(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
27 February 2020 (27.02.2020)

WIPO | PCT

(10) International Publication Number
WO 2020/040693 A1

(51) International Patent Classification:
H04W 72/04 (2009.01) *H04L 5/00* (2006.01)
H04B 7/0452 (2017.01) *H04W 84/12* (2009.01)
H04W 28/06 (2009.01)

(21) International Application Number:
PCT/SG2019/050386

(22) International Filing Date:
01 August 2019 (01.08.2019)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
10201807233S 24 August 2018 (24.08.2018) SG

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME,

(54) Title: COMMUNICATION APPARATUS AND COMMUNICATION METHOD FOR CONTROL SIGNALING

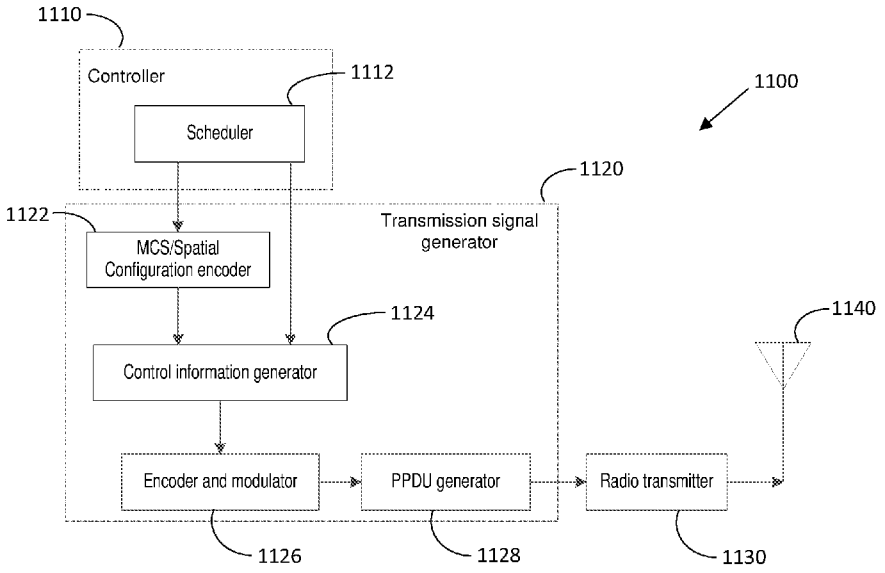


FIGURE 11

(57) Abstract: According to aspects of the present disclosure, communication apparatus and methods are provided. According to one aspect, a communication apparatus may include a controller which, in operation, determines resource allocation information; a signal generation circuitry which, in operation, receives the resource allocation information from the controller and generates a Physical Layer Protocol Data Unit (PPDU) therefrom; and a transmitter which, in operation, transmits the PPDU. The generated PPDU includes a plurality of signaling fields that are associated with a Multi-User Multiple Input Multiple Output (MU-MIMO) allocation, each comprising a signaling subfield, based on the resource allocation information determined by the controller, containing spatial configuration and modulation and coding scheme (MCS) information.

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MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*

— *in black and white; the international application as filed contained color or greyscale and is available for download from PATENTSCOPE*

COMMUNICATION APPARATUS AND COMMUNICATION METHOD FOR CONTROL SIGNALING

TECHNICAL FIELD

The present disclosure is generally related to a communication apparatus and a communication method. In particular, the disclosure relates, but is not limited, to a communication apparatus and a communication method for wireless transmission control signaling.

BACKGROUND ART

Reference to background art herein is not to be construed as an admission that such art constitutes common general knowledge.

In the standardization of next-generation Wireless Local Area Network (WLAN) technologies, a new radio access technology having backward compatibility with earlier standards, such as IEEE 802.11a/b/g/n/ac/ax technologies, has been discussed.

In order to increase peak throughput and capacity over 802.11ax HE (High Efficiency) WLAN, it has been considered to increase the maximum number of spatial streams, e.g. increasing the maximum number of spatial streams from 8 to 16, especially for Multi-User Multiple Input Multiple Output (MU-MIMO) transmissions.

However, the spatial configuration information required for an MU-MIMO transmission in a Physical Layer Protocol Data Unit (PPDU) need to be extended to handle an increased maximum number of spatial streams, which has the effect of increasing the size of the signaling field. This is exacerbated where support for a large number of users in a PPDU is mandated.

CITATION LIST

Non-Patent Literature

[NPL 1]: IEEE 802.11-18/0818r3, 16 Spatial Stream Support in Next Generation WLAN, May 2018

[NPL 2]: IEEE 802.11-17/0288r2, CRs on 28.3.10.8.4 and 28.3.10.8.5, May 2017

[NPL 3]: IEEE 802.11-15/1350r1, Spatial Configuration and Signaling for MU-MIMO, November 2015

SUMMARY OF INVENTION

One non-limiting and exemplary embodiment facilitates providing resource allocation information for a wireless communication system using a Physical Layer Protocol Data Unit containing a plurality of signaling fields including a signaling subfield that contains both spatial configuration and modulation and coding scheme (MCS) information.

In one general aspect, the techniques disclosed here feature a communication apparatus comprising:

a controller which, in operation, determines resource allocation information;

a signal generation circuitry which, in operation, receives the resource allocation information from the controller and generates a Physical Layer Protocol Data Unit (PPDU) therefrom; and

a transmitter which, in operation, transmits the PPDU;

wherein the generated PPDU includes a plurality of signaling fields that are associated with a Multi-User Multiple Input Multiple Output (MU-MIMO) allocation, each comprising a signaling subfield, based on the resource allocation information determined by the controller, containing spatial configuration and modulation and coding scheme (MCS) information.

In another general aspect, the techniques described here feature a communication apparatus comprising:

a receiver which, in operation, receives a Physical Layer Protocol Data Unit (PPDU);

a signal processing circuitry which, in operation, receives the PPDU from the receiver and obtains a plurality of signaling fields that contains per-user allocation information; and

a controller which, in operation, determines one of the plurality of signaling fields specific to the communication apparatus and determines spatial configuration and modulation and coding scheme (MCS) information from a signaling subfield of the determined one of the plurality of signaling fields if the determined one of the plurality of signaling fields is associated with a Multi-User Multiple Input Multiple Output (MU-MIMO) allocation;

wherein the signal processing circuitry demodulates and decodes data contained in the PPDU according to the spatial configuration and MCS information received from the controller.

It should be noted that general or specific embodiments may be implemented as a system, a method, an integrated circuit, a computer program, a storage medium, or any selective combination thereof.

In another general aspect, the techniques disclosed here feature a communication method for transmitting data, the communication method comprising:

determining resource allocation information; and

generating a Physical Layer Protocol Data Unit (PPDU) that includes a plurality of signaling fields that are associated with a Multi-user Multiple Input Multiple Output (MU-MIMO) allocation, each comprising a signaling subfield, based on the determined resource allocation information, containing spatial configuration and modulation and coding scheme (MCS) information; and

transmitting the PPDU.

In another general aspect, the techniques disclosed here feature a communication method for receiving data, the communication method comprising:

receiving a Physical Layer Protocol Data Unit (PPDU);

obtaining a plurality of signaling fields that contains per-user allocation information;

determining one of the plurality of signaling fields specific to the communication apparatus and spatial configuration and modulation and coding scheme (MCS) information from a signaling subfield of the determined one of the plurality of signaling fields if the determined one of the plurality of signaling fields is associated with a Multi-user Multiple Input Multiple Output (MU-MIMO) allocation; and

demodulating and decoding data contained in the PPDU according to the spatial configuration and MCS information.

It should be noted that general or specific embodiments may be implemented as a system, a method, an integrated circuit, a computer program, a storage medium, or any selective combination thereof.

The communication apparatus and communication method described in the present disclosure may be utilized to facilitate communication devices and methods using signaling subfields that contain both spatial configuration and modulation and coding scheme (MCS) information in an efficient manner.

Additional benefits and advantages of the disclosed embodiments will become apparent from the specification and drawings. The benefits and/or advantages may be individually

obtained by the various embodiments and features of the specification and drawings, which need not all be provided in order to obtain one or more of such benefits and/or advantages.

BRIEF DESCRIPTION OF THE DRAWINGS

By way of example only, embodiments of the disclosure will be described more fully hereinafter with reference to the accompanying figures, wherein:

Figure 1 illustrates an example wireless transmitting apparatus in the form of an access point;

Figure 2 illustrates an example wireless receiving apparatus in the form of a terminal;

Figure 3 illustrates an example Physical Layer Protocol Data Unit (PPDU) format;

Figure 4 illustrates subfields of an example EHT-SIG-B field of figure 3;

Figure 5 illustrates an example non-structural encoding for the Spatial Configuration/MCS subfield of a User field associated with a Multi-user Multiple Input Multiple Output (MU-MIMO) allocation;

Figure 6 is a table showing the size of a combined spatial configuration and MCS look-up table for the example signaling subfield encoding of figure 5;

Figure 7 is a table showing the size of a spatial configuration look-up table for the example signaling subfield encoding of figure 17;

Figure 8 illustrates an example structural encoding for the Spatial Configuration/MCS subfield of a User field associated with an MU-MIMO allocation where two bits indicate the configuration of the subfield;

Figure 9 illustrates another example structural encoding for the Spatial Configuration/MCS subfield of a User field associated with an MU-MIMO allocation where four bits indicate the configuration of the subfield;

Figure 10 is a table showing the size of a spatial configuration look-up table for the example signaling subfield encodings of figure 8 or figure 9;

Figure 11 illustrates an example wireless transmitting apparatus, such as the one illustrated in figure 1 but in greater detail, implementing an encoding system;

Figure 12 illustrates an example wireless receiving apparatus, such as the one illustrated in figure 2 but in greater detail, implementing a decoding system;

Figure 13 illustrates a flow chart for an example processing of User fields at a station using the example signaling subfield encoding of figure 5;

Figure 14 illustrates a flow chart for another example processing of User fields at a station using the example signaling subfield encoding of figure 17, 8 or 9;

Figure 15 illustrates steps for deriving an MCS index and a spatial configuration index according to the example signaling subfield encoding of figure 8;

Figure 16 illustrates steps for deriving an MCS index and a spatial configuration index according to the example signaling subfield encoding of figure 9;

Figure 17 is another example non-structural encoding for the Spatial Configuration/MCS subfield of a User field associated with an MU-MIMO allocation;

Figure 18 is a spatial configuration table where the number of users in an MU-MIMO allocation equals 2 or 3;

Figure 19 is a spatial configuration table where the number of users in an MU-MIMO allocation equals 4;

Figure 20 is a spatial configuration table where the number of users in an MU-MIMO allocation equals 5;

Figure 21 is a spatial configuration table where the number of users in an MU-MIMO allocation equals 6;

Figure 22 is a spatial configuration table where the number of users in an MU-MIMO allocation equals 7; and

Figure 23 is a spatial configuration table where the number of users in an MU-MIMO allocation equals 8.

DETAILED DESCRIPTION

The present disclosure can be better understood with the aid of following figures and embodiments. The embodiments described here are merely exemplary in nature and are used to describe some of the possible applications and uses of the present disclosure and should not be taken as limiting the present disclosure with regard to alternative embodiments that are not explicitly described herein.

Figure 1 illustrates an example wireless transmitting apparatus in the form of an access point (AP) 100, in which the present disclosure may be applied. The AP 100 of figure 1 has a controller 110 and signal generation circuitry in the form of a transmission signal generator 120 that operates under control of the controller 110. A radio transmitter 130 thereby transmits generated transmission signals via a transmit antenna 140.

Figure 2 illustrates an example wireless receiving apparatus in the form of a terminal 150, in which the present disclosure may be applied. The terminal 150 of figure 2 has a receive antenna 160 coupled to a radio receiver 170. Signal processing circuitry in the form of a receive signal processor 180 receives signals from the radio receiver 170 and processes them under control of a controller 190.

Transmitted and received signals may take any suitable form, but in the present disclosure the signal typically includes a Physical Layer Protocol Data Unit (PPDU) and the AP 100 and terminal 150 may therefore be configured to, in operation, transmit and receive a PPDU, respectively.

Figure 3 illustrates an example PPDU format 200 suited to multiuser transmission such as Orthogonal Frequency Division Multiple Access (OFDMA) transmission including Multi-User Multiple Input Multiple Output (MU-MIMO) transmission in a single Resource Unit (RU) or full bandwidth MU-MIMO transmission. The PPDU format of figure 3 comprises a designated Extremely High Throughput Signal B field (EHT-SIG-B) 210. The EHT-SIG-B field 210 provides OFDMA and MU-MIMO resource allocation information to allow apparatus, such as terminals or wireless stations (STAs), to obtain resources to be used in the Data field 220.

Figure 4 illustrates subfields of an example EHT-SIG-B field format, comprising a Common field 230 followed by a User Specific field 240. The Common field may contain information regarding RU allocation such as, for example, a RU assignment to be used in the Data field 220 in the frequency domain, the RUs allocated for MU-MIMO transmissions, and the number of users (N_{user}) per MU-MIMO allocation. It should be appreciated that the Common field 230 may not be present in the case of full-bandwidth MU-MIMO transmission, in which case the number of MU-MIMO users is signaled in an Extremely High Throughput Signal A (EHT-SIG-A) field 208 (refer figure 3). The User Specific field 240 can consist of one or more User fields, containing per-user allocation information, for non-MU-MIMO allocation(s) and/or MU-MIMO allocation(s). For example, User field 0 is

associated with a non-MU-MIMO allocation 242 while User fields 1, 2 and 3 are associated with an MU-MIMO allocation 244 having $N_{user} = 3$.

For the purpose of example for the present disclosure, an MU-MIMO transmission with up to 16 spatial streams, up to 8 users, and up to 4 spatial streams per user will be discussed. Previously considered systems with the same characteristics but only allowing for up to 8 spatial streams had a 21 bit User field 244 for an MU-MIMO allocation having an 11 bit Station Identifier (STA-ID) subfield, a 4 bit Spatial Configuration subfield indicating the Number of Space-Time Streams (NSTS) and a Starting Stream Index (SSI), a 4 bit Modulation and Coding Scheme (MCS) subfield indicating a modulation and coding scheme (set to 'n' for MCSn, where n = 0, 1, 2, ..., 11; with values 12 to 15 being reserved), a 1 bit Coding subfield indicating whether Binary Convolutional Coding (BCC) or Low Density Parity Check (LDPC) coding is used, and a 1 bit Reserved subfield.

While increasing the spatial configuration subfield from 4 bits to 6 bits to allow for up to 16 spatial streams could be a solution, since the number of spatial configurations is up to 38 for a given N_{user} in an MU-MIMO allocation as illustrated in Figures 18 to 23, this significantly increases EHT-SIG-B field overhead considering low MCS is typically used for EHT-SIG-B transmission and a large number of users is supported in the PPDU. The present disclosure therefore contemplates constructing a User field having a 9 bit combined signaling subfield called Spatial Configuration/MCS subfield with the requisite spatial configuration and MCS information jointly encoded. Various schemes are discussed herein that would allow for, in the present example, up to 16 spatial streams without compromising other subfields or increasing the number of bits of the User field. Notice that the 9 bit Spatial Configuration/MCS subfield has the same size of the 4 bit Spatial Configuration subfield, the 4 bit MCS subfield and the 1 bit Reserved subfield in the previously considered systems.

Figure 5 illustrates an example non-structural encoding 250 for the 9 bit Spatial Configuration/MCS subfield of a User field associated with an MU-MIMO allocation. For the MU-MIMO allocation in the described example there are 2 to 8 users (N_{user} = 2-8). In conjunction with a determined number of users 252 in the MU-MIMO allocation, the Spatial Configuration/MCS subfield indicates a combination of MCS index 256 and spatial configuration 258, whereby the spatial configuration 258 defines that the NSTS for each user associated with the MU-MIMO allocation.

For example, in case of $N_{user} = 2$, the subfield value is set to 0 to indicate the MCS index for the intended recipient of the User field is 0, the NSTS for the first user associated with the MU-MIMO allocation is 1, and the NSTS for the second user associated with the MU-MIMO allocation is 1; the subfield value is set to 1 to indicate the MCS index for the intended recipient of the User field is 1, the NSTS for the first user associated with the MU-MIMO allocation is 1, and the NSTS for the second user associated with the MU-MIMO allocation is 1, and so on. Based on N_{user} in the MU-MIMO allocation and the User field position in the User Specific field, the intended recipient of the User field is able to derive the NSTS and SSI based on the subfield value. For example, in case of $N_{user} = 2$ in the MU-MIMO allocation and the intended recipient of the User field is the second user associated with the MU-MIMO allocation, if the subfield value is 2, then the MCS index, NSTS and SSI for the intended recipient of the User field is 2, 1, and 1, respectively.

For decoding the Spatial Configuration/MCS subfield with the encoding of figure 5, STAs can search one or more look-up tables to ascertain the requisite spatial configuration and MCS information. For example, a combined Spatial Configuration/MCS look-up table may be used to retrieve an MCS index and NSTS and to derive a SSI according to a value of the Spatial Configuration/MCS subfield. The table of figure 6 illustrates the size of a combined Spatial Configuration/MCS look-up table for decoding the Spatial Configuration/MCS subfield with the encoding of figure 5 having a total memory requirement of 37,896 bits.

Figure 17 illustrates another example non-structural encoding for the 9 bit Spatial Configuration/MCS subfield of a User field associated with an MU-MIMO allocation. The 9 bit Spatial Configuration/MCS subfield indicates a combination of spatial configuration index and MCS index. Then, for a given number of users in the MU-MIMO allocation, the spatial configuration index indicates a spatial configuration, as illustrated in Figures 18-23.

For decoding the Spatial Configuration/MCS subfield with the encoding of figure 17, STAs can search an index look-up table to retrieve an MCS index and a spatial configuration index according to a value of the Spatial Configuration/MCS subfield. The size of this index look-up table would be 4,560 bits (38*12 entries in index look-up table with 10 bits per entry (4 for MCS index and 6 for spatial configuration index)). The STA can then search a separate spatial configuration look-up table to retrieve NSTS and derive a SSI according to the spatial configuration index. The table of figure 7 illustrates the size of the spatial configuration look-up table, totaling 2,318 bits. The total memory requirement for decoding

the Spatial Configuration/MCS subfield with the encoding of figure 17 is therefore 6,878 (4,560 + 2,318) which is significantly less than the memory requirement for decoding the Spatial Configuration/MCS subfield with the encoding of figure 5.

A structural encoding can also be utilized. For example, a predetermined portion of the Spatial Configuration/MCS subfield can indicate a configuration of the signaling subfield. The location of the MCS index and the bit length of the spatial configuration index can vary according to the subfield configuration. Figure 8 illustrates an example structural encoding for the 9 bit Spatial Configuration/MCS subfield of a User field associated with an MU-MIMO allocation where two bits indicate the configuration of the subfield. With such a structural encoding for the 9 bit Spatial Configuration/MCS subfield of a User field associated with an MU-MIMO allocation the two Most Significant Bits (MSBs) of the 9 bit Spatial Configuration/MCS subfield (i.e. B8B7) indicate either a first subfield configuration 262 or a second subfield configuration 264.

The two MSBs (i.e. B8B7) are set to 00, 01, or 10 to indicate the first subfield configuration 262. In the first subfield configuration 262, the four MSBs (i.e. B8B7B6B5) indicate an MCS index (partially designated with the letter x) and the five Least Significant Bits (LSBs) (i.e. B4B3B2B1B0) indicate a spatial configuration index (designated with the letter y). The two MSBs (i.e. B8B7) are set to 11 to indicate the second subfield configuration 264, which should not be applied to the User field associated with an MU-MIMO allocation having only 2 or 3 users. In the second subfield configuration 264, the four bits following the two MSBs (i.e. B6B5B4B3) indicate an MCS index (designated with the letter x) and the remaining three LSBs indicate a spatial configuration index (designated with the letter y) adjusted by a predetermined offset. For example, in the second subfield configuration 264, the three LSBs indicate a spatial configuration index minus an offset of 32. In this example, the first subfield configuration 262 is used if a spatial configuration index is within the range 0 to 31, the second subfield configuration 264 is used if a spatial configuration index is within the range 32 to 39, and there are two reserved spatial configuration indexes.

Figure 9 illustrates another example structural encoding for the 9 bit Spatial Configuration/MCS subfield of a User field associated with an MU-MIMO allocation where four bits indicate the configuration of the subfield. With such a structural encoding for the 9 bit Spatial Configuration/MCS subfield of a User field associated with an MU-MIMO allocation the four MSBs of the 9 bit Spatial Configuration/MCS subfield (i.e. B8B7B6B5)

indicate one of a first subfield configuration 272, a second subfield configuration 274, or a third subfield configuration 276. The two MSBs (i.e. B8B7) are set to 00, 01, or 10 to indicate the first subfield configuration 272. In the first subfield configuration 272, the four MSBs (i.e. B8B7B6B5) indicate an MCS index (partially designated with the letter x) and the five LSBs (i.e. B4B3B2B1B0) indicate a spatial configuration index (designated with the letter y). The two MSBs (i.e. B8B7) are set to 11 and the following two bits (i.e. B6B5) are set to 00, 01, or 10 to indicate the second subfield configuration 274. In the second subfield configuration 274, the four bits following the two MSBs (i.e. B6B5B4B3) indicate an MCS index (again partially designated with the letter x) and the remaining three LSBs (i.e. B2B1B0) indicate a spatial configuration index (again designated with the letter y) adjusted by a predetermined offset (e.g. minus 32). The four MSBs (i.e. B8B7B6B5) are set to 1111 to indicate the third subfield configuration 276. In the third subfield configuration 276, the four bits following the four MSBs (i.e. B4B3B2B1) indicate an MCS index (designated with the letter x) and the remaining LSB (i.e. B0) indicates a spatial configuration index adjusted by a different predetermined offset (e.g. minus 40). In this example, the first subfield configuration 272 is used if a spatial configuration index is within the range 0 to 31, the second subfield configuration 274 is used if a spatial configuration index is within the range 32 to 39, the third subfield configuration 276 is used if a spatial configuration index is 40 or 41, and there are four reserved spatial configuration indexes.

For decoding of the Spatial Configuration/MCS subfield with the encoding of figures 8 or 9, STAs first derive an MCS index and a spatial configuration index directly from a value of the Spatial Configuration/MCS subfield. STAs may then search a spatial configuration look-up table to retrieve NSTS and derive a SSI according to the spatial configuration index. The table of figure 10 illustrates the size of the spatial configuration look-up table, totaling 2,318 bits. The total memory requirement for decoding the Spatial Configuration/MCS subfield with the encoding of figure 8 or 9 is therefore the least of the described options.

It should be appreciated that the four examples are non-exhaustive, and that other structural or non-structural encoding may be implemented with differing complexity and memory and/or processing requirements.

Figure 11 illustrates an example wireless transmitting apparatus in the form of an AP 1100, such as the one illustrated in figure 1 but in greater detail, implementing an example encoding system. The AP 1100 of figure 11 has a controller 1110, a transmission signal generator 1120, a radio transmitter 1130, and a transmit antenna 1140. The controller 1110

has a scheduler 1112 that determines RU allocation and per-user allocation information, for example the NSTS, SSI, and MCS index for each user associated with an MU-MIMO allocation.

The transmission signal generator 1120 generates a signal, such as a PPDU, under the control of the controller 1110. A signaling subfield encoder, in the form of an MCS/Spatial configuration encoder 1122, generates the Spatial Configuration/MCS subfields for all users associated with MU-MIMO allocations according to their respective NSTS, SSI, and MCS index. A control signal generator, in the form of a control information generator 1124, then generates a control portion of a PPDU, such as an EHT-SIG-B field, including User fields. This is passed to an encoder and modulator 1126 which encodes and modulates the generated control portion of the PPDU and passes it to a PPDU generator 1128 which generates the PPDU which, in operation is transmitted by the radio transmitter 1130.

Figure 12 illustrates an example wireless receiving apparatus in the form of a terminal 1150, such as the one illustrated in figure 2 but in greater detail, implementing an example decoding system. The terminal 1150 of figure 12 has a receive antenna 1160, a radio receiver 1170, a receive signal processor 1180, and a controller 1190. In operation, the radio receiver 1170 receives a signal from the receive antenna 1160 such as a PPDU. This is passed to a control signal processor, in the form of a control demodulator and decoder 1182, which demodulates and decodes a control portion of the received PPDU, such as the EHT-SIG-B field including a plurality of User fields, of the received PPDU.

The control portion of the received PPDU is communicated to a parser, in the form of a control information parser 1192, of the controller 1190. The control information parser 1192 analyses the control portion of the received PPDU (e.g. the EHT-SIG-B field including the plurality of User fields) and determines whether the terminal 1150 is an intended recipient of the PPDU and whether it is associated with a non-MU-MIMO allocation or a MU-MIMO allocation, and obtains user-specific allocation information. For example, if it is determined that the terminal 1150 is associated with an MU-MIMO allocation, a signaling subfield decoder, in the form of an MCS/Spatial Configuration decoder 1194, decodes the Spatial Configuration/MCS subfield of the corresponding User field to obtain spatial configuration and MCS information such as, for example, its NSTS, SSI, and MCS index. Depending on the encoding system chosen, this may be performed with the assistance of one of more look-up tables 1196 such as described in the previous examples. A data demodulator and decoder

1184 of the receive signal processor 1180 then demodulates and decodes transmitted data according to the user specific allocation information determined by the controller 1190.

Figure 13 illustrates a flow chart for an example method for processing User fields in a received PPDU at a STA using, for example, the example encoding for the Spatial Configuration/MCS subfield of figure 5 hereinbefore described. The method starts with a received PPDU at step 500 and then initializes a User field counter to 0 at step 510. At step 512 a determination is made as to whether a STA ID of the STA matches the value of a STA-ID subfield. If not, the User field counter is increased at step 514 and a determination is made as to whether the User field counter is now equal to the total number of User fields in the User Specific field, or not, at step 516. If no, then this process (i.e. steps 512, 514, and 516) are carried out iteratively until either the STA ID matches the value of the STA-ID subfield at step 512 or the User field counter equals the total number of User fields in the User Specific field at step 516. If the latter determination is made at step 516 the method completes at step 550.

Assuming that the STA ID at some point matches the value of the STA-ID subfield at step 512, the method continues to a determination of whether the User field is associated with a MU-MIMO allocation at step 518. If not, i.e. if the User field is associated with a non-MU-MIMO allocation, relevant signaling information such as, for example, the NSTS, MCS index, DCM (Dual Carrier Modulation) usage, Tx BF (Transmit Beamforming) usage, and coding scheme information can be obtained and the method completes at step 550. If, on the other hand, the User field is associated with a MU-MIMO allocation then the method progresses to determine a User field position in the User Specific field at step 522.

An MCS index and spatial configuration information, such as an NSTS and SSI, according to the value of the Spatial Configuration/MCS subfield is then derived, as well as the number of the users and the User field position in the User Specific field, at step 524. For example, for a given number of users (N_{user}) in the MU-MIMO allocation, the STA may utilize a spatial configuration/MCS look-up table to obtain the MCS index and NSTS allocated to it by using the row corresponding to the value of the Spatial Configuration/MCS subfield and the column corresponding to the User field position in the User Specific field. The SSI allocated to the STA may then be determined by summing the NSTS in the columns prior to the column indicated by the STA's User field position in the User Specific field. Finally, at step 526 the coding scheme is obtained and the method completes at step 550.

Figure 14 illustrates a flow chart for an example method for processing User fields in a received PPDU at a STA using, for example, the example encoding for the Spatial Configuration/MCS subfield of figure 17, 8 or 9 hereinbefore described. The method of figure 14 starts similarly to the method described with reference to figure 13, with a received PPDU at step 600 and then initializing a User field counter to 0 at step 610. At step 612 a determination is made as to whether a STA ID of the STA matches the value of a STA-ID subfield. If not, the User field counter is increased at step 614 and a determination is made as to whether the User field counter is now equal to the total number of User fields in the User Specific field, or not, at step 616. If no, then this process (i.e. steps 612, 614, and 616) are carried out iteratively until either the STA ID matches the value of the STA-ID subfield at step 612 or the User field counter equals the total number of user fields in the User Specific field at step 616. If the latter determination is made at step 616 the method completes at step 650.

Assuming that the STA ID at some point matches the value of the STA-ID subfield at step 612, the method continues to a determination of whether the User field is associated with an MU-MIMO allocation at step 618. If not, i.e. if the User field is associated with a non-MU-MIMO allocation, relevant signaling information such as, for example, the NSTS, MCS index, DCM usage, Tx BF usage, and coding scheme information can be obtained and the method completes at step 650. If, on the other hand, the User field is associated with an MU-MIMO allocation then the method progresses to determine a User field position in the User Specific field at step 622.

Spatial configuration and MCS information are determined, for example, by first, at step 624, deriving an MCS index and spatial configuration index according to the value of the Spatial Configuration/MCS subfield. Figures 15 and 16 illustrate example methods according to the structural encoding for the Spatial Configuration/MCS subfield of figure 8 or 9 hereinbefore described in further detail.

Figure 15 illustrates steps for deriving an MCS index and spatial configuration according to the example structural encoding of figure 8 which utilizes two subfield configurations. The method starts by considering the values of a predetermined portion of the signaling subfield, in this case the two MSBs (i.e. B8B7). At step 700 a determination of the values of the two MSBs is made. The location of the MCS index and the bit length of the spatial configuration index are varied depending on the values of this predetermined portion of the signaling subfield. If the two MSBs (i.e. B8B7) are set to 00, 01, or 10 then an MCS

index is indicated by the four MSBs (i.e. B8B7B6B5) at step 702 and a spatial configuration index is indicated by the remaining five bits (i.e. B4B3B2B1B0) at step 704. If the two MSBs (i.e. B8B7) are set to 11 then an MCS index is indicated by the following four bits (i.e. B6B5B4B3) at step 706 and a spatial configuration index is indicated by the remaining three bits (i.e. B2B1B0) at step 708.

Figure 16 illustrates steps for deriving an MCS index and spatial configuration according to the example structural encoding of figure 9 which utilizes three subfield configurations. The method also starts by considering the values of a predetermined portion of the signaling subfield, in this case the four MSBs (i.e. B8B7B6B5). At step 750 a determination of the values of the four MSBs is made. The location of the MCS index and the bit length of the spatial configuration index are varied depending on the values of this predetermined portion of the signaling subfield. If the four MSBs (i.e. B8B7B6B5) are set to anything other than 1111, then a further determination is made, at step 752, as to the value of the two MSBs (i.e. B8B7). If the two MSBs (i.e. B8B7) are 00, 01, or 10 then an MCS index is indicated by the four MSBs (i.e. B8B7B6B5) at step 754 and a spatial configuration index is indicated by the remaining five bits (i.e. B4B3B2B1B0) at step 756. If the two MSBs (i.e. B8B7) are set to 11 then an MCS index is indicated by the following four bits (i.e. B6B5B4B3) at step 758 and a spatial configuration index is indicated by the remaining three bits (i.e. B2B1B0) at step 760. If the four MSBs (i.e. B8B7B6B5) are set to 1111 then an MCS index is indicated by the following four bits (i.e. B4B3B2B1) at step 762 and a spatial configuration index is indicated by the final remaining bit (i.e. B0).

Turning back to figure 14, once the MCS index and spatial configuration index have been derived at step 624, spatial configuration information, such as an NSTS and SSI, may be determined at step 626. For example, for a given user number (N_{user}), an STA may utilize a spatial configuration look-up table to derive the NSTS allocated to it using the row corresponding to the spatial configuration index and the column corresponding to the User field position in the User Specific field. The SSI for the STA may then be determined by summing the NSTS in the columns prior to the column indicated by the STA's User field position. Finally, at step 628 the coding scheme is obtained and the method completes at step 650.

Apparatus of the present disclosure may comprise many other components that are not illustrated for the sake of clarity. Only those components that are most pertinent to the present disclosure are illustrated.

The present disclosure can be realized by software, hardware, or software in cooperation with hardware. Each functional block used in the description of each embodiment described above can be partly or entirely realized by an LSI such as an integrated circuit (IC), and each process described in each embodiment may be controlled partly or entirely by the same LSI or a combination of LSIs. The LSI may be individually formed as chips, or one chip may be formed so as to include a part or all of the functional blocks. The LSI may include a data input and output coupled thereto. The LSI here may be referred to as an IC, a system LSI, a super LSI, or an ultra LSI depending on a difference in the degree of integration. However, the technique of implementing an integrated circuit is not limited to the LSI and may be realized by using a dedicated circuit, a general-purpose processor, or a special-purpose processor. In addition, a FPGA (Field Programmable Gate Array) that can be programmed after the manufacture of the LSI or a reconfigurable processor in which the connections and the settings of circuit cells disposed inside the LSI can be reconfigured may be used. The present disclosure can be realized as digital processing or analogue processing. If future integrated circuit technology replaces LSIs as a result of the advancement of semiconductor technology or other derivative technology, the functional blocks could be integrated using the future integrated circuit technology. Biotechnology can also be applied.

In addition, the present disclosure can be realized by any kind of apparatus, device or system having a function of communication, which is referred to as a communication apparatus. Some non-limiting examples of such a communication apparatus include a phone (e.g, cellular (cell) phone, smart phone), a tablet, a personal computer (PC) (e.g, laptop, desktop, netbook), a camera (e.g, digital still/video camera), a digital player (digital audio/video player), a wearable device (e.g, wearable camera, smart watch, tracking device), a game console, a digital book reader, a telehealth/telemedicine (remote health and medicine) device, and a vehicle providing communication functionality (e.g., automotive, airplane, ship), and various combinations thereof.

The communication apparatus is not limited to be portable or movable, and may also include any kind of apparatus, device or system being non-portable or stationary, such as a smart home device (e.g, an appliance, lighting, smart meter, control panel), a vending machine, and any other “things” in a network of an “Internet of Things (IoT)”.

The communication may include exchanging data through, for example, a cellular system, a wireless LAN system, a satellite system, etc., and various combinations thereof.

The communication apparatus may comprise a device such as a controller or a sensor which is coupled to a communication device performing a function of communication described in the present disclosure. For example, the communication apparatus may comprise a controller or a sensor that generates control signals or data signals which are used by a communication device performing a communication function of the communication apparatus.

The communication apparatus also may include an infrastructure facility, such as a base station, an access point, and any other apparatus, device or system that communicates with or controls apparatuses such as those in the above non-limiting examples.

CLAIMS

1. A communication apparatus comprising:

circuitry which, in operation, determines the resource allocation information and generates a Physical Layer Protocol Data Unit (PPDU) therefrom; and

a transmitter which, in operation, transmits the PPDU;

wherein the generated PPDU includes a plurality of signaling fields that are associated with a Multi-User Multiple Input Multiple Output (MU-MIMO) allocation, each comprising a signaling subfield, based on the determined resource allocation information, containing spatial configuration and modulation and coding scheme (MCS) information.

2. A communication apparatus comprising:

a receiver which, in operation, receives a Physical Layer Protocol Data Unit (PPDU); and

circuitry which, in operation, obtains a plurality of signaling fields that contains per-user allocation information, determines one of the plurality of signaling fields specific to the communication apparatus, and determines spatial configuration and modulation and coding scheme (MCS) information from a signaling subfield of the determined one of the plurality of signaling fields if the determined one of the plurality of signaling fields is associated with a Multi-User Multiple Input Multiple Output (MU-MIMO) allocation;

wherein the circuitry demodulates and decodes data contained in the PPDU according to the spatial configuration and MCS information received from the controller.

3. The communication apparatus of claim 1 or claim 2, wherein the spatial configuration information contains a Number of Space-Time Streams (NSTS) and a Starting Stream Index (SSI).

4. The communication apparatus of claim 1 or claim 2, further comