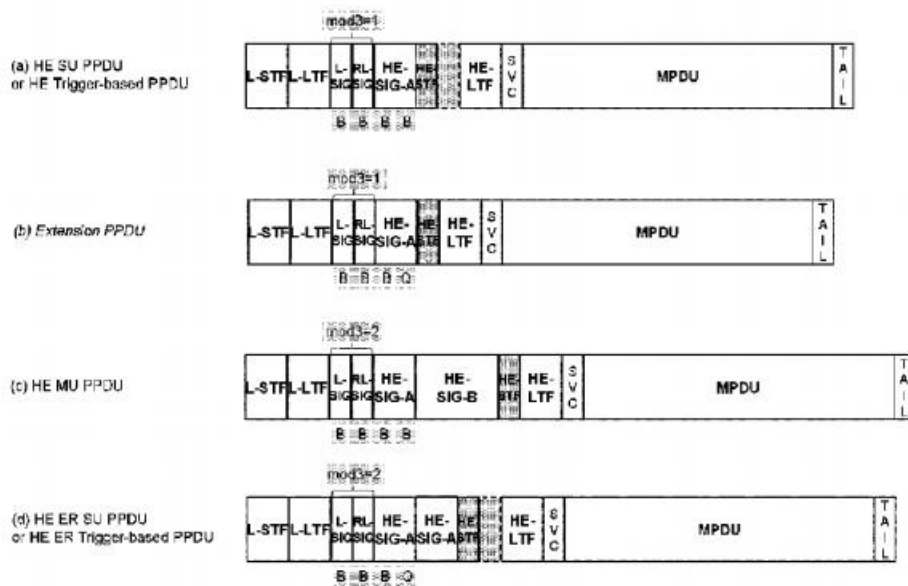
[FIG. 4]



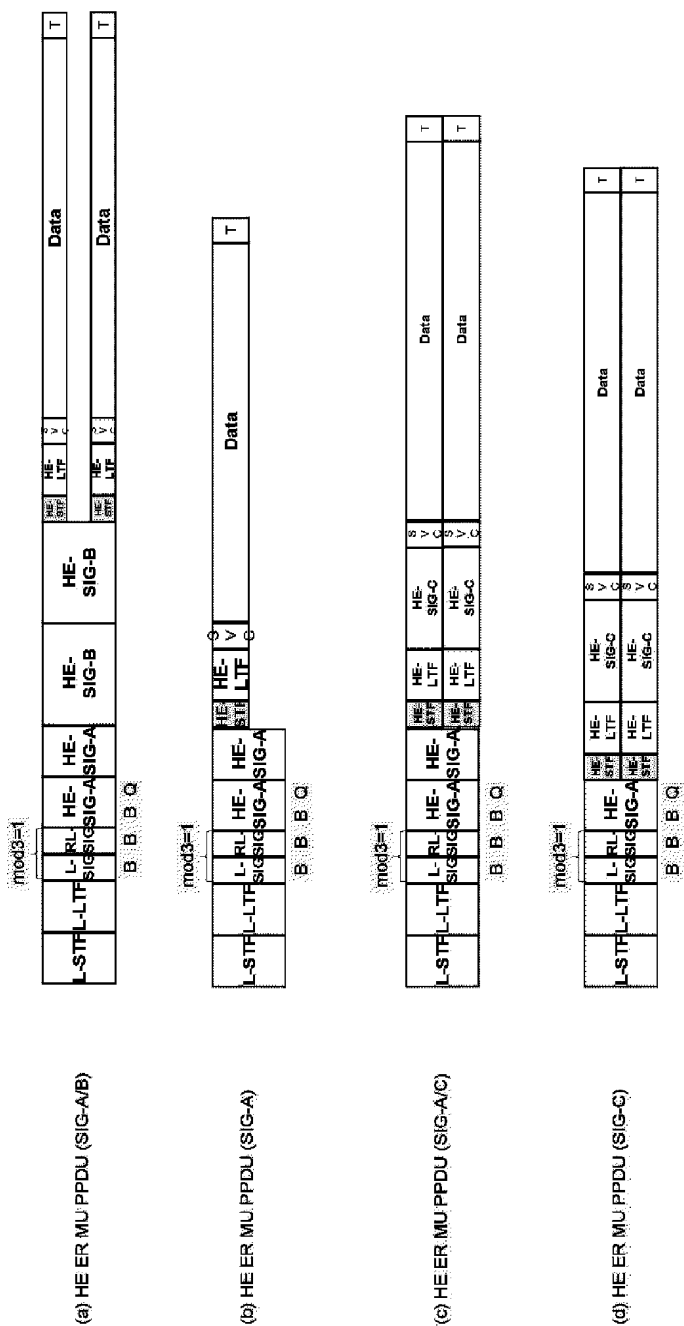
[FIG. 5]



[FIG. 6]



[FIG. 7]



[FIG. 8]



(a) HESU PPDU			(b) HEMU PPDU			(c) HE Trigger-based PPDU		
Field	Bit	Descriptions	Field	Bit	Descriptions	Field	Bit	Descriptions
DU/LI	1		SI/LI	1		Format		
1		SI(LI)/Trigger(s)	BSS Color	6	BSS identification information	BSS Color	5	BSS identification information
6		BSS identifi/cation information	Spatial Reuse	5		Spatial Reuse	5	
5			TXOP Duration	1		TXOP Duration	1	
2			Bandwidth	10/2		Bandwidth	6	
2	20/40/80/160		SG-B MCS	3	MCS/MCS5			
4			CP+LTF Size	9	1x_LTF=0.8us_CP (%) 2x_LTF=0.8us_CP 4x_LTF=1.6us_CP 8x_LTF=3.2us_CP			
9			LDPC Extra SYM	1				
2	BCC/LDPC, LDPC Extra SYM		Num of HE LTF SYM	9	1-8			
9	1-8		SG-B Compression	CS1				
1	on/off		SG-B Dual MCS	m				
1	on/off		SG-B SCM	1	Dual carrier modulation			
1	Dual carrier modulation		Packet Extension	3	*4-factor			
3	*4-factor		Num of SG-B SYM	4				
1			CRC	4		CRC	4	
4			Tail	6		Tail	6	
6			Total	95	44+5+45+1m	Total	17	4+4+6+5
95	44+5+45+1m							

[FIG. 9]

(b) Resource Allocation

dir.	RA (8bits)	#1	#2	#3	#4	#5	#6	#7	#8	#9	Entries
	000 0 0000	26	26	26	26	26	26	26	26	26	1
	000 0 0001	26	26	26	26	26	26	26	26	52	1
	000 0 0010	26	26	26	26	26	26	26	26	52	1
	000 0 0011	26	26	26	26	26	26	26	26	52	1
	000 0 0100	26	26	26	26	26	26	26	26	26	1
	000 0 0101	26	26	26	26	26	26	26	26	52	1
	000 0 0110	26	26	26	26	26	26	26	26	52	1
	000 0 0111	26	26	26	26	26	26	26	26	52	1
	000 0 1000	52	26	26	26	26	26	26	26	26	1
	000 0 1001	52	26	26	26	26	26	26	26	52	1
	000 0 1010	52	26	26	26	26	26	26	26	52	1
	000 0 1011	52	26	26	26	26	26	26	26	52	1
	000 0 1100	52	52	26	26	26	26	26	26	26	1
	000 0 1101	52	52	26	26	26	26	26	26	52	1
	000 0 1110	52	52	26	26	26	26	26	26	52	1
	000 0 1111	52	52	26	26	26	26	26	26	52	1
	000 1 0xxx	52	52	-	-	-	-	-	-	108	8
	000 1 1yyy	108	-	-	-	-	-	-	-	52	8
	0010 0 yyy	26	26	26	26	26	26	26	26	108	8
	0010 1 yyy	26	26	26	26	26	26	26	26	108	8
	0011 0 yyy	52	52	26	26	26	26	26	26	108	8
	0011 1 yyy	52	52	26	26	26	26	26	26	108	8
	0100 0 yyy	108	26	26	26	26	26	26	26	26	8
	0100 1 yyy	108	26	26	26	26	26	26	26	52	8
	0101 0 yyy	108	26	26	26	26	26	26	26	52	8
	0101 1 yyy	108	26	26	26	26	26	26	26	52	8
	0110 zzz	108	-	-	-	-	-	-	-	108	16
	0111 0000	52	52	-	-	-	-	-	-	52	1
	0111 0001	242	Null	-	-	-	-	-	-	242	1
	0111 0010	484	Null	-	-	-	-	-	-	484	1
	0111 0011	996	Null	-	-	-	-	-	-	996	1
	0111 01xx	Definition TBD	-	-	-	-	-	-	-	4	4
	0111 1xxx	Definition TBD	-	-	-	-	-	-	-	8	8
	10 yyy yyy	108	26	26	26	26	26	26	26	108	64
	11 0 00yy	242	-	-	-	-	-	-	-	242	8
	11 0 01yy	484	-	-	-	-	-	-	-	484	8
	11 0 10yy	996	-	-	-	-	-	-	-	996	8
	11 0 11yy	242	-	-	-	-	-	-	-	242	8
	11 1 xxxxx	Definition TBD	-	-	-	-	-	-	-	32	32

(c) HE SIG-B

L	R	HE-SIG-A	HE-SIG-B	HE-LTF	SVC	T
0	0	0	0	0	0	0

(d) HE SIG-B padding

STA A	CIT	STA B	CIT	STA A	CIT	STA B	CIT
0	0	0	0	0	0	0	0

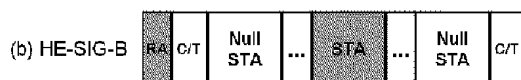
(e) RU Allocation

Field	Bit	Description
C26	1	Existence of Center 26 tone RU data (at >= 80MHz)
RA	8	Resource Allocation
Total	9	

(f) STA ID

Field	Bit
-------	-----

[FIG. 10]



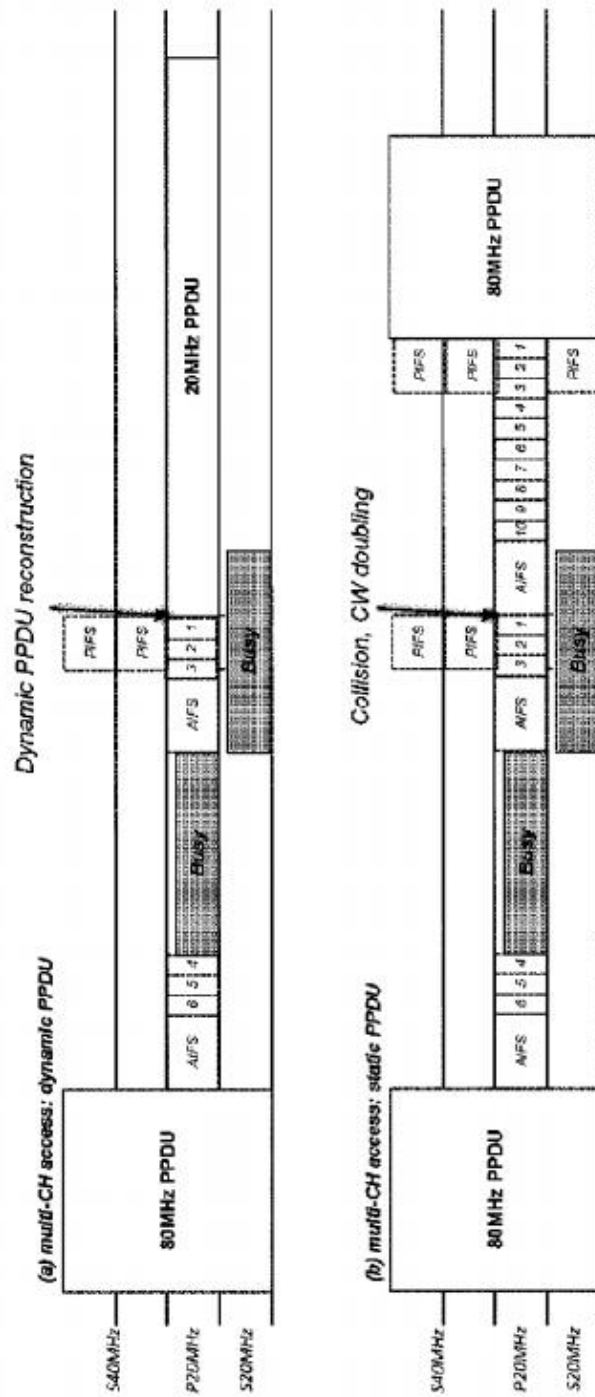
(c) UL Partial RU Resource Allocation

direction	RA (8bits)	#1	#2	#3	#4	#5	#6	#7	#8	#9	Entries
DL	others	X	X	X	X	X	X	X	X	X	X
UL	TBD	26	-	-	-	-	-	-	-	-	1
	TBD	-	26	-	-	-	-	-	-	-	1
	TBD	-	-	26	-	-	-	-	-	-	1
	TBD	-	-	-	26	-	-	-	-	-	1
	TBD	-	-	-	-	26	-	-	-	-	1
	TBD	-	-	-	-	-	26	-	-	-	1
	TBD	-	-	-	-	-	-	26	-	-	1
	TBD	-	-	-	-	-	-	-	26	-	1
	TBD	-	-	-	-	-	-	-	-	26	1
	TBD	52	-	-	-	-	-	-	-	-	1
	TBD	-	52	-	-	-	-	-	-	-	1
	TBD	-	-	-	52	-	-	-	-	-	1
	TBD	-	-	-	-	52	-	-	-	-	1
	TBD	-	-	-	-	-	52	-	-	-	1
	TBD	-	-	-	-	-	-	106	-	-	1
	TBD	-	-	-	-	-	-	-	106	-	1

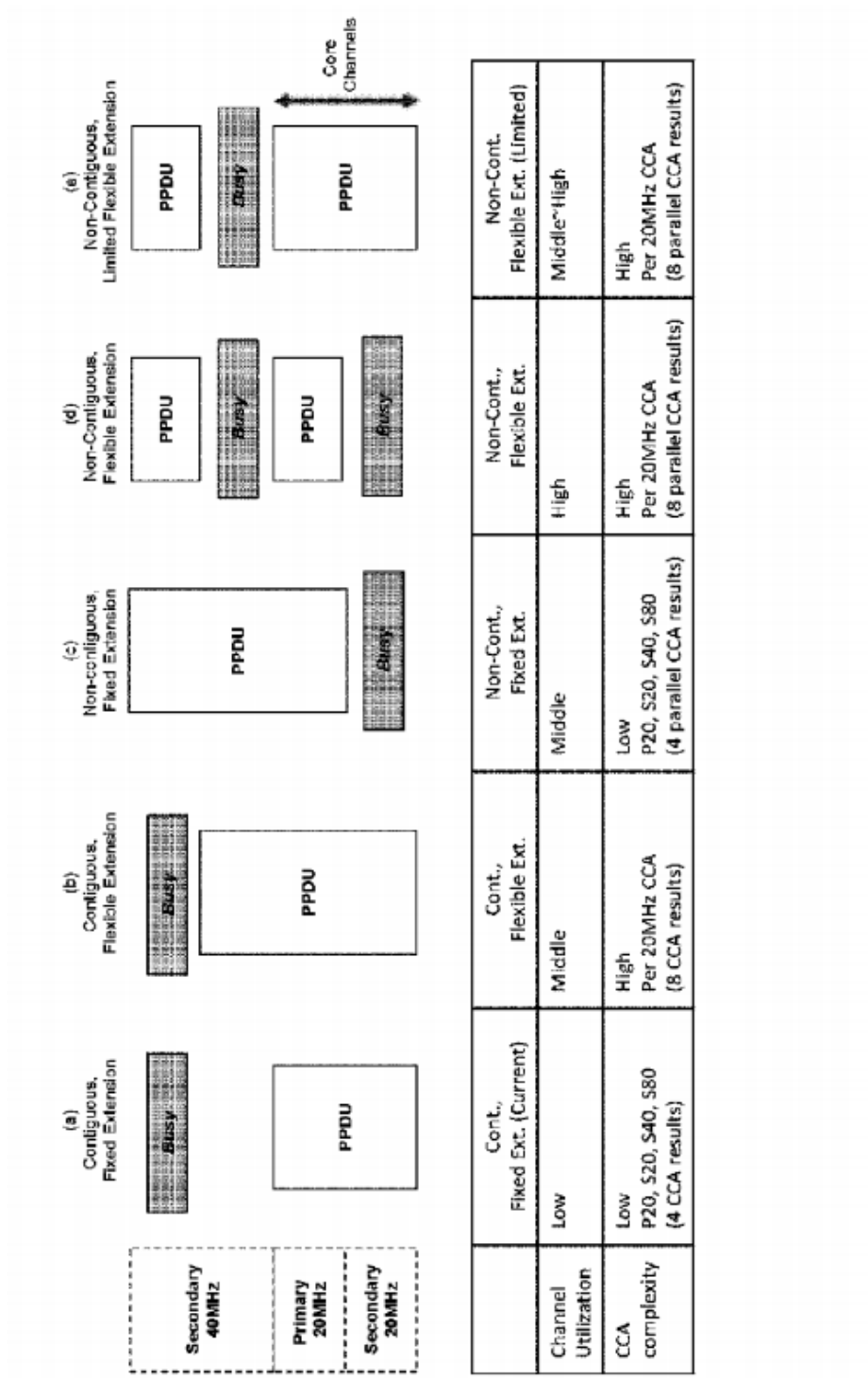
(d) HE-SIG-A (HE MU PPDU)

Field	Bit	Descriptions
SIG-B Compression	1	DL HE MU PPDU case - "0" refer RA field in SIG-B - "1" MU-MIMO user specific info UL HE MU PPDU case - "0" refer RA field in SIG-B - "1" OFDMA user specific info

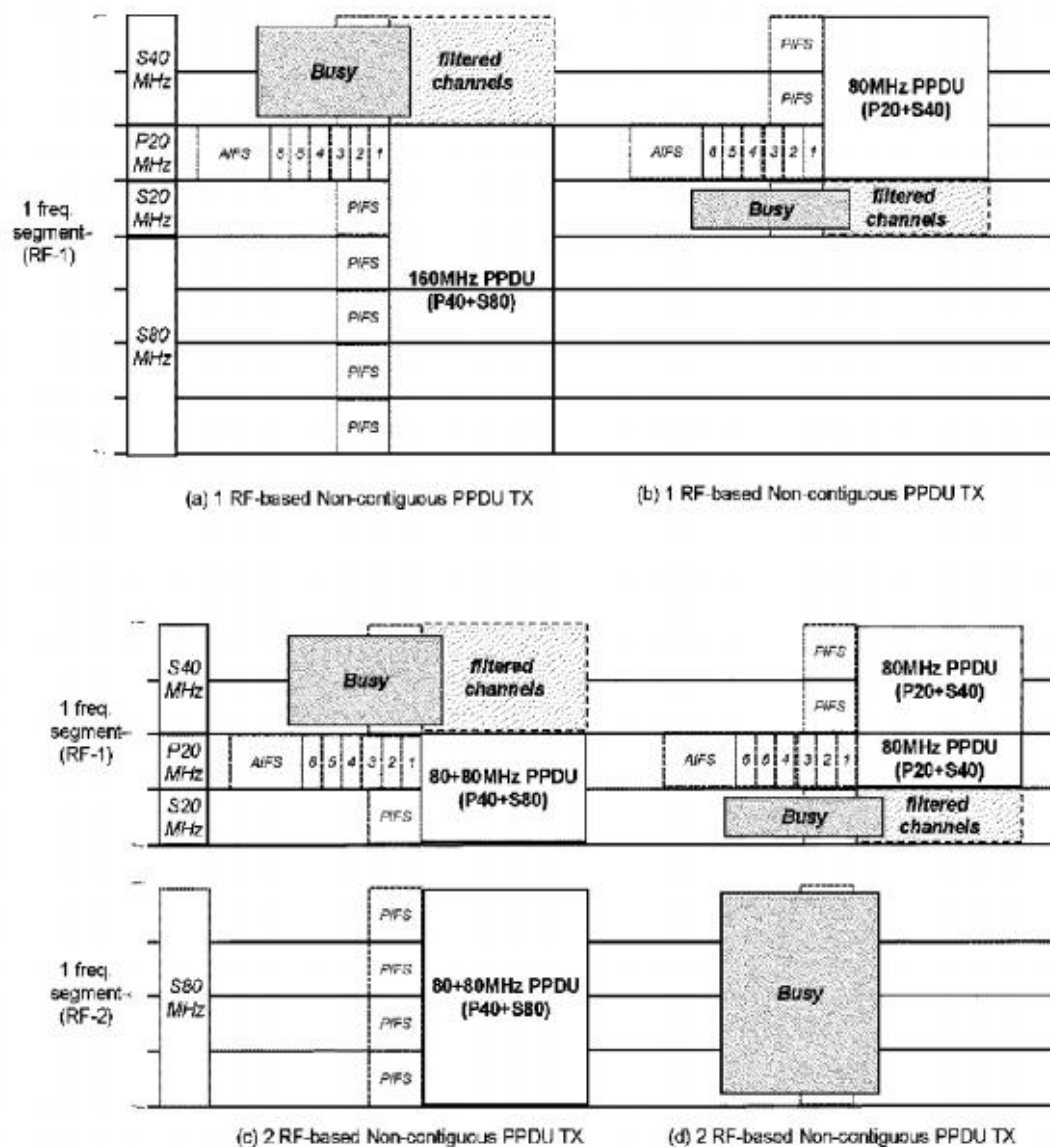
[FIG. 11]



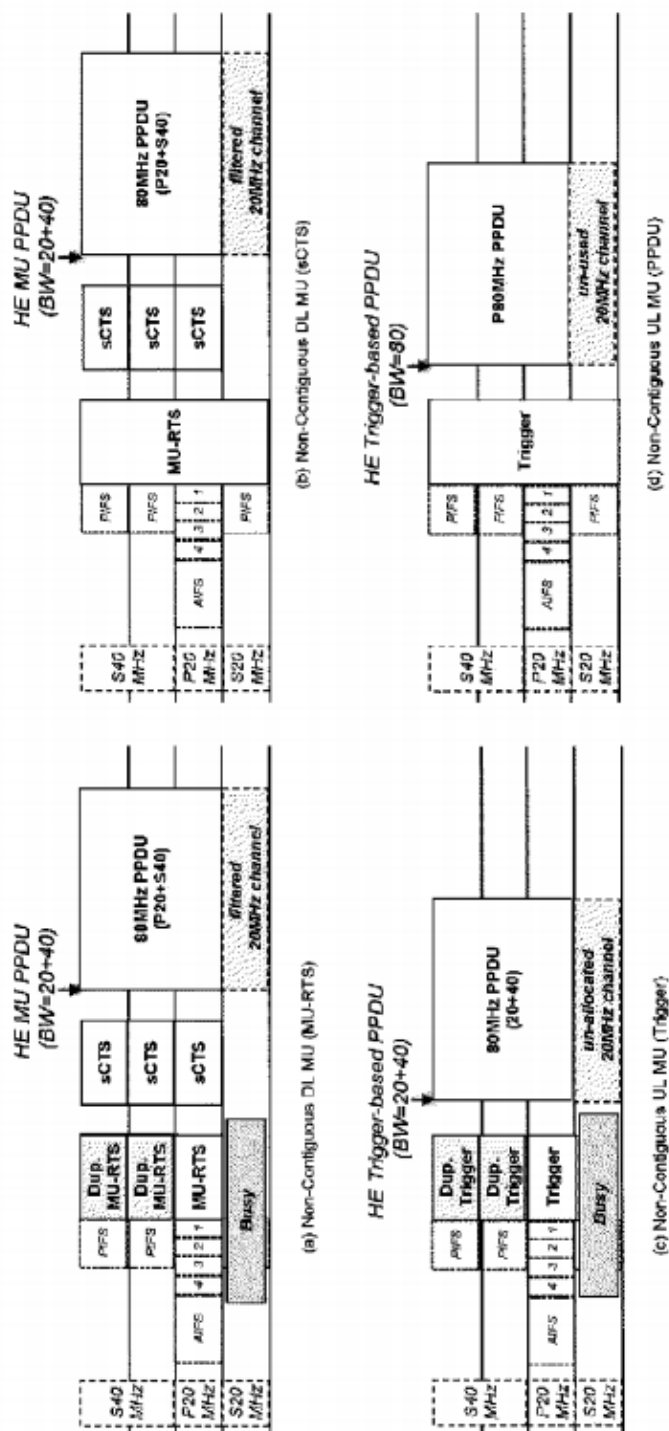
[FIG. 12]



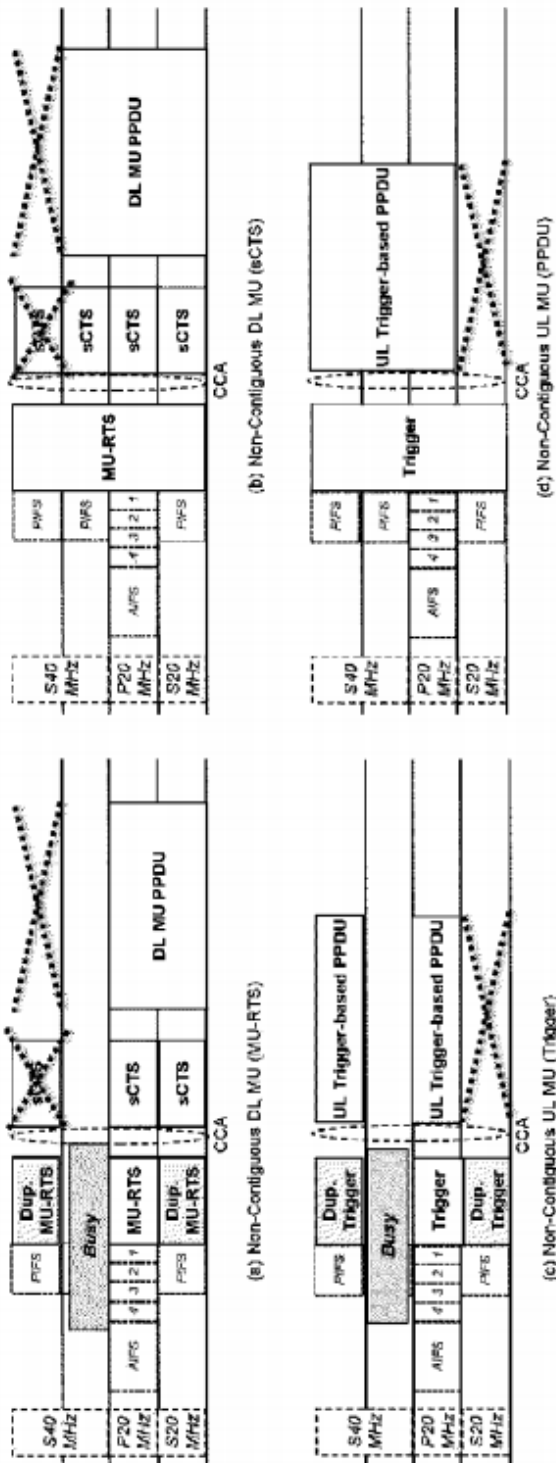
[FIG. 13]



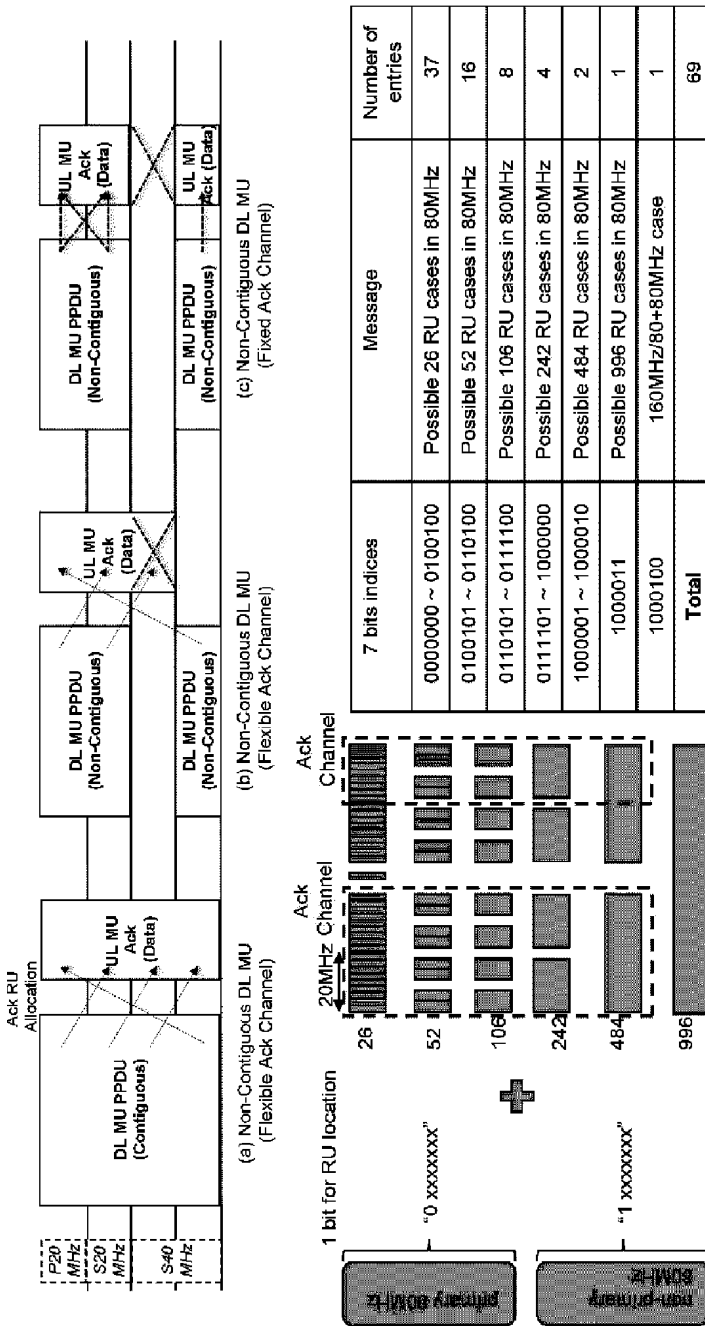
[FIG. 14]



[FIG. 15]

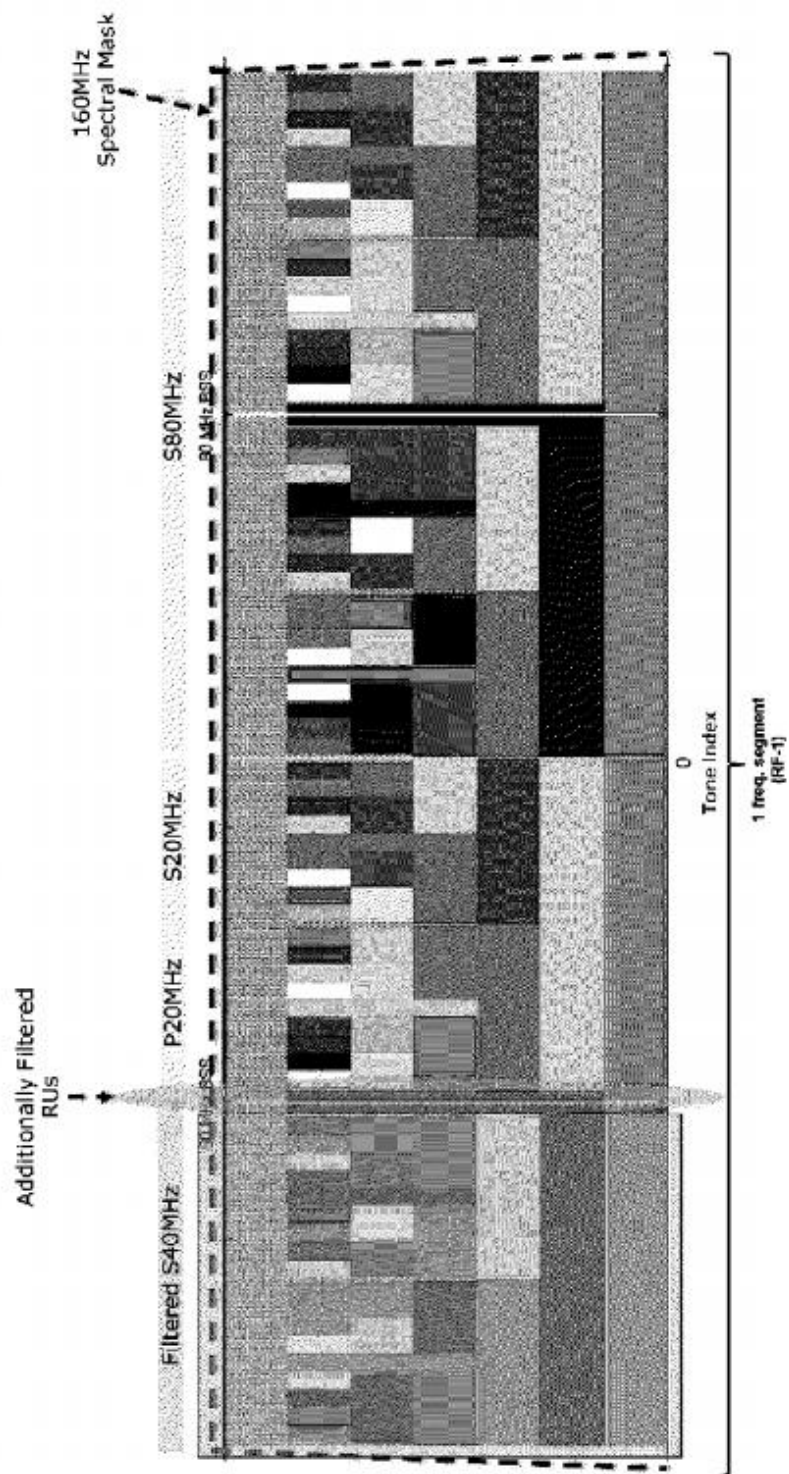


[FIG. 16]

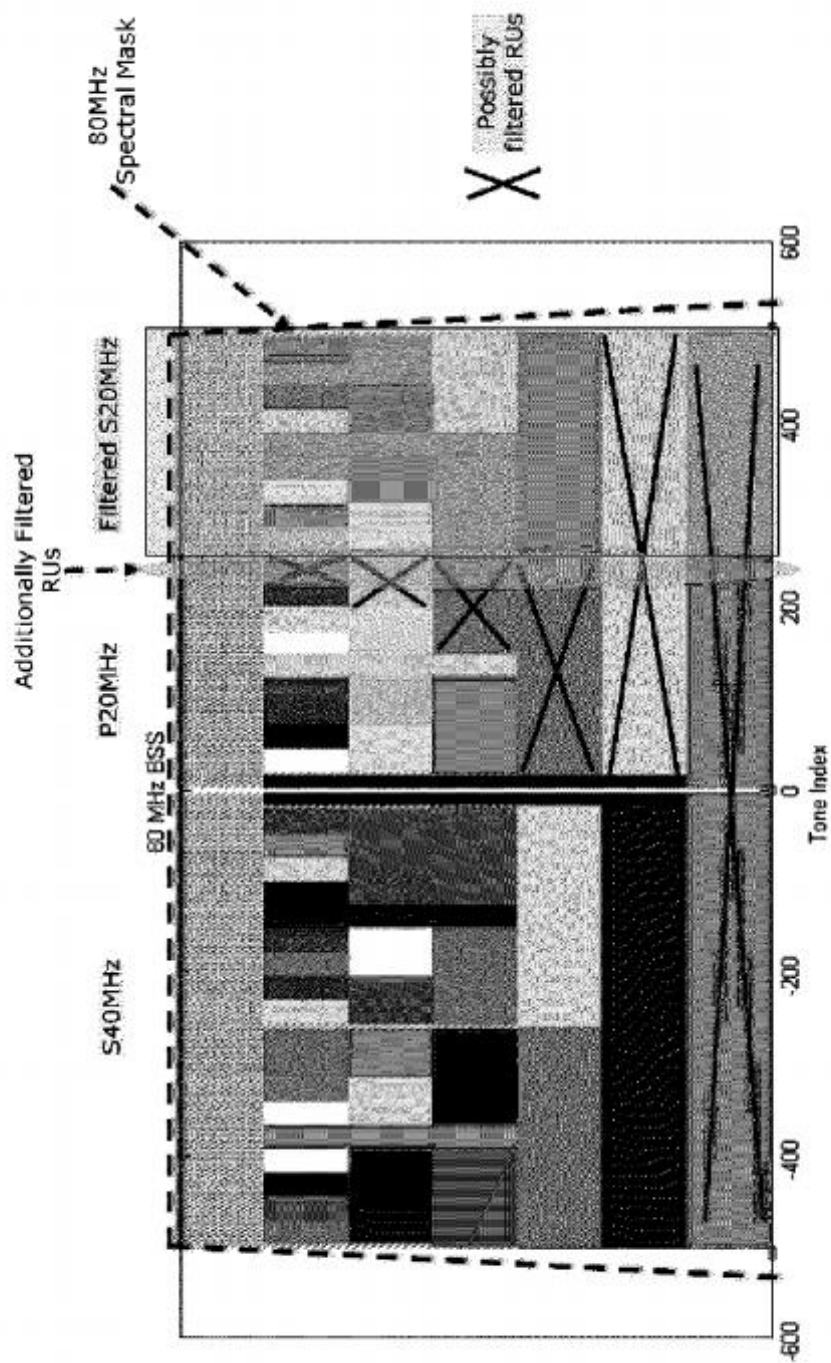


(d) RU Allocation signaling in Trigger Frame or UL MU Response field

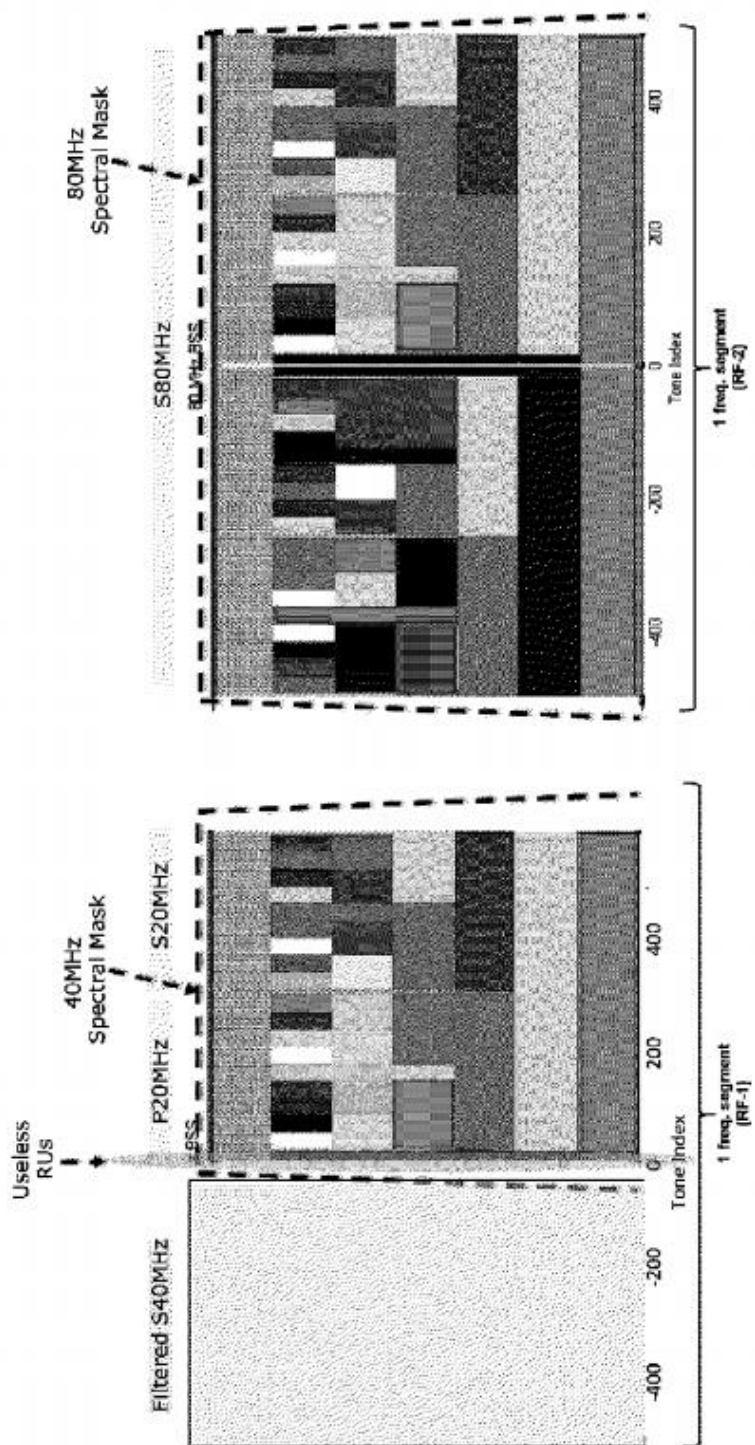
[FIG. 17]



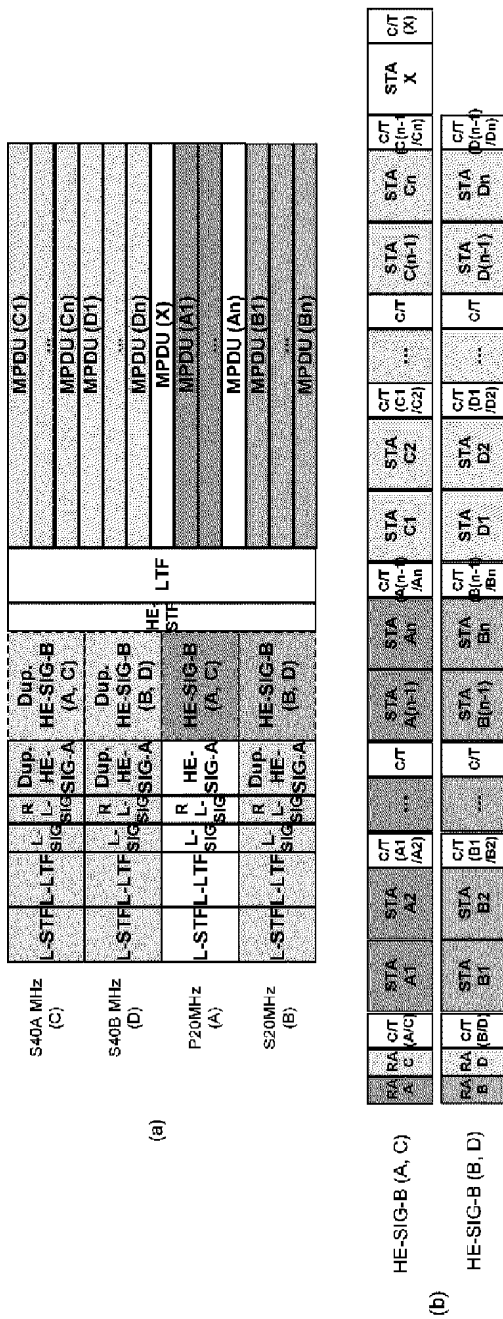
[FIG. 18]



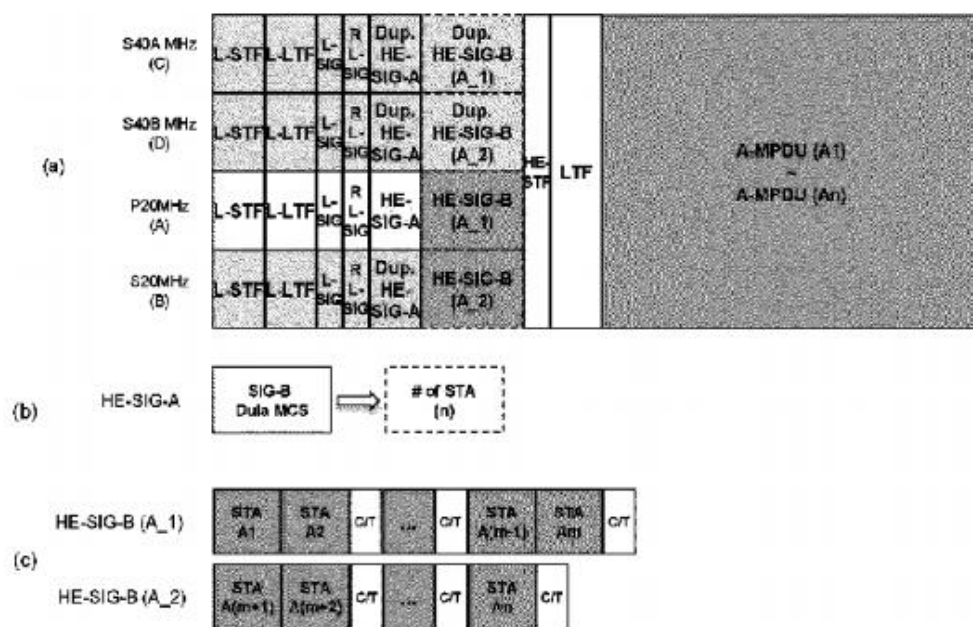
[FIG. 19]



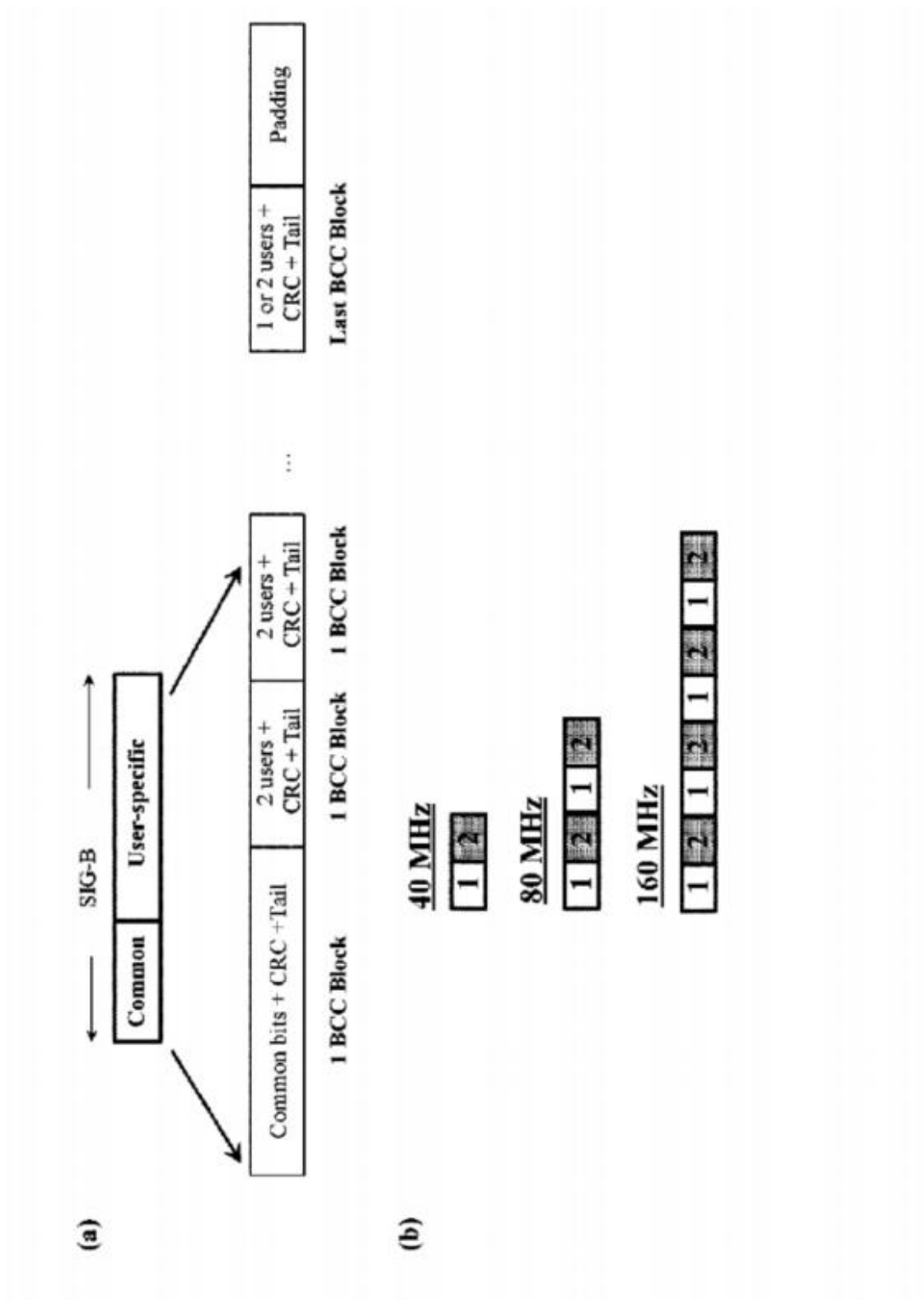
[FIG. 20]



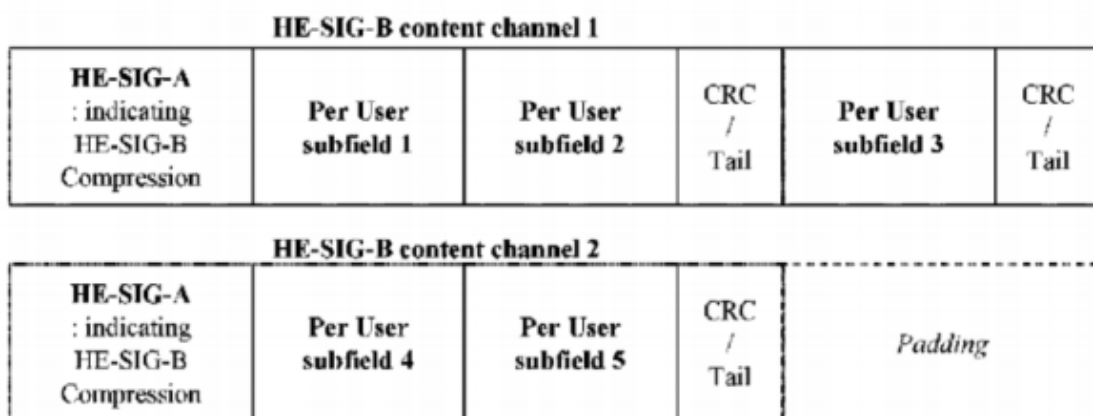
[FIG. 21]



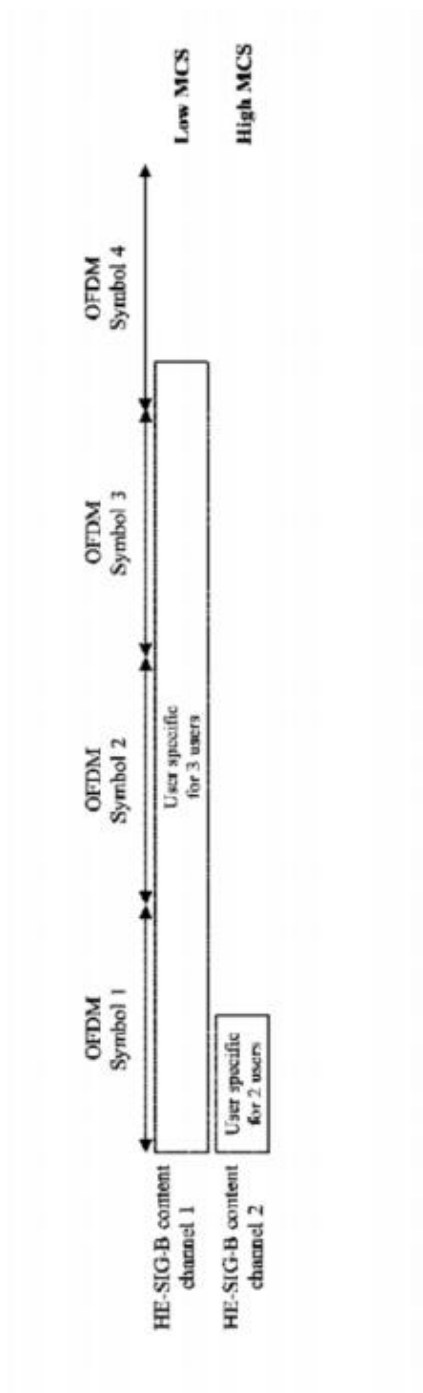
[FIG. 22]



[FIG. 23]



[FIG. 24]

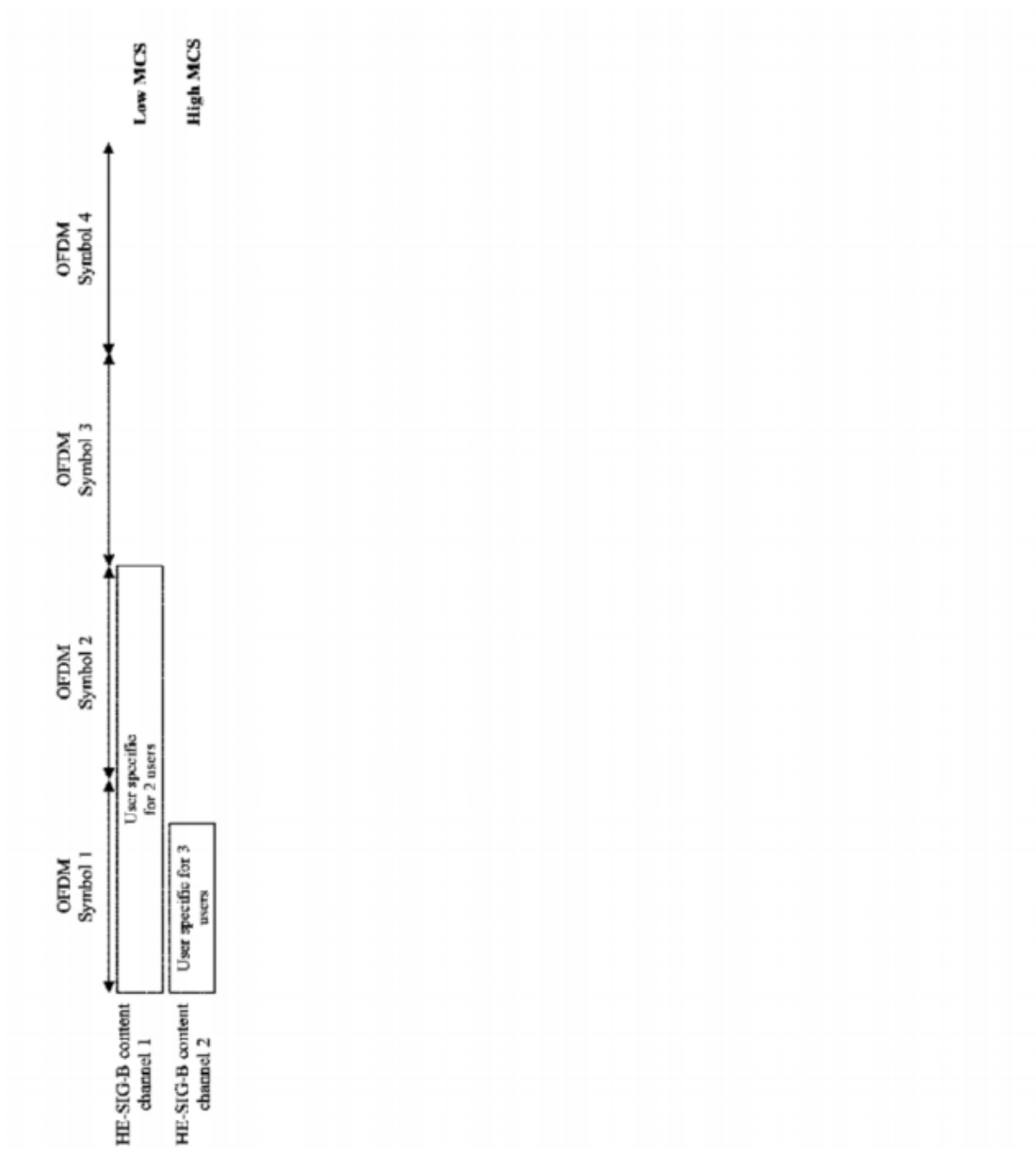


[FIG. 25]

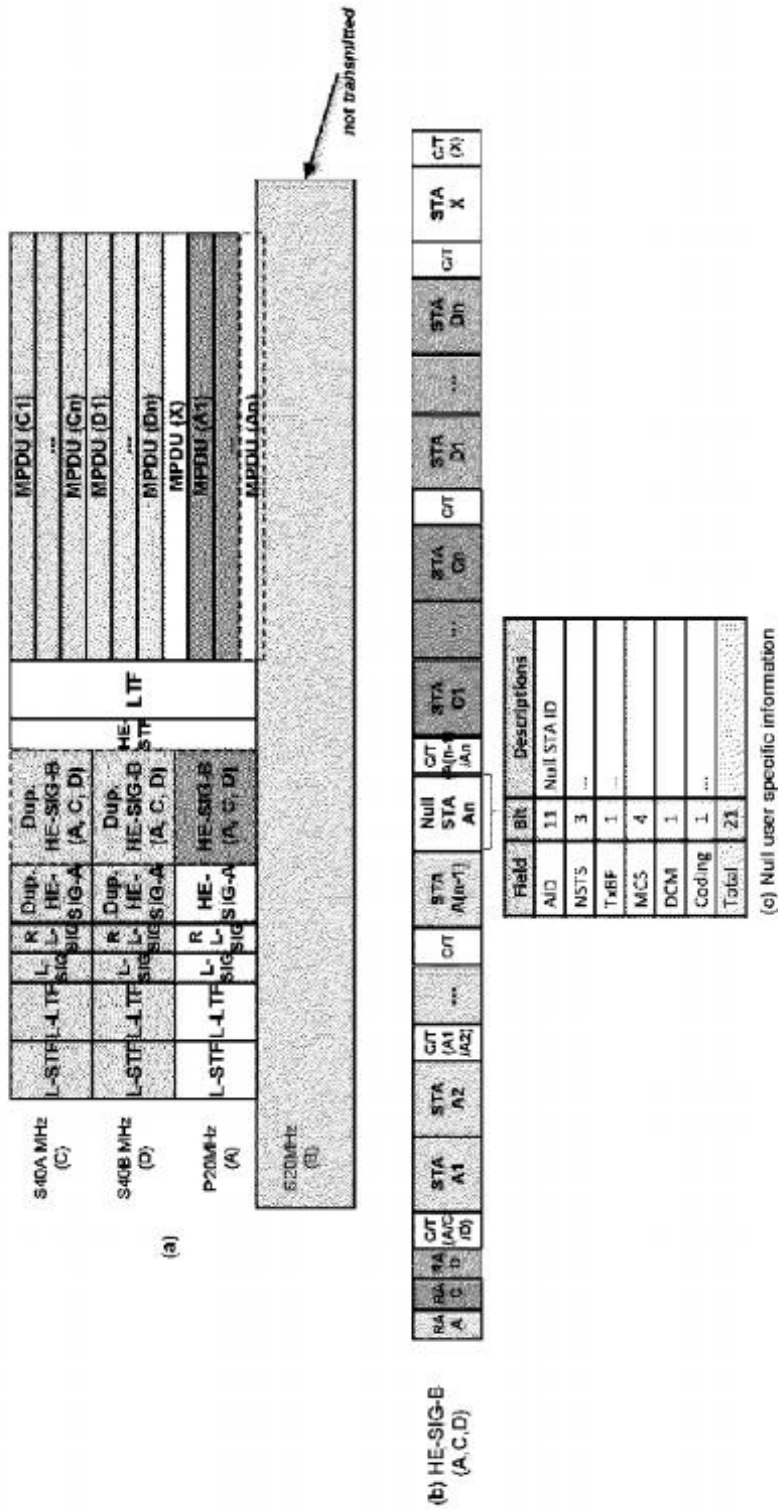
Number of users	Data bits for HE-SIG-B User Specific field	Coded bits (MCS 0, w/o DCM)	Number of OFDM symbols (MCS 0, w/o DCM)	Coded bits (MCS 1, w/o DCM)	Number of OFDM symbols (MCS 1, w/o DCM)	Coded bits (MCS 2, w/o DCM)	Number of OFDM symbols (MCS 2, w/o DCM)	Coded bits (MCS 3, w/o DCM)	Number of OFDM symbols (MCS 3, w/o DCM)	Coded bits (MCS 4, w/o DCM)	Number of OFDM symbols (MCS 4, w/o DCM)	Coded bits (MCS 5, w/o DCM)	Number of OFDM symbols (MCS 5, w/o DCM)
1	31	62	2	62	1	42	1	62	1	42	1	47	1
2	52	104	2	104	1	70	1	104	1	70	1	78	1
3	83	166	4	166	2	111	2	166	1	111	1	125	1
4	104	208	4	208	2	139	2	208	1	139	1	156	1
5	135	270	6	270	3	180	2	270	2	180	1	203	1
6	156	312	6	312	3	208	2	312	2	208	1	234	1
7	187	374	8	374	4	250	3	374	2	250	2	281	1
8	208	416	8	416	4	278	3	416	2	278	2	312	1

Number of users	Data bits for HE-SIG-B User Specific field	Coded bits (MCS 0, w/o DCM)	Number of OFDM symbols (MCS 0, w/o DCM)	Coded bits (MCS 1, w/o DCM)	Number of OFDM symbols (MCS 1, w/o DCM)	Coded bits (MCS 2, w/o DCM)	Number of OFDM symbols (MCS 2, w/o DCM)	Coded bits (MCS 3, w/o DCM)	Number of OFDM symbols (MCS 3, w/o DCM)	Coded bits (MCS 4, w/o DCM)	Number of OFDM symbols (MCS 4, w/o DCM)	Coded bits (MCS 5, w/o DCM)	Number of OFDM symbols (MCS 5, w/o DCM)
1	31	124	3	124	2	84	1	124	1	84	1	94	1
2	52	208	4	208	2	140	2	208	1	140	1	156	1
3	83	332	7	332	4	222	3	332	2	222	2	250	1
4	104	416	8	416	4	278	3	416	2	278	2	312	1
5	135	540	11	540	6	360	4	540	3	360	2	406	2
6	156	624	12	624	6	416	4	624	3	416	2	468	2
7	187	748	15	748	8	500	5	748	4	500	3	562	2
8	208	832	16	832	8	556	6	832	4	556	3	624	2

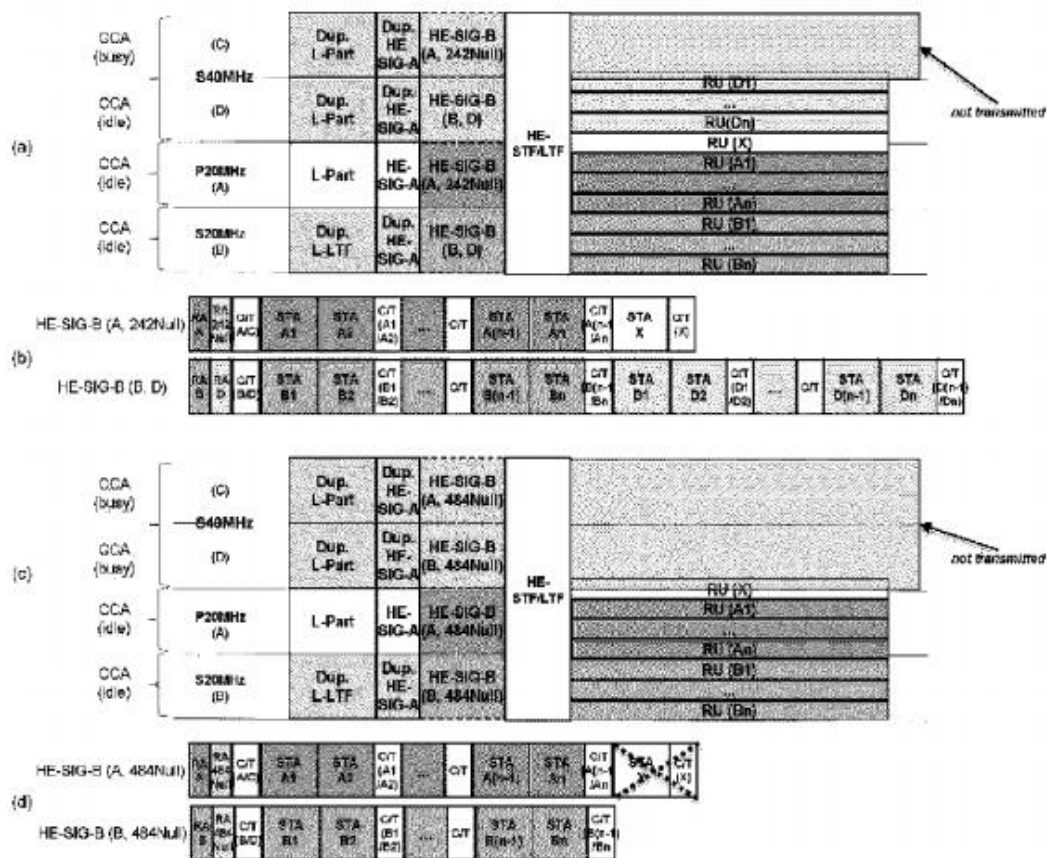
[FIG. 26]



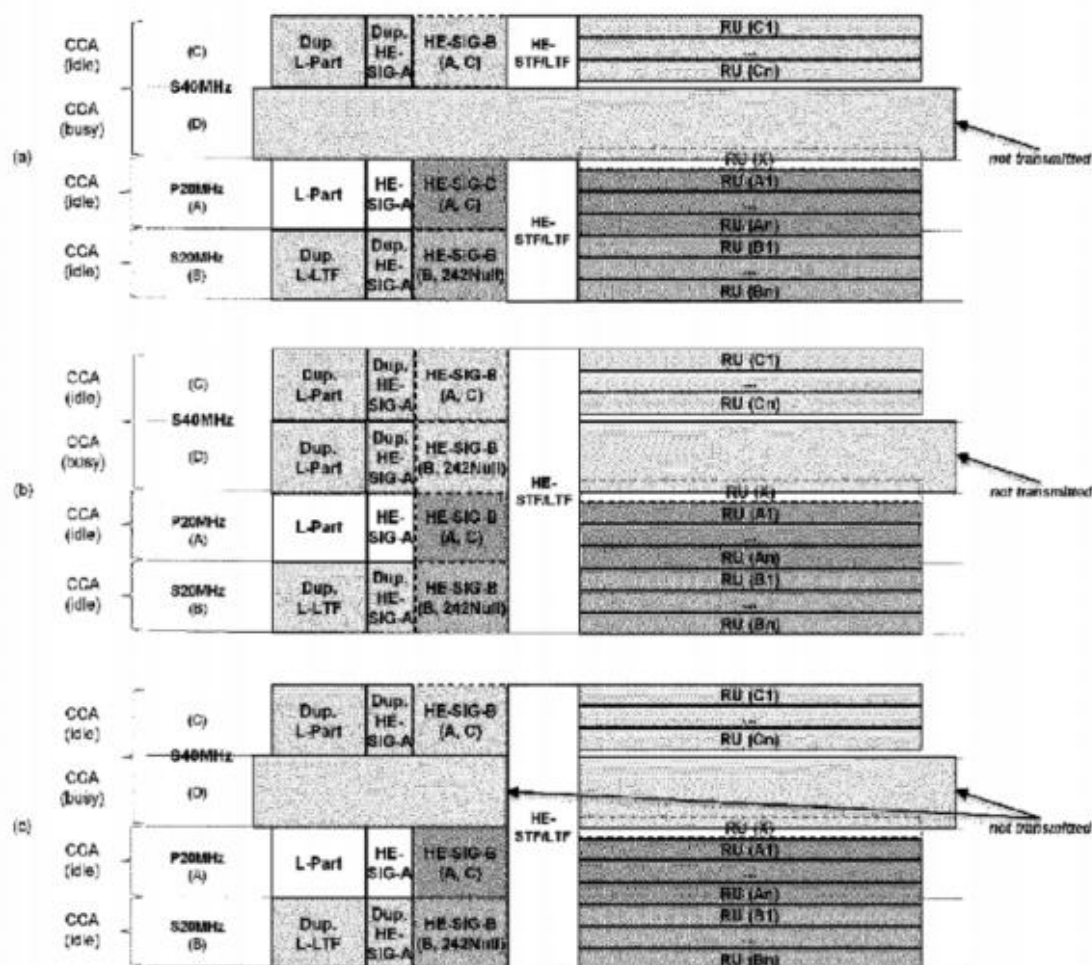
[FIG. 27]



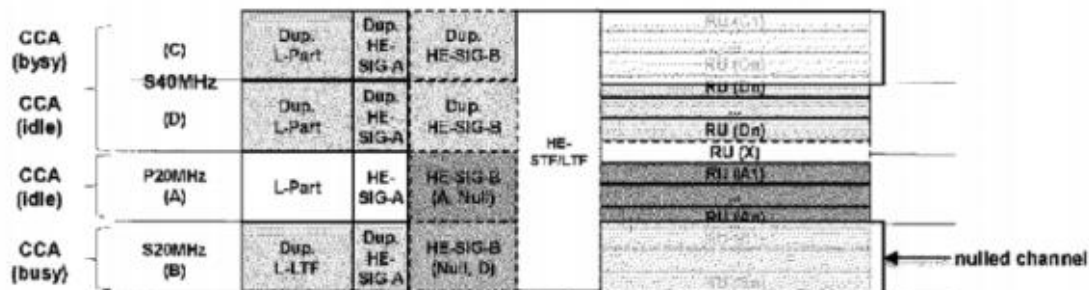
[FIG. 28]



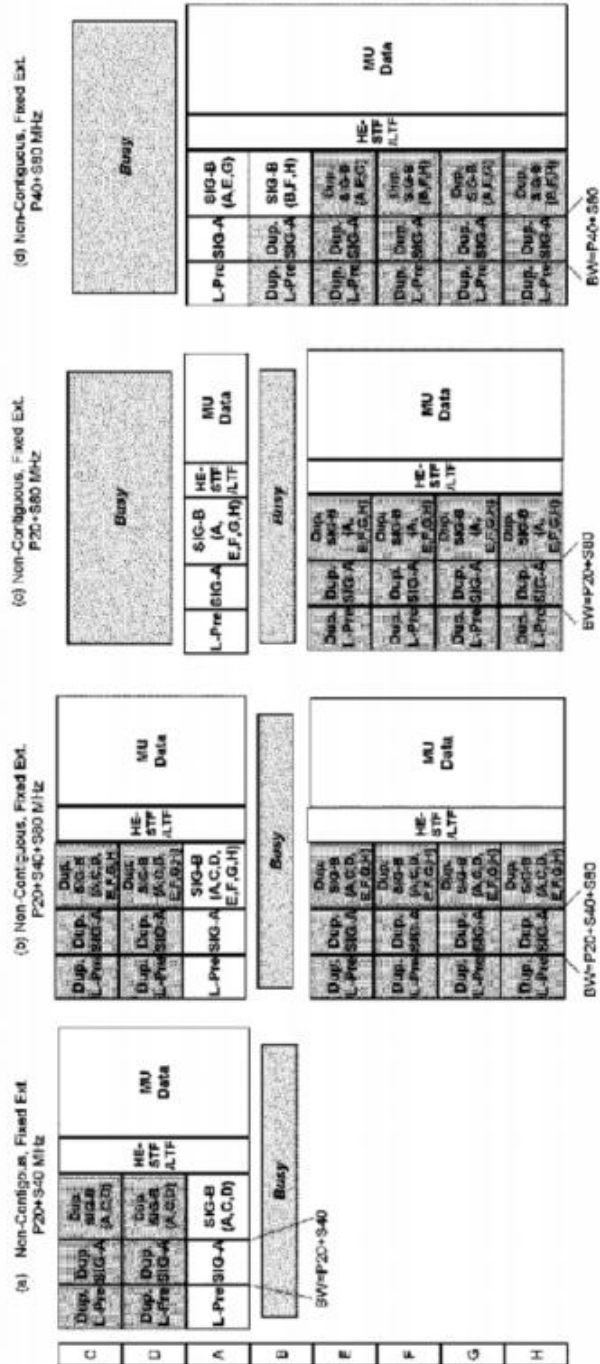
[FIG. 29]



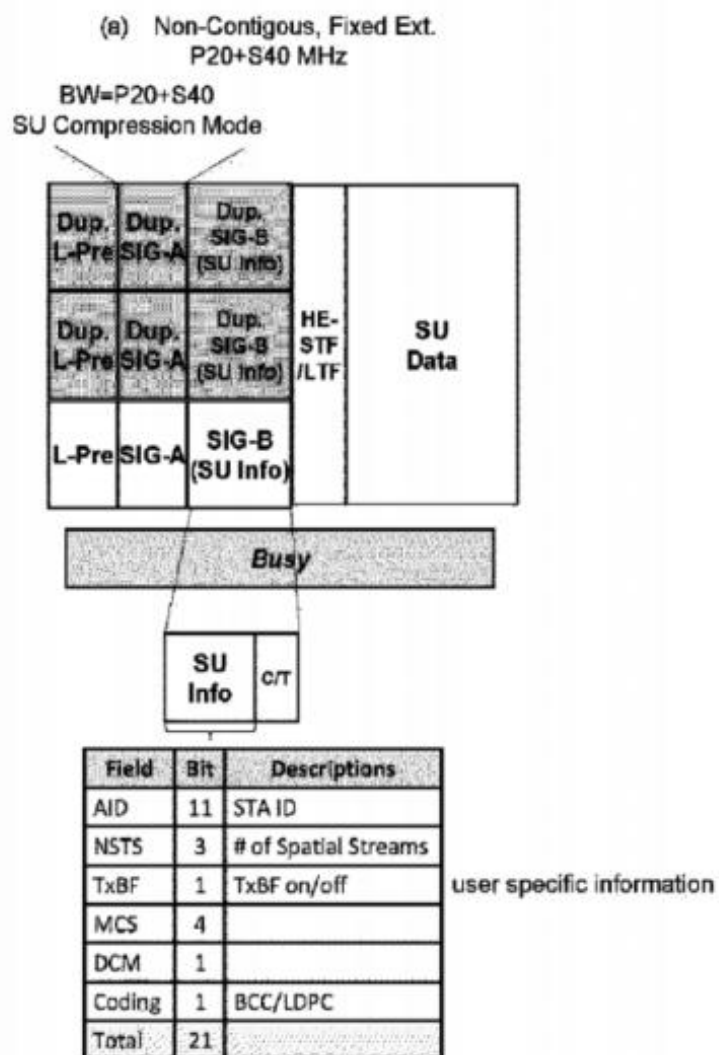
[FIG. 30]



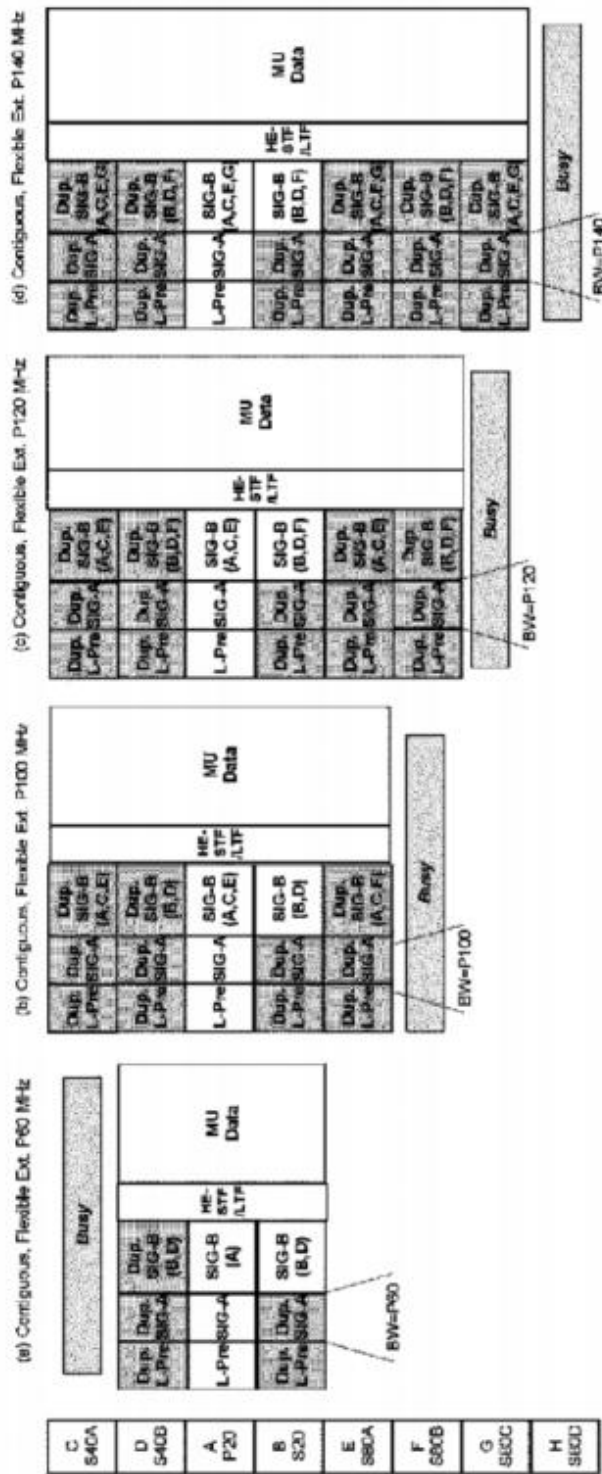
[FIG. 31]



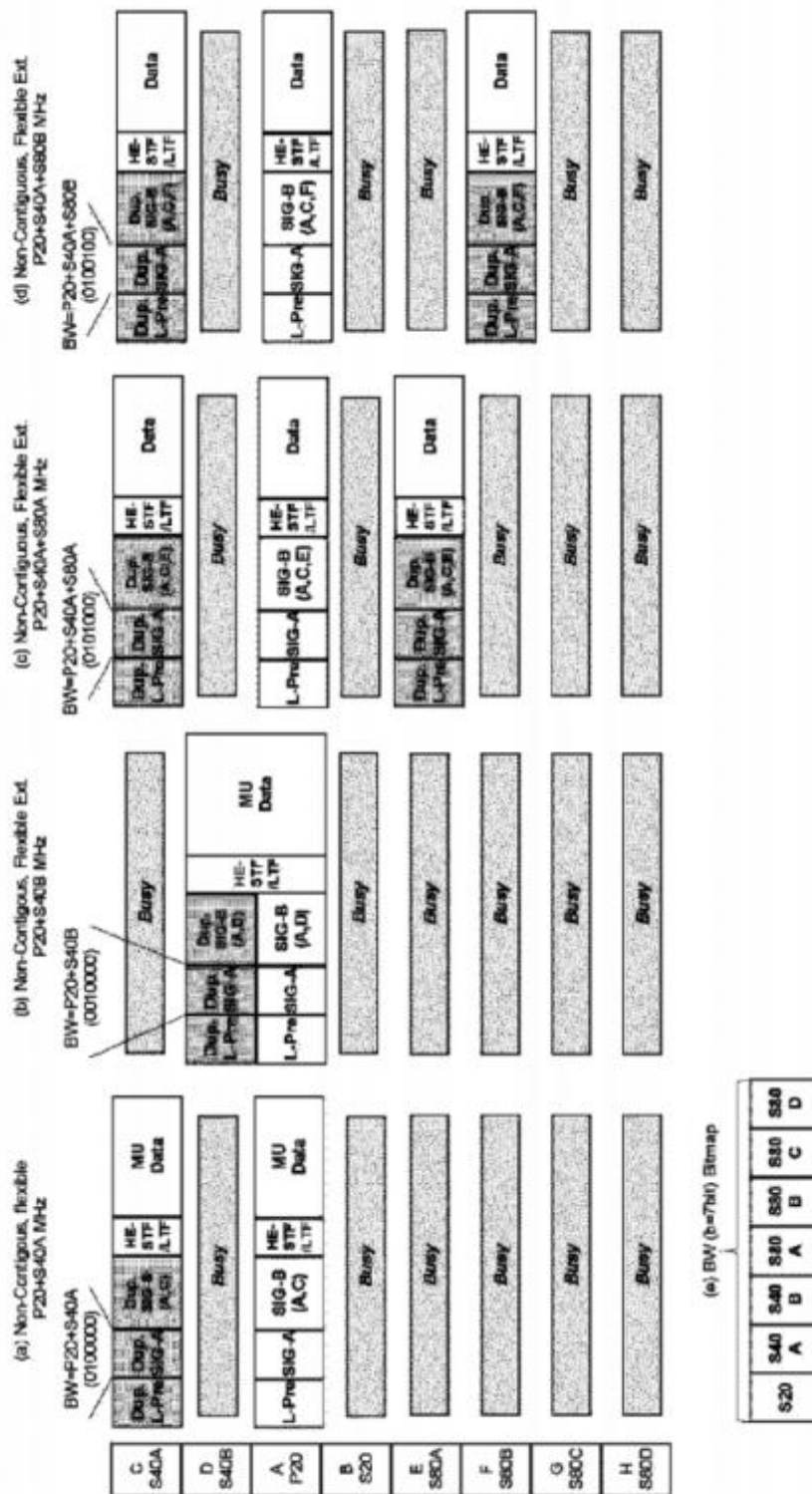
[FIG. 32]



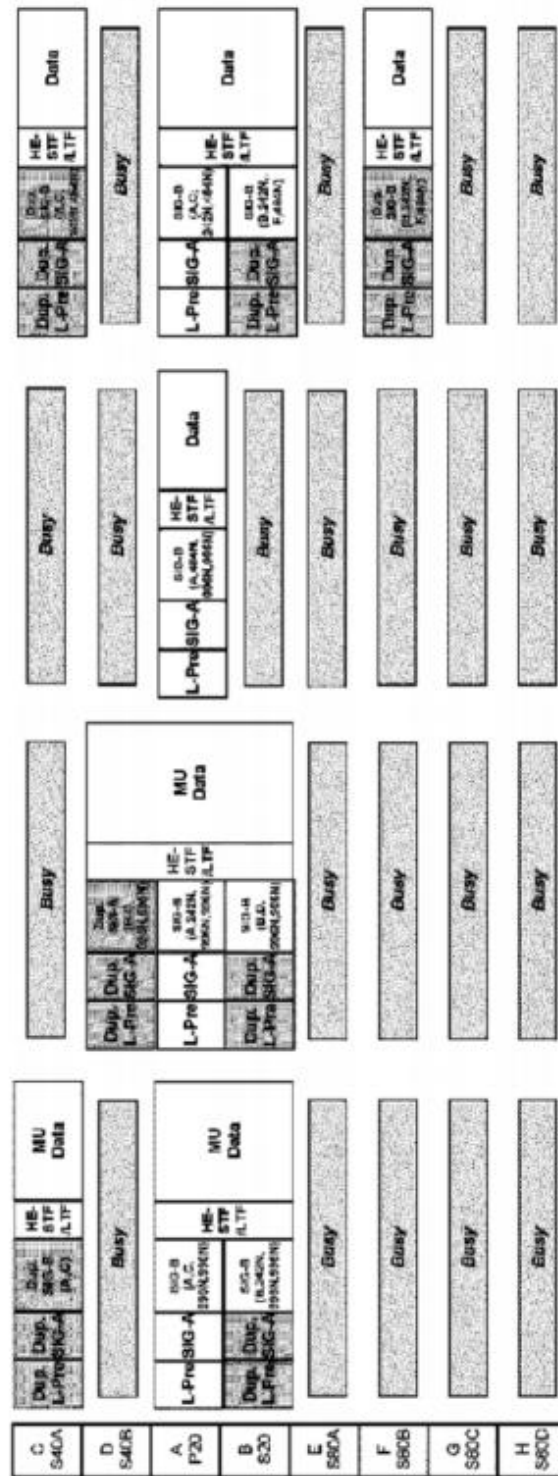
[FIG. 33]



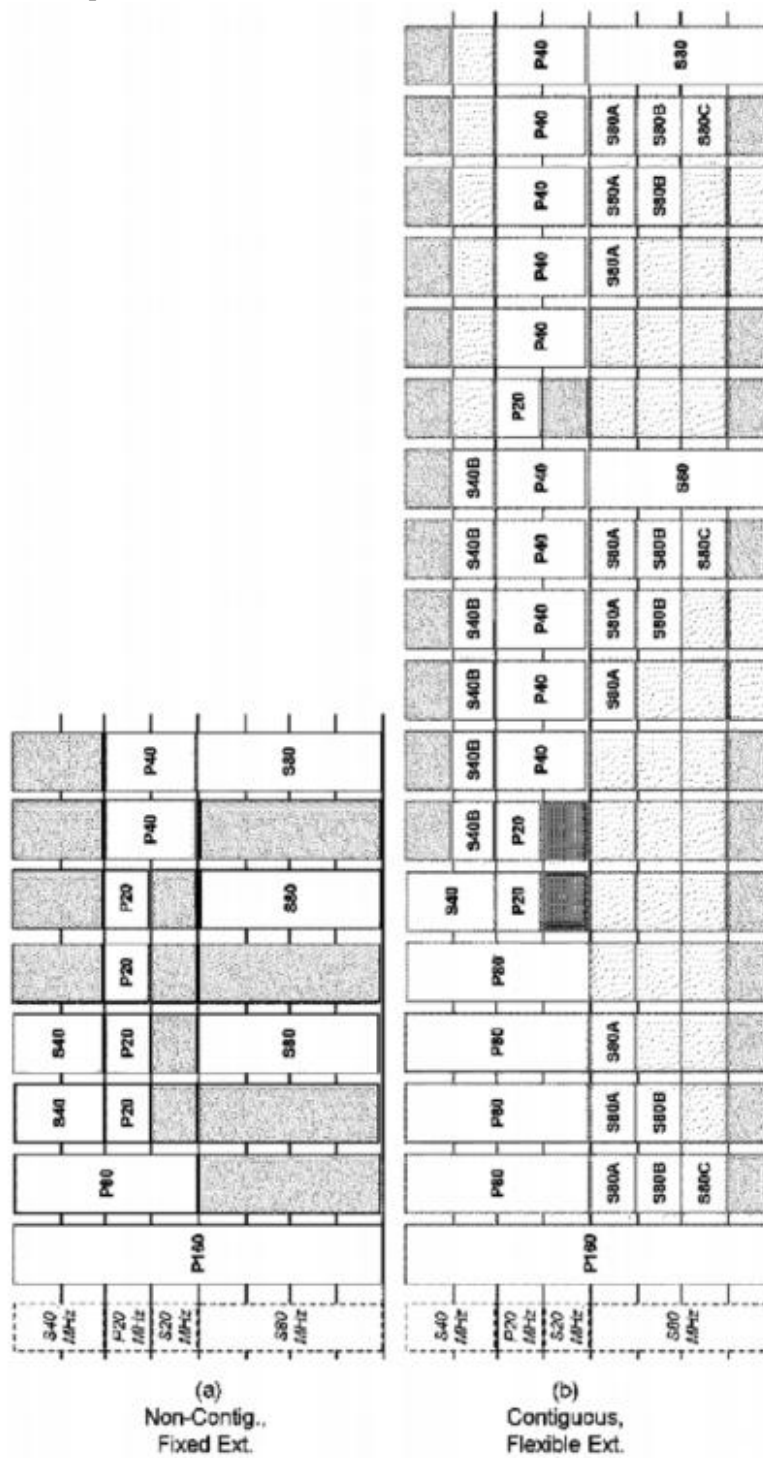
[FIG. 34]



[FIG. 35]



[FIG. 36]



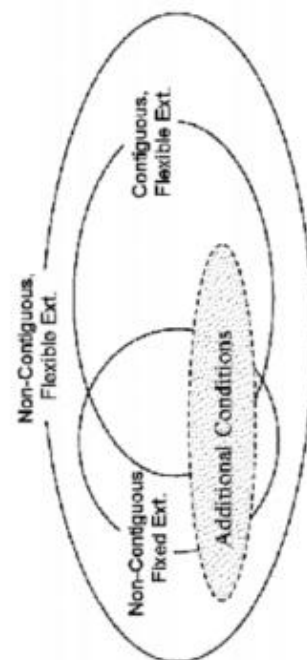
[FIG. 37]

(a) NC, Limited Flexible BW=80

(b) NC, Limited Flexible BW=160

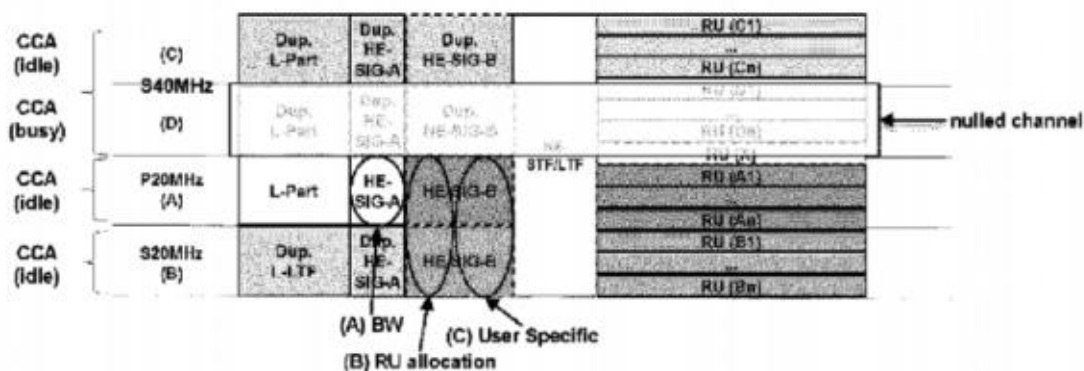
[FIG. 38]

(a) Combined PPDU BW Options



(b) Combination of PPDU BW Options

[FIG. 39]



[FIG. 40]

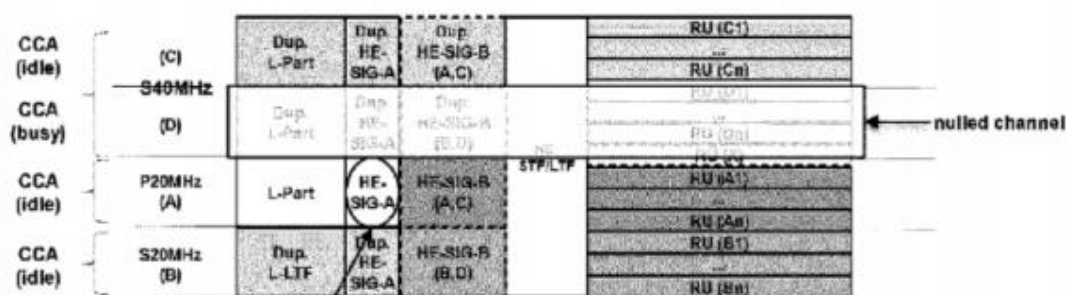
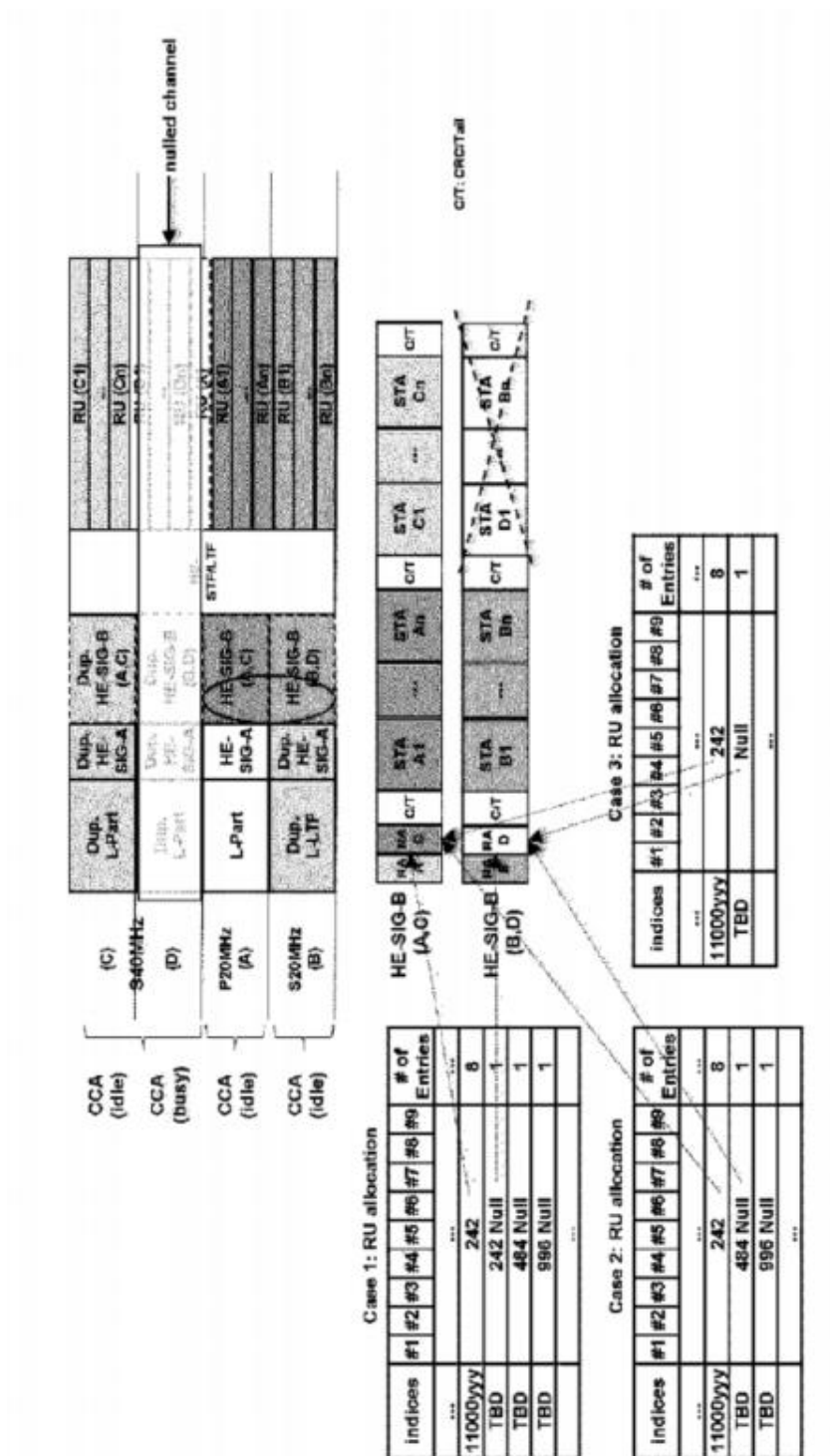


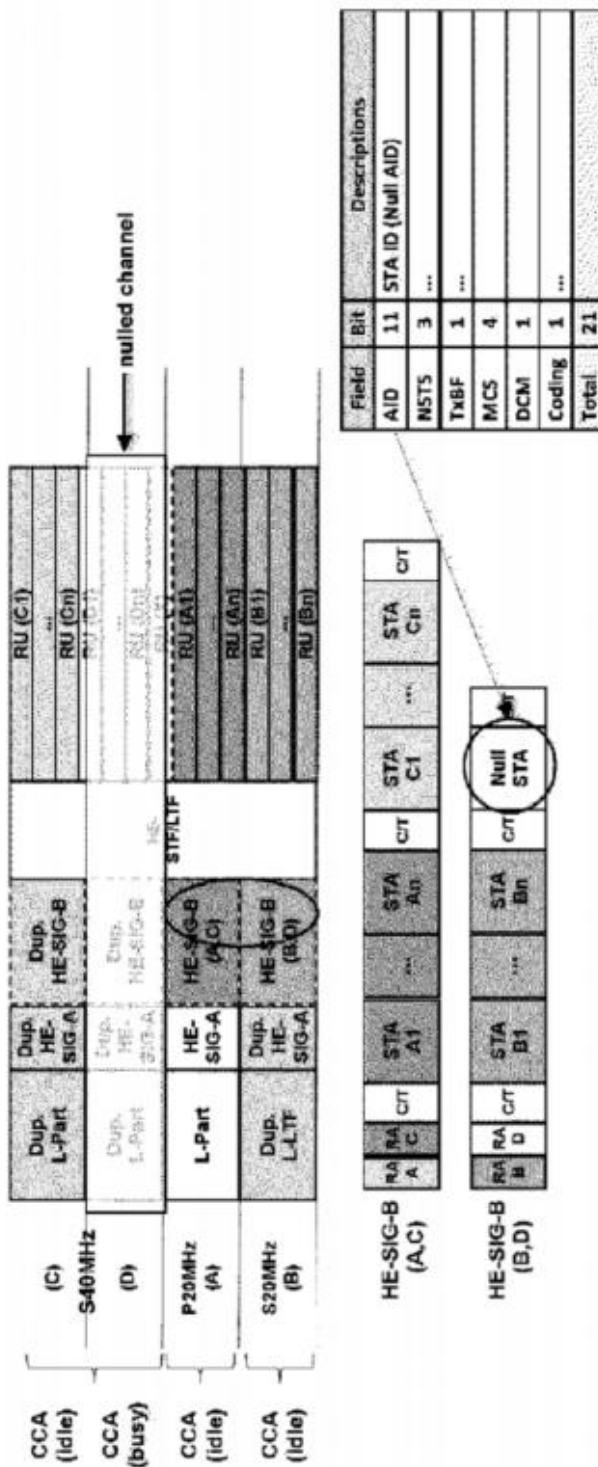
Table 2 - HE-SIG-A field for an HE MU PPDU

Field	Length (bits)	Description
...		
Bandwidth	≥ 2	May accommodate more than in SU case to take advantage of OFDMA
...		

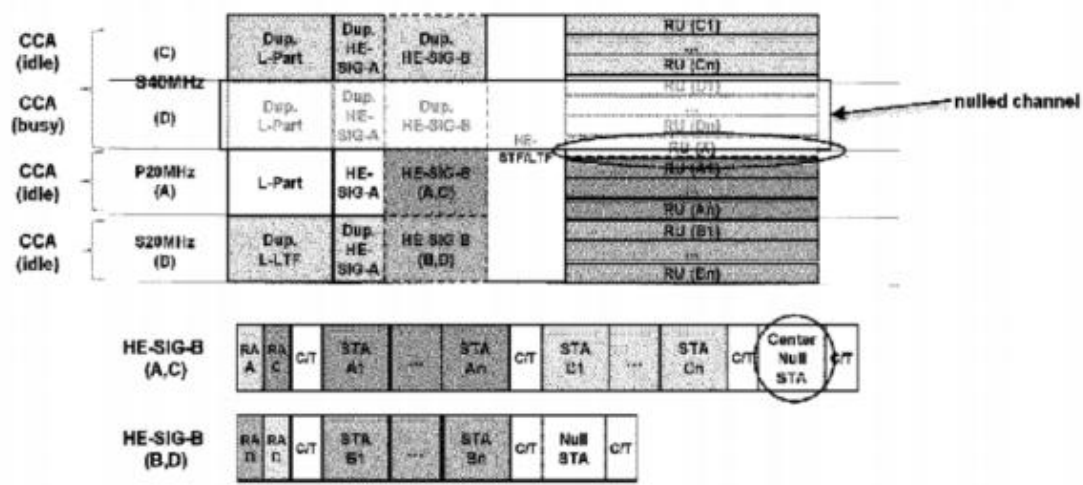
[FIG. 41]



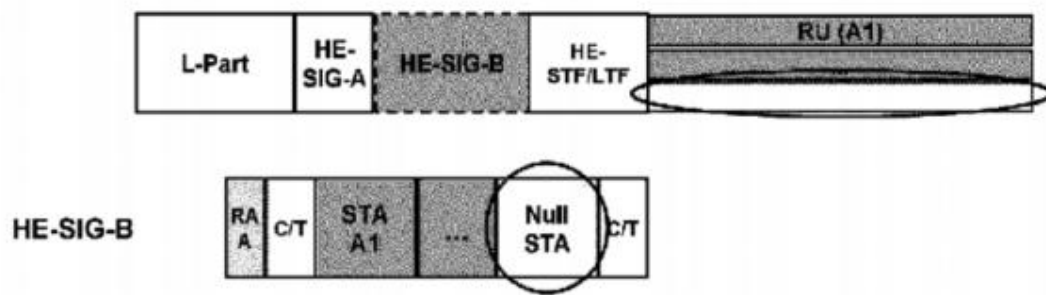
[FIG. 42]



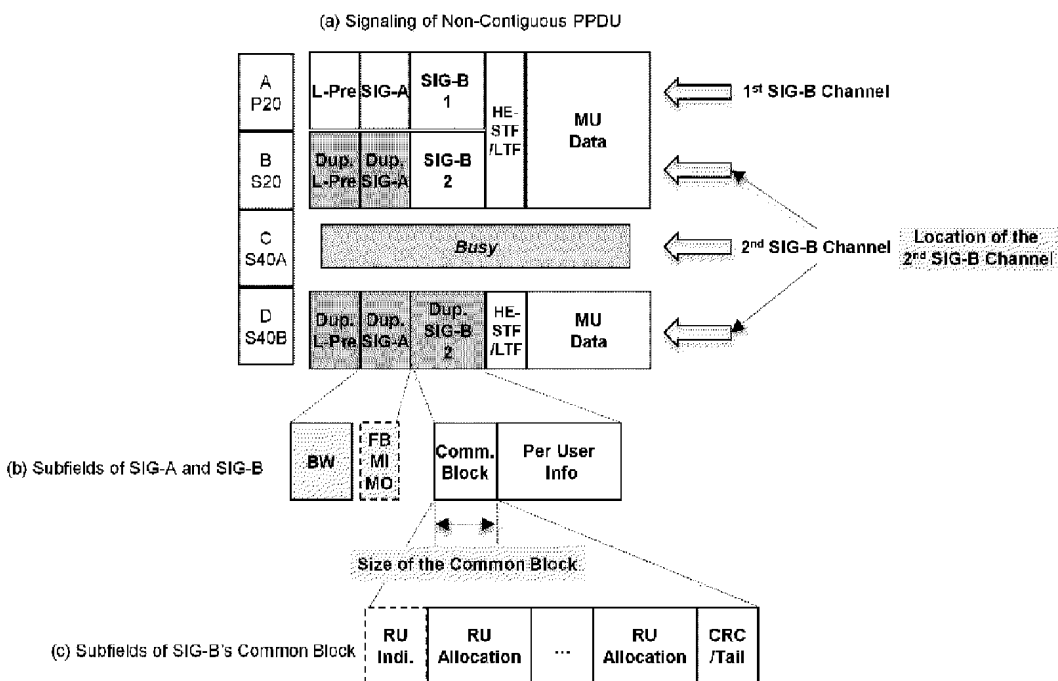
[FIG. 43]



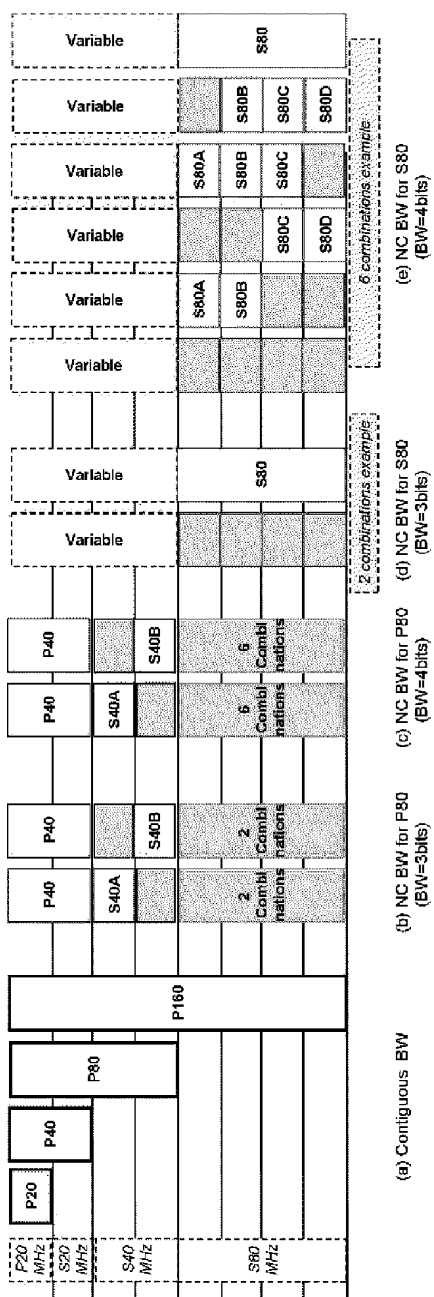
[FIG. 44]



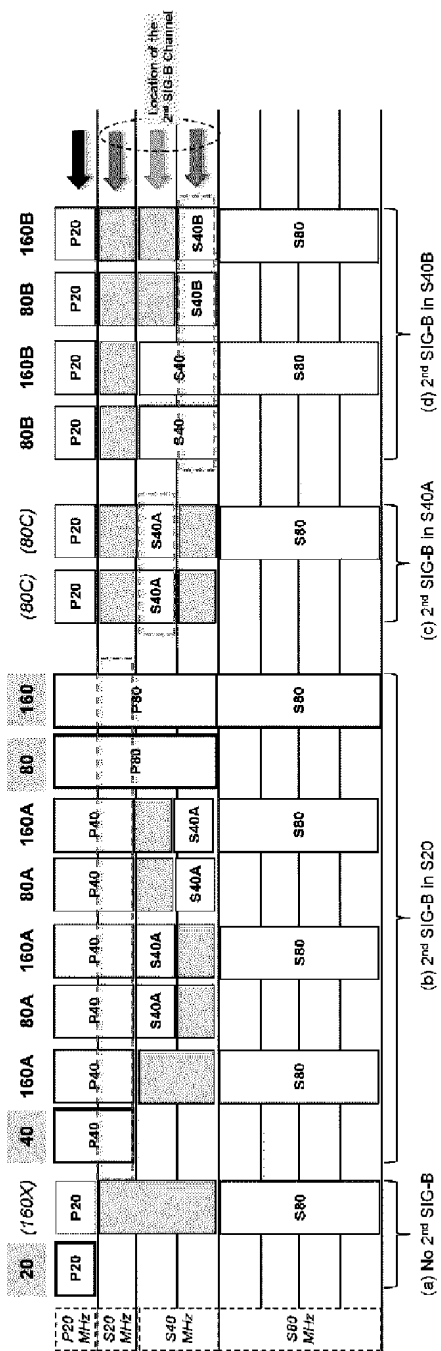
[FIG. 45]



[FIG. 46]



[FIG. 47]



[FIG. 48]

