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This is to certify that the following application attached hereto is a true copy from the records of the Korean Intellectual Property Office. [*English*]

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**Commissioner of the Korean Intellectual Property Office**
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# [Bibliography]

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| **[Applicant]** | |
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| **[General Power of Attorney Reg. No.]** | 2014-036557-3 |
| **[Title of the Invention in Korean]** | METHOD, APPARATUS, AND SYSTEM FOR LENGTH FIELD SETTING IN L-SIG AND SIGNALING USING THE FIELD IN WIRELESS LAN |
| **[Title of the Invention in English]** | METHOD, APPARATUS, AND SYSTEM FOR LENGTH FIELD SETTING IN L-SIG AND SIGNALING USING THE FIELD IN WIRELESS LAN |
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**[National R&D Project That Supported This Invention]**

| | |
|---|---|
| **[Project No.]** | R0166-15-1030 |
| **[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]** | IEEE 802.11 High Efficiency WLAN (HEW) Standard Development |
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**[Purpose]** This is hereby submitted to the Commissioner of the Korean Intellectual Property Office (KIPO) as stated above.

*Agent or Attorney* Kook Il Lim (signature or seal)

**[Fees]**

| | | |
|---|---|---|
| **[Application Filing Fee]** | 0 page(s) | 46,000 KRW |
| **[Additional Application Filing Fee]** | 34 page(s) | 0 |
| **[Priority Claim Fee]** | 0 case(s) | 0 |
| **[Fee for Request for Examination]** | 0 claim(s) | 0 |
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| **[Reason for Fee Reduction]** | Small Business (70% reduction) [1] | |
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# [Description of the Invention]

## [Title of the Invention]

METHOD, APPARATUS, AND SYSTEM FOR LENGTH FIELD SETTING IN L-SIG AND SIGNALING USING THE FIELD IN WIRELESS LAN [*Korean*] {METHOD, APPARATUS, AND SYSTEM FOR LENGTH FIELD SETTING IN L-SIG AND SIGNALING USING THE FIELD IN WIRELESS LAN [*English*]}

## [Technical Field]

<1> The present invention relates to a wireless communication method, and more particularly, to various methods, apparatuses, and systems for setting the L-SIG Length Field in a wireless LAN and performing signaling using the same.

## [Background of the Invention]

<2> In recent years, as mobile devices have become increasingly popular, wireless LAN technologies capable of providing fast wireless Internet services to these devices are garnering significant attention. Wireless LAN technology enables mobile devices such as smartphones, tablets, laptop computers, portable multimedia players, and embedded devices to wirelessly access the Internet in a home, business, or specific service area using short-range wireless communication technology.

<3> Since the Institute of Electrical and Electronics Engineers (IEEE) 802.11 supported early wireless LAN technologies using the 2.4 GHz frequency band, standards for a variety of technologies have been put into practical use or are currently 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 following IEEE 802.11b, it uses frequencies in the 5 GHz band rather than the 2.4 GHz band, which reduces the impact of interference compared to the significantly more congested 2.4 GHz band, and employs 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. IEEE 802.11g, like IEEE 802.11b, uses frequencies in the 2.4 GHz band to achieve communication speeds of up to 54 Mbps and ensures backward compatibility, which has garnered significant attention. It also offers an advantage over IEEE 802.11a in terms of communication range.

<4> IEEE 802.11n is a technical specification designed to overcome the limitations on communication speed that have been identified as a weakness in wireless LANs. IEEE 802.11n aims to increase the speed and reliability of networks and extend the operating range 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 Input Multiple Output (MIMO) technology, which uses multiple antennas at both the transmitter and receiver ends to minimize transmission errors and optimize data rates. The standard also employs a coding scheme that transmits multiple redundant copies of the data to enhance 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—referred to as VHT (Very High Throughput)—than the data rates supported by IEEE 802.11n. Among these, IEEE 802.11ac supports a wide bandwidth (80 MHz to 160 MHz) in the 5 GHz frequency band. Although the

IEEE 802.11ac standard is defined only for the 5 GHz band, early 11ac chipsets will also support operation in the 2.4 GHz band to ensure backward compatibility with existing 2.4 GHz band products. In theory, the standard will enable 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/5 GHz 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 content such as large-capacity data or uncompressed HD video.

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

**[Summary 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 for wireless LAN communication can be provided.

## [Effect of the Invention]

<9> According to an embodiment of the present invention, a method is provided for efficiently performing random access in multi-user transmission. The present invention can be used in various communication devices, such as stations or access points utilizing wireless LANs, stations or base stations utilizing communications, and the like.

## [Brief Description of the Drawings]

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

FIG. 2 is a diagram 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 is an equation representing the transmission time of an HE packet according to an embodiment of the present invention.

FIG. 6 is an expression representing the L_LENGTH setting according to an embodiment of the present invention.

FIG. 7 is an equation representing the PE-Disambiguity field setting criterion according to an embodiment of the present invention.

FIG. 8 is an equation representing the calculation of N_SYM and T-PE in a next-generation wireless LAN receiver according to an embodiment of the present invention.

FIG. 9 is an equation illustrating the reception time calculation for a legacy terminal related to an embodiment of the present invention.

FIG. 10 is an equation illustrating the L_LENGTH setting according to an embodiment of the present invention.

FIG. 11 shows the equations for calculating N_SYM and T_PE in a next-generation wireless LAN receiver according to an embodiment of the present invention.

FIG. 12 shows the equation representing the L_LENGTH setting according to an embodiment of the present invention.

FIG. 13 shows the equations for calculating N_SYM and T_PE in a next-generation WLAN receiver according to an embodiment of the present invention.

**[Detailed Description of Embodiments 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 the emergence of new technologies, etc. In addition, in certain cases, terms have been chosen at the applicant's discretion, in which case their meaning will be provided in the description of the invention to which they relate. It is therefore intended that the terms used in this specification should be interpreted 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 component 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 stated otherwise. In addition, the limitation of "the same or more" or "the same or less" with respect to a particular threshold may be appropriately substituted with "more than" or "less than," respectively, depending on the embodiment.

