

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:	:	Customer Number: 31824
Yongho SEOK	:	
	:	
Application No.: 62/080,026	:	Confirmation No.: 5871
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Filed: November 14, 2014	:	
	:	
For: ENHANCED DOWNLINK MU-MIMO	:	
PROCEDURE	:	

SUBMISSION OF ENGLISH TRANSLATION

Commissioner for Patents
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Sir:

Pursuant to 37 CFR. 1.78(a)(5) Applicant hereby submits an English translation of the above-identified provisional application and asserts that the translation is accurate.

Applicant believes no fee is due with this response. However, if a fee is due, please charge our Deposit Account No. 50-2624.

Respectfully submitted,

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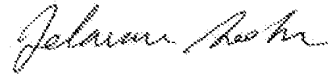
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STATEMENT OF ACCURATE TRANSLATION

I, Je-Kwan Sohn, hereby declare and state that I am knowledgeable of each of the Korean and English languages. I state that Korean to English translation of Specification and Drawings of US provisional application No. 62/080,026, filed on November 14, 2014, titled "ENHANCED DOWNLINK MU-MIMO PROCEDURE," is an accurate translation.

October 22, 2015
(Date)



(Signature)

Je-Kwan Sohn
(Typed Name)

The present invention relates to an IEEE 802.11ax High Efficiency WLAN (HEW) PPDU format used with a 20-MHz above or 40/80/160MHz channel bandwidth in 2.4GHz or 5GHz. Particularly, the present invention relates to simultaneous transmission from an AP to a plurality of STAs, that is, downlink MU-MIMO transmission. Downlink MU-MIMO transmission significantly increases downlink throughput by Orthogonal Frequency Division Multiple Access (OFDMA) and Uplink MU-MIMO.

The following figure shows the HEW PPDP format proposed in the present invention.

L-STF	L-LTF	L-SIG	HEW SIG-A	HEW-STF	HEW-LTF	HEW-LTF	...	HEW-LTF	HEW SIG-B	PSDU (AP to STA6)
				HEW-STF	HEW-LTF	HEW-LTF	...	HEW-LTF	HEW SIG-B	PSDU (AP to STA5)
				HEW-STF	HEW-LTF	HEW-LTF	...	HEW-LTF	HEW SIG-B	PSDU (AP to STA3, STA4)
				HEW-STF	HEW-LTF	HEW-LTF	...	HEW-LTF	HEW SIG-B	PSDU (AP to STA1, STA2)

'L-STF' stands for 'Legacy Short Training Field' which is used to perform frequency offset estimation and phase offset estimation for preamble decoding of a legacy station (STA) such as that of IEEE 802.11a/g/n/ac. 'L-LTF' stands for 'Legacy Long Training Field' which is used to perform channel estimation for preamble decoding of a legacy STA, such as that of IEEE 802.11a/g/n/ac. 'L-SIG' stands for 'Legacy Signal Field' which provides the function of preamble decoding of the legacy STA, such as that of IEEE 802.11a/g/n/ac and protection against PPDU transmission by a third party.

'HEW SIG-A' stands for 'High Efficiency WLAN (HEW) Signal A Field' which provides HEW PPDU modulation parameters or the like for HEW preamble decoding of a HEW STA. The parameters included in the HEW SIG-A field include very high throughput (VHT) PPDU modulation parameters, which are transmitted by the following IEEE 802.11ac terminals, so as to realize compatibility with the IEEE 802.11ac terminals.

Length of VHT SIG-A	Bit	Field	Number of bits	Description
VHT SIG-A	0-3	Rate	2	Set to 0 for 20 MHz, 1 for 40 MHz, 2 for 80 MHz, and 3 for 160 MHz and 80+80 MHz.
	4	Reserved	4	Reserved, set to 1.
	8-11	TXBPS	4	For a VHT SU PPDU: Set to 1 if space-time block coding is used and set to 0 otherwise. For a VHT MU PPDU: Set to 0.
	16-20	Group ID	5	Set to the value of the VHT TXBPS parameter (0-15) for 20 MHz, 16-49 for 40 MHz, 50-119 for 80 MHz, and 120-255 for 160 MHz, otherwise, indicates a VHT MU PPDU.
	24-32	TXBPS Phase Shift	9	For a VHT MU PPDU, the TXBPS phase shift is set to 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 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The sub-channel information allocated to each HEW STA is configured by including a group ID and N_{BW} in the HEW SIG-A field. When each HEW STA accesses the HEW AP, the HEW AP allocates a group ID and the STA position information of the corresponding HEW STA for the group ID to the HEW STA.

For example, the following table shows that STA position 1 is allocated to group ID 1, STA position 2 is allocated to group ID 2, STA position 4 is allocated to group ID 61, and STA position 1 is allocated to group ID 62. The HEW STA to which the information of the table of the group IDs and STA positions is allocated receives an HEW PPDU and then determines its own sub-channel in the following manner.

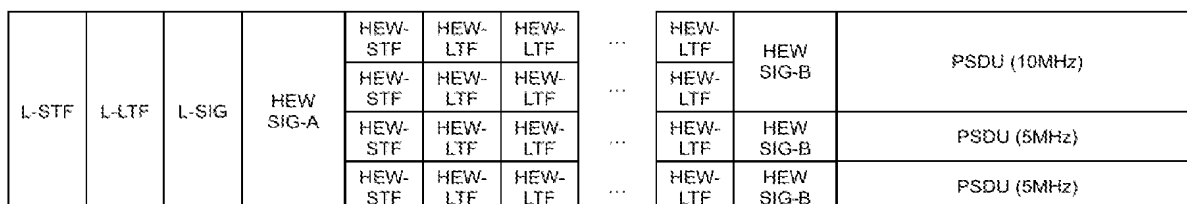
Group ID	Group ID 1	Group ID 2	...	Group ID 61	Group ID 62
STA position	1	2	...	4	1

For example, it is assumed that, in the received HEW PPDU, the group ID value of the HEW SIG-A field is 61 and the values of N_{BW} are b001, b001, b001, and b010.

The N_{BW} value is for notifying the HEW STAs corresponding to STA position 1, STA position 2, STA position 3, and STA position 4 of sub-channel bandwidths respectively allocated thereto. If HEW PPDU transmission of 5 MHz, 10 MHz, 20 MHz, 40 MHz, 80 MHz, and 160 MHz is permitted, N_{BW} is composed of 12 bits to support a total of four HEW STAs in such a way as to include 3 bits of the sub-channel bandwidth of the HEW STA corresponding to STA position 1, 3 bits of the sub-channel bandwidth of the HEW STA corresponding to STA position 2, 3 bits of the sub-channel bandwidth of the HEW STA corresponding to STA position 3, and 3 bits of the sub-channel bandwidth of the HEW STA corresponding to STA position 4.

In the above example, the corresponding HEW STA has been allocated as STA position 4 for group ID 61. Therefore, the HEW STA is aware that sub-channel bandwidth allocated thereto is 10 MHz, with reference to the N_{BW} value of b010 corresponding to the STA position 4 of the received HEW PPDU. Here, for the encoding of N_{BW} , it is assumed that b000 is 0 MHz, b001 is 5 MHz, b010 is 10 MHz, b011 is 20 MHz, b100 is 40 MHz, b101 is 80 MHz, and b110 is 160 MHz. However, the encoding scheme may be set in different forms depending on the implementation.

Further, in relation to the group ID and N_{BW} , it can be seen from the above example that a sub-channel bandwidth of 0 MHz is assigned to the HEW STA to which STA position 1 has been allocated for group ID 61. That is, it means that no HEW PPDU transmission is performed. Further, it can be seen that a sub-channel bandwidth of 5 MHz is assigned to the HEW STA to which STA position 2 has been allocated for group ID 61, and that a sub-channel bandwidth of 5 MHz is assigned to the HEW STA to which STA position 3 has been allocated for group ID 61. The following figure shows the HEW PPDU transmission based on the above example.



In such HEW PPDU transmission, sub-channels allocated to the respective HEW STAs must be sequential to each other, and as a result, empty sub-channels, which are not allocated, must not be present within a single 20 MHz channel. Further, sub-channels allocated to the respective HEW STAs must be implemented only in a single channel on a 20 MHz channel basis. Consequently, in each of multiple 20 MHz channels, the allocation of partially overlapping sub-channels must be prohibited.

The HEW PPDU format proposed in the present invention is intended to support MU MIMO-OFDMA. For this, information about the numbers of spatial streams to be transmitted to HEW STAs that are allocated to respective sub-channels may be included in the HEW SIG-A field. The following figure illustrates an embodiment of such MIMO-OFDMA transmission.

L-STF	L-LTF	L-SIG	HEW SIG-A	HEW-STF	HEW-LTF	HEW-LTF	HEW-LTF	HEW-LTF	HEW SIG-B	PSDU (AP to STA6)
				HEW-STF	HEW-LTF	HEW-LTF	HEW-LTF	HEW-LTF	HEW SIG-B	PSDU (AP to STA5)
				HEW-STF	HEW-LTF	HEW-LTF	HEW-LTF	HEW-LTF	HEW SIG-B	PSDU (AP to STA3, STA4)
				HEW-STF	HEW-LTF	HEW-LTF	HEW-LTF	HEW-LTF	HEW SIG-B	PSDU (AP to STA1, STA2)

This figure shows that a first 5 MHz sub-channel is allocated to STA1 and STA2, and a total of four spatial streams are transmitted to STA1 and STA2, two spatial streams for each STA, through the corresponding sub-channel in a downlink MU-MIMO manner. Further, for this, it can be seen that, after the HEW SIG-A field, a HEW-STF, a HEW-LTF, a HEW-LTF, a HEW-LTF, a HEW-LTF, and a HEW SIG-B field are transmitted through the corresponding sub-channel. The HEW-STF is used to perform frequency offset estimation and phase offset estimation for the 5MHz sub-channel. The HEW-LTF is used to perform channel estimation for the 5 MHz sub-channel. Since the total number of spatial streams that are transmitted is 4, a total of four HEW-LTFs are transmitted in order to enable MIMO transmission. The present invention proposes a scheme in which, when the total number of spatial streams to be transmitted is 2, a total of two HEW-LTFs are transmitted, when the total number of spatial streams to be transmitted is 3, a total of four HEW-LTFs are transmitted, when the total number of spatial streams to be transmitted is 4, a total of four HEW-LTFs are transmitted, when the total number of spatial streams to be transmitted is 5, a total of six HEW-LTFs are transmitted, when the total number of spatial streams to be transmitted is 6, a total of six HEW-LTFs are transmitted, when the total number of spatial streams to be transmitted is 7, a total of 8 HEW-LTFs are transmitted, and when the total number of spatial streams to be transmitted is 8, a total of eight HEW-LTFs are transmitted.

The above figure shows that a second 5 MHz sub-channel has been allocated to STA3 and STA4, and a total of two spatial streams have been transmitted to STA3 and STA4, one spatial stream for each STA, through the corresponding sub-channel in the downlink MU-MIMO manner. For this, it can be seen that, after the HEW SIG-A field, the HEW-STF, HEW-LTF, HEW-LTF, HEW-LTF, HEW-LTF, and HEW SIG-B field are transmitted through the corresponding sub-channel. In the above description, the rule related to the transmission of the HEW-LTFs of the present invention has been designated such that when the total number of spatial streams to be transmitted is 2, a total of two HEW-LTFs are transmitted. However, it can be seen that, in the second 5 MHz sub-channel transmitted to STA3 and STA4, a total of four HEW-LTFs are transmitted. This operation is intended to add a separate condition in relation to the HEW-LTF transmission, and is configured to cause the starting times of transmission of Physical Layer Service Data Units (PSDUs) that are transmitted in different sub-channels to coincide with each other. If a number of HEW-LTFs substantially required in the second 5 MHz sub-channel, that is, only two HEW-LTFs, are transmitted, a problem arises in that the starting times of PSDUs transmission in the first 5 MHz sub-channel and in the second 5 MHz sub-channel differ from each other. To solve this problem, the present invention adds the following HEW-LTF transmission rule.

For all HEW STAs allocated to respective sub-channels (for SU-MIMO transmission, meaning a single HEW STA and, for MU-MIMO transmission, meaning multiple HEW STAs that are destination terminals of MU-MIMO transmission), the numbers of HEW-LTFs to be transmitted through other sub-channels are set to the same number as the number of HEW-LTFs in the sub-channel requiring the largest number of HEW-LTFs, among all of the numbers of HEW-LTFs required depending on the numbers of spatial streams to be transmitted through respective sub-channels (for SU-MIMO transmission, meaning the number of spatial streams to be transmitted to a single HEW STA and, for MU-MIMO transmission, meaning the total number of spatial streams heading for multiple HEW STAs that are destination terminals of MU-MIMO transmission).

Through the application of this rule, in the above example, a third 5 MHz sub-channel is allocated to STA5 and one spatial stream is transmitted through the corresponding sub-channel in an SU-MIMO manner. However, it can be seen that, even if it is actually sufficient to transmit only a single HEW-LTF, a total of four HEW-LTFs are transmitted to match the number of HEW-LTFs to be transmitted through other sub-channels.

Further, in the above example, a fourth 5 MHz sub-channel has been allocated to STA6, and one spatial stream has been transmitted through the corresponding sub-channel in the SU-MIMO manner. However, it can be seen that, even if it is actually sufficient to transmit only a single HEW-LTF, a total of four HEW-LTFs are transmitted to match the number of HEW-LTFs to be transmitted through other sub-channels.

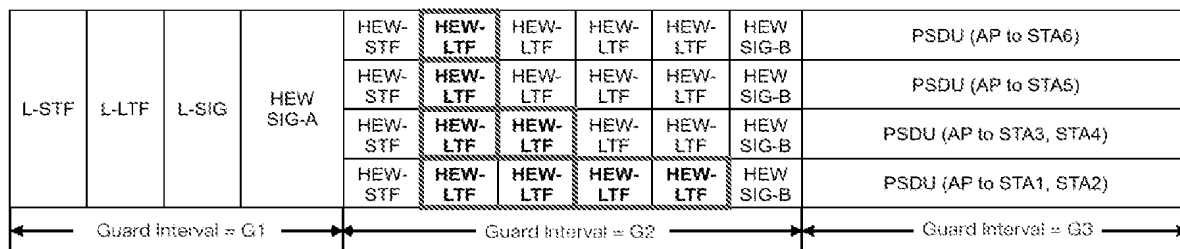
Meanwhile, in order for the HEW PPDU format proposed in the present invention to effectively support Multi-User (MU)-MIMO, independent signaling information needs to be transmitted through each sub-channel. In the case of MU-MIMO, different numbers of spatial streams may be transmitted to multiple HEW STAs, which are destination terminals of MU-MIMO transmission. For this, information about the number of spatial streams to be transmitted to each of the HEW STAs must be transferred. If the maximum number of spatial streams that can be transferred to a single HEW STA via MU-MIMO transmission is 4, and the maximum number of destination terminals of MU-MIMO transmission is 4, a total of 12 bits is required for each sub-channel. When a maximum of four sub-channels can be configured in a 20 MHz channel, a total of 48 bits of signaling information is required. Therefore, for the purpose of reducing protocol overhead, it is preferable to independently transmit such spatial stream allocation information for each sub-channel. For this purpose, in the following figure, the HEW SIG-B field includes spatial stream allocation information for each sub-channel, and indicates the number of spatial streams (N_{STS}) to be transmitted to STAs belonging to the corresponding group (group ID) of MU-MIMO in the form of a group ID and N_{STS} .

L-STF	L-LTF	L-SIG	HEW SIG-A	HEW-STF	HEW-LTF	HEW SIG-B	HEW-LTF	HEW-LTF	HEW-LTF	HEW-LTF	HEW SIG-C	PSDU (AP to STA6)
				HEW-STF	HEW-LTF	HEW SIG-B	HEW-LTF	HEW-LTF	HEW-LTF	HEW-LTF	HEW SIG-C	PSDU (AP to STA5)
				HEW-STF	HEW-LTF	HEW SIG-B	HEW-LTF	HEW-LTF	HEW-LTF	HEW-LTF	HEW SIG-C	PSDU (AP to STA3, STA4)
				HEW-STF	HEW-LTF	HEW SIG-B	HEW-LTF	HEW-LTF	HEW-LTF	HEW-LTF	HEW SIG-C	PSDU (AP to STA1, STA2)

Finally, the HEW-SIG field transmitted after the HEW-LTFs includes Modulation and Coding Scheme (MCS) information and PSDU length information for each PSDU.

Each of the L-STF, L-LTF, L-SIG, and HEW SIG-A fields is composed of OFDM symbols having a length of 4.0 μ s based on 64-Fast Fourier Transform (FFT). At this time, a single OFDM symbol has a Guard Interval (GI) value of 0.8 μ s, and this guard interval value is defined as G1 in the present invention.

Each of the HEW-STF, HEW-LTF, HEW SIG-B, and PSDU that are subsequently transmitted is composed of OFDM symbols having a length of 16 μ s based on 256 FFT (but the duration of an OFDM symbol may vary with the GI value). In this case, a single OFDM symbol may have two GI values for respective intervals. The first guard interval is the value applied to the OFDM symbols of the HEW-STF, HEW-LTF, and HEW SIG-B, and is defined as G2 in the following figure. The second guard interval is the value applied to the OFDM symbols of the PSDU, and is defined as G3 in the following figure. G2 and G3 may be either identical to each other or different from each other. Further, unlike G1, the values of G2 and G3 are variable depending on respective PPDU transmission vectors that are transmitted, without being fixed. For example, when G1 is fixed at 0.8 μ s, G2 may be randomly selected from among 3.2 μ s, 1.6 μ s, 0.8 μ s, and 0.4 μ s. Similarly, G3 may also be randomly selected from among 3.2 μ s, 1.6 μ s, 0.8 μ s, and 0.4 μ s. Further, signaling information for indicating the selected G2 and G3 values may be included in the HEW SIG-A field. Once the G2 and G3 values are selected, they are applied in common to all OFDM symbols that are transmitted during the corresponding interval, or to all sub-channels.

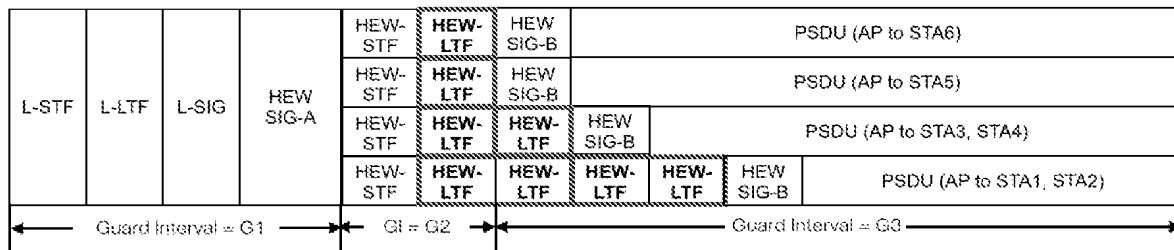


In the present invention, when G2 and G3 values are different from each other, a problem arises in that, if the transmission times of PSDUs do not coincide with each other, OFDM symbol timing, at which OFDM symbols are transmitted through respective sub-channels, is not synchronized. However, when the HEW PPDU format proposed in the present invention is used, as shown in the above figure, the transmission times of

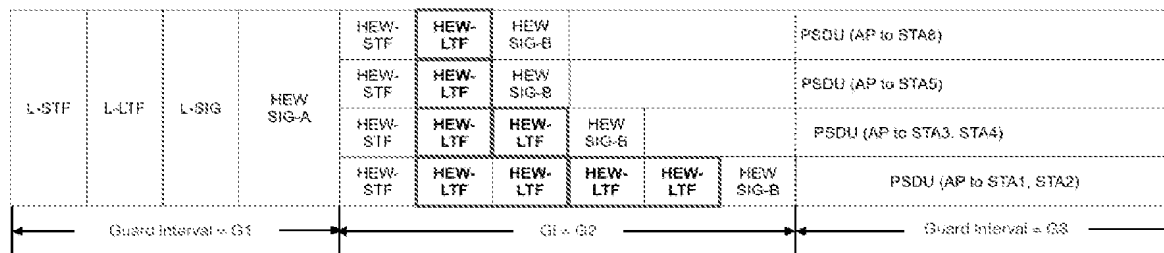
PSDUs through the respective sub-channels coincide with each other, and thus no problem is caused by the G2 and G3 values.

Another embodiment of the HEW PPDU format proposed in the present invention is intended to newly propose a method for synchronizing OFDM symbol timing at which OFDM symbols are transmitted through respective sub-channels in the situation in which PSDU transmission times do not coincide with each other. In the previous proposal (see the above figure), the length of the interval to which the guard interval G2 of the HEW PPDU format is applied is designated to be variable. That is, the lengths of transmission intervals for the HEW-STF, HEW-LTF, and HEW SIG-B field were variable depending on the PPDU transmission vectors to be transmitted. However, the new proposal is intended to fix the interval, to which the guard interval G2 of the HEW PPDU format is applied, to the HEW-STF and HEW-LTF (depending on the implementation, the interval to which the guard interval G2 is applied may be limited only to HEW-STF. Further, depending on the implementation, the interval may be limited to the range above HEW-STF. Furthermore, depending on the implementation, the interval to which guard interval G2 is applied may be limited to '0'). After the corresponding interval to which the guard interval G2 is applied, guard interval G3 is equally applied to 0 or one or more HEW-LTFs, the HEW SIG-B, and the PSDU for respective sub-channels depending on the transmission vectors for respective sub-channels.