<14> 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.

<15> As illustrated in FIG. 1, infrastructure BSS (BSS1, BSS2) includes one or more stations (STA-1, STA-2, STA-3, STA-4, STA-5), an access point (PCP/AP-1, PCP/AP-2) which 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).

<16> A 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 and access points (APs). Additionally, the term "terminal" may be used in this specification to refer to a concept that encompasses both stations and wireless LAN communication devices, such as APs. A wireless communication station includes a processor and a transceiver, and may further include a user interface, a display unit, and the like, depending on the specific implementation. The processor may generate frames to be transmitted over the wireless network, process frames received over the wireless network, and perform various other processing tasks to control the station. The transceiver is functionally connected to the processor and transmits and receives frames over the wireless network on behalf of the station.

<17> 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 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.

<18> 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).

<20> FIG. 2 illustrates an independent BSS, which is a wireless LAN system according to another embodiment of the present invention. In the embodiment of FIG. 2, portions that are identical or corresponding to the embodiment of FIG. 1 are omitted to avoid redundant description.

<21> 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 connected to an AP. An independent BSS is not permitted to connect to the distribution system and forms a self-contained network. In an independent BSS, each station (STA-6, STA-7) can connect directly to one another.

<23> FIG. 3 is a block diagram illustrating the configuration of a station 100 according to one embodiment of the present invention.

<24> 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.

<25> First, the network interface card 120 is a module for providing wireless LAN connectivity and

handles 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 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 as a standalone component or may be integrated into a single chip.

<26> 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. Furthermore, the user interface portion 140 may utilize various output means to perform outputs based on instructions from the processor 110.

<27> 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 from 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 establish connections with APs or external stations.

<28> 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. Furthermore, the processor 110 may read information regarding the priority condition of the station 100 included in the communication setup message and may request access to the AP based on that information. Specific embodiments of this will be described later.

<29> 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 included in the station 100.

<31> FIG. 4 is a block diagram illustrating the configuration of an AP 200 according to one embodiment of the present invention.

<32> 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.

<33> Referring now to FIG. 4, an AP 200 according to the present invention 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 include a plurality of network interface modules utilizing different frequency bands from one another. In other words, the AP 200 according to an embodiment of the present invention may comprise two or more network interface card modules operating 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 operating in a frequency band above 6 GHz and a network interface card module operating in 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 AP 200 may operate only one network interface card module at a time or may operate multiple network interface card

modules simultaneously, depending on the performance and requirements of the AP 200.

<34> 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. Furthermore, 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 to a station stored in the memory 260 and transmit a communication setup message for one or more stations. The communication setup message may include information about the access priority conditions of each station. Furthermore, the processor 210 performs the connection setup according to the connection request from the station. A specific embodiment of this will be described later.

<36> In the following description of FIG. 5 through FIG. 13, the meanings of the variables included in each figure are as follows.

<37> $\lceil x \rceil$ denotes the smallest integer (ceiling) among the numbers greater than or equal to x.

<38> $\lfloor x \rfloor$ denotes the largest integer (flooring) that is less than or equal to x.

<39> $T_{L\_PREAMBLE}$(T_{L_PREAMBLE}) denotes the L preamble duration (the sum of the L-STF, L-LTF, and L-SIG durations).

<40> $T_{HE\_PREAMBLE}$(T_{HE_PREAMBLE}) refers to the duration of the HE preamble.

<41> $T_{PE}$ (T_PE) denotes the duration of the packet extension.

<42> $T_{SYM}$(T_SYM) refers to the duration of the HE symbol.

<43> TXTIME refers to the duration of a PPDU.

<44> L_LENGTH refers to the value of the Length field in the L-SIG.

<45> $b_{PE\_Disambiguity}$(b_{PE_Disambiguity}) refers to the value of the PE-Disambiguity field (0 or 1).

<46> aSymbolLength refers to the duration of a symbol.

<47> aPLCPServiceLength refers to the number of bits in the PLCP SERVICE field.

<48> aPLCPTailLength refers to the number of bits contained in the tail bits.

<49> $N_{OPS}$(N_OPS) refers to the number of octets that can be transmitted during one aSymbolLength. According to an embodiment of the present invention, $N_{OPS}$(N_OPS) may also refer to the number of octets that can be transmitted during one aSymbolLength at the rate specified by L_DATARATE.

<51> FIG. 5 is an expression representing the transmission time of an HE packet according to an embodiment of the present invention.

<52> Referring to FIG. 5, the transmission time (TXTIME) of an HE packet can be calculated as the

sum of T_{L_PREAMBLE}, T_{HE_PREAMBLE}, T_{HE_DATA}, and T_PE, where T_{L_PREAMBLE}, T_{HE_PREAMBLE}, T_{HE_DATA}, T_PE represent the L preamble duration, HE preamble duration, data duration, and packet extension duration, respectively. Furthermore, T_{HE_DATA} can be expressed by multiplying the HE OFDM symbol duration, T_{HE_SYM}, by the number of data symbols, N_SYM. Furthermore, T_{HE_SYM} can be expressed as the 12.8 μs signal length (after IDFT/IFFT during OFDM symbol generation), excluding the OFDM symbol's guard interval (cyclic prefix), plus the guard interval duration T_GI. The packet extension is a field appended to the end of the PPDU to provide processing time.

<54> FIG. 6 shows the equation representing the L_LENGTH setting according to an embodiment of the present invention.

<55> Referring to FIG. 6, the Length field of the L-SIG can be utilized to signal the packet length in next-generation wireless LANs, and L_LENGTH—the value to be entered into the L Length field—is calculated from the TXTIME value computed as shown in the equation in FIG. 5. By retaining the L part at the beginning of the PPDU and setting the L_LENGTH value of the L-SIG in a format that legacy devices can read, legacy devices can appropriately defer transmission even when they encounter new Wi-Fi packets.

<56> The following describes the equation in FIG. 6. TXTIME - T_{L_PREAMBLE} yields the packet length minus the legacy preamble length, and T_{L_PREAMBLE} can be 20 μs, which is the sum of the L-STF length (8 μs), the L-LTF length (8 μs), and the L-SIG length (4 μs).

aSymbolLength represents the length of one OFDM symbol. To set L_LENGTH so that legacy devices can also handle it correctly, you must use aSymbolLength as the legacy OFDM symbol length, which is 4 [us/symbol]. Dividing the value obtained by subtracting the L preamble length from TXTIME by the 1-symbol duration and applying the ceiling function yields the number of 4-us symbols in the portion of the packet excluding the L preamble. Multiplying this by N_OPS—the number of octets transmitted during aSymbolLength when transmitting at the L_DATARATE rate—yields the number of octets (at the L_DATARATE rate) in the portion of the packet excluding the L preamble. For 11n and 11ac, L_DATARATE is set to a value corresponding to 6 Mbps, and it can be set to the same value for next-generation Wi-Fi; in such cases, N_OPS—the number of octets that can be transmitted in a 4-μs symbol—is 3. Next, the number of bytes for the Service field and Tail bits is calculated by adding aPLCPServiceLength (the number of bits in the Service field) and aPLCPTailLength (the number of Tail bits), dividing the result by 8, and taking the ceiling. In Wi-Fi, this value is 3. Therefore, the overall formula for L_LENGTH in FIG. 6 represents the number of bytes when the rate is L_DATARATE for the portion excluding the L preamble, Service field, and Tail bits.

<58> FIG. 7 shows the equation representing the PE-Disambiguity field setting criterion according to an embodiment of the present invention.

<59> In next-generation wireless LANs, the introduction of packet extensions causes ambiguity when calculating the number of OFDM symbols at the receiving end. This is because the last received symbol could be actual data, or it could be a signal containing no information due to the packet extension.

Therefore, to eliminate this ambiguity, the PE-Disambiguity field can be set to 1 if the symbol length is appended to the end of the packet via packet extension, and to 0 otherwise. In this case, whether the symbol length has been added to the end of the packet can be determined using the expression in FIG. 7. If the expression shown in FIG. 7 is satisfied, the symbol length has been added, and the PE-Disambiguity field is set to 1; if the expression in FIG. 7 is not satisfied, the symbol length has not been added, and the PE-Disambiguity field can be set to 0.

<60> In the equation in FIG. 7, 701 represents the portion added to align the Length setting with the legacy symbol unit (i.e., 4 μs symbol unit) expressed in symbol units. Multiplying this value (701) by aSymbolLength expresses the portion added to set the Length to the legacy symbol unit in time units. Adding T_PE to this yields the length starting from the last OFDM symbol following the point where the actual information must be extracted from the rear portion of the packet; this value is then compared to T_SYM, the HE OFDM symbol length.

<61> Furthermore, there may be cases where there is no PE ambiguity for specific values of T_PE and GI, and in such cases, the PE-Disambiguity field can be used for other purposes. For example, when T_PE is 0, 4, or 8 μs for GI 0.8 and 1.6 μs, the equation in FIG. 7 is not always satisfied; however, when T_PE is 0, 4, 8, or 12 μs for GI 3.2 μs, the equation in FIG. 7 is not always satisfied, and when T_PE is 16 us for a GI of 3.2 us, the equation in FIG. 7 is always satisfied. Therefore, if the possible T_PE values are limited by the terminal's PE capability, it is possible to determine the T_PE value simply by knowing the GI value.

In this case, it is possible to use the PE-Disambiguity field for signaling purposes other than PE-Disambiguity, or to use it as a CRC to ensure more robust transmission.

<63> FIG. 8 shows the equations for calculating N_SYM and T_PE in a next-generation wireless LAN receiver according to an embodiment of the present invention.

<64> In the equation in FIG. 8, N_SYM is the number of HE OFDM symbols in the data portion of the packet, and T_PE is the duration of the packet extension; L_LENGTH is the L_LENGTH value set according to the method described in FIG. 6, and b_{PE_Disambiguity} is the value of the PE-Disambiguity field set according to the method described in FIG. 7. 801 is the length of the packet from the start of the HE preamble to the end. The value 3 in 802 is calculated by expressing the Service field and Tail bit sections in bytes. The value 3 in 803 is calculated because, when L_DATARATE is set to 6 Mbps, 3 bytes can be transmitted during the 4 µs legacy OFDM symbol duration. The value of 4 in the equation in FIG. 8 represents the legacy OFDM symbol duration of 4 µs (or 4 µs/symbol). In the formula for calculating T_PE, the numerator of the floor operation is the length starting from the last OFDM symbol from which actual information must be extracted in the packet, plus the increased packet length resulting from setting the Length to 4 µs, which is the sum of the packet extension and the legacy symbol duration.

<66> FIG. 9 shows the formula for calculating the reception time of a legacy terminal in an embodiment of the present invention.

<67> Referring to FIG. 9, when a legacy terminal receives a Wi-Fi packet, it can calculate the packet length by examining L_LENGTH, the value of the Length field in the L-SIG. Therefore, even if the packet is not addressed to the legacy terminal itself, it can determine the packet length and defer transmission appropriately. In the equation in FIG. 9, the number of symbols including the portion represented by L_LENGTH, the Service field, and the Tail bit (i.e., the number of symbols from the end of the L preamble to the end) is calculated using the ceiling operation. This value is then multiplied by aSymbolLength to convert it into time, and T_{L_PREAMBLE} is added to calculate the total packet length. However, looking at the part where the ceiling operation is performed, it is divided by N_OPS (3) and then rounded up. Since the Service field and Tail bit are 3 bytes, the value derived after the ceiling operation and the final RXTIME value will be the same when L_LENGTH is 3x, (3x-1), or (3x-2) (where x = 1, 2, 3, ⋯n). Therefore, this can be used as a signaling mechanism to set L_LENGTH.

<69> FIG. 10 is an equation representing the L_LENGTH setting according to an embodiment of the present invention.

<70> Referring to FIG. 10, the Length field of the L-SIG can be utilized to signal the packet length in next-generation wireless LANs, and L_LENGTH—the value to be entered into the L Length field—is calculated from the TXTIME value computed as shown in the equation in FIG. 5. By reserving the L part at the beginning of the PPDU and setting the L_LENGTH value in the L-SIG so that legacy devices can read it, legacy devices can appropriately defer transmission even when they encounter the new Wi-Fi packet.

<71> As described in FIG. 9, there are three values of L_LENGTH that yield the same RXTIME, so

these can be used for signaling. As shown in FIG. 10, the m value used for signaling can be added to the L_LENGTH value, and if appropriate corrections are made when calculating N_SYM and T_PE at the receiving end, there will be no impact on next-generation wireless LANs.

<72> The following describes the equation in FIG. 10. TXTIME - T_{L_PREAMBLE} yields the packet length minus the legacy preamble length, and T_{L_PREAMBLE} can be 20 μs, which is the sum of the L-STF length (8 μs), the L-LTF length (8 μs), and the L-SIG length (4 μs). aSymbolLength is the length of one OFDM symbol. To set L_LENGTH so that legacy devices can also defer correctly, aSymbolLength must be set to 4 [us/symbol], which is the legacy OFDM symbol length. Dividing the value obtained by subtracting the L preamble length from TXTIME by 1 symbol duration and applying the ceiling function yields the number of 4-us symbols in the portion of the packet excluding the L preamble. Multiplying this by N_OPS—the number of octets transmitted during aSymbolLength when transmitting at the L_DATARATE rate—yields the number of octets in the portion of the packet excluding the L preamble (at the L_DATARATE rate). For 11n and 11ac, L_DATARATE is set to a value corresponding to 6 Mbps, and it can be set to the same value for next-generation Wi-Fi; in such cases, N_OPS—the number of octets that can be transmitted in a single 4-μs symbol—is 3. Next, the number of bytes for the Service field and Tail bits is calculated by adding aPLCPServiceLength (the number of bits in the Service field) and aPLCPTailLength (the number of Tail bits), dividing the result by 8, and taking the ceiling. In Wi-Fi, this value is 3. Therefore, the overall formula for L_LENGTH in FIG. 10 represents the number of bytes obtained by adding the signaling m to the value of L_DATARATE for the portion excluding the L preamble, Service field, and Tail bits.

<73> In one embodiment, the value of m can be set to 1 or 2. As shown in FIG. 9, when calculating RXTIME, if L_LENGTH is set as shown in FIG. 10, RXTIME is calculated to be one symbol length longer than in the case of FIG. 6, where m signaling is not used, and terminals that receive this packet will defer transmission for that much longer. Consequently, the transmitter and receiver can achieve the effect of protecting the transmitted packet for a longer duration. The information signaled by the value of m includes whether HE-SIG-A is repeated and whether HE-SIG-B is present. Additionally, when HE-SIG-A is repeated, signaling is possible depending on whether the modulation of the first HE-SIG-A and the repeated HE-SIG-A is BPSK-BPSK or BPSK-QBPSK, and the information signaled at this time includes the presence of HE-SIG-B. Here, modulating the first HE-SIG-A using BPSK is intended to ensure that legacy terminals and 11ax terminals can perform auto-detection without difficulty.

<74> In another embodiment, the value of m can be set to a value greater than 2. In this case, a terminal that receives this packet will defer transmission for a duration longer than the actual packet length, and the transmitting and receiving ends can achieve the effect of protecting the transmitted packet for a duration longer than the actual packet length.

<76> FIG. 11 shows the equations for calculating N_SYM and T_PE in a next-generation wireless LAN receiver according to an embodiment of the present invention.

<77> In the equation in FIG. 11, N_SYM is the number of HE OFDM symbols in the data portion of the packet, and T_PE is the duration of the packet extension; L_LENGTH is the L_LENGTH value set according to the method described in FIG. 10, and b_{PE_Disambiguity} is the value of the PE-Disambiguity field set according to the method described in FIG. 7. As described in FIG. 10, when using m signaling, if appropriate corrections are applied when calculating N_SYM and T_PE at the receiver, there is no impact on next-generation wireless LANs, and it is possible to include the -m term in the equation as shown in FIG. 11. 1101 is the length from the start of the HE preamble to the end of the packet. The value 3 in 1102 is calculated by expressing the Service field and Tail bit sections in bytes, and the value 3 in 1103 is calculated because 3 bytes can be transmitted during the 4us legacy OFDM symbol duration when L_DATARATE is set to 6Mbps. The value of 4 in the equation in FIG. 11 represents the legacy OFDM symbol duration of 4 μs (or 4 μs/symbol). In the equation for calculating T_PE, the numerator of the floor operation is the length starting from the last OFDM symbol from which actual information must be extracted in the packet, combined with the increased packet length resulting from setting the Length to 4 μs—the duration of the packet extension and the legacy symbol.

<78> Additionally, to determine the m value at the receiving end, an operation such as (L_LENGTH mod 3) can be performed.

<80> FIG. 12 is an expression representing the L-LENGTH setting according to an embodiment of the present invention.

<81> Referring to FIG. 12, the Length field of L-SIG can be utilized to signal the packet length in

next-generation wireless LANs, and L_LENGTH—the value to be entered into the L Length field—is calculated from the TXTIME value computed as shown in the equation in FIG. 5. By retaining the L part at the beginning of the PPDU and configuring the L_LENGTH setting of the L-SIG within it in a format that legacy devices can read, legacy devices can appropriately defer transmission even when they encounter the new Wi-Fi packet.

<82> As described in FIG. 9, there are three values of L_LENGTH that yield the same RXTIME, so these can be used for signaling. As shown in FIG. 12, the m value used for signaling can be subtracted from the L_LENGTH value, and if appropriate corrections are made when calculating N-SYM and T_PE at the receiving end, there will be no impact on next-generation wireless LANs.

<83> The following describes the equation in FIG. 12. TXTIME - T_{L_PREAMBLE} yields the packet length minus the legacy preamble length, and T_{L_PREAMBLE} can be 20 μs, which is the sum of the L-STF length (8 μs), the L-LTF length (8 μs), and the L-SIG length (4 μs). aSymbolLength is the length of one OFDM symbol. To set L_LENGTH so that legacy devices can also defer correctly, aSymbolLength must be set to 4 [us/symbol], which is the legacy OFDM symbol length. Dividing the value obtained by subtracting the L preamble length from TXTIME by 1 symbol duration and applying the ceiling function yields the number of 4-us symbols in the portion of the packet excluding the L preamble. Multiplying this by N_OPS—the number of octets transmitted during aSymbolLength when transmitting at the L_DATARATE rate—yields the number of octets in the portion of the packet excluding the L preamble (at the L_DATARATE rate). For 11n and 11ac, L_DATARATE is set to a value

corresponding to 6 Mbps, and it can be set to the same value for next-generation wireless LANs; in such cases, N_OPS—the number of octets that can be transmitted in a single 4-us symbol—is 3. Next, add aPLCPServiceLength (the number of bits in the Service field) and aPLCPTailLength (the number of Tail bits), then divide by 8 and round up to calculate the number of bytes for the Service field and Tail bits, and subtract this value; in Wi-Fi, this value is 3. Therefore, the overall formula for L_LENGTH in FIG. 10 represents the number of bytes when the rate is L_DATARATE for the portion excluding the L preamble, Service field, and Tail bits, minus the signaling m.

<84> In one embodiment, the value of m can be set to 1 or 2. As shown in FIG. 9, when calculating RXTIME, the result is exactly the same as in FIG. 6—where m signaling is not used—when L_LENGTH is set as shown in FIG. 12. Therefore, there is absolutely no impact on legacy terminals, and this approach is fairer to legacy terminals compared to the L_LENGTH setting method described in FIG. 10, which causes legacy terminals to defer for a duration longer than the actual packet length. The information signaled by the value of m includes whether HE-SIG-A is repeated and whether HE-SIG-B is present. Furthermore, when HE-SIG-A is repeated, it is possible to signal based on whether the modulation of the first HE-SIG-A and the repeated HE-SIG-A is BPSK-BPSK or BPSK-QBPSK, and the information signaled in this case includes the presence or absence of HE-SIG-B. Here, modulating the first HE-SIG-A using BPSK is intended to ensure that legacy terminals and 11ax terminals can perform auto-detection without issues.

<85> In another embodiment, the value of m can be set to 0, 1, or 2. When RXTIME is calculated as shown in FIG. 9, the result is exactly the same as in FIG. 6 (which doe s not use m signaling) when L_LENGTH

is set as shown in FIG. 12. Therefore, there is absolutely no impact on legacy terminals, and it is fairer to legacy terminals compared to the L_LENGTH setting method described in FIG. 10, which causes legacy terminals to defer longer than the actual packet length. The information signaled by the m value can include three types of guard intervals (0.8, 1.6, 3.2 us), among others.

<86> In another embodiment, the value of m can be set to a value greater than 2. In this case, a terminal that receives this packet will defer transmission for a duration longer than the actual packet length, and the transmitting and receiving ends can achieve the effect of protecting the transmitted packet for a duration longer than the actual packet length.

<88> FIG. 13 shows the equations for calculating N_SYM and T_PE in a next-generation wireless LAN receiver according to an embodiment of the present invention.

<89> In the equation in FIG. 13, N_SYM is the number of HE OFDM symbols in the data portion of the packet, and T_PE is the duration of the packet extension; L_LENGTH is the L_LENGTH value set according to the method described in FIG. 12, and b_{PE_Disambiguity} is the value of the PE-Disambiguity field set according to the method described in FIG. 7. As described in FIG. 12, when using m signaling, if appropriate corrections are applied when calculating N_SYM and T_PE at the receiver, there is no impact on next-generation wireless LANs, and it is possible to include the +m term in the equation as shown in FIG. 13. 1301 is the length of the packet from the start of the HE preamble to the end.

The value of 3 in 1302 is calculated by representing the Service field and Tail bit sections in bytes, while the value of 3 in 1303 is calculated based on the fact that 3 bytes can be transmitted during the 4 μs legacy OFDM symbol duration when L_DATARATE is set to 6 Mbps. The value 4 in the equation in FIG. 13 represents the legacy OFDM symbol length of 4 μs (or 4 μs/symbol). In the equation for calculating T_PE, the numerator of the floor operation is the length starting from the OFDM symbol following the last one from which actual information must be extracted from the packet, combined with the packet extension and the 4 μs legacy symbol duration, which is the total length of the packet.

<90> Additionally, to determine the value of m at the receiver, an operation such as (3 - (L_LENGTH mod 3)) can be performed.

<92> Although the present invention has been described using wireless LAN communication as an example, the invention is not limited thereto and may be equally applied to other communication systems, such as cellular communication. Furthermore, although the methods, devices, and systems of the present invention have been described in relation to specific embodiments, some or all of the components and operations of the present invention may be implemented using a computer system having a general-purpose hardware architecture.

<93> The foregoing description of the invention is for illustrative purposes only, and those having ordinary knowledge in the technical field to which the invention belongs will understand that it is readily adaptable to other specific forms without altering the technical idea or essential features of the invention. The embodiments described above should therefore be interpreted as examples and not limiting in all respects. For example, each configuration element described as a single type may be distributed, and

similarly, configuration elements described as distributed may be combined.

<94> The scope of the present invention is indicated by the patent claims described below rather than by the detailed description above, and the meaning and scope of the claims, as well as all modifications or variations derived from their conceptual equivalents, are to be construed as falling within the scope of the present invention.

**[Description of Numeral Symbols]**

<95> 100: station

200: access point

# [Scope of Patent Claims]

## [Claim 1]

Method, apparatus, and system for wireless LANs.

# [Summary]

## [Abstract]

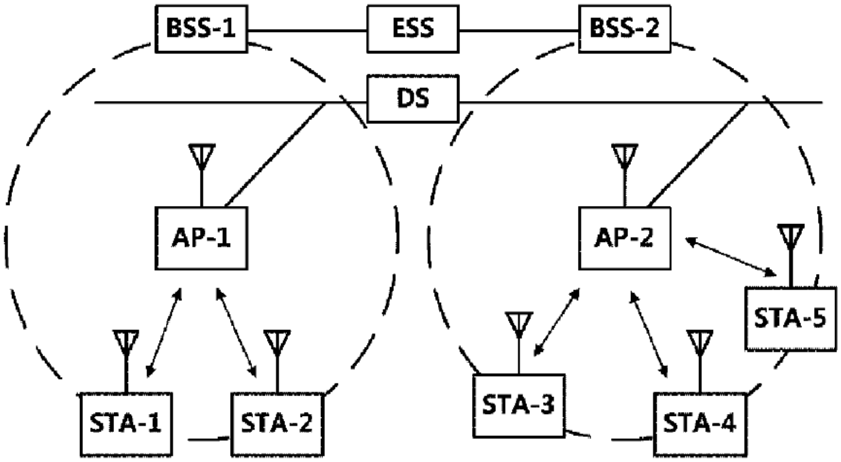
The present invention relates to a wireless communication method. According to an embodiment of the present invention, various methods, devices, and systems for setting an L-SIG Length Field in a wireless LAN and performing signaling using the same may be provided.

## [Representative Drawings]

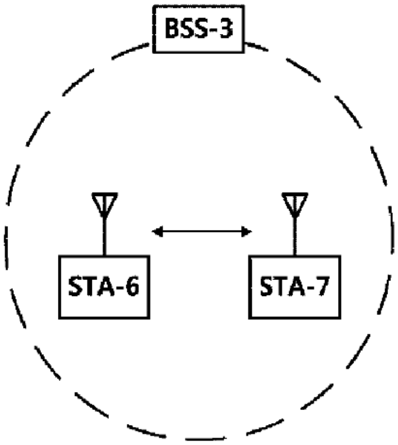
FIG. 12

# [Drawings]

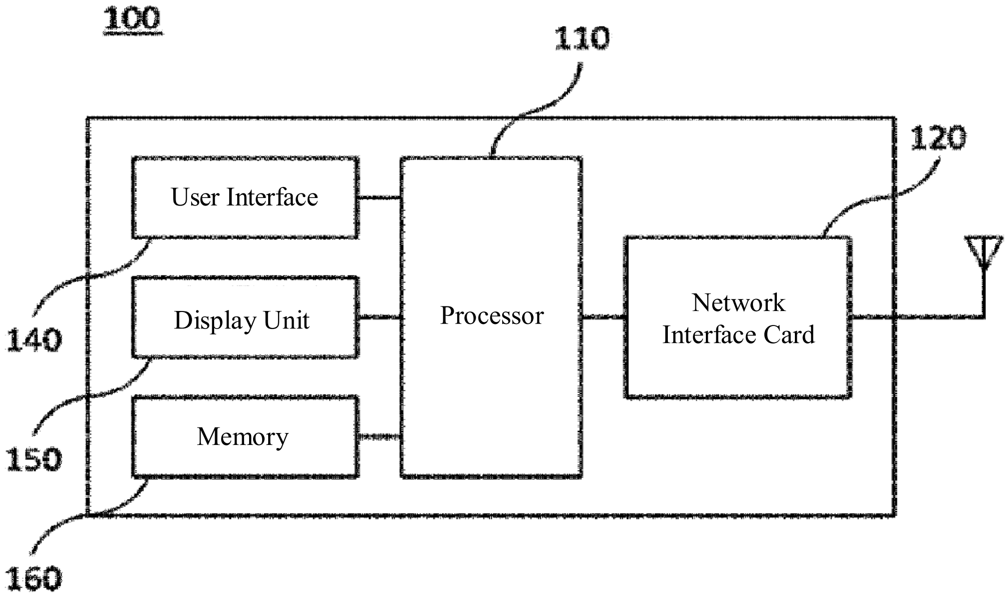
**[FIG. 1]**



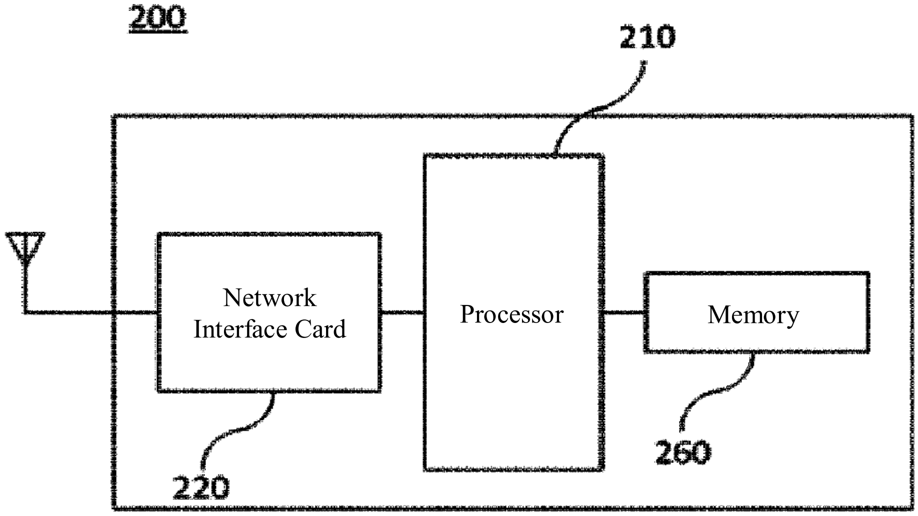
**[FIG. 2]**



**[FIG. 3]**


100
110
120
User Interface
Display Unit
Memory
Processor
Network Interface Card
140
150
160

**[FIG. 4]**


200
210
Network Interface Card
Processor
Memory
220
260

**[FIG. 5]**

$$TXTIME = T_{L\_PREAMBLE} + T_{HE\_PREAMBLE} + T_{HE\_DATA} + T_{PE}$$

where $T_{HE\_DATA} = T_{HE\_SYM} \times N_{SYM} = (12.8 + T_{GI}) \times N_{SYM}$

**[FIG. 6]**

$$\begin{aligned} L\_LENGTH &= \left\lceil \frac{TXTIME - T_{L\_PREAMBLE}}{aSymbolLength} \right\rceil \times N_{OPS} - \left\lceil \frac{aPLCPServiceLength + aPLCPTailLength}{8} \right\rceil \\ &= \left\lceil \frac{TXTIME-20}{4} \right\rceil \times 3 - 3 \end{aligned}$$

| where | |
|---|---|
| $\lceil x \rceil$ | denotes the smallest integer greater than or equal to $x$ (ceiling) |
| $TXTIME$ | is the duration of PPDU |
| $T_{L\_PREAMBLE}$ | is the duration of L preamble (that is, summation of L-STF, L-LTF, and L-SIG durations) |
| $aSymbolLength$ | is the duration of a symbol |
| $N_{OPS}$ | is the number of octets transmitted during a period of $aSymbolLength$ at the rate specified by L_DATARATE |
| $aPLCPServiceLength$ | is the number of bits in the PLCP SERVICE field |
| $aPLCPTailLength$ | is the number of bits in the tail bit |

**[FIG. 7]**

$$\overbrace{T_{PE} + aSymbolLength \times \left( \left\lceil \frac{TXTIME - T_{L\_PREAMBLE}}{aSymbolLength} \right\rceil - \left( \frac{TXTIME - T_{L\_PREAMBLE}}{aSymbolLength} \right) \right) \geq T_{SYM}}^{701}$$

$$\Rightarrow T_{PE} + 4 \times \left( \left\lceil \frac{TXTIME-20}{4} \right\rceil - \left( \frac{TXTIME-20}{4} \right) \right) \geq T_{SYM}$$

| where | |
|---|---|
| $\lceil x \rceil$ | denotes the smallest integer greater than or equal to $x$ (ceiling) |
| $TXTIME$ | is the duration of PPDU |
| $T_{L\_PREAMBLE}$ | is the duration of L preamble (that is, summation of L-STF, L-LTF, and L-SIG durations) |
| $aSymbolLength$ | is the duration of a symbol |
| $T_{PE}$ | is the duration of packet extension |
| $T_{SYM}$ | is the duration of HE symbol |

**[FIG. 8]**

802 801

803

$$N_{SYM}=\left\lfloor\left(\frac{L\_LENGTH+3}{3}\times4-T_{HE\_PREAMBLE}\right)/T_{SYM}\right\rfloor-b_{PE\_Disambiguity}$$

$$T_{PE}=\left\lfloor\frac{\left(\frac{L\_LENGTH+3}{3}\times4-T_{HE\_PREAMBLE}\right)-N_{SYM}\times T_{SYM}}{4}\right\rfloor\times4$$

| where | |
|---|---|
| $\lfloor x \rfloor$ | denotes the largest integer less than or equal to $x$ (flooring) |
| $L\_LENGTH$ | is the Length field value in L-SIG |
| $b_{PE\_Disambiguity}$ | is PE-Disambiguity field value (0 or 1) |
| $T_{HE\_PREAMBLE}$ | is the duration of HE preamble |
| $T_{SYM}$ | is the duration of HE symbol |

**[FIG. 9]**

$$RXTIME=\left\lceil\frac{L\_LENGTH+\left\lceil\frac{aPLCPServiceLength+aPLCPTailLength}{8}\right\rceil}{N_{OPS}}\right\rceil\times aSymbolLength+T_{L\_PREAMBLE}$$
$$=\left\lceil\frac{L\_LENGTH+3}{3}\right\rceil\times4+20$$

| where | |
|---|---|
| $\lceil x \rceil$ | denotes the smallest integer greater than or equal to $x$ (ceiling) |
| $L\_LENGTH$ | is the Length field value in L-SIG |
| $aSymbolLength$ | is the duration of a symbol |
| $N_{OPS}$ | is the number of octets transmitted during a period of $aSymbolLength$ at the rate specified by L_DATARATE |
| $aPLCPServiceLength$ | is the number of bits in the PLCP SERVICE field |
| $aPLCPTailLength$ | is the number of bits in the tail bit |
| $T_{L\_PREAMBLE}$ | is the duration of L preamble (that is, summation of L-STF, L-LTF, and L-SIG durations) |

**[FIG. 10]**

$$L\_LENGTH_{protection} = \left\lceil \frac{TXTIME - T_{L\_PREAMBLE}}{aSymbolLength} \right\rceil \times N_{OPS} - \left\lceil \frac{aPLCPServiceLength + aPLCPTailLength}{8} \right\rceil + m$$

$$= \left\lceil \frac{TXTIME-20}{4} \right\rceil \times 3 - 3 + m \;,\; m = 1 \text{ or } 2$$

| | | |
|---|---|---|
| where | $\lceil x \rceil$ | denotes the smallest integer greater than or equal to $x$ (ceiling) |
| | $TXTIME$ | is the duration of PPDU |
| | $T_{L\_PREAMBLE}$ | is the duration of L preamble (that is, summation of L-STF, L-LTF, and L-SIG durations) |
| | $aSymbolLength$ | is the duration of a symbol |
| | $N_{OPS}$ | is the number of octets transmitted during a period of $aSymbolLength$ at the rate specified by L_DATARATE |
| | $aPLCPServiceLength$ | is the number of bits in the PLCP SERVICE field |
| | $aPLCPTailLength$ | is the number of bits in the tail bit |

**[FIG. 11]**

$$N_{SYM} = \left\lfloor \overbrace{\left( \underbrace{\frac{L\_LENGTH - m + 3}{3}}_{1103} \overset{1102}{\times 4} - T_{HE\_PREAMBLE} \right)}^{1101} / T_{SYM} \right\rfloor - b_{PE\_Disambiguity}$$

$$T_{PE} = \left\lfloor \frac{\left( \underbrace{\frac{L\_LENGTH - m + 3}{3}}_{1103} \times 4 - T_{HE\_PREAMBLE} \right) - N_{SYM} \times T_{SYM}}{4} \right\rfloor \times 4$$

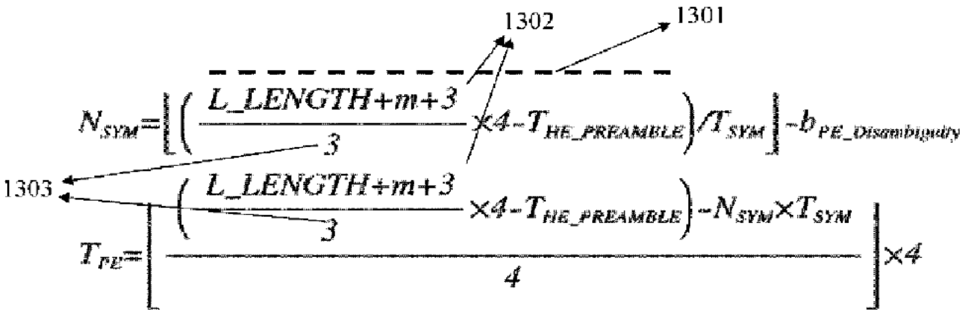
| | | |
|---|---|---|
| where | $\lfloor x \rfloor$ | denotes the largest integer less than or equal to $x$ (flooring) |
| | $L\_LENGTH$ | is the Length field value in L-SIG |
| | $b_{PE\_Disambiguity}$ | is PE-Disambiguity field value (0 or 1) |
| | $T_{HE\_PREAMBLE}$ | is the duration of HE preamble |
| | $T_{SYM}$ | is the duration of HE symbol |

**[FIG. 12]**

$$
\begin{aligned}
L\_LENGTH_{fairness} &= \left\lceil \frac{TXTIME - T_{L\_PREAMBLE}}{aSymbolLength} \right\rceil \times N_{OPS} - \left\lceil \frac{aPLCPServiceLength + aPLCPTailLength}{8} \right\rceil - m \\
&= \left\lceil \frac{TXTIME - 20}{4} \right\rceil \times 3 - 3 - m \ , m = 1 \text{ or } 2
\end{aligned}
$$

| where | | |
|---|---|---|
| | $\lceil x \rceil$ | denotes the smallest integer greater than or equal to $x$ (ceiling) |
| | $TXTIME$ | is the duration of PPDU |
| | $T_{L\_PREAMBLE}$ | is the duration of L preamble (that is, summation of L-STF, L-LTF, and L-SIG durations) |
| | $aSymbolLength$ | is the duration of a symbol |
| | $N_{OPS}$ | is the number of octets transmitted during a period of *aSymbolLength* at the rate specified by L_DATARATE |
| | $aPLCPServiceLength$ | is the number of bits in the PLCP SERVICE field |
| | $aPLCPTailLength$ | is the number of bits in the tail bit |

**[FIG. 13]**



$$
N_{SYM} = \left\lfloor \left( \frac{L\_LENGTH + m + 3}{3} \times 4 - T_{HE\_PREAMBLE} \right) / T_{SYM} \right\rfloor - b_{PE\_Disambiguity}
$$

$$
T_{PE} = \left\lfloor \frac{\left( \frac{L\_LENGTH + m + 3}{3} \times 4 - T_{HE\_PREAMBLE} \right) - N_{SYM} \times T_{SYM}}{4} \right\rfloor \times 4
$$

| where | | |
|---|---|---|
| | $\lfloor x \rfloor$ | denotes the largest integer less than or equal to $x$ (flooring) |
| | $L\_LENGTH$ | is the Length field value in L-SIG |
| | $b_{PE\_Disambiguity}$ | is PE-Disambiguity field value (0 or 1) |
| | $T_{HE\_PREAMBLE}$ | is the duration of HE preamble |
| | $T_{SYM}$ | is the duration of HE symbol |

# CERTIFICATION OF TRANSLATION

# and

# DECLARATION

State of California )
) S. S.
Los Angeles County )

I, Soomi Ko, the undersigned, declare that I am a duly certified Korean Court Interpreter approved by the United States District Courts, certified by the State of California and the Los Angeles County Superior Courts, with competent knowledge of Korean and English, and that I have truthfully and correctly translated file no.WILUS_0150090 from Korean to English and that the said translation is, to the best of my knowledge and belief, a true and correct translation. I further declare that I am neither counsel for, related to, nor employed by any of the parties, and that I have no financial or other interest in the outcome of any action related to this translation. I declare that the foregoing is true and correct.

## Description of Translated Documents

File no.: WILUS_0150090

Executed on March 23, 2026

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Specializing in Korean and Chinese Languages