To reduce the decoding complexity of the destination terminal, the guard interval value for the first OFDM symbol transmitted subsequent to the HEW SIG-A field, that is, guard interval G2, must be set to a fixed value. However, unlike G1 and G2, G3 is a variable value depending on the individual PPDU transmission vectors that are transmitted, rather than a fixed value. For example, when G1 is fixed at 0.8 μ s and G2 is fixed at one of 3.2 μ s, 1.6 μ s, 0.8 μ s, and 0.4 μ s, G3 may be randomly selected from among 3.2 μ s, 1.6 μ s, 0.8 μ s, and 0.4 μ s, and signaling information for indicating the selected G3 value may be included in the HEW SIG-A field.



In the present invention, it has been specified that, depending on the implementation, the interval to which guard interval G2 is applied may be limited to the range above the HEW-STF and HEW-LTF. The following figure shows the case where the interval to which guard interval G2 is applied is limited to the range of the HEW SIG-B field. In this case, as shown in the following figure, guard interval G2 is used for some of the PSDUs transmitted to STA3, STA4, STA5, and STA6, and guard interval G3 is used for the remaining PSDUs. In other words, it means that when a single PSDU is transmitted, different guard intervals may be used for two or more transmission intervals. In the above embodiment, when the interval to which guard interval G2 is applied is limited to a specific range, the corresponding range may be previously fixed between all terminals, or may be signaled via the HEW SIG-A field.



The HEW PPDU format in 40/80/160 MHz channel bandwidth is described below.

The following figure shows that, of the above-proposed two types of HEW PPDU formats, the first HEW

PPDU format, proposed to allow PSDU transmission times to coincide with each other, is extended to the format for two or more 20 MHz channels. When the format is extended to 40/80/160 MHz channel bandwidth, no portion in the HEW PPDU format is revised. However, for respective 20 MHz channels, OFDM Symbol durations and guard intervals must be identical.

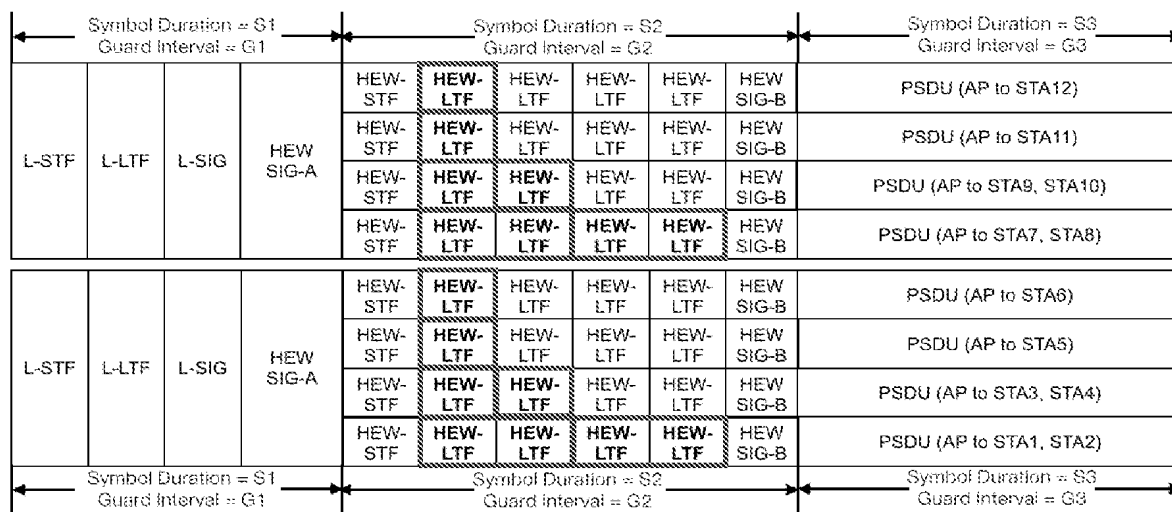
In the 20 MHz channel, shown in the lower portion of the following figure, the OFDM symbol duration and guard interval of L-STF, L-LTF, L-SIG, and HEW SIG-A are S1 and G1, respectively. In this case, it can be seen that, in the 20 MHz channel in the upper portion of the following figure, the OFDM symbol duration and guard interval of L-STF, L-LTF, L-SIG, and HEW SIG-A are S1 and G1, respectively, in the same manner.

In the 20 MHz channel in the lower portion of the following figure, the OFDM symbol duration and guard interval of the HEW-STF, HEW-LTF, and HEW SIG-A are S2 and G2, respectively. In this case, it can be seen that, in the 20 MHz channel in the upper portion, the OFDM symbol duration and guard interval of the HEW-STF, HEW-LTF, and HEW SIG-A are S2 and G2, respectively, in the same manner.

In the 20 MHz channel in the lower portion of the following figure, the OFDM symbol duration and guard interval of the PSDU are S3 and G3, respectively. In this case, it can be seen that, in the 20 MHz channel in the upper portion, the OFDM symbol duration and guard interval of the PSDU are S3 and G3, respectively, in the same manner.

It means that, if the OFDM symbol duration and guard interval are configured and used for transmission based on 64 FFT in any one 20 MHz channel, the OFDM symbol duration and guard interval must also be configured and used for transmission based on 64 FFT in the remaining 20 MHz channel. In other words, if the OFDM symbol duration and guard interval are configured and used for transmission based on 64 FFT in any one 20 MHz channel, it is impossible to configure and use the OFDM symbol duration and guard interval for transmission based on 256 FFT in the remaining 20 MHz channel.

However, depending on the implementation, the OFDM symbol duration and guard interval values in the respective 20 MHz channels, that is, S2 and G2 and S3 and G3 in the following figure, may be set to different values for respective 20 MHz channels (for reference, S1 and G1 are always fixed for all 20 MHz channels). However, even in this case, in a single 20 MHz channel, the same values are applied to S2, G2, S3, and G3 for respective sub-channels.



The following figure shows that, of the two types of proposed HEW PPDU formats, the second HEW PPDU format, proposed in the situation in which the PSDU transmission times do not coincide with each other, is extended to two or more 20 MHz channels. When the format is extended to 40/80/160 MHz channel bandwidth, no portion in the HEW PPDU format is revised. However, for respective 20 MHz channels, OFDM symbol durations and guard intervals must be identical.

In the 20 MHz channel, shown in the lower portion of the following figure, the OFDM symbol duration and

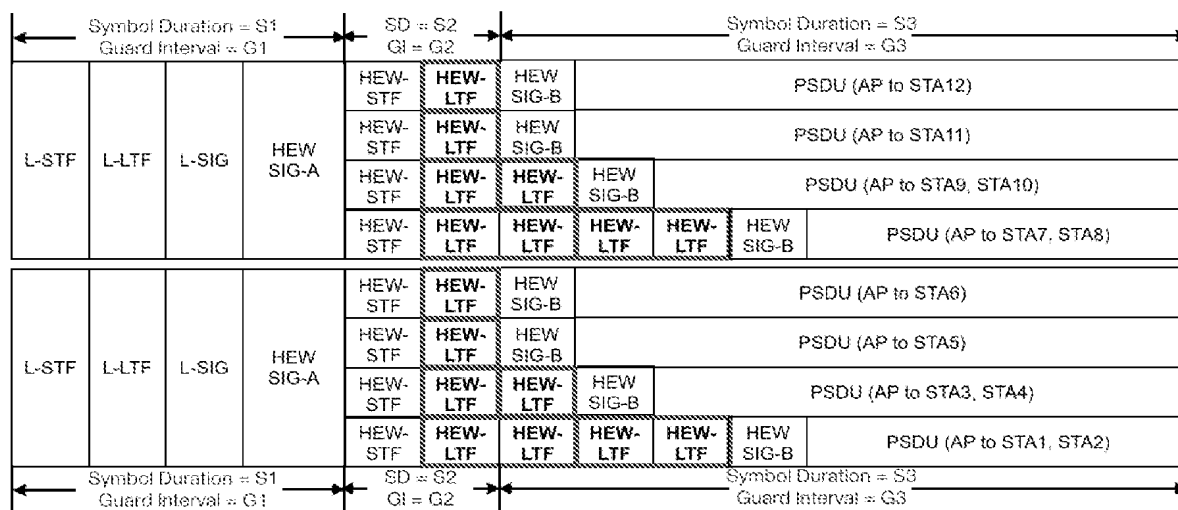
guard interval of the L-STF, L-LTF, L-SIG, and HEW SIG-A are S1 and G1, respectively. In this case, it can be seen that, in the 20 MHz channel in the upper portion, the OFDM symbol duration and guard interval of the L-STF, L-LTF, L-SIG, and HEW SIG-A are S1 and G1, respectively, in the same manner.

In the 20 MHz channel in the lower portion of the following figure, the OFDM symbol duration and guard interval of the HEW-STF and HEW-LTF are S2 and G2, respectively. In this case, it can be seen that, in the 20 MHz channel in the upper portion, the OFDM symbol duration and guard interval of the HEW-STF and HEW-LTF are S2 and G2, respectively, in the same manner.

In the 20 MHz channel in the lower portion of the following figure, the OFDM symbol duration and guard interval are S3 and G3, respectively, for the period during which 0 or one or more HEW-LTFs, HEW SIG-B, and PSDU are transmitted depending on the transmission vectors for respective sub-channels. In this case, it can be seen that, in the 20 MHz channel in the upper portion, the OFDM symbol duration and guard interval of the HEW-LTF, HEW SIG-B, and PSDU are also S3 and G3, respectively, in the same manner.

This means that, if the OFDM symbol duration and guard interval are configured and used for transmission based on 64 FFT in any one 20 MHz channel, the OFDM symbol duration and the guard interval must be configured and used for transmission based on 64 FFT in the remaining 20 MHz channel. In other words, this means that when the OFDM symbol duration and the guard interval are configured and used for transmission based on 64 FFT in any one 20 MHz channel, it is impossible to configure and use the OFDM symbol duration and the guard interval for transmission based on 256 FFT in the remaining 20 MHz channel.

However, depending on the implementation, the OFDM symbol duration values and guard interval values in the respective 20 MHz channels, that is, S2, G2, S3, and G3 in the following figure, may be set to different values for respective 20 MHz channels (for reference, S1 and G1 are always fixed for all 20 MHz channels). However, even in this case, in a single 20 MHz channel, the same values are applied to S2, G2, S3, and G3 for respective sub-channels.



In the case of HEW uplink PPDU transmission, in which multiple terminals perform simultaneous transmission to a single AP, the above-proposed HEW PPDU format may be utilized without change. However, a point to be additionally considered is that, unlike downlink HEW PPDU transmission, information about the numbers of spatial streams that are transmitted by HEW STAs, allocated to respective sub-channels, cannot be included in the HEW SIG-A field. Generally, the HEW SIG-A field includes common transmission parameters related to simultaneously transmitted HEW PSDUs. The transmission parameters, such as spatial streams, MCS, and Space-Time Block Coding (STBC), may have different values for HEW PSDUs that are transmitted. The above-proposed HEW PPDU format has presented a scheme in which, when the transmission parameters are different from each other for respective HEW PSDUs that are transmitted, they are included in the HEW SIG-B field transmitted just before the PSDU. MCS corresponds to such a scheme, and the respective HEW PSDUs may have different MCS values. However, spatial streams and STBC play an important role in checking the configuration information of preambles and PSDUs in the HEW PPDU format.

The reason for this is that the number of HEW-LTFs is determined based on the combination of spatial streams and STBC. Therefore, spatial streams and STBC need to be transmitted prior to the HEW SIG-B field.

In the HEW uplink PPDU transmission in which multiple terminals perform simultaneous transmission to a single AP, if a protocol is designed such that the AP designates the numbers of spatial streams that are transmitted by HEW STAs allocated to respective sub-channels and such that the HEW STAs must conform to the designated numbers, all HEW STAs may consider the protocol to be common information and transmit the HEW SIG-A field containing the same information. In this case, no change to the above-proposed HEW PPDU format is required.

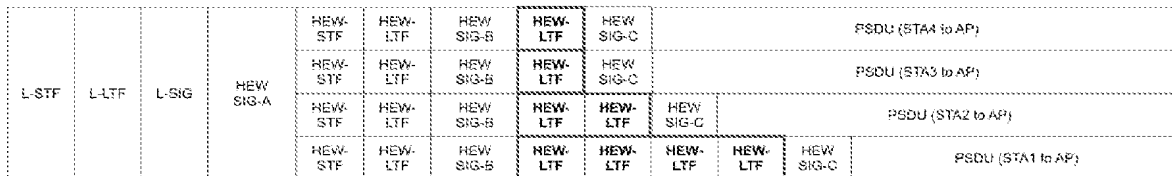
Otherwise, the HEW PPDU format that will be described below must be used for uplink PPDU transmission. The HEW PPDU format proposed in the following figure is intended to use the formats of the above-proposed HEW SIG-A, HEW SIG-B, and HEW SIG-C fields for uplink PPDU transmission. The HEW SIG-A field is transmitted per 20 MHz channel, and includes common transmission parameters for HEW PSDUs that are simultaneously transmitted. Therefore, for uplink PPDU that are transmitted by HEW STAs allocated to the respective sub-channels, the same information up to the HEW SIG-A field is transmitted, thus allowing the AP to correctly receive overlapping signals. The HEW SIG-B field is transmitted on a sub-channel basis in the 20 MHz channel, and may have different values for respective sub-channels in accordance with the transmission characteristics of HEW PSDUs transmitted to the respective sub-channels. The HEW SIG-B field must include information about the spatial streams and STBC of the HEW PSDUs that are transmitted through the corresponding sub-channels. If MU-MIMO is used in a specific sub-channel, the HEW SIG-B field includes common transmission information for terminals belonging to an MU-MIMO transmission group. The HEW SIG-C field is transmitted using the same sub-channel as the HEW SIG-B field, and has information about MCS and packet length. If MU-MIMO is used in a specific sub-channel, the HEW SIG-C field includes each piece of transmission information about the HEW PSDU of each terminal belonging to an MU-MIMO transmission group.

L-STF	L-LTF	L-SIG	HEW SIG-A	HEW-STF	HEW-LTF	HEW SIG-B	HEW-LTF	HEW-LTF	HEW-LTF	HEW-LTF	HEW SIG-C	PSDU (STA4 to AP)
				HEW-STF	HEW-LTF	HEW SIG-B	HEW-LTF	HEW-LTF	HEW-LTF	HEW-LTF	HEW SIG-C	PSDU (STA3 to AP)
				HEW-STF	HEW-LTF	HEW SIG-B	HEW-LTF	HEW-LTF	HEW-LTF	HEW-LTF	HEW SIG-C	PSDU (STA2 to AP)
				HEW-STF	HEW-LTF	HEW SIG-B	HEW-LTF	HEW-LTF	HEW-LTF	HEW-LTF	HEW SIG-C	PSDU (STA1 to AP)

The above figure illustrates an example of HEW uplink PPDU transmission, and shows that STA1, STA2, STA3, and STA4 simultaneously transmit HEW PPDU to the AP. The figure shows that STA1 transmits 4 spatial streams, STA2 transmits 2 spatial streams, STA3 transmits 1 spatial stream, and STA4 transmits 1 spatial stream, to the AP. It can be seen that, compared to HEW downlink PPDU transmission, HEW-STF and HEW-LTF are transmitted subsequent to the HEW SIG-A field, and the HEW SIG-B field is subsequently transmitted. The HEW SIG-B field includes information about the number of spatial streams (or the number of space-time streams) and information indicating whether STBC has been used. By means of this information, the number of HEW-LTFs to be transmitted after the HEW SIG-B field may be detected. The present invention proposes a scheme in which, when the total number of spatial streams to be transmitted is 2, a total of two HEW-LTFs are transmitted, when the total number of spatial streams to be transmitted is 3, a total of four HEW-LTFs are transmitted, when the total number of spatial streams to be transmitted is 4, a total of four HEW-LTFs are transmitted, when the total number of spatial streams to be transmitted is 5, a total of six HEW-LTFs are transmitted, when the total number of spatial streams to be transmitted is 6, a total of six HEW-LTFs are transmitted, when the total number of spatial streams to be transmitted is 7, a total of eight HEW-LTFs are transmitted, and when the total number of spatial streams to be transmitted is 8, a total of eight HEW-LTFs are transmitted. The HEW SIG-C field includes an MCS value or the like as a transmission parameter for the HEW PSDU that is transmitted through the corresponding sub-channel.

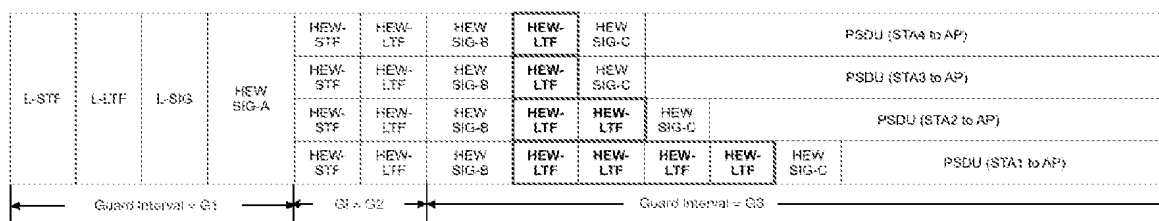
In the same manner as the above-described HEW downlink PPDU transmission, a problem arises in that the starting times of PSDU transmission are different from each other even in the case of HEW uplink PPDU transmission (this causes misalignment between OFDM symbols, thus resulting in the problem of increasing the implementation complexity of an AP that simultaneously receives multiple PSDUs). To solve this problem, a method of adjusting the numbers of HEW-LTFs that are transmitted in HEW uplink PPDU transmission so that they are identical between respective sub-channels may be used. In the above example, the

transmission of 4, 2, 1, and 1 HEW-LTFs for respective sub-channels is actually required, but it can be seen that 0, 2, 3, and 3 HEW-LTFs are additionally transmitted to adjust all of the numbers of HEW-LTFs that are transmitted to be identical.

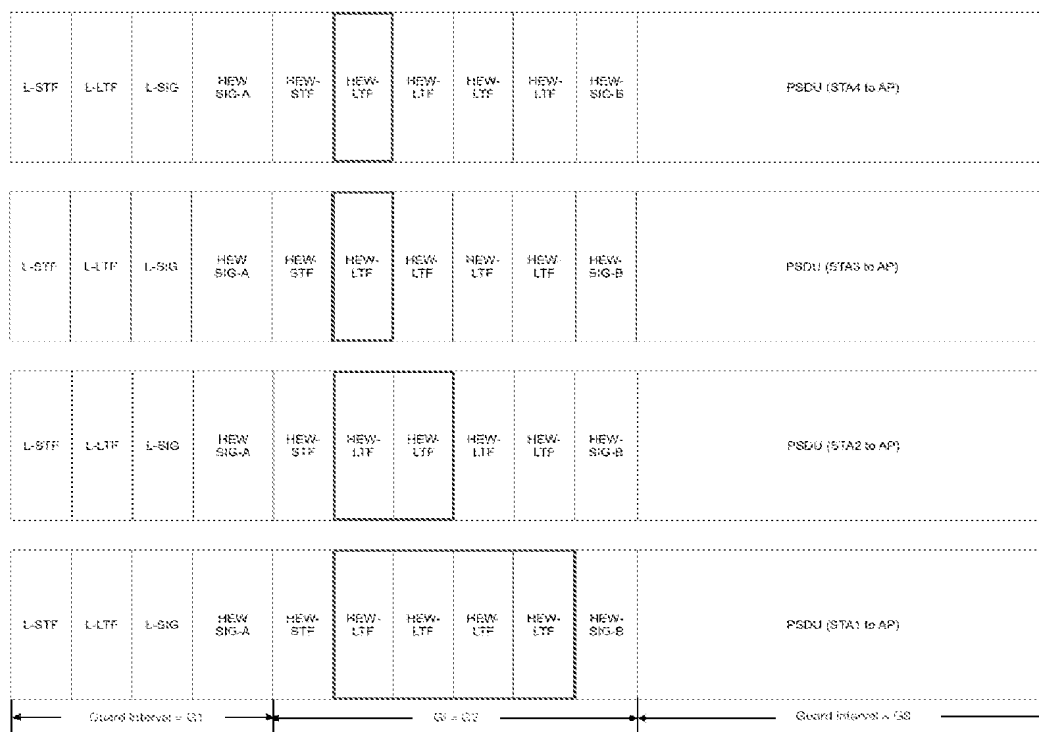


The above figure illustrates another example of HEW uplink PPDU transmission, and shows that STA1, STA2, STA3, and STA4 simultaneously transmit HEW PPDU to the AP. More specifically, STA1 transmits 4 spatial streams, STA2 transmits 2 spatial streams, STA3 transmits 1 spatial stream, and STA4 transmits 1 spatial stream, to the AP. It can be seen that, compared to the HEW downlink PPDU transmission, HEW-STF and HEW-LTF are transmitted subsequent to the HEW SIG-A field, the HEW SIG-B field is subsequently transmitted. The HEW SIG-B field includes information about the number of spatial streams (or the number of space-time streams) and information indicating whether STBC has been used. By means of this, the number of HEW-LTFs that are transmitted after the HEW SIG-B field can be detected. The present invention proposes a scheme in which, when the total number of spatial streams to be transmitted is 2, a total of two HEW-LTFs are transmitted, when the total number of spatial streams to be transmitted is 3, a total of four HEW-LTFs are transmitted, when the total number of spatial streams to be transmitted is 4, a total of four HEW-LTFs are transmitted, when the total number of spatial streams to be transmitted is 5, a total of six HEW-LTFs are transmitted, when the total number of spatial streams to be transmitted is 6, a total of six HEW-LTFs are transmitted, when the total number of spatial streams to be transmitted is 7, a total of eight HEW-LTFs are transmitted, and when the total number of spatial streams to be transmitted is 8, a total of eight HEW-LTFs are transmitted. The HEW SIG-C field includes an MCS value or the like as a transmission parameter for the HEW PSDU that is transmitted through the corresponding sub-channel.

In the same manner as the above-described HEW downlink PPDU transmission, a problem arises in that the starting times of PSDU transmission are different from each other even in the case of HEW uplink PPDU transmission (this causes misalignment between OFDM symbols, thus resulting in the problem of increasing the implementation complexity of an AP that simultaneously receives multiple PSDUs). To solve this problem, as shown in the following figure, the interval to which the guard interval G2 of the HEW PPDU format is applied is fixed at HEW-STF and HEW-LTF (depending on the implementation, the interval to which the guard interval G2 is applied may be limited only to the HEW-STF. Further, depending on the implementation, the interval may be limited to the range above the HEW-STF. Furthermore, depending on the implementation, the interval to which guard interval G2 is applied may be limited to '0'). After the interval to which guard interval G2 is applied, guard interval G3 is equally applied to 0 or one or more HEW-LTFs, the HEW SIG-C, and the PSDU for respective sub-channels depending on the transmission vectors for respective sub-channels. Depending on the implementation, the interval to which guard interval G2 is applied may extend to the HEW SIG-C field. In this case, guard interval G2 is used for some of the PSDUs transmitted by STA2, STA3, and STA4, and guard interval G3 is used for the remaining PSDUs.



If MU-MIMO technology is applied when multiple terminals perform simultaneous transmission to a single AP, performance may be further improved. Uplink MU-MIMO technology is applicable to the case where the AP is capable of simultaneously receiving multiple spatial streams through multiple antennas.



The above figure illustrates an example in which STA1, STA2, STA3, and STA4 simultaneously transmit uplink data frames to the AP. In a procedure for performing simultaneous transmission via uplink MU-MIMO technology, a signaling procedure is conducted in advance in which the AP determines the terminals that are sources of uplink data frame transmission and designates both the numbers of spatial streams transmittable by the corresponding terminals and the guard intervals to be used for PSDU transmission. The above figure illustrates the case where the AP determines the terminals that are sources of uplink data frame transmission to be STA1, STA2, STA3, and STA4, and designates the numbers of spatial streams transmittable by the corresponding terminals as 4, 2, 1, and 1, respectively.

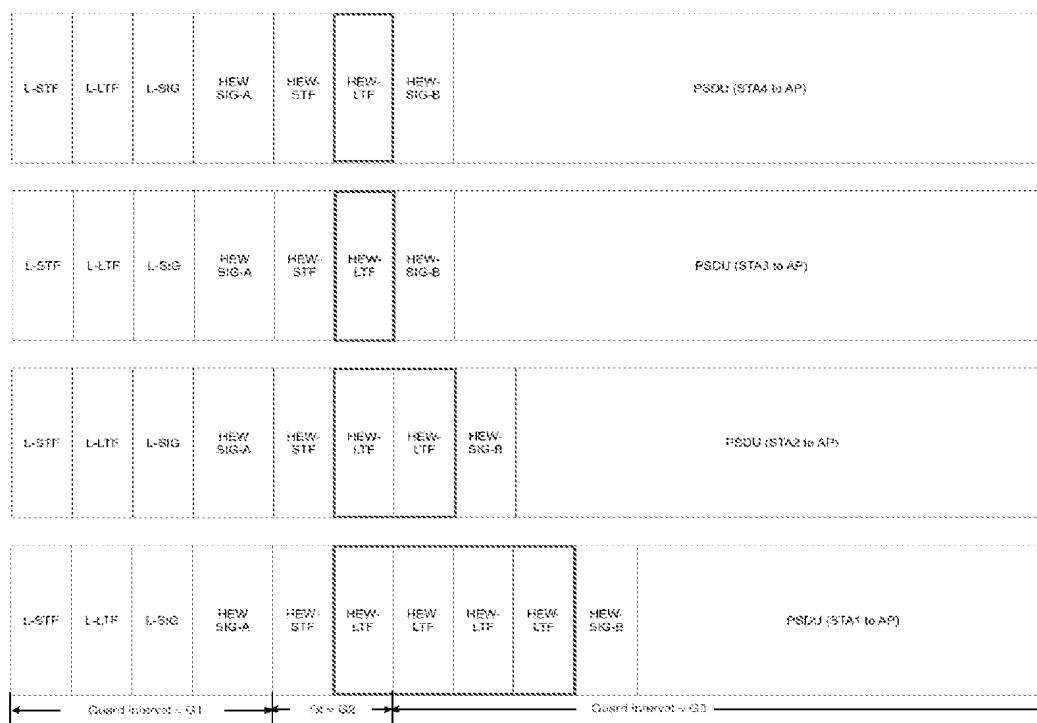
L-STFs, L-LTFs, L-SIG fields, and HEW SIG-A fields have common values when the STA1, STA2, STA3, and STA4 simultaneously transmit uplink data frames to the AP (otherwise, the AP is incapable of correctly receiving the corresponding fields). The HEW SIG-A fields include information about terminals that are the sources of uplink data frame transmission and the numbers of spatial streams transmittable by the corresponding terminals, thus allowing destination terminals to correctly receive the HEW-STF, HEW-LTF, HEW SIG-B, and PSDU.

In the above example, the AP designated the numbers of transmittable spatial streams of STA1, STA2, STA3, and STA4 as 4, 2, 1, and 1, respectively. If the STA1, STA2, STA3, and STA4 transmit PSDUs in conformity with the numbers of transmittable spatial streams designated by the AP, spatial stream information such as 4 spatial streams, 2 spatial streams, 1 spatial stream, and 1 spatial stream needs to be included only in the HEW SIG-A fields. However, if the STA1, STA2, STA3, and STA4 may randomly select the numbers of spatial streams to be actually transmitted under the condition that the randomly selected number does not exceed the number of transmittable spatial streams designated by the AP, for example, if 2 spatial streams, 1 spatial stream, 1 spatial stream, and 1 spatial stream are respectively used for actual PSDU transmission, information about the corresponding spatial streams needs to be included in the HEW SIG-B fields for indicating user-specific information. In other words, pieces of information about the numbers of spatial streams, that is, 4, 2, 1, and 1, are included in the HEW SIG-A fields, and function to indicate the HEW-STF and the numbers of HEW-LTFs (as in the above example, when the numbers of HEW-LTFs transmitted by the terminals are identical to each other, information about the total number of HEW-LTFs actually transmitted, that is, 4, may be included in each HEW SIG-A field without individually indicating 4 spatial streams, 2 spatial streams, 1 spatial stream, and 1 spatial stream). Further, pieces of information about the 2 spatial streams, 1 spatial stream, 1 spatial stream, and 1 spatial stream are included in respective HEW SIG-B fields, thus indicating the

numbers of spatial streams that are actually used for PSDU transmission.

Even in uplink MU-MIMO transmission, when the starting times of PSDU transmission are different from each other, the problem of misalignment between OFDM symbols arises. To solve this problem, a method of causing the numbers of HEW-LTFs transmitted in uplink MU-MIMO for all terminals to be identical to each other may be used. In the above example, the terminals require the transmission of 4, 2, 1, and 1 HEW-LTFs, respectively, in uplink data frame transmission, but it can be seen that 0, 2, 3, and 3 HEW-LTFs are additionally transmitted, respectively, so as to adjust the numbers of HEW-LTFs that are transmitted to be identical to each other.

In the above example, the L-STF, L-LTF, L-SIG, and HEW SIG-A fields are transmitted using guard interval G1, the HEW-STF, HEW-LTF, and HEW SIG-B fields are transmitted using guard interval G2, and the PSDU is transmitted using guard interval G3. The guard intervals G2 and G3 may be implemented using fixed values or variable values. If the guard intervals G2 and G3 are variable, information indicating the values of the guard intervals G2 and G3 is included in the HEW SIG-A field.



The above figure illustrates another example in which STA1, STA2, STA3, and STA4 simultaneously transmit uplink data frames to the AP. In a procedure for performing simultaneous transmission via uplink MU-MIMO technology, a signaling procedure is conducted in advance in which the AP determines terminals that are sources of uplink data frame transmission, and designates both the numbers of spatial streams transmittable by the corresponding terminals and the guard intervals to be used for PSDU transmission. The above figure illustrates the case where the AP determines the terminals that are sources of uplink data frame transmission to be STA1, STA2, STA3, and STA4, and designates the numbers of spatial streams transmittable by the corresponding terminals as 4, 2, 1, and 1, respectively.

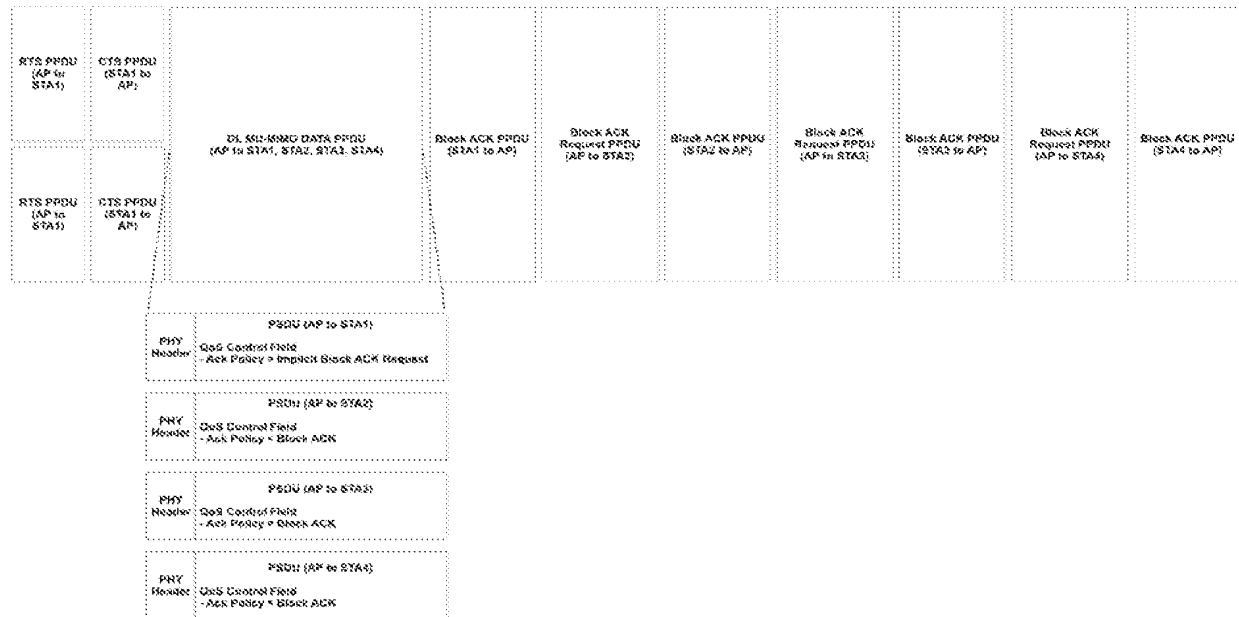
In the above example, the AP designated the numbers of transmittable spatial streams of STA1, STA2, STA3, and STA4 as 4, 2, 1, and 1, respectively. If the STA1, STA2, STA3, and STA4 transmit PSDUs in conformity with the numbers of transmittable spatial streams designated by the AP, spatial stream information such as 4 spatial streams, 2 spatial streams, 1 spatial stream, and 1 spatial stream needs to be included only in the HEW SIG-A field. However, if the STA1, STA2, STA3, and STA4 may randomly select the numbers of spatial streams to be actually transmitted under the condition that the randomly selected number does not exceed the number of transmittable spatial streams designated by the AP, for example, if 2 spatial streams, 1 spatial stream, 1 spatial stream, and 1 spatial stream are respectively used for actual PSDU transmission, information

about the corresponding spatial streams needs to be included in the HEW SIG-B fields for indicating user-specific information. That is, pieces of information about the numbers of spatial streams, such as 4, 2, 1, and 1, are included in the HEW SIG-A fields, and function to indicate the HEW-STF and the numbers of HEW-LTFs (HEW-LTFs must be transmitted such that the number of HEW-LTFs is adjusted to be identical to the number of transmittable spatial streams designated by the AP even if the number of spatial streams that are actually transmitted by each of STA1, STA2, STA3, and STA4 is less than the number of transmittable spatial streams designated by the AP. Even if 2, 1, 1, and 1 spatial streams have been respectively used for actual PSDU transmission, the numbers of HEW-LTFs to be transmitted by the STA1, STA2, STA3, and STA4 must be 4, 2, 1, and 1, respectively). Further, pieces of information about the numbers of spatial streams, that is, 2, 1, 1, and 1, are included in respective HEW SIG-B fields, thus indicating the numbers of spatial streams that are actually used for PSDU transmission.

Even in uplink MU-MIMO transmission, when the starting times of PSDU transmission are different from each other, a problem of misalignment between OFDM symbols arises. To solve this problem, the interval to which the guard interval G2 of the HEW PPDU format is applied is fixed at HEW-STF and HEW-LTF (depending on the implementation, the interval to which the guard interval G2 is applied may be limited only to the HEW-STF. Further, depending on the implementation, the interval may be limited to the range above the HEW-STF. Furthermore, depending on the implementation, the interval to which guard interval G2 is applied may be limited to '0'). After the interval to which guard interval G2 is applied, guard interval G3 is equally applied to all terminals for 0 or one or more HEW-LTFs, the HEW SIG-B, and the PSDU depending on the uplink MU-MIMO transmission vectors transmitted by the respective terminals. Depending on the implementation, the interval to which guard interval G2 is applied may extend to the HEW SIG-B field. In this case, guard interval G2 is used for some of the PSDUs transmitted by STA2, STA3, and STA4, and guard interval G3 is used for the remaining PSDUs.

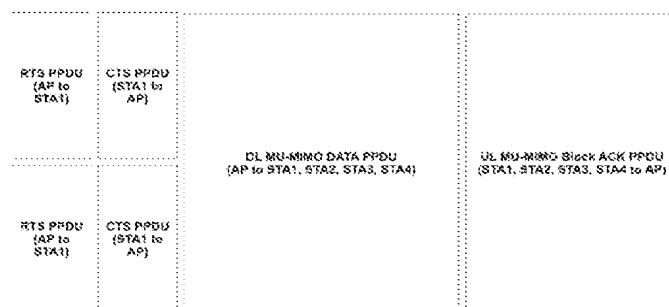
If uplink MU-MIMO transmission is performed together with downlink MU-MIMO transmission, downlink throughput can be increased significantly.

The basic operation of downlink MU-MIMO transmission will be described below. First, an AP exchanges an RTS frame and a CST frame with one of the destination STAs of downlink MU-MIMO transmission. Subsequently, the AP transmits a downlink MU-MIMO PPDU to the destination STAs of the downlink MU-MIMO transmission. Herein, the AP sets the Ack Policy of the downlink MU-MIMO PPDU to Block ACK. However, the AP may set the Ack Policy to Implicit Block ACK Request only for one of the destination STAs of the downlink MU-MIMO transmission. In this case, the STA replies to the AP with a Block ACK frame an SIFS after receiving the downlink MU-MIMO PPDU. The STAs for which the Ack Policy of the downlink MU-MIMO PPDU has been set to Block ACK reply to the AP with Block ACK frames an SIFS after receiving Block ACK Request frames. If the Ack Policy is set to Implicit Block ACK Request for two or more of the destination STAs of the downlink MU-MIMO transmission, the plurality of STAs transmit Block ACK frames simultaneously, thereby causing collision. To avoid collision, the Ack Policy is set to Implicit Block ACK Request only for one or none of the destination STAs of the downlink MU-MIMO PPDU.



The above figure illustrates the afore-described basic principle of downlink MU-MIMO transmission. Before a downlink (DL) MU-MIMO DATA PPDU is transmitted on a 40-MHz channel, an RTS frame and a CTS frame are transmitted in 20-MHz channel duplicated PPDUs on the 40-MHz channel. The destination STA of the RTS frame is one of the destination STAs of the downlink MU-MIMO DATA PPDU, STA1 and STA1 replies with a CTS frame after receiving the RTS frame. The downlink MU-MIMO DATA PPDU transmitted by the AP includes PSDUs directed to the destination STAs, STA1, STA2, STA3, and STA4, and the Ack Policy of each PSDU is set to Block ACK except for the PSDU directed to STA1. STA1 determines that the Ack Policy of its received PSDU of the downlink MU-MIMO DATA PPDU is Implicit Block ACK Request and transmits a Block ACK PPDU to the AP after an SIFS. To receive Block ACK PPDUs from the other destination STAs of the downlink MU-MIMO DATA PPDU, STA2, STA3, and STA4, the AP transmits Block ACK Request PPDUs sequentially to STA2, STA3, and STA4.

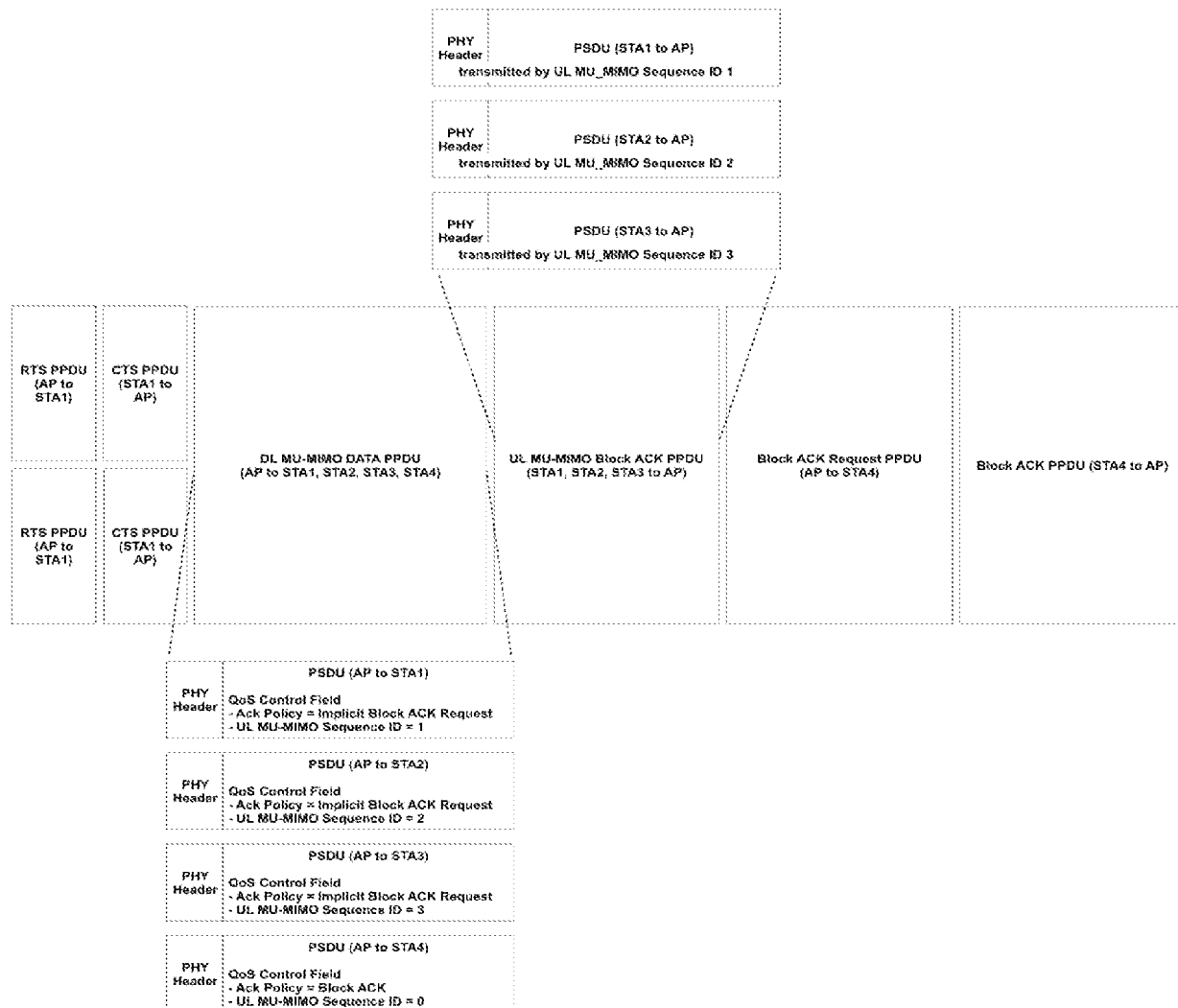
Improved performance of downlink MU-MIMO transmission can be expected from the use of uplink MU-MIMO in a Block ACK PPDU reception procedure. For example, if all of the destination STAs of a downlink MU-MIMO DATA PPDU support uplink MU-MIMO, the Block ACK PPDU reception procedure is simplified as follows.



The uplink MU-MIMO-based Block ACK PPDU reception procedure for downlink MU-MIMO transmission will be described below in detail.

First of all, it may not be assumed that all of the destination STAs of a downlink MU-MIMO DATA PPDU support uplink MU-MIMO. Therefore, the destination STAs of the downlink MU-MIMO DATA PPDU need to be classified into two types, Uplink MU-MIMO Supported STA and Uplink MU-MIMO Non-supported STA. Uplink MU-MIMO-based Block ACK PPDU transmission may be requested to Uplink MU-MIMO Supported STAs. On the contrary, only transmission of a legacy Block ACK PPDU (compared to MU-MIMO transmission, it may be regarded as a Single User PPDU) may be requested to Uplink MU-MIMO Non-supported STAs. To

receive Block ACK PPDU from the Uplink MU-MIMO Supported STAs and the Uplink MU-MIMO Non-supported STAs, the AP needs to sequentially transmit Block ACK Request PPDU to the Uplink MU-MIMO Supported STAs and the Uplink MU-MIMO Non-supported STAs.



In the above figure, STA1, STA2, and STA3 are Uplink MU-MIMO Supported STAs and STA4 is an Uplink MU-MIMO Non-supported STA. If the destination STAs of a downlink MU-MIMO DATA PPDU include Uplink MU-MIMO Supported STAs and an Uplink MU-MIMO Non-supported STA in this manner, the Ack Policies of PSDUs are set to Block ACK in the downlink MU-MIMO DATA PPDU. However, the AP may set the Ack Policy to Implicit Block ACK Request only for one of the uplink MU-MIMO Non-supported STAs among the destination STAs of the downlink MU-MIMO transmission. In this case, the STA replies to the AP with a legacy Block ACK frame an SIFS after receiving the downlink MU-MIMO PPDU. Further, the AP may set the Ack Policy to Implicit Block ACK Request for one or more of Uplink MU-MIMO Supported STAs among the destination STAs of the downlink MU-MIMO transmission. In this case, the one or more STAs reply to the AP with uplink MU-MIMO Block ACK frames an SIFS after receiving the downlink MU-MIMO PPDU. The STAs for which the Ack Policy of the downlink MU-MIMO PPDU has been set to Block ACK reply to the AP with Block ACK frames an SIFS after receiving Block ACK Request frames from the AP.

If Uplink MU-MIMO Supported STAs are included in the destination STAs of downlink MU-MIMO transmission, the Ack Policies of PSDUs may be set to Implicit Block ACK Request for the Uplink MU-MIMO Supported STAs. The AP may receive a plurality of Block ACK frames from the Uplink MU-MIMO Supported STAs using different Channel Estimation Sequences (HEW-STFs and HEW-LTFs) in uplink MU-MIMO, without collision. However, it is still necessary to set the Ack Policy to Implicit Block ACK Request in the downlink

MU-MIMO PPDU, only for one or none of Uplink MU-MIMO Non-supported STAs included in the destination STAs of the downlink MU-MIMO transmission.

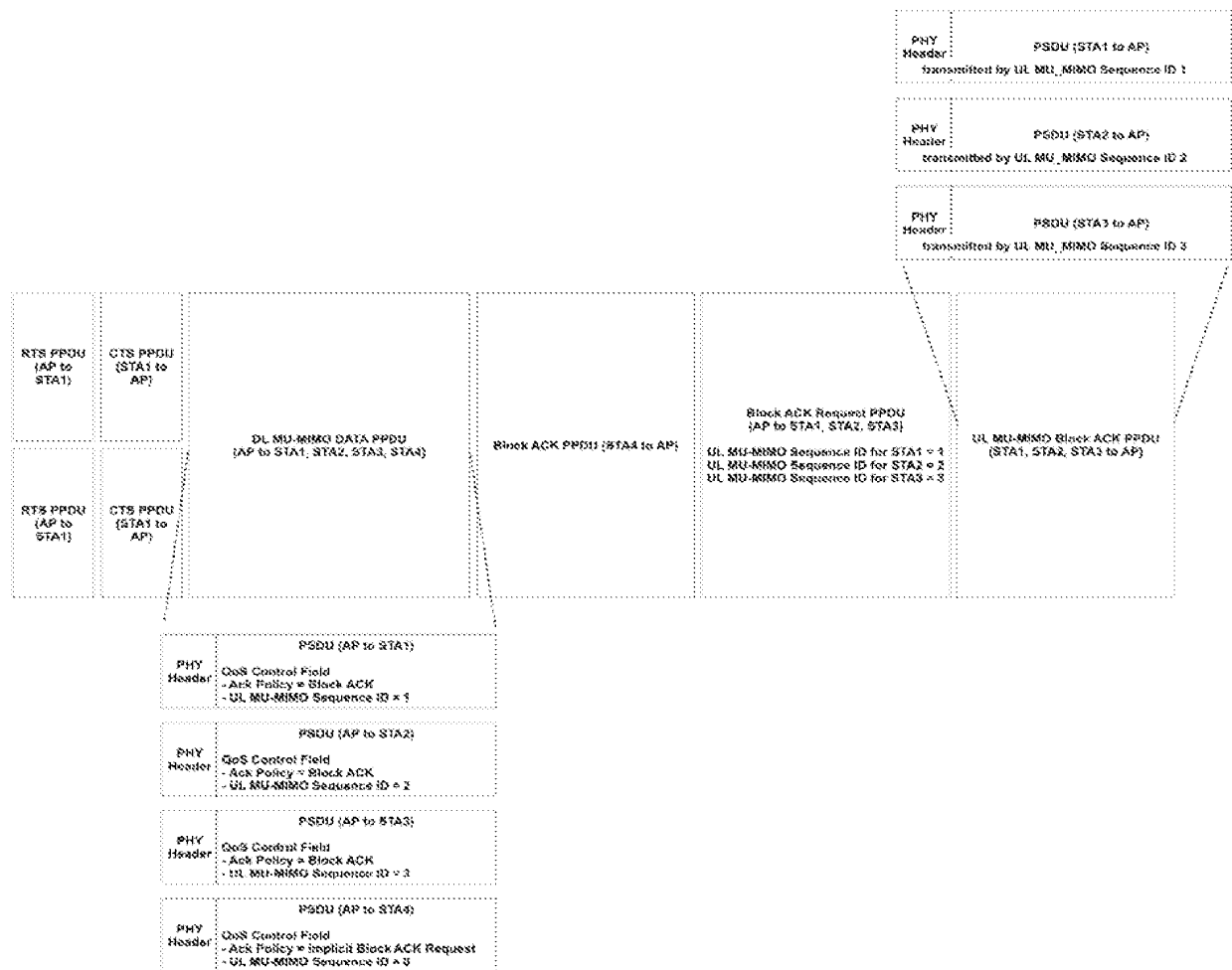
In the above figure, the Ack Policies of PSDUs directed to the Uplink MU-MIMO Supported STAs, STA1, STA2, and STA3 are set to Implicit Block ACK Request. On the contrary, the Ack Policy of a PSDU directed to the Uplink MU-MIMO Non-supported STA, STA4 may not be set to Implicit Block ACK Request and thus is set to Block ACK. The Uplink MU-MIMO Non-supported STA, STA4 replies to the AP with a Block ACK frame after receiving a Block ACK Request frame from the AP.

If the Ack Policy of a PSDU in a downlink MU-MIMO DATA PPDU is Implicit Block ACK Request, the destination STA of the PSDU may transmit a Block ACK frame an SIFS after receiving the downlink MU-MIMO PPDU using a PPDU type of Legacy PPDU or Uplink MU-MIMO PPDU. If the STA transmits the Block ACK frame in an Uplink MU-MIMO PPDU, identification information that determines a different Channel Estimation Sequence (a HEW-STF, and a HEW-LTF) for use in uplink MU-MIMO PPDU transmission is additionally required. For this purpose, the present invention proposes that a UL MU-MIMO Sequence ID field is included in the QoS Control field of a PSDU in a downlink MU-MIMO DATA PPDU. If the UL MU-MIMO Sequence ID field is 0 (or any predetermined value), Legacy PPDU is used as the PPDU type for transmission of a Block ACK frame an SIFS after reception of the downlink MU-MIMO PPDU. On the other hand, if the UL MU-MIMO Sequence ID field is 1 (or any predetermined value), UL MU-MIMO PPDU is used as the PPDU type for transmission of a Block ACK frame an SIFS after reception of the downlink MU-MIMO PPDU. If a set of Channel Estimation Sequences (HEW-STFs and HEW-LTFs) is predefined for use in uplink MU-MIMO PPDU transmission, a Channel Estimation Sequence (a HEW-STF and a HEW-LTF) is determined from the Channel Estimation Sequence set based on the UL MU-MIMO Sequence ID, for use in UL MU-MIMO PPDU transmission.

In the above figure, the Ack Policies of PSDUs directed to Uplink MU-MIMO Supported STAs, STA1, STA2, and STA3 are set to Implicit Block ACK Request and UL MU-MIMO Sequence ID fields of the PSDUs are set to 1, 2, and 3. STA1, STA2, and STA3 transmit Block ACK frames using different Channel Estimation Sequences based on the UL MU-MIMO Sequence ID, 1, 2 and 3, an SIFS after receiving a downlink MU-MIMO PPDU.

When the Uplink MU-MIMO Supported STAs transmit the Block ACK frames in an uplink MU-MIMO PPDU, the transmission times of the Block ACK frames should be same. This implies that the transmission MCSs (Modulation Code Schemes) of the Block ACK frames transmitted in the uplink MU-MIMO PPDU should be identical. For this purpose, the present invention proposes that a UL MU-MIMO MCS field is included in the QoS Control field of a downlink MU-MIMO DATA PPDU. If the UL MU-MIMO MCS field is set, an Uplink MU-MIMO Supported STA should transmit a Block ACK frame in an Uplink MU-MIMO PPDU, using a corresponding MCS value. In addition, when the Uplink MU-MIMO Supported STAs transmit the Block ACK frames in the uplink MU-MIMO PPDU, the Duration fields of the Block ACK frames have the same value. This value is obtained by subtracting the transmission time of a corresponding Block ACK frame and an SIFS from the value of the Duration field included in a previous received downlink MU-MIMO DATA PPDU.

The UL MU-MIMO Sequence ID field and the UL MU-MIMO MCS field proposed by the present invention may be included in a VHT Control field, a HEW Control field, a Service field, etc. as well as the QoS Control field depending on implementation.



In the above figure, STA1, STA2, and STA3 are Uplink MU-MIMO Supported STAs, and STA4 is an Uplink MU-MIMO Non-supported STA. Unlike the foregoing example, the AP sets the Ack Policy of a PSDU directed to STA4 being an Uplink MU-MIMO Non-supported STA to Implicit Block ACK Request. In this case, the Ack Policies of PSDUs directed to the Uplink MU-MIMO Supported STAs, STA1, STA2, and STA3 may not be set to Implicit Block ACK Request and thus are set to Block ACK. The destination STA of a PSDU with an Ack Policy set to Implicit Block ACK Request, STA4 transmits a Block ACK frame an SIFS after receiving a corresponding downlink MU-MIMO PPDU. In contrast, the destination STAs of PSDUs each having an Ack Policy set to Block ACK, STA1, STA2, and STA3 reply to the AP with Block ACK frames after receiving Block ACK Request frames transmitted later by the AP. Information indicating that the Block ACK frames transmitted by the destination STAs may be configured in an Uplink MU-MIMO PPDU and identification information determining a Channel Estimation Sequence (a HEW-STF and a HEW-LTF) to be used in the Uplink MU-MIMO PPDU may be additionally included in the Block ACK Request frames transmitted by the AP. For this purpose, the afore-proposed Uplink MU-MIMO Sequence ID field and Uplink MU-MIMO MCS field may be included in a Block ACK Request frame, and the information is included individually for the STAs that will transmit the Block ACK frames in the uplink MU-MIMO PPDU. In the above figure, upon receipt of Block ACK Request frames, STA1, STA2, and STA3 transmit Block ACK frames in an uplink MU-MIMO PPDU an SIFS after receiving the Block ACK Request frames. STA1, STA2, and STA3 use different Channel Estimation Sequences based on UL MU-MIMO Sequence IDs 1, 2, and 3 in transmitting the Block ACK frames.

Electronic Acknowledgement Receipt

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First Named Inventor/Applicant Name:	Yongho SEOK
Customer Number:	83220
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		62080026EnglishTranslation.pdf	1066624 572657c04aed9d41497e614b36c9e08a9d0fef79	yes	18

	Multipart Description/PDF files in .zip description		
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62/080,026	11/14/2014	Yongho SEOK	A303AA-005800PV

CONFIRMATION NO. 5871

IMPROPER PROVISIONAL LETTER



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Date Mailed: 02/12/2015

Letter re Non-English Language Application Papers in a Provisional Application

The above-identified provisional application was filed in a language other than English. An English-language translation of a non-English provisional application and a statement that the translation is accurate must be filed in the provisional application. See 37 CFR 1.78(a)(5). Applicants are strongly encouraged to file the English-language translation of the provisional application and the statement that the translation is accurate in the provisional application before a nonprovisional application claiming the benefit of the provisional application is filed, or, alternatively, when making a claim for the benefit of the provisional application in a nonprovisional application. If, however, an English translation and a statement that the translation is accurate have not been filed in the above-identified provisional application when a nonprovisional application is filed claiming the benefit of the filing date of the provisional application, the Office should mail a Notice requiring an English translation and the statement to be filed in the provisional application and a confirmation to be filed in the nonprovisional application.

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/hchin/

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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO	TOT CLAIMS	IND CLAIMS
62/080,026	11/14/2014		130	A303AA-005800PV		

CONFIRMATION NO. 5871

FILING RECEIPT



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Date Mailed: 02/12/2015

Receipt is acknowledged of this provisional patent application. It will not be examined for patentability and will become abandoned not later than twelve months after its filing date. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

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Applicant(s)

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Power of Attorney:

Steve Cho--44612

Permission to Access - A proper **Authorization to Permit Access to Application by Participating Offices** (PTO/SB/39 or its equivalent) has been received by the USPTO.

If Required, Foreign Filing License Granted: 02/11/2015

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 62/080,026**

Projected Publication Date: None, application is not eligible for pre-grant publication

Non-Publication Request: No

Early Publication Request: No

**** SMALL ENTITY ****

Title

ENHANCED DOWNLINK MU-MIMO PROCEDURE

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

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Title 37, Code of Federal Regulations, 5.11 & 5.15

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	A303AA-005800PV
		Application Number	
Title of Invention	ENHANCED DOWNLINK MU-MIMO PROCEDURE		
The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76. This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.			

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☐	Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)
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	Yongho		SEOK			
Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service						
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Title of the Invention	ENHANCED DOWNLINK MU-MIMO PROCEDURE		
Attorney Docket Number	A303AA-005800PV	Small Entity Status Claimed	☒
Application Type	Provisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)		Suggested Figure for Publication (if any)	
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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	A303AA-005800PV
		Application Number	
Title of Invention	ENHANCED DOWNLINK MU-MIMO PROCEDURE		

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For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

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☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

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Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	A303AA-005800PV
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Title of Invention	ENHANCED DOWNLINK MU-MIMO PROCEDURE		

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Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	A303AA-005800PV
		Application Number	
Title of Invention	ENHANCED DOWNLINK MU-MIMO PROCEDURE		

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In accordance with 37 CFR 1.14(h)(3), access will be provided to a copy of the instant patent application with respect to: 1) the instant patent application-as-filed; 2) any foreign application to which the instant patent application claims priority under 35 U.S.C. 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the instant patent application; and 3) any U.S. application-as-filed from which benefit is sought in the instant patent application.

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Address 1	9008 Research Drive		
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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	A303AA-005800PV
		Application Number	
Title of Invention	ENHANCED DOWNLINK MU-MIMO PROCEDURE		
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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	A303AA-005800PV
		Application Number	
Title of Invention	ENHANCED DOWNLINK MU-MIMO PROCEDURE		

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PROVISIONAL PATENT APPLICATION

ENHANCED DOWNLINK MU-MIMO PROCEDURE

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본 발명은, 2.4GHz, 5GHz 주파수, 20MHz 이상, 40/80/160MHz channel bandwidth 에서 동작하는 IEEE 802.11ax High Efficiency WLAN (HEW) PPDU format 에 관한 것이다. 특별히, AP 가 복수의 단말로 서로 동시 전송을 수행하는 Downlink MU-MIMO 전송에 관한 것으로 Orthogonal Frequency Division Multiple Access (OFDMA), Uplink MU-MIMO 기술을 활용하여 Downlink throughput 을 크게 향상 시킨다.

아래 그림은 본 발명에서 제안하는 HEW PPDU format 을 보여 준다.

L-STF	L-LTF	L-SIG	HEW SIG-A	HEW-STF	HEW-LTF	HEW-LTF	...	HEW-LTF	HEW SIG-B	PSDU (AP to STA6)
				HEW-STF	HEW-LTF	HEW-LTF	...	HEW-LTF	HEW SIG-B	PSDU (AP to STA5)
				HEW-STF	HEW-LTF	HEW-LTF	...	HEW-LTF	HEW SIG-B	PSDU (AP to STA3, STA4)
				HEW-STF	HEW-LTF	HEW-LTF	...	HEW-LTF	HEW SIG-B	PSDU (AP to STA1, STA2)

L-STF 는 Legacy Short Training Field 에 해당되며, IEEE 802.11a/g/n/ac 와 같은 legacy STA 의 preamble decoding 을 위한 frequency offset estimation, phase offset estimation 을 위한 용도로 사용된다. L-LTF 는 Legacy Long Training Field 에 해당되며, IEEE 802.11a/g/n/ac 와 같은 legacy STA 의 preamble decoding 을 위한 channel estimation 용도로 사용된다. L-SIG 는 Legacy Signal Field 에 해당되며, IEEE 802.11a/g/n/ac 와 같은 legacy STA 의 preamble decoding 및 3rd party PPDU 전송에 대한 protection 기능을 제공한다.

HEW SIG-A 는, High Efficiency WLAN Signal A field 에 해당되며, HEW STA 의 HEW preamble decoding 을 위한 HEW PPDU modulation parameter 등을 제공한다. HEW SIG-A 에 포함되는 parameter 들은, IEEE 802.11ac 단말과 호환을 위해 아래와 같은 IEEE 802.11ac 단말들이 전송하는 VHT PPDU modulation parameter 들을 포함한다.

Two parts of VHT SIG-A	Bit	Field	Number of bits	Description
VHT SIG-A1	B0-B1	BW	2	Set to 0 for 20 MHz, 1 for 40 MHz, 2 for 80 MHz, and 3 for 160 MHz and 99-100 MHz.
	B2	Reserved	1	Reserved. Set to 1.
	B3	STBC	1	For a VHT SU PPDU: Set to 1 if space-time block coding is used and set to 0 otherwise. For a VHT MU PPDU: Set to 0.
	B4-B8	Group ID	5	Set to the value of the TXVECTOR parameter GROUP_ID. A value of 0 or 60 indicates a VHT SU PPDU; otherwise, indicates a VHT MU PPDU.
	B10-B21	NSTS/Partial AID	12	For a VHT MU PPDU: NSTS is divided into 4 user positions of 3 bits each. User position p , where $0 \leq p \leq 3$, uses bits $B(10 + 3p)$ to $B(12 + 3p)$. The number of space-time streams for user n are indicated at user position $p = \text{USER_POSITION}[n]$ where $n = 0, 1, \dots, \text{NSTA_USERS} - 1$, and the antenna $A[n]$ denotes the value of array A at index n . Zero space-time streams are indicated at positions not listed in the USER_POSITION array. Each user position is set as follows: Set to 0 for 0 space-time streams Set to 1 for 1 space-time stream Set to 2 for 2 space-time streams Set to 3 for 3 space-time streams Set to 4 for 4 space-time streams Values 5-7 are reserved. For a VHT SU PPDU: B10-B12 Set to 0 for 1 space-time stream Set to 1 for 2 space-time streams Set to 2 for 3 space-time streams Set to 3 for 4 space-time streams Set to 4 for 5 space-time streams Set to 5 for 6 space-time streams Set to 6 for 7 space-time streams Set to 7 for 8 space-time streams B12-B21 Partial AID: Set to the value of the TXVECTOR parameter PARTIAL_AID. Partial AID provides an abbreviated indication of the intended recipient(s) of the PSDU (see 9.20 Group ID and partial AID in VHT PPDU).
	B24	TXOP_PS_NOT_ALLOWED	1	Set to 0 by VHT AP if it allows non-AP VHT STAs in TXOP power save mode to enter Doze state during a TXOP. Set to 1 otherwise. The bit is reserved and set to 1 in VHT PPDU transmitted by a non-AP VHT STA.
	B22	Reserved	1	Set to 1.

Two parts of VHT SIG-A	Bit	Field	Number of bits	Description
VHT SIG-A2	B0	Short GI	1	Set to 0 if short guard interval is not used in the Data field. Set to 1 if short guard interval is used in the Data field.
	B1	Short GI Nym Disambiguation	1	Set to 1 if short guard interval is used and $Nym_{\text{guard}} \neq 0$; otherwise, set to 0. Nym_{guard} is defined in 22.4.3.11.11.1 and PSDU_LENGTH calculation.
	B2	STBC/CP Coding	1	For a VHT SU PPDU: B2 is set to 0 for BCC, 1 for LDPC. For a VHT MU PPDU: If the MU[1]:NSTS field is nonzero, then B2 indicates the coding used for user n with $\text{USER_POSITION}[n] = 0$; set to 0 for BCC and 1 for LDPC. If the MU[1]:NSTS field is 0, then this field is reserved and set to 1.
	B3	LDPC Extra OFDM Symbols	1	Set to 1 if the LDPC PPDU encoding process (if an ST PPDU), or at least one LDPC user's PPDU encoding process (if a VHT MU PPDU), results in an extra OFDM symbol (as symbols as described in 22.3.10.5.4 (LDPC coding) and 22.3.10.5.5 (Encoding process for VHT MU PPDU)); set to 0 otherwise.
	B4-B7	STBC/CP Coding	4	For a VHT SU PPDU: VHT SIG-A2 index. For a VHT MU PPDU: If the MU[1]:NSTS field is nonzero, then B4 indicates coding for user n with $\text{USER_POSITION}[n] = 1$; set to 0 for BCC, 1 for LDPC. If the MU[1]:NSTS field is 0, then B4 is reserved and set to 1. If the MU[1]:NSTS field is nonzero, then B5 indicates coding for user n with $\text{USER_POSITION}[n] = 2$; set to 0 for BCC, 1 for LDPC. If the MU[1]:NSTS field is 0, then B5 is reserved and set to 1. If the MU[1]:NSTS field is nonzero, then B6 indicates coding for user n with $\text{USER_POSITION}[n] = 3$; set to 0 for BCC, 1 for LDPC. If the MU[1]:NSTS field is 0, then B6 is reserved and set to 1. B7 is reserved and set to 1.
	B8	Beamforming	1	For a VHT SU PPDU: Set to 1 if a Beamforming steering matrix is applied to the waveform in an SC transmission as described in 20.2.11.11.2 (Spatial mapping); set to 0 otherwise. For a VHT MU PPDU: Reserved and set to 1. NOTE—It is equal to 1 according to not recommended.
	B9	Reserved	1	Reserved and set to 1.
VHT SIG-B	B10-B17	CRC	8	CRC calculated as: in 20.3.3.4.4 (CRC calculation for HT-SIG) with $c7$ at B10, Bits 0-23 of HT-SIG1 and bits 0-3 of HT-SIG2 are replaced by bits 0-23 of VHT-SIG-A1 and bits 0-3 of VHT-SIG-A2, respectively.
	B18-B23	Tail	6	Used to terminate the trellis of the convolutional decoder. Set to 0.

하지만, 본 발명에서 제안하는 HEW PPDU format 은 MU MIMO-OFDMA 을 지원하기 위함이며, 이를

위해 각각의 HEW STA 에게 할당되는 sub-channel 에 대한 정보가 HEW SIG-A 에 포함될 수 있다.

HEW STA 에게 할당되는 sub-channel 정보는, Group ID, N_{BW} 을 HEW SIG-A 에 포함함으로 이루어 진다. HEW STA 이 HEW AP 에 접속하게 되면, HEW AP 는 해당 HEW STA 에게 Group ID 와 각각의 Group ID 별로 해당 HEW STA 의 STA Position 정보를 할당한다.

예를 들어, 아래 테이블의 경우, Group ID 1 은 STA Position 1, Group ID 2 은 STA Position 2, Group ID 61 은 STA Position 4, Group ID 62 은 STA Position 1 이 할당 됨을 의미한다. 이러한 Group ID, STA Position 테이블 정보를 할당받은 HEW STA 은 HEW PPDU 을 수신한 후 다음과 같이 방식으로 자신의 sub-channel 을 결정한다.

Group ID	Group ID 1	Group ID 2	...	Group ID 61	Group ID 62
STA Position	1	2	...	4	1

예를 들어, 수신한 HEW PPDU 에서 HEW SIG-A 의 Group ID 값이 61 이었고, 이어 N_{BW} 값이 b000, b001, b001, b010 있다고 가정한다.

N_{BW} 은 STA Position 1, STA Position 2, STA Position 3, STA Position 4 에 해당하는 HEW STA 들에게 각각 할당된 sub-channel bandwidth 을 알려준다. 만약, 5MHz, 10MHz, 20MHz, 40MHz, 80MHz, 160MHz HEW PPDU 전송이 허용되는 경우, N_{BW} 은 STA Position 1 에 해당하는 HEW STA 의 sub-channel bandwidth 3 bits, STA Position 2 에 해당하는 HEW STA 의 sub-channel bandwidth 3 bits, STA Position 3 에 해당하는 HEW STA 의 sub-channel bandwidth 3 bits, STA Position 4 에 해당하는 HEW STA 의 sub-channel bandwidth 3 bits, 이렇게 총 4 개의 HEW STA 을 지원하기 위해 12 bits 으로 구성 된다.

위의 예제에서 해당 HEW STA 는 Group ID 61 에 대해서 STA Position 으로 4 을 할당 받았다. 따라서, 수신한 HEW PPDU 의 STA Position 4 의 N_{BW} 값 b010 을 통해 자신에게 할당된 sub-channel bandwidth 가 10MHz 임을 알게 된다. 여기서, N_{BW} 의 encoding 은 b000 은 0MHz, b001 은 5MHz, b010 은 10MHz, b011 은 20MHz, b100 은 40MHz, b101 은 80MHz, b110 은 160MHz 임을 가정하였으며, encoding 방식은 구현에 따라 다른 형태로 설정 될 수 있다.

또한, Group ID, N_{BW} 관련해, 위의 예제를 통해 알 수 있는 것은, Group ID 61 에 STA Position 1 을 할당 받은 HEW STA 로 0MHz sub-channel bandwidth 가 할당 되었다는 것이다. 즉, 어떠한 HEW PPDU 전송도 이루어지지 않음을 나타낸다. 그리고, Group ID 61 에 STA Position 2 을 할당 받은 HEW STA 로 5MHz sub-channel bandwidth 가 할당 되었다는 것과 Group ID 61 에 STA Position 3 을 할당 받은 HEW STA 로 5MHz sub-channel bandwidth 가 할당 되었다는 것이다. 아래 그림은 위의 예제에 따른 HEW PPDU 전송을 보여 주고 있다.

L-STF	L-LTF	L-SIG	HEW SIG-A	HEW-STF	HEW-LTF	HEW-LTF	...	HEW-LTF	HEW SIG-B	PSDU (10MHz)
				HEW-STF	HEW-LTF	HEW-LTF	...	HEW-LTF		
				HEW-STF	HEW-LTF	HEW-LTF	...	HEW-LTF	HEW SIG-B	PSDU (5MHz)
				HEW-STF	HEW-LTF	HEW-LTF	...	HEW-LTF	HEW SIG-B	PSDU (5MHz)

이와 같은 HEW PPDU 전송에 있어, 각각의 HEW STA 들에게 할당되는 sub-channel 들은 서로

sequential 해야 하며, 결과적으로 하나의 20MHz channel 안에 할당 되지 않고 중간에 비어 있는 sub-channel 들이 존재 해서는 안된다. 또한, 각각의 HEW STA 들에게 할당되는 sub-channel 들은 20MHz channel 단위로 하나의 channel 안에서만 이루어져야 하며, 결과적으로 복수의 20MHz channel 안에서 부분적으로 겹쳐진 sub-channel 할당은 허용되지 않아야 한다.

본 발명에서 제안하는 HEW PPDU format 은 MU MIMO-OFDMA 을 지원하기 위함이며, 이를 위해 각각의 sub-channel 에 할당된 HEW STA 들로 전송될 spatial steam 수에 대한 정보가 HEW SIG-A 에 포함될 수 있다. 아래 그림은, 이러한 MIMO-OFDMA 전송에 대한 실시예를 보여 주고 있다.

L-STF	L-LTF	L-SIG	HEW SIG-A	HEW-STF	HEW-LTF	HEW-LTF	HEW-LTF	HEW-LTF	HEW SIG-B	PSDU (AP to STA6)
				HEW-STF	HEW-LTF	HEW-LTF	HEW-LTF	HEW-LTF	HEW SIG-B	PSDU (AP to STA5)
				HEW-STF	HEW-LTF	HEW-LTF	HEW-LTF	HEW-LTF	HEW SIG-B	PSDU (AP to STA3, STA4)
				HEW-STF	HEW-LTF	HEW-LTF	HEW-LTF	HEW-LTF	HEW SIG-B	PSDU (AP to STA1, STA2)

STA1, STA2 에게 첫번째 5MHz sub-channel 이 할당 되었고, 해당 sub-channel 을 통해 각각 2 spatial stream, 총 4 개의 spatial stream 이 STA1, STA2 을 향해 downlink MU-MIMO 방식으로 전송됨을 보여 주고 있다. 그리고, 이를 위해, HEW-SIG-A 이후에 HEW-STF, HEW-LTF, HEW-LTF, HEW-LTF, HEW-LTF, HEW-SIG-B 가 해당 sub-channel 을 통해 전송 됨을 볼 수 있다. HEW-STF 는, 5MHz sub-channel 에 대한 frequency offset estimation, phase offset estimation 용도로 사용된다. HEW-LTF 는, 5MHz sub-channel 에 대한 channel estimation 용도로 사용된다. 전체 전송되는 spatial stream 수가 총 4 개 이므로 MIMO 전송을 허용하기 위해 HEW-LTF 는 총 4 개가 전송되어 진다. 본 발명에서는, 전체 전송되는 spatial stream 수가 총 2 개 일 경우, HEW-LTF 는 총 2 개가 전송되며, 전체 전송되는 spatial stream 수가 총 3 개 일 경우 HEW-LTF 는 총 4 개가 전송되며, 전체 전송되는 spatial stream 수가 총 4 개 일 경우 HEW-LTF 는 총 4 개가 전송되며, 전체 전송되는 spatial stream 수가 총 5 개 일 경우 HEW-LTF 는 총 6 개가 전송되며, 전체 전송되는 spatial stream 수가 총 6 개 일 경우 HEW-LTF 는 총 6 개가 전송되며, 전체 전송되는 spatial stream 수가 총 7 개 일 경우 HEW-LTF 는 총 8 개가 전송되며, 전체 전송되는 spatial stream 수가 총 8 개 일 경우 HEW-LTF 는 총 8 개가 전송되는 것을 제안한다.

STA3, STA4 에게 두번째 5MHz sub-channel 이 할당 되었고, 해당 sub-channel 을 통해 각각 1 spatial stream, 총 2 개의 spatial stream 이 STA3, STA4 을 향해 downlink MU-MIMO 방식으로 전송됨을 보여 주고 있다. 그리고, 이를 위해, HEW-SIG-A 이후에 HEW-STF, HEW-LTF, HEW-LTF, HEW-LTF, HEW-LTF, HEW-SIG-B 가 해당 sub-channel 을 통해 전송 됨을 볼 수 있다. 앞서 본 발명의 HEW-LTF 전송과 관련된 규칙은, 전체 전송되는 spatial stream 수가 총 2 개 일 경우, HEW-LTF 는 총 2 개가 전송된다고 하였다. 하지만, STA3, STA4 에게 전송되는 두번째 5MHz sub-channel 에 대해서는, 4 개의 HEW-LTF 가 전송됨을 볼 수 있다. 이러한 동작은, HEW-LTF 전송과 관련해 별도의 조건을 추가하는 것으로, 서로 다른 sub-channel 에서 전송되는 PSDU 의 전송 시작 시점을 동일하게 맞추기 위함이다. 만약, 두 번째 5MHz sub-channel 에서 실질적으로 요구되는 HEW-LTF 개수, 즉 2 개의 HEW-LTF 만 전송된다면 첫 번째 5MHz sub-channel, 두 번째 5MHz sub-channel 에 대한 PSDU 전송 시작 시점이 서로 달라지는 문제가 발생한다. 따라서, 이러한 문제점을 해결하기 위해, 본 발명에서는 다음과 같은 HEW-LTF 전송 규칙을 추가한다.

각각의 sub-channel 에 할당된 전체 HEW STA 을 대상으로 (SU-MIMO 전송의 경우 하나의 HEW STA 을 의미하며, MU-MIMO 전송의 경우 MU-MIMO 전송의 수신 단말이 되는 복수의 HEW STA 을 의미함), 각각의 sub-channel 에 전송되는 전체 spatial steam 수 (SU-MIMO 전송의 경우 하나의 HEW STA 으로 전송되는 spatial stream 수를 의미하며, MU-MIMO 전송의 경우 MU-MIMO 전송의 수신 단말이 되는 복수의 HEW STA 들로 향하는 전체 spatial stream 수를 의미함) 와 그에 따라 요구되는 전체 HEW-LTF

개수 중, 가장 많은 HEW-LTF 전송이 요구되는 sub-channel 에 맞게 다른 sub-channel 의 HEW-LTF 전송 수가 동일한 값으로 정해진다.

이와 같은 규칙이 적용되어, 위의 예제에서 STA5 에게 세번째 5MHz sub-channel 이 할당 되었고, 해당 sub-channel 을 통해 1 spartial stream 이 SU-MIMO 방식으로 전송되지만, 실제 하나의 HEW-LTF 전송만으로 충분함에도 불구하고 다른 sub-channel 의 HEW-LTF 전송 개수와 맞춰 주기 위해 총 4 개의 HEW-LTF 가 전송됨을 볼 수 있다.

또한, 위의 예제에서 STA6 에게 네번째 5MHz sub-channel 이 할당 되었고, 해당 sub-channel 을 통해 1 spartial stream 이 SU-MIMO 방식으로 전송되었지만, 실제 하나의 HEW-LTF 전송만으로 충분함에도 불구하고 다른 sub-channel 의 HEW-LTF 전송 개수와 맞춰 주기 위해 총 4 개의 HEW-LTF 가 전송됨을 볼 수 있다.

한편, 본 발명에서 제안하는 HEW PPDU format 이 Multi-User (MU)-MIMO 을 효과적으로 지원하기 위해서, 각각의 sub-channel 별로 독립된 signaling information 이 전송될 필요가 있다. MU-MIMO 의 경우, MU-MIMO 전송의 수신 단말이 되는 복수의 HEW STA 들에 대해 서로 다른 spatial stream 수가 각각 전송될 수 있다. 이를 위해서, 각각의 HEW STA 들에게 각각 전송될 spatial stream 수가 전달되어야 한다. 만약, 하나의 HEW STA 에게 MU-MIMO 전송을 통해 전달할 수 있는 최대 spartial stream 수가 4 개, MU-MIMO 전송의 수신 단말이 최대 4 개라면, 각각의 sub-channel 별로 총 12 bits 이 요구 된다. 20MHz channel 안에 최대 4 개의 sub-channel 을 구성할 수 있다면, 총 48 bit 의 signaling information 이 요구 된다. 따라서, protocol overhead 을 줄이기 위한 목적으로, 이러한 spartial stream 할당 정보는 각각의 sub-channel 별로 독립적으로 전송하는 것이 바람직하다. 이러한 목적으로, 아래 그림에서 HEW-SIG-B 는 각각의 sub-channel 별로 spatial stream 할당 정보를 포함하며, Group ID, N_{STS} 와 같은 형태로 MU-MIMO 의 해당 group (Group ID)에 속하는 STA 들에 대해서 전송될 spatial stream 개수 (N_{STS})를 나타낸다.

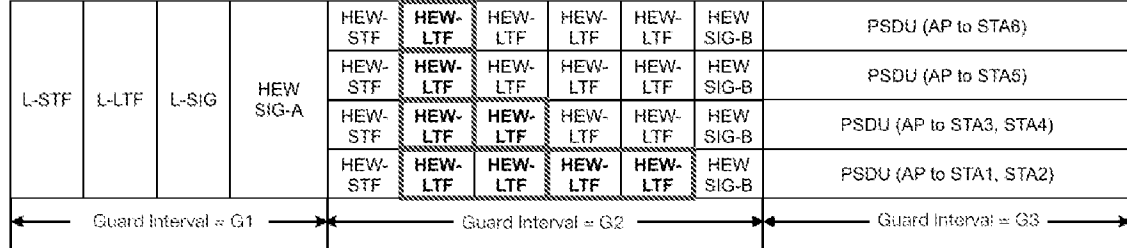
L-STF	L-LTF	L-SIG	HEW SIG-A	HEW-STF	HEW-LTF	HEW SIG-B	HEW-LTF	HEW-LTF	HEW-LTF	HEW-LTF	HEW SIG-C	PSDU (AP to STA6)
				HEW-STF	HEW-LTF	HEW SIG-B	HEW-LTF	HEW-LTF	HEW-LTF	HEW-LTF	HEW SIG-C	PSDU (AP to STA5)
				HEW-STF	HEW-LTF	HEW SIG-B	HEW-LTF	HEW-LTF	HEW-LTF	HEW-LTF	HEW SIG-C	PSDU (AP to STA3, STA4)
				HEW-STF	HEW-LTF	HEW SIG-B	HEW-LTF	HEW-LTF	HEW-LTF	HEW-LTF	HEW SIG-C	PSDU (AP to STA1, STA2)

마지막으로, HEW-LTF 이후에 전송되는 HEW-SIG field 는 PSDU 별로 MCS 정보와 PSDU Length 정보를 포함한다.

L-STF, L-LTF, L-SIG, HEW SIG-A 는, 64 FFT 을 바탕으로 4.0us 길이의 OFDM symbol 들로 구성된다. 이때, 하나의 OFDM symbol 은 0.8us 의 Guard Interval (GI) 값을 가지며, 이하 발명에서는 이러한 Guard Interval 값을 G1 으로 정의하였다.

이어서 전송되는, HEW-STF, HEW-LTF, HEW SIG-B, PSDU 는 256 FFT 을 바탕으로 한 16us 길이의 OFDM symbol 들로 구성된다 (하지만, Guard Interval 값에 따라 OFDM symbol duration 은 변경 될 수 있다). 이때, 하나의 OFDM symbol 은 구간 별로 두 종류의 Guard Interval (GI) 값을 가질 수 있다. 첫 번째, Guard Interval 은 HEW-STF, HEW-LTF, HEW SIG-B 의 OFDM symbol 에 적용되는 값이며, 아래 그림에서는 이러한 Guard Interval 값을 G2 로 정의하였다. 두 번째, Guard Interval 은 PSDU 의 OFDM symbol 에 적용되는 값이며, 아래 그림에서는 이러한 Guard Interval 값을 G3 로 정의하였다. G2 와 G3 값은 서로 같거나, 또는 다를 수 있다. 또한, G1 과 다르게 G2, G3 는 고정된 값이 아니라 각각의 전송되는 PPDU 전송 벡터에 따라 가변될 수 있다. 예를 들어, G1 이 0.8us 로 고정되었다면, G2 는 3.2us,

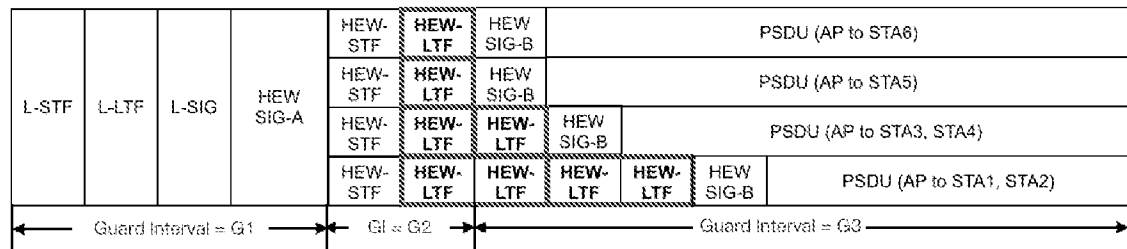
1.6us, 0.8us, 0.4us 중에 임의로 선택 될 수 있다. 마찬가지로, G3 또한 3.2us, 1.6us, 0.8us, 0.4us 중에 임의로 선택 될 수 있다. 그리고, 선택된 G2, G3 값을 지시하기 위한 시그널링 정보는 HEW SIG-A 에 포함될 수 있다. G2, G3 값이 선택 되게 되면, 해당 G2, G3 값은 해당 구간에 전송되는 모든 OFDM symbol 에 대해, 또한 모든 sub-channel 에 대해 공통적으로 적용된다.



본 발명에서, G2, G3 값이 이 서로 다른 경우, PSDU 전송 시점이 동일하지 않으면 각각의 sub-channel 마다 전송되는 OFDM symbol timing 이 서로 일치하지 않는 문제가 발생한다. 하지만, 위 그림에서와 같이 본 발명에서 제안하는 HEW PPDU format 을 사용하게 되면, 각각의 sub-channel 에 대한 PSDU 전송 시점이 동일하여 G2, G3 값에 의한 어떠한 문제도 발생하지 않게 된다.

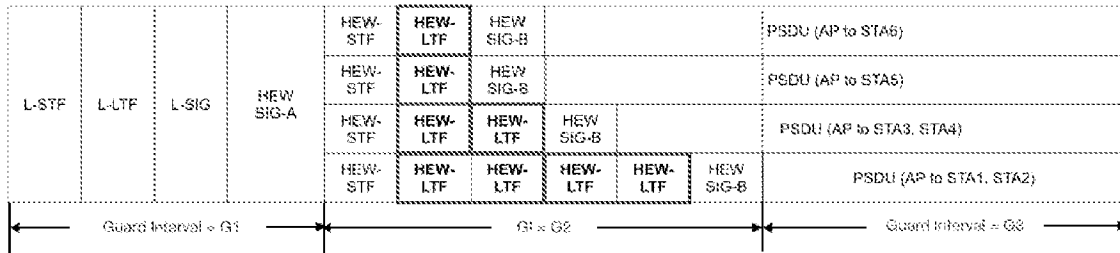
본 발명에서 제안하는 HEW PPDU format 의 다른 실시예로, PSDU 전송 시점이 동일하지 않은 상황에서 각각의 sub-channel 마다 전송되는 OFDM symbol timing 이 일관 되게 유지 될 수 있는 방법을 새롭게 제안한다. 이전 제안에서(위의 그림 참조) HEW PPDU format 의 Guard Interval G2 가 적용되는 구간의 길이는 가변하는 것으로 되어 있다. 즉, HEW-STF, HEW-LTF, HEW SIG-B 의 전송 구간의 길이는 전송되는 PPDU 전송 벡터에 따라 가변될 수 있었다. 하지만, 새롭게 제안하는 것은, 아래 그림과 같이 HEW PPDU format 의 Guard Interval G2 가 적용되는 구간을 HEW-STF, HEW-LTF 로 고정하는 것이다 (구현에 따라서 Guard Interval G2 가 적용되는 구간을 HEW-STF 만으로 한정할 수 있다. 또한, 구현에 따라서 그 이상의 다른 값으로 한정할 수도 있다. 또한, 구현에 따라서 Guard Interval G2 가 적용되는 구간을 0 으로 한정 할 수 있다). Guard Interval G2 가 적용되는 해당 구간 이후로, Guard Interval G3 가 각각의 sub-channel 별 전송 벡터에 따라 0 개 또는 1 개 이상의 HEW-LTF, HEW SIG-B, PSDU 에 대해 sub-channel 별로 동일하게 적용된다.

HEW SIG-A 바로 다음에 전송되는 첫번째 OFDM symbol 에 대한 Guard Interval 값, 즉 Guard Interval G2 는 고정된 값으로 정하는 것이 수신 단말의 decoding complexity 을 줄일 수 있다. 하지만, G1, G2 와 다르게 G3 는 고정된 값이 아니라 각각의 전송되는 PPDU 전송 벡터에 따라 가변될 수 있다. 예를 들어, G1 이 0.8us 로 고정되었고 G2 가 3.2us, 1.6us, 0.8us, 0.4us 중에 하나의 값으로 고정 되었다면, G3 는 3.2us, 1.6us, 0.8us, 0.4us 중에 임의로 선택 되고 선택된 G3 값을 지시하기 위한 시그널링 정보가 HEW SIG-A 에 포함될 수 있다.



위의 발명에서 구현에 따라, Guard Interval G2 가 적용되는 구간을 HEW-STF, HEW-LTF 이상의 다른

값으로 한정할 수도 있다고 명시하였다. 아래 그림은 Guard Interval G2 가 적용되는 구간이 HEW SIG-B 까지로 한정된 경우를 보여 주고 있다. 이 경우, 아래 그림에서 볼 수 있듯이 STA3, STA4, STA5, STA6 으로 전송되는 PSDU 의 일부는 Guard Interval G2 가 사용되고, 나머지 PSDU 는 Guard Interval G3 가 사용되게 된다. 이것을 다르게 설명하면, 하나의 PSDU 전송에 있어서 두 개 이상의 전송 구간에 대해서로 다른 Guard Interval 이 사용될 수 있음을 의미한다. 위의 발명에서, Guard Interval G2 가 적용되는 구간이 특정 값으로 한정된 경우, 해당 값은 모든 단말들간에 사전에 미리 고정 되거나 또는 HEW SIG-A 을 통해 시그널링 될 수 있다.



40/80/160MHz channel bandwidth 에서 HEW PPDU format 은 다음과 같다.

아래 그림은, 앞서 제안한 두 가지 HEW PPDU format 중 PSDU 전송 시점이 동일하도록 제안한 첫번째 HEW PPDU format 을 2 개 이상의 20MHz channel 들에 대해 확장한 것이다. 40/80/160MHz channel bandwidth 로 확장될 때, HEW PPDU format 에 수정되는 부분은 없다. 하지만, 각각의 20MHz channel 들에 대해서, OFDM Symbol Duration, Guard Interval 은 서로 동일해야 한다.

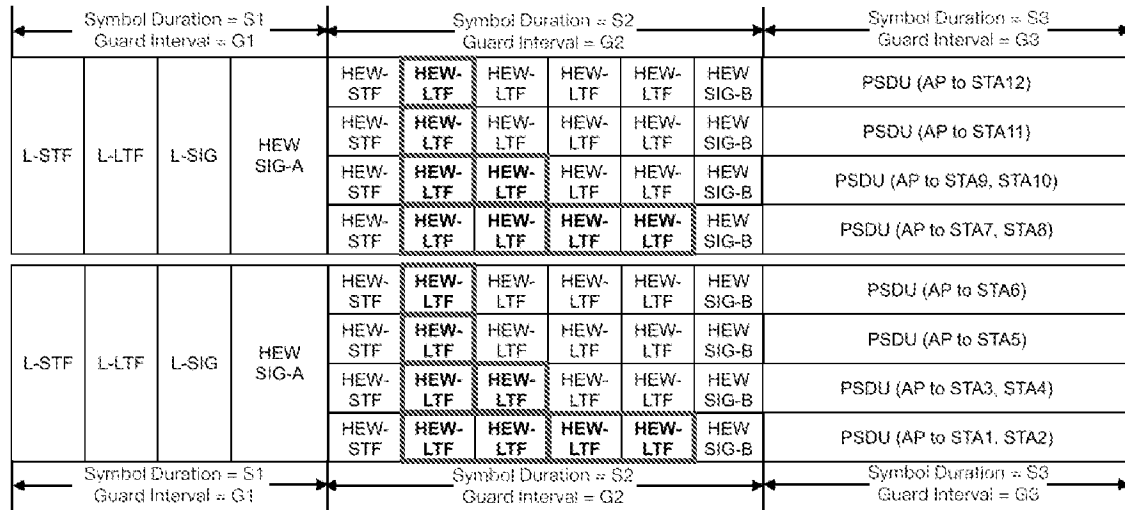
아래 그림의 아래쪽 20MHz channel 에서, L-STF, L-LTF, L-SIG, HEW SIG-A 의 OFDM Symbol Duration 은 S1, Guard Interval 은 G1 이었다. 이 경우, 위쪽 20MHz channel 에서 L-STF, L-LTF, L-SIG, HEW SIG-A 의 OFDM Symbol Duration, Guard Interval 역시 동일하게 S1, G1 가 됨을 볼 수 있다.

아래 그림의 아래쪽 20MHz channel 에서, HEW-STF, HEW-LTF, HEW SIG-A 의 OFDM Symbol Duration 은 S2, Guard Interval 은 G2 이었다. 이 경우, 위쪽 20MHz channel 에서 HEW-STF, HEW-LTF, HEW SIG-A 의 OFDM Symbol Duration, Guard Interval 역시 동일하게 S2, G2 가 됨을 볼 수 있다.

아래 그림의 아래쪽 20MHz channel 에서, PSDU 의 OFDM Symbol Duration 은 S3, Guard Interval 은 G3 이었다. 이 경우, 위쪽 20MHz channel 에서 PSDU 의 OFDM Symbol Duration, Guard Interval 역시 동일하게 S3, G3 가 됨을 볼 수 있다.

이것은 어느 하나의 20MHz channel 에서 OFDM Symbol Duration, Guard Interval 이 64 FFT 기반으로 구성되어 전송된다면, 다른 나머지 20MHz channel 에서 OFDM Symbol Duration, Guard Interval 역시 64 FFT 기반으로 구성되어 전송되어야 함을 의미한다. 이것을 다르게 말하면, 어느 하나의 20MHz channel 에서 OFDM Symbol Duration, Guard Interval 이 64 FFT 기반으로 구성되어 전송된다면, 다른 나머지 20MHz channel 에서 OFDM Symbol Duration, Guard Interval 은 256 FFT 기반으로 구성되어 전송될 수 없음을 의미한다.

하지만, 구현에 따라 각각의 20MHz channel 에 대한 OFDM Symbol Duration, Guard Interval 값, 즉 아래 그림에서 S2, G2, S3, G3 값은 각각의 20MHz channel 에 대해 다르게 설정될 수도 있다. (참고로, 모든 20MHz channel 에 대해 S1, G1 은 항상 고정된 값이다.) 그러나, 이 경우에도 하나의 20MHz channel 안에서 S2, G2, S3, G3 값은 각각의 sub-channel 마다 동일한 값이 적용된다.



아래 그림은, 앞서 제안한 두 가지 HEW PPDU format 중 PSDU 전송 시점이 동일하지 않은 상황에서 제안한 두 번째 HEW PPDU format 을 2 개 이상의 20MHz channel 들에 대해 확장한 것이다. 40/80/160MHz channel bandwidth 로 확장될 때, HEW PPDU format 에 수정되는 부분은 없다. 하지만, 각각의 20MHz channel 들에 대해서, OFDM Symbol Duration, Guard Interval 은 서로 동일해야 한다.

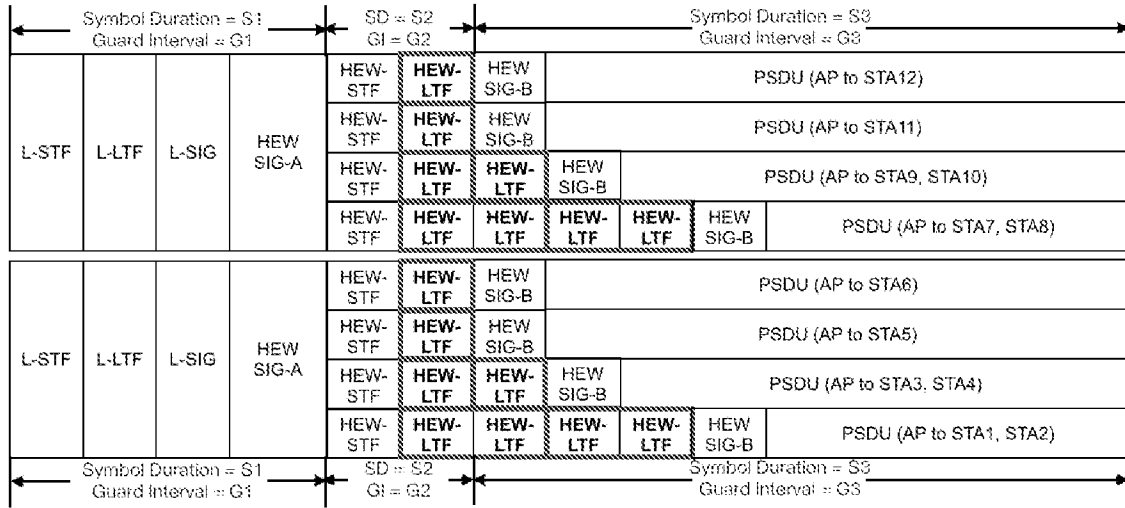
아래 그림의 아래쪽 20MHz channel 에서, L-STF, L-LTF, L-SIG, HEW SIG-A 의 OFDM Symbol Duration 은 S1, Guard Interval 은 G1 이었다. 이 경우, 위쪽 20MHz channel 에서 L-STF, L-LTF, L-SIG, HEW SIG-A 의 OFDM Symbol Duration, Guard Interval 역시 동일하게 S1, G1 가 됨을 볼 수 있다.

아래 그림의 아래쪽 20MHz channel 에서, HEW-STF, HEW-LTF 의 OFDM Symbol Duration 은 S2, Guard Interval 은 G2 이었다. 이 경우, 위쪽 20MHz channel 에서 HEW-STF, HEW-LTF 의 OFDM Symbol Duration, Guard Interval 역시 동일하게 S2, G2 가 됨을 볼 수 있다.

아래 그림의 아래쪽 20MHz channel 에서, 각각의 sub-channel 별 전송 벡터에 따라 0 개 또는 1 개 이상의 HEW-LTF, HEW SIG-B, PSDU 가 전송되고 이 기간에 대해서 OFDM Symbol Duration 은 S3, Guard Interval 은 G3 이었다. 이 경우, 위쪽 20MHz channel 에서 HEW-LTF, HEW SIG-B, PSDU 의 OFDM Symbol Duration, Guard Interval 역시 동일하게 S3, G3 가 됨을 볼 수 있다.

이것은 어느 하나의 20MHz channel 에서 OFDM Symbol Duration, Guard Interval 이 64 FFT 기반으로 구성되어 전송된다면, 다른 나머지 20MHz channel 에서 OFDM Symbol Duration, Guard Interval 역시 64 FFT 기반으로 구성되어 전송되어야 함을 의미한다. 이것을 다르게 말하면, 어느 하나의 20MHz channel 에서 OFDM Symbol Duration, Guard Interval 이 64 FFT 기반으로 구성되어 전송된다면, 다른 나머지 20MHz channel 에서 OFDM Symbol Duration, Guard Interval 은 256 FFT 기반으로 구성되어 전송될 수 없음을 의미한다.

하지만, 구현에 따라 각각의 20MHz channel 에 대한 OFDM Symbol Duration, Guard Interval 값, 즉 아래 그림에서 S2, G2, S3, G3 값은 각각의 20MHz channel 에 대해 다르게 설정될 수도 있다. (참고로, 모든 20MHz channel 에 대해 S1, G1 은 항상 고정된 값이다.) 그러나, 이 경우에도 하나의 20MHz channel 안에서 S2, G2, S3, G3 값은 각각의 sub-channel 마다 동일한 값이 적용된다.



복수의 단말이 하나의 AP 로 서로 동시 전송을 수행하는 HEW Uplink PPDU 전송에 경우, 앞서 제안한 HEW PPDU format 을 그대로 활용할 수 있다. 다만 추가적으로 고려해야하는 것은, Downlink HEW PPDU 전송과 다르게 각각의 sub-channel 에 할당된 HEW STA 들이 전송하는 spatial steam 수에 대한 정보가 HEW SIG-A 에 포함될 수 없다는 것이다. 일반적으로 HEW SIG-A 에는, 동시 전송되는 HEW PSDU 에 대한 공통된 전송 파라미터들이 포함된다. Spatial stream, MCS, STBC 등과 같은 전송 파라미터들은 전송되는 HEW PSDU 각각에 대해 서로 다른 값을 가질 수 있다. 앞서 제안한 HEW PPDU format 에서 전송 파라미터들이 전송되는 HEW PSDU 각각에 대해 서로 다른 경우, PSDU 직전에 전송되는 HEW SIG-B 에 포함될 것을 제안하였다. MCS 가 이에 해당하며, HEW PSDU 각각은 서로 다른 MCS 값을 가질 수 있었다. 그러나, spatial stream, STBC 와 같은 경우, HEW PPDU format 에서 pre-amble 과 PSDU 에 대한 구성 정보를 확인하는데 중요한 역할을 한다. Spatial stream, STBC 의 조합에 따라, HEW-LTF 의 개수가 결정되기 때문이다. 따라서, spatial stream, STBC 와 같은 경우 HEW SIG-B 이전에 전송될 필요가 있다.

만약, 복수의 단말이 하나의 AP 로 서로 동시 전송을 수행하는 HEW Uplink PPDU 전송에서, AP 가 각각의 sub-channel 에 할당된 HEW STA 들이 전송하는 spatial steam 수를 지정하고 HEW STA 들이 이를 반드시 따르도록 프로토콜을 디자인 한다면, 모든 HEW STA 들은 이를 공통 정보로 간주하여 동일한 정보를 구성 HEW SIG-A 을 전송할 수 있다. 이 경우, 앞서 제안한 HEW PPDU format 에 어떠한 변경도 요구되지 않는다.

그렇지 않다면, 다음과 같은 HEW PPDU format 이 Uplink PPDU 전송에 사용되어야 한다. 아래 그림에서 제안하는 HEW PPDU format 은, 앞서 제안한 HEW SIG-A, HEW SIG-B, HEW SIG-C 형태를 Uplink PPDU 전송에 사용하는 것이다. HEW SIG-A 는 20MHz channel 단위로 전송되며, 동시 전송되는 HEW PSDU 에 대한 공통된 전송 파라미터들을 포함한다. 따라서, 각각의 sub-channel 에 할당된 HEW STA 들이 전송하하는 Uplink PPDU 에 대해서 HEW SIG-A 까지는 동일한 정보가 전송되어, AP 로 하여금 중복된 시그널들을 올바로 수신할 수 있게 한다. HEW SIG-B 는 20MHz channel 내에서 sub-channel 단위로 전송되며, 각각의 sub-channel 로 전송되는 HEW PSDU 전송 특성에 맞게 sub-channel 마다 서로 다른 값을 값을 가질 수 있다. HEW SIG-B 에는 해당 sub-channel 로 전송되는 HEW PSDU 의 spatial stream, STBC 에 대한 정보를 포함해야 한다. 만약, 특정 sub-channel 에서 MU-MIMO 가 사용되어 진다면, HEW SIG-B 는 MU-MIMO 전송 그룹에 속한 단말을 대상으로 공통된 전송 정보가 포함된다. HEW SIG-C 는, HEW SIG-B 와 동일한 sub-channel 을 사용해 전송되며, MCS 와 Packet Length 와 같은 정보를 가진다. 만약, 특정 sub-channel 에서 MU-MIMO 가 사용되어 진다면, HEW SIG-C 는 MU-MIMO 전송 그룹에 속한 단말을 대상으로 각각의 HEW PSDU 에 대한 서로 개별적인 전송 정보가 포함된다.

L-STF	L-LTF	L-SIG	HEW SIG-A	HEW-STF	HEW-LTF	HEW SIG-B	HEW-LTF	HEW-LTF	HEW-LTF	HEW-LTF	HEW SIG-C	PSDU (STA4 to AP)
				HEW-STF	HEW-LTF	HEW SIG-B	HEW-LTF	HEW-LTF	HEW-LTF	HEW-LTF	HEW SIG-C	PSDU (STA3 to AP)
				HEW-STF	HEW-LTF	HEW SIG-B	HEW-LTF	HEW-LTF	HEW-LTF	HEW-LTF	HEW SIG-C	PSDU (STA2 to AP)
				HEW-STF	HEW-LTF	HEW SIG-B	HEW-LTF	HEW-LTF	HEW-LTF	HEW-LTF	HEW SIG-C	PSDU (STA1 to AP)

위의 그림은, HEW Uplink PPDU 전송에 관한 예제로써 STA1, STA2, STA3, STA4 가 동시에 AP 로 HEW PPDU 을 전송하는 것을 보여 준다. STA1 는 4 spatial stream, STA2 는 2 spatial stream, STA3 는 1 spatial stream, STA4 는 1 spatial stream 을 AP 로 전송하는 것을 보여 준다. HEW Downlink PPDU 전송과 비교해서, HEW SIG-A 이후에 HEW-STF, HEW-LTF 가 전송되고 이어서 HEW SIG-B 가 전송되는 것을 볼 수 있다. HEW SIG-B 에는 number of spatial streams (or number of space time streams), STBC 사용 여부를 나타내는 정보가 포함된다. 이를 통해 HEW SIG-B 이후에 전송되는 HEW-LTF 의 개수를 알 수 있다. 본 발명에서는, 전체 전송되는 spatial stream 수가 총 2 개 일 경우, HEW-LTF 는 총 2 개가 전송되며, 전체 전송되는 spatial stream 수가 총 3 개 일 경우 HEW-LTF 는 총 4 개가 전송되며, 전체 전송되는 spatial stream 수가 총 4 개 일 경우 HEW-LTF 는 총 4 개가 전송되며, 전체 전송되는 spatial stream 수가 총 5 개 일 경우 HEW-LTF 는 총 6 개가 전송되며, 전체 전송되는 spatial stream 수가 총 6 개 일 경우 HEW-LTF 는 총 6 개가 전송되며, 전체 전송되는 spatial stream 수가 총 7 개 일 경우 HEW-LTF 는 총 8 개가 전송되며, 전체 전송되는 spatial stream 수가 총 8 개 일 경우 HEW-LTF 는 총 8 개가 전송되는 것을 제안한다. HEW SIG-C 는, 해당 sub-channel 로 전송되는 HEW PSDU 에 대한 전송 파라미터로 MCS 값등이 포함된다.

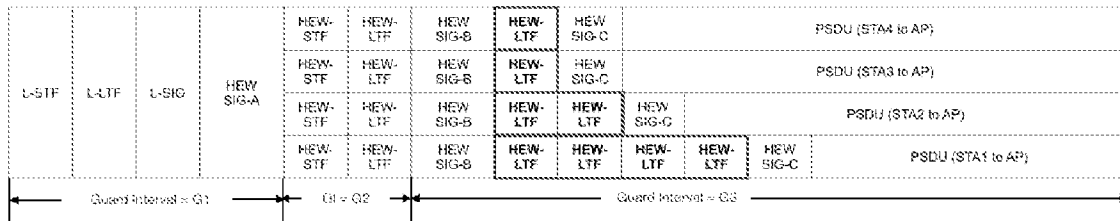
앞선 HEW Downlink PPDU 전송과 동일하게, HEW Uplink PPDU 전송에서도 PSDU 전송 시작 시점이 서로 달라지는 문제가 발생한다. (이것은 OFDM symbol mis-alignment 유발하여 복수의 PSDU 을 동시에 수신하는 AP 의 구현 복잡도가 증가되는 문제를 발생시킨다.) 이러한 문제를 해결하기 위해, HEW Uplink PPDU 에서 전송되는 HEW LTF 의 수를 sub-channel 별로 동일하게 맞추는 방법을 사용할 수 있다. 위의 예제에서, 각각의 sub-channel 별로는 4, 2, 1, 1 개의 HEW-LTF 전송이 실제 요구되지만, 전체 전송되는 HEW-LTF 의 수를 동일하게 맞추기 위해 0, 2, 3, 3 개의 HEW-LTF 가 추가적으로 전송되는 것을 볼 수 있다.

L-STF	L-LTF	L-SIG	HEW SIG-A	HEW-STF	HEW-LTF	HEW SIG-B	HEW-LTF	HEW SIG-C	PSDU (STA4 to AP)			
				HEW-STF	HEW-LTF	HEW SIG-B	HEW-LTF	HEW SIG-C	PSDU (STA3 to AP)			
				HEW-STF	HEW-LTF	HEW SIG-B	HEW-LTF	HEW SIG-C	PSDU (STA2 to AP)			
				HEW-STF	HEW-LTF	HEW SIG-B	HEW-LTF	HEW-LTF	HEW-LTF	HEW SIG-C	PSDU (STA1 to AP)	

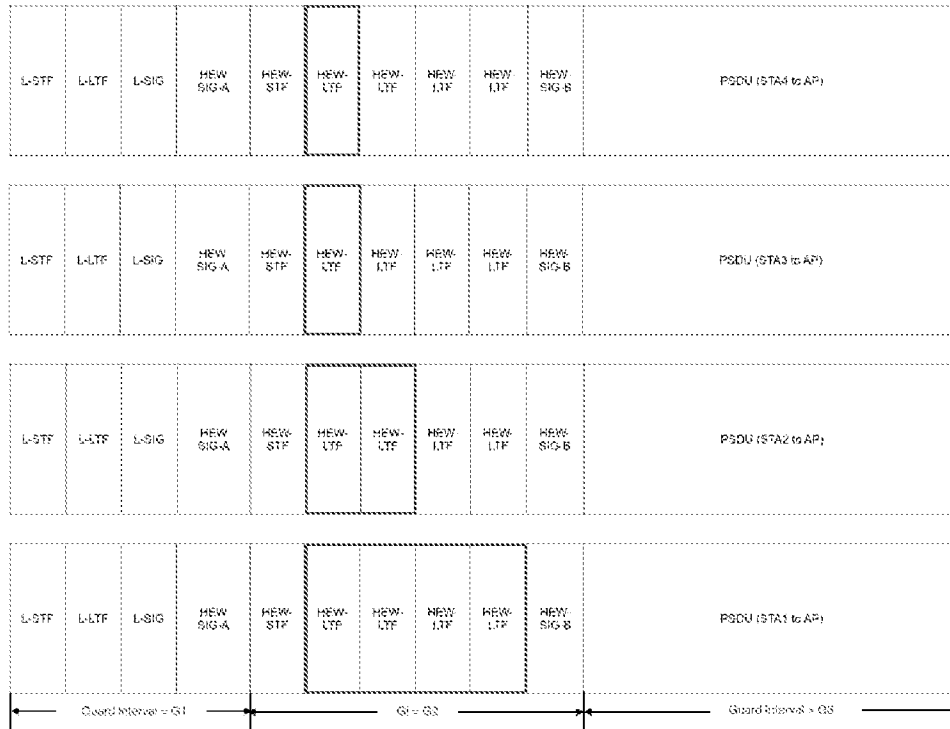
위의 그림은, HEW Uplink PPDU 전송에 관한 다른 예제로써 STA1, STA2, STA3, STA4 가 동시에 AP 로 HEW PPDU 을 전송하는 것을 보여 준다. STA1 는 4 spatial stream, STA2 는 2 spatial stream, STA3 는 1 spatial stream, STA4 는 1 spatial stream 을 AP 로 전송하는 것을 보여 준다. HEW Downlink PPDU 전송과 비교해서, HEW SIG-A 이후에 HEW-STF, HEW-LTF 가 전송되고 이어서 HEW SIG-B 가 전송되는 것을 볼 수 있다. HEW SIG-B 에는 number of spatial streams (or number of space time streams), STBC 사용 여부를 나타내는 정보가 포함된다. 이를 통해 HEW SIG-B 이후에 전송되는 HEW-LTF 의 개수를 알 수 있다. 본 발명에서는, 전체 전송되는 spatial stream 수가 총 2 개 일 경우, HEW-LTF 는 총 2 개가 전송되며, 전체 전송되는 spatial stream 수가 총 3 개 일 경우 HEW-LTF 는 총 4 개가 전송되며, 전체 전송되는 spatial stream 수가 총 4 개 일 경우 HEW-LTF 는 총 4 개가 전송되며, 전체 전송되는 spatial stream 수가 총 5 개 일 경우 HEW-LTF 는 총 6 개가 전송되며, 전체 전송되는 spatial stream 수가 총 6 개 일 경우 HEW-LTF 는 총 6 개가 전송되며, 전체 전송되는 spatial stream 수가 총 7 개 일 경우 HEW-LTF 는 총 8 개가 전송되며, 전체 전송되는 spatial stream 수가 총 8 개 일 경우 HEW-LTF 는 총 8 개가 전송되는 것을 제안한다.

전송되는 것을 제안한다. HEW SIG-C 는, 해당 sub-channel 로 전송되는 HEW PSDU 에 대한 전송 파라미터로 MCS 값등이 포함된다.

앞선 HEW Downlink PPDU 전송과 동일하게, HEW Uplink PPDU 전송에서도 PSDU 전송 시작 시점이 서로 달라지는 문제가 발생한다. (이것은 OFDM symbol mis-alignment 유발하여 복수의 PSDU 을 동시에 수신하는 AP 의 구현 복잡도가 증가되는 문제를 발생시킨다.) 이러한 문제를 해결하기 위해, 아래 그림과 같이 HEW PPDU format 의 Guard Interval G2 가 적용되는 구간을 HEW-STF, HEW-LTF 로 고정하는 것이다 (구현에 따라서 Guard Interval G2 가 적용되는 구간을 HEW-STF 만으로 한정할 수 있다. 또한, 구현에 따라서 그 이상의 다른 값으로 한정할 수도 있다. 또한, 구현에 따라서 Guard Interval G2 가 적용되는 구간을 0 으로 한정 할 수 있다). Guard Interval G2 가 적용되는 해당 구간 이후로, Guard Interval G3 가 각각의 sub-channel 별 전송 벡터에 따라 0 개 또는 1 개 이상의 HEW-LTF, HEW SIG-C, PSDU 에 대해 sub-channel 별로 동일하게 적용된다. 구현에 따라서 Guard Interval G2 가 적용되는 구간이 HEW SIG-C 까지도 될 수 있으며, 이 경우 STA2, STA3, STA4 가 전송하는 PSDU 의 일부는 Guard Interval G2 가 사용되고, 나머지 PSDU 는 Guard Interval G3 가 사용되게 된다.



복수의 단말이 하나의 AP 로 서로 동시 전송을 수행할 때, MU-MIMO 기술을 적용하게 되면 보다 높은 성능 향상을 이룰 수 있다. Uplink MU-MIMO 기술은, AP 가 복수의 안테나를 통해 복수의 spatial stream 을 동시에 수신할 수 있는 경우에 적용 가능하다.



위의 그림은, STA1, STA2, STA3, STA4 가 동시에 AP 로 Uplink DATA frame 을 전송하는 예를 보여 주고 있다. Uplink MU-MIMO 기술을 통한 동시 전송을 수행하는 과정에서, AP 가 Uplink DATA frame 전송 대상이 되는 단말들을 결정하고 해당 단말들의 전송 가능한 spatial stream 개수 및 PSDU 전송에 사용될 Guard Interval 를 지정하는 signaling 과정이 선행되어진다. 위의 그림은, AP 가 Uplink DATA frame 전송 대상이 되는 단말들을 STA1, STA2, STA3, STA4 들로 결정하고 해당 단말들의 전송 가능한 spatial stream 개수를 각각 4 spatial stream, 2 spatial stream, 1 spatial stream, 1 spatial stream 로 지정한 경우이다.

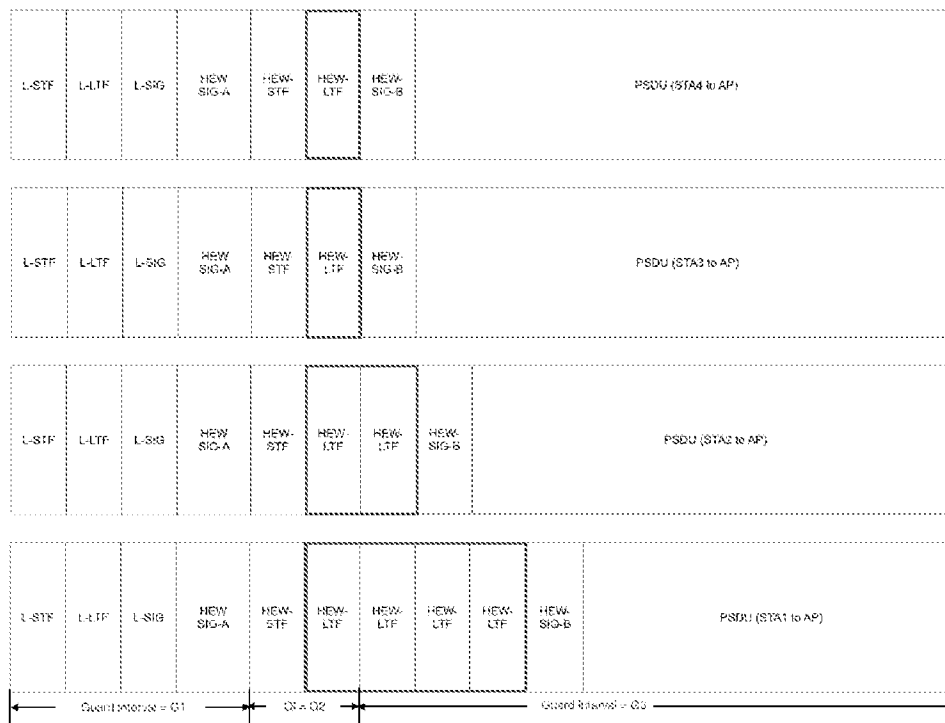
STA1, STA2, STA3, STA4 가 동시에 AP 로 Uplink DATA frame 들을 전송할 때, L-STF, L-LTF, L-SIG, HEW SIG-A field 들은 모두 공통된 값을 가진다. (그렇지 않다면, AP 는 해당 field 들을 올바르게 수신하지 못한다.) HEW SIG-A field 에는 Uplink DATA frame 전송 대상이 되는 단말들 그리고 해당 단말들의 전송 가능한 spatial stream 개수 정보가 포함되어, 목적 단말들이 HEW-STF, HEW-LTF, HEW-SIG-B, PSDU 을 올바르게 수신할 수 있게 한다.

위의 예제에서, AP 가 STA1, STA2, STA3, STA4 에게 각각 4 spatial stream, 2 spatial stream, 1 spatial stream, 1 spatial stream 을 전송 가능한 spatial stream 개수로 지정하였다. 만약, STA1, STA2, STA3, STA4 가 AP 가 지정한 전송 가능한 spatial stream 개수에 맞추어 PSDU 을 전송한다면, 4 spatial stream, 2 spatial stream, 1 spatial stream, 1 spatial stream 과 같은 spatial stream 정보는 HEW SIG-A 에만 포함될 필요가 있다. 하지만, STA1, STA2, STA3, STA4 가 AP 가 지정한 전송 가능한 spatial stream 개수를 초과하지 않는 조건에서 실제 전송되는 spatial stream 수를 임의로 선택할 수 있다면, 예를 들어 2 spatial stream, 1 spatial stream, 1 spatial stream, 1 spatial stream 이 실제 PSDU 전송에 각각 사용되었다면, 해당 spatial stream 정보가 user-specific information 을 지시하는 HEW-SIG-B 에 포함될 필요가 있다. 즉, 4 spatial stream, 2 spatial stream, 1 spatial stream, 1 spatial stream 의 정보가 HEW SIG-A 에 포함되어 HEW-STF, HEW-LTF 의 개수를 전달하는 역할을 수행하며 (위의 예제와 같이 단말들이 전송하는 전체 HEW-LTF 의 개수가 동일한 경우, 4 spatial stream, 2 spatial stream, 1 spatial stream, 1 spatial stream 을 모두 지시하지 않고 실질적으로 전송되는 전체 HEW-LTF 개수, 곧 4 가 HEW SIG-A 에 포함될 수 있다)

그리고, 2 spartial stream, 1 spartial stream, 1 spartial stream, 1 spartial stream 에 대한 정보가 HEW-SIG-B 에 개별적으로 각각 포함되어 PSDU 전송에 사용된 실제 spartial steam 수를 나타낸다.

Uplink MU-MIMO 전송에서도 PSDU 전송 시작 시점이 서로 달라지면, OFDM symbol mis-alignment 문제가 발생한다. 이러한 문제를 해결하기 위해, Uplink MU-MIMO 에서 전송되는 HEW LTF 의 수를 모든 단말별로 동일하게 맞추는 방법을 사용할 수 있다. 위의 예제에서, 각각의 단말들은 Uplink DATA frame 전송에 있어 4, 2, 1, 1 개의 HEW-LTF 전송이 실제 요구되지만, 전체 전송되는 HEW-LTF 의 수를 동일하게 맞추기 위해 0, 2, 3, 3 개의 HEW-LTF 가 추가적으로 전송되는 것을 볼 수 있다.

위의 예제에서, L-STF, L-LTF, L-SIG, HEW SIG-A fields 는 Guard Interval G1 을 사용하여 전송되며, HEW-STF, HEW-LTF, HEW-SIG-B 는 Guard Interval G2 을 사용하여 전송되고, PSDU 는 Guard Interval G3 을 사용하여 전송된다. Gurad Interval G2, G3 은 정해진 값을 사용하거나 가변 될 수 있다. 만약, Gurad Interval G2, G3 가 가변 될 경우, Gurad Interval G2, G3 값을 지시하는 정보가 HEW SIG-A field 에 포함된다.



위의 그림은, STA1, STA2, STA3, STA4 가 동시에 AP 로 Uplink DATA frame 을 전송하는 다른 예제를 보여 주고 있다. Uplink MU-MIMO 기술을 통한 동시 전송을 수행하는 과정에서, AP 가 Uplink DATA frame 전송 대상이 되는 단말들을 결정하고 해당 단말들의 전송 가능한 spartial stream 개수 및 PSDU 전송에 사용될 Guard Interval 를 지정하는 signaling 과정이 선행되어진다. 위의 그림은, AP 가 Uplink DATA frame 전송 대상이 되는 단말들을 STA1, STA2, STA3, STA4 들로 결정하고 해당 단말들의 전송 가능한 spartial stream 개수를 각각 4 spartial stream, 2 spartial stream, 1 spartial stream, 1 spartial stream 로 지정한 경우이다.

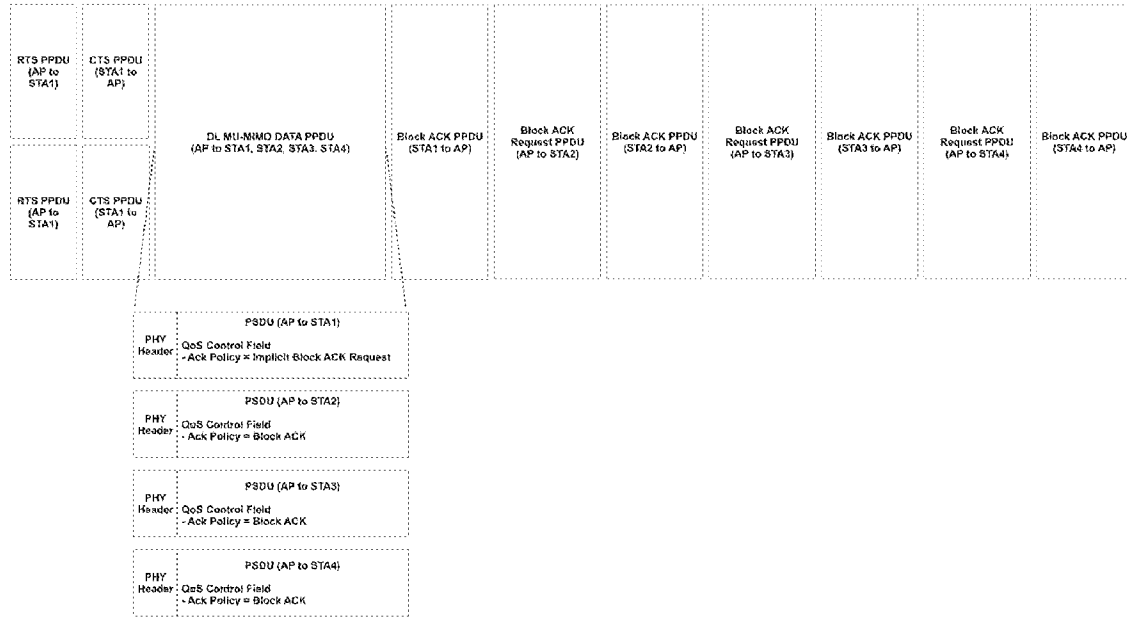
위의 예제에서, AP 가 STA1, STA2, STA3, STA4 에게 각각 4 spartial stream, 2 spartial stream, 1 spartial stream, 1 spartial stream 을 전송 가능한 spartial stream 개수로 지정하였다. 만약, STA1, STA2, STA3, STA4

가 AP 가 지정한 전송 가능한 spatial stream 개수에 맞추어 PSDU 을 전송한다면, 4 spatial stream, 2 spatial stream, 1 spatial stream, 1 spatial stream 과 같은 spatial stream 정보는 HEW SIG-A 에만 포함될 필요가 있다. 하지만, STA1, STA2, STA3, STA4 가 AP 가 지정한 전송 가능한 spatial stream 개수를 초과하지 않는 조건에서 실제 전송되는 spatial stream 수를 임의로 선택할 수 있다면, 예를 들어 2 spatial stream, 1 spatial stream, 1 spatial stream, 1 spatial stream 이 실제 PSDU 전송에 각각 사용되었다면, 해당 spatial stream 정보가 user-specific information 을 지시하는 HEW-SIG-B 에 포함될 필요가 있다. 즉, 4 spatial stream, 2 spatial stream, 1 spatial stream, 1 spatial stream 의 정보가 HEW SIG-A 에 포함되어 HEW-STF, HEW-LTF 의 개수를 전달하는 역할을 수행하며 (STA1, STA2, STA3, STA4 가 실제 전송하는 spatial stream 수가 AP 가 지정한 전송 가능한 spatial stream 개수보다 적은 경우에도 HEW-LTF 의 수는 AP 가 지정한 전송 가능한 spatial stream 개수에 맞추어 전송되어야 한다. 2 spatial stream, 1 spatial stream, 1 spatial stream 이 실제 PSDU 전송에 각각 사용되었다거나 STA1, STA2, STA3, STA4 가 전송하는 HEW-LTF 의 개수는 각각 4 HEW-LTF, 2 HEW-LTF, 1 HEW-LTF, 1 HEW-LTF 가 되어야 한다) 그리고, 2 spatial stream, 1 spatial stream, 1 spatial stream, 1 spatial stream 에 대한 정보가 HEW-SIG-B 에 개별적으로 각각 포함되어 PSDU 전송에 사용된 실제 spatial stream 수를 나타낸다.

Uplink MU-MIMO 전송에서도 PSDU 전송 시작 시점이 서로 달라지면, OFDM symbol mis-alignment 문제가 발생한다. 이러한 문제를 해결하기 위해, Uplink MU-MIMO 에서 HEW PPDU format 의 Guard Interval G2 가 적용되는 구간을 HEW-STF, HEW-LTF 로 고정하는 것이다 (구현에 따라서 Guard Interval G2 가 적용되는 구간을 HEW-STF 만으로 한정할 수 있다. 또한, 구현에 따라서 그 이상의 다른 값으로 한정할 수도 있다. 또한, 구현에 따라서 Guard Interval G2 가 적용되는 구간을 0 으로 한정 할 수 있다). Guard Interval G2 가 적용되는 해당 구간 이후로, Guard Interval G3 가 각각의 단말들이 전송하는 Uplink MU-MIMO 전송별 전송 벡터에 따라 0 개 또는 1 개 이상의 HEW-LTF, HEW-SIG-B, PSDU 에 대해 모든 단말들에게 동일하게 적용된다. 구현에 따라서 Guard Interval G2 가 적용되는 구간이 HEW-SIG-B 까지도 될 수 있으며, 이 경우 STA2, STA3, STA4 가 전송하는 PSDU 의 일부는 Guard Interval G2 가 사용되고, 나머지 PSDU 는 Guard Interval G3 가 사용되게 된다.

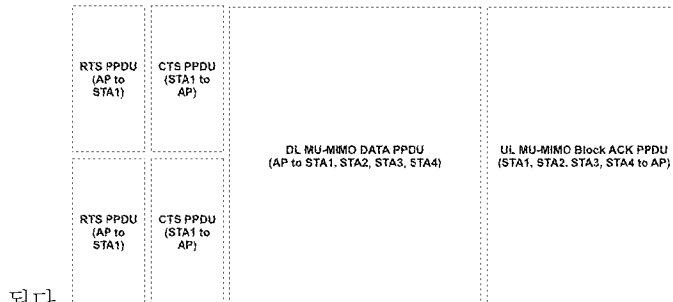
Uplink MU-MIMO 전송이 Downlink MU-MIMO 전송과 함께 사용될 경우, Downlink throughput 을 크게 향상 시킬 수 있다.

Downlink MU-MIMO 전송에 대한 기본적인 동작을 살펴보면 다음과 같다. 우선, AP 는 Downlink MU-MIMO 전송의 목적 단말들 중에 하나의 단말과 RTS frame, CTS frame 을 주고 받는다. 이어서, Downlink MU-MIMO 전송의 목적 단말들을 대상으로 Downlink MU-MIMO PPDU 을 전송한다. 이때, 해당 Downlink MU-MIMO PPDU 의 Ack Policy 는 Block ACK 으로 설정한다. 하지만, AP 가 Downlink MU-MIMO 전송의 목적 단말들 중에 하나의 단말에 한해서 Implicit Block ACK Request 을 Ack Policy 로 설정할 수 있다. 이 경우, 해당 단말 하나는 Downlink MU-MIMO PPDU 을 수신한 이후에 SIFS 시간 후 Block ACK frame 을 AP 로 응답하게 된다. 그 외에 Downlink MU-MIMO PPDU 의 Ack Policy 가 Block ACK 으로 설정된 단말들은, AP 로부터 Block ACK Request frame 을 수신한 이후에 SIFS 시간 후 Block ACK frame 을 AP 로 응답한다. Downlink MU-MIMO 전송의 목적 단말들 중에 두 개 이상의 단말에 대해 Implicit Block ACK Request 가 Ack Policy 로 설정되면, 복수의 단말들이 Block ACK frame 을 동시에 응답하게 되어 collision 이 발생한다. 때문에, 이러한 일이 발생하지 않도록 Downlink MU-MIMO PPDU 에서 Implicit Block ACK Request 을 Ack Policy 로 가지는 경우는 오직 한 단말을 대상으로 하거나 그렇지 않으면 사용되지 않아야 한다.



위의 그림은, 앞서 설명한 Downlink MU-MIMO 전송에 대한 기본적인 동작을 보여준다. Downlink (DL) MU-MIMO DATA PPDU 가 40 MHz channel 로 전송되기에 앞서, RTS frame, CTS frame 이 20MHz channel 단위의 duplicated PPDU 형식으로 40 MHz channel 로 전송된다. RTS frame 의 목적 단말은 Downlink MU-MIMO DATA PPDU 의 목적 단말들 중에 하나인 STA1 에 해당되며, STA1 이 RTS frame 을 수신한 이후 CTS frame 을 응답하는 것을 볼 수 있다. AP 가 전송하는 Downlink MU-MIMO DATA PPDU 는 목적 단말들 곧 STA1, STA2, STA3, STA4 로 향하는 PSDU 들을 포함하며, 이때 각각의 PSDU 에 대한 Ack Policy 는 STA1 으로 향하는 PSDU 을 제외하고 모두 Block ACK 으로 설정된 것을 볼 수 있다. STA1 의 경우, 자신이 수신한 Downlink MU-MIMO DATA PPDU 의 PSDU 로부터 Ack Policy 가 Implicit Block ACK Request 임을 확인하고 SIFS 시간 후에 Block ACK PPDU 을 AP 로 전송하는 것을 볼 수 있다. AP 가 Downlink MU-MIMO DATA PPDU 의 다른 목적 단말들 곧 STA2, STA3, STA4 로부터 Block ACK PPDU 을 수신하기 위해, 순차적으로 Block ACK Request PPDU 을 STA2, STA3, STA4 에게 전송하는 것을 볼 수 있다.

Downlink MU-MIMO 전송에서 성능 향상을 기대할 수 있는 부분은, Block ACK PPDU 수신 절차에 Uplink MU-MIMO 기법을 활용하는 것이다. 예를 들어 Downlink MU-MIMO DATA PPDU 의 목적 단말들이 모두 Uplink MU-MIMO 기법을 지원한다면, 아래 같이 Block ACK PPDU 수신 절차가 간소화

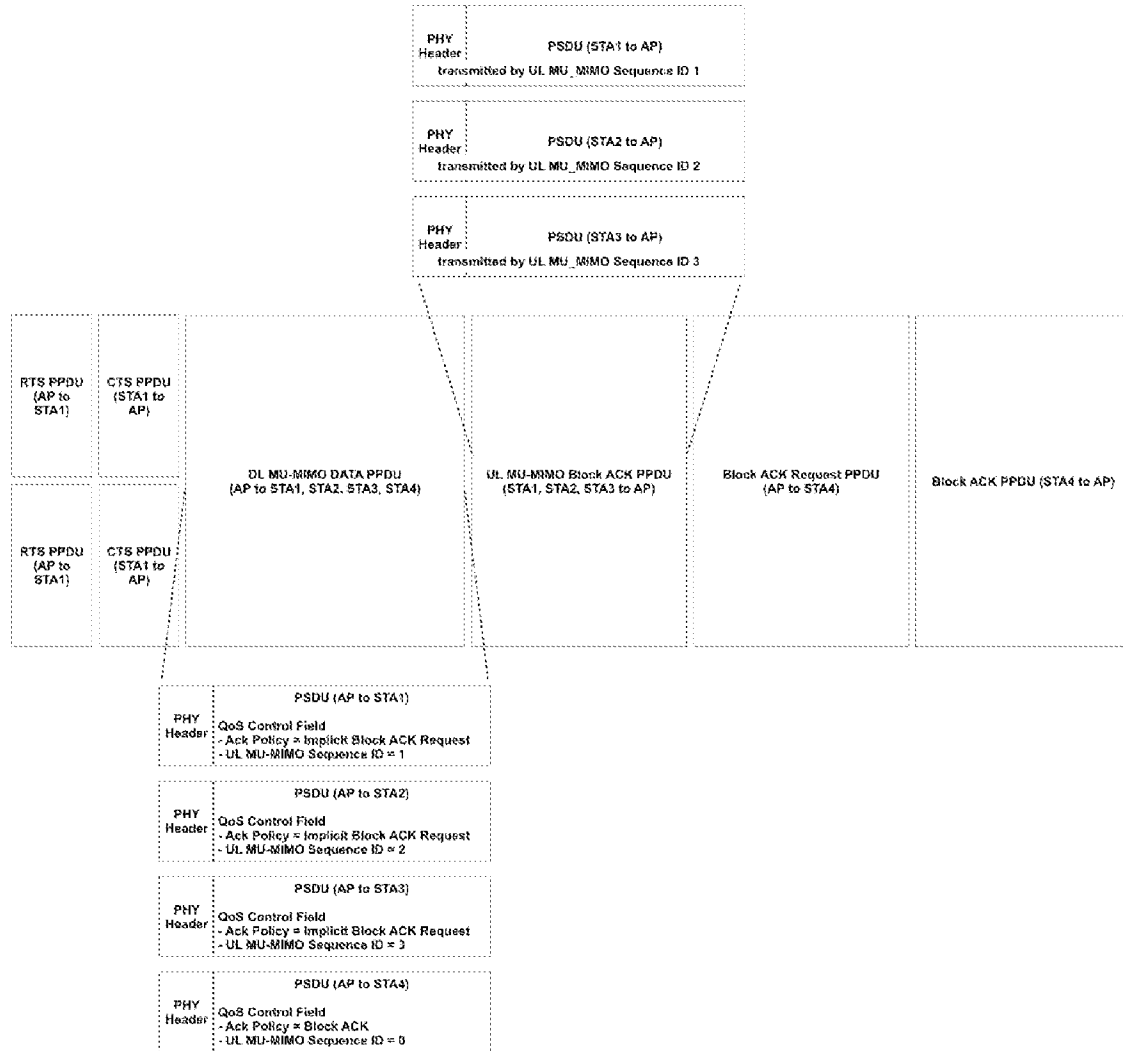


된다.

Downlink MU-MIMO 전송에서 Uplink MU-MIMO 기반의 Block ACK PPDU 수신 절차에 대해 보다 구체적인 내용을 살펴 보면 다음과 같다.

우선, Downlink MU-MIMO DATA PPDU 의 목적 단말들이 모두 Uplink MU-MIMO 기법을 지원한다고

가정할 수 없다. 따라서, Downlink MU-MIMO DATA PPDU 의 목적 단말들을 두 가지 유형, Uplink MU-MIMO Supported STA, Uplink MU-MIMO Non-supported STA 으로 구분할 필요가 있다. Uplink MU-MIMO Supported STA 을 대상으로는 Uplink MU-MIMO 기반의 Block ACK PPDU 전송을 요청할 수 있다. 그러나, Uplink MU-MIMO Non-supported STA 을 대상으로는 기존의 Legacy Block ACK PPDU (MU-MIMO 전송에 상반되는 의미로 Single User PPDU 로 볼 수 있음) 전송만을 요청할 수 있다. Uplink MU-MIMO Supported STA, Uplink MU-MIMO Non-supported STA 들을 대상으로는 Block ACK PPDU 을 수신하기 위해, 순차적으로 Block ACK Request PPDU 을 Uplink MU-MIMO Supported STA, Uplink MU-MIMO Non-supported STA 에게 전송하는 것이 필요하다.



위의 그림에서, STA1, STA2, STA3 은 Uplink MU-MIMO Supported STA 에 해당하며, STA4 는 Uplink MU-MIMO Non-supported STA 에 해당한다. 이와 같이 Downlink MU-MIMO DATA PPDU 의 목적 단말들이 Uplink MU-MIMO Supported STA, Uplink MU-MIMO Non-supported STA 들로 함께 구성된 경우, Downlink MU-MIMO DATA PPDU 에 PSDU 의 Ack Policy 는 Block ACK 으로 설정한다. 하지만, AP 가 Downlink MU-MIMO 전송의 목적 단말들 중에 Uplink MU-MIMO Non-supported STA 의 한 단말에 한해서 Implicit Block ACK Request 을 Ack Policy 로 설정할 수 있다. 이 경우, 해당 단말 하나는 Downlink MU-MIMO PPDU 을 수신한 이후에 SIFS 시간 후 Legacy Block ACK frame 을 AP 로 응답하게 된다. 또한, AP 가 Downlink MU-MIMO 전송의 목적 단말들 중에 Uplink MU-MIMO Supported STA 의

하나 이상의 단말에 한해서 Implicit Block ACK Request 을 Ack Policy 로 설정할 수 있다. 이 경우, 해당하는 하나 이상의 단말은 Downlink MU-MIMO PPDU 을 수신한 이후에 SIFS 시간 후 Uplink MU-MIMO Block ACK frame 을 AP 로 응답하게 된다. 그 외에 Downlink MU-MIMO PPDU 의 Ack Policy 가 Block ACK 으로 설정된 단말들은, AP 로부터 Block ACK Request frame 을 수신한 이후에 SIFS 시간 후 Block ACK frame 을 AP 로 응답한다.

Uplink MU-MIMO Supported STA 들이 Downlink MU-MIMO 전송의 목적 단말에 포함된 경우, 해당하는 Uplink MU-MIMO Supported STA 들을 대상으로 PSDU 의 Ack Policy 가 Implicit Block ACK Request 로 설정될 수 있다. Uplink MU-MIMO Supported STA 들이 전송하는 Block ACK frame 들은 Uplink MU-MIMO 기법을 통해 서로 다른 Channel Estimation Sequence (HEW-STF, HEW-LTF) 을 활용, AP 로 하여금 복수의 Block ACK frame 들을 collision 없이 수신 가능하게 만든다. 하지만, Downlink MU-MIMO 전송의 목적 단말에 포함된 Uplink MU-MIMO Non-supported STA 들에 대해서는, 여전히 Downlink MU-MIMO PPDU 에서 Implicit Block ACK Request 을 Ack Policy 로 가지는 경우가 오직 한 단말을 대상으로 하거나 그렇지 않으면 사용되지 않는 것이 필요하였다.

위의 그림에서, Uplink MU-MIMO Supported STA 에 해당하는 STA1, ST2, STA3 으로 향하는 PSDU 의 Ack Policy 는 Implicit Block ACK Request 가 설정된것을 볼 수 있다. 하지만, Uplink MU-MIMO Non-supported STA 에 해당하는 STA4 로 향하는 PSDU 의 Ack Policy 는 Implicit Block ACK Request 을 Ack Policy 로 설정할 수 없으며 따라서 Block ACK 으로 Ack Policy 가 설정된것을 볼 수 있다. Uplink MU-MIMO Non-supported STA 에 해당하는 STA4 는 이후에 AP 로부터 Block ACK Request frame 을 수신 한 후에 Block ACK frame 을 AP 로 응답하는 것을 볼 수 있다.

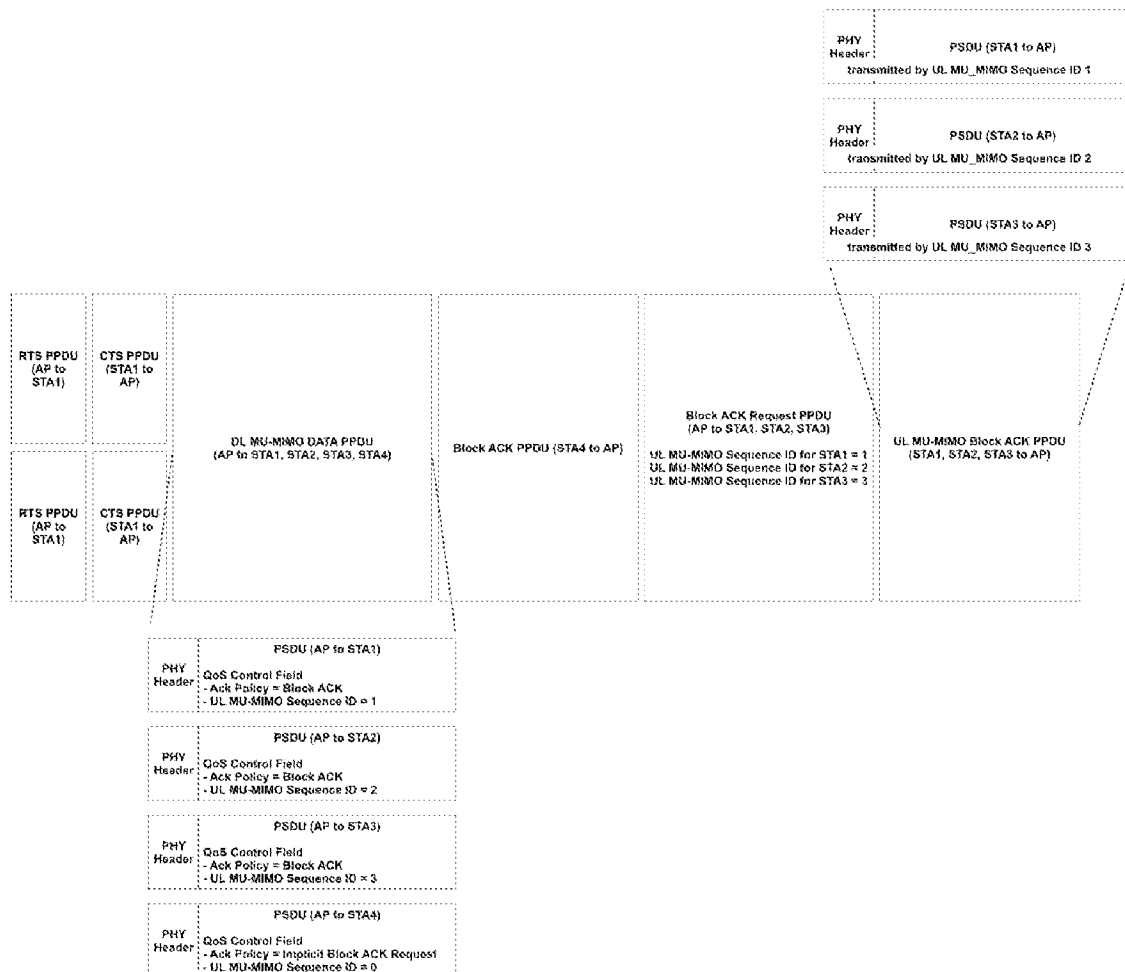
Downlink MU-MIMO DATA PPDU 에 PSDU 의 Ack Policy 가 Implicit Block ACK Request 일 경우, 해당 PSDU 의 목적 단말이 해당 Downlink MU-MIMO PPDU 을 수신한 이후에 SIFS 시간 후 Block ACK frame 을 전송할 때 사용할 PPDU 유형은 Legacy PPDU or Uplink MU-MIMO PPDU 일 수 있다. 또한, Block ACK frame 을 전송할 때 사용할 PPDU 유형이 Uplink MU-MIMO PPDU 일 경우, Uplink MU-MIMO PPDU 전송에 사용될 서로 다른 Channel Estimation Sequence (HEW-STF, HEW-LTF) 을 결정하는 식별 정보가 추가적으로 요구된다. 이를 위해, 본 발명에서는 Downlink MU-MIMO DATA PPDU 에 PSDU 의 QoS Control field 에 UL MU-MIMO Seqnece ID field 을 포함하는 것을 제안한다. UL MU-MIMO Seqnece ID field 가 0 (또는 임의의 정해정 값) 일 경우, 해당 Downlink MU-MIMO PPDU 을 수신한 이후에 SIFS 시간 후 Block ACK frame 을 전송할 때 사용할 PPDU 유형은 Legacy PPDU 가 된다. 하지만, UL MU-MIMO Seqnece ID field 가 0 (또는 임의의 정해정 값) 이 아닌 경우, 해당 Downlink MU-MIMO PPDU 을 수신한 이후에 SIFS 시간 후 Block ACK frame 을 전송할 때 사용할 PPDU 유형은 UL MU-MIMO PPDU 가 된다. 그리고, Uplink MU-MIMO PPDU 전송에 사용될 Channel Estimation Sequence (HEW-STF, HEW-LTF) 집합이 사전에 정의되어 있을때, Channel Estimation Sequence 집합에서 자신이 UL MU-MIMO PPDU 전송에 사용할 Channel Estimation Sequence (HEW-STF, HEW-LTF) 을 결정하는 것은 UL MU-MIMO Seqnece ID 에 의해 이루어 진다.

위의 그림에서, Uplink MU-MIMO Supported STA 에 해당하는 STA1, ST2, STA3 으로 향하는 PSDU 의 Ack Policy 는 Implicit Block ACK Request 가 설정되었고, UL MU-MIMO Seqnece ID field 는 1, 2, 3 으로 설정되었다. 해당 Downlink MU-MIMO PPDU 을 수신한 이후에 SIFS 시간 후 Block ACK frame 을 Uplink MU-MIMO PPDU 로 전송할 때, STA1, STA2, STA3 이 각각 UL MU-MIMO Seqnece ID 1, 2, 3 을 바탕으로 서로 다른 Channel Estimation Sequence 을 사용해 전송하는 것을 볼 수 있다.

Uplink MU-MIMO Supported STA 이 Block ACK frame 을 Uplink MU-MIMO PPDU 로 전송할 때에, 해당 Block ACK frame 의 Transmission Time 은 모두 동일해야 한다. 이것은, Uplink MU-MIMO PPDU 로 전송되는 Block ACK frame 의 Transmission MCS (Modulation Code Scheme) 가 모두 동일해야 함을

의미한다. 이를 위해서, 본 발명에서는 Downlink MU-MIMO DATA PPDU 에 PSDU 의 QoS Control field 에 UL MU-MIMO MCS field 을 포함하는 것을 제안한다. UL MU-MIMO MCS field 가 설정되었을 경우, Uplink MU-MIMO Supported STA 이 Block ACK frame 을 Uplink MU-MIMO PPDU 로 전송 할때 해당 MCS 값이 사용되어야 한다. 또한, Uplink MU-MIMO Supported STA 이 Block ACK frame 을 Uplink MU-MIMO PPDU 로 전송할 때에, 해당 Block ACK frame 에 포함되는 Duration field 는 모두 동일한 값을 가진다. 그리고 이 값은, 이전에 수신한 Downlink MU-MIMO DATA PPDU 에 포함된 Duration field 값에서 해당 Block ACK frame 의 Transmission Time 과 SIFS 시간을 제외한 값이 된다.

본 발명에서 제안하는 UL MU-MIMO Sequence ID field, UL MU-MIMO MCS field 는 구현에 따라, QoS Control field 외에 VHT Control field, HEW Control field, Service field 등에 포함되어 질 수 있다.



위의 그림에서, STA1, STA2, STA3 은 Uplink MU-MIMO Supported STA 에 해당하며, STA4 는 Uplink MU-MIMO Non-supported STA 에 해당한다. 앞선 예제와 달리, AP 가 Uplink MU-MIMO Non-supported STA 에 해당하는 STA4 로 향하는 PSDU 의 Ack Policy 을 Implicit Block ACK Request 로 설정하였다. 이 경우, Uplink MU-MIMO Supported STA 에 해당하는 STA1, STA2, STA3 으로 향하는 PSDU 의 Ack Policy 는 Implicit Block ACK Request 가 될 수 없으며, 따라서 Block ACK 으로 Ack Policy 가 설정된것을 볼 수 있다. Ack Policy 가 Implicit Block ACK Request 로 설정된 PSDU 의 목적 단말 STA4 는 해당 Downlink MU-MIMO PPDU 을 수신한 이후에 SIFS 시간 후 Block ACK frame 을 전송한다. 하지만, Ack Policy 가 Block ACK 으로 설정된 PSDU 의 목적 단말 STA1, 2, 3 은 AP 로 부터 이후에 전송된 Block ACK Request frame 을 수신한 후에 Block ACK frame 을 응답하게 된다. 이때, AP 가 전송하는 Block ACK Request

frame 에는 목적 단말들로 하여금 응답하는 Block ACK frame 이 Uplink MU-MIMO PPDU 형식일 수 있다는 것과 그리고 Uplink MU-MIMO PPDU 형식에서 사용해야할 Channel Estimation Sequence (HEW-STF, HEW-LTF) 을 결정하는 식별 정보가 추가적으로 포함될 수 있다. 이를 위해 앞서 제안한 Uplink MU-MIMO Sequence ID field, Uplink MU-MIMO MCS field 가 Block ACK Request frame 에도 포함될 수 있으며, 해당 정보는 Block ACK frame 을 Uplink MU-MIMO PPDU 형식으로 응답할 STA 들을 대상으로 각각 개별적으로 포함된다. 위의 그림에서, Block ACK Request frame 을 수신한 STA1, STA2, STA3 은 Block ACK Request frame 수신한 이후에 SIFS 시간 후 Block ACK frame 을 Uplink MU-MIMO PPDU 로 전송하며, STA1, STA2, STA3 이 각각 UL MU-MIMO Sequence ID 1, 2, 3 을 바탕으로 서로 다른 Channel Estimation Sequence 을 사용해 전송하는 것을 볼 수 있다.

Electronic Patent Application Fee Transmittal

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Filing Date:

Title of Invention:

ENHANCED DOWNLINK MU-MIMO PROCEDURE

First Named Inventor/Applicant Name:

Yongho SEOK

Filer:

Steve Yong Soo Cho

Attorney Docket Number:

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Description

Fee Code

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Title of Invention:	ENHANCED DOWNLINK MU-MIMO PROCEDURE
First Named Inventor/Applicant Name:	Yongho SEOK
Customer Number:	83220
Filer:	Steve Yong Soo Cho
Filer Authorized By:	
Attorney Docket Number:	A303AA-005800PV
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	2014_11_14_ADS_A303AA-005800PV.pdf	1560835 57a8dda2b4d32c414cd7efaf51e72f22145173e5	no	7

Warnings:**Information:**

2	Specification - Not in English	2014_11_14_SPEC_A303AA-005800PV.pdf	1283145 68cb935922197da25395b76866fdb7f91add0a01	no	19
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Warnings:**Information:**

3	Fee Worksheet (SB06)	fee-info.pdf	29450 e3e4245d064a6c47342184a0b023eb41cf3ea65b	no	2
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Warnings:**Information:**

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National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

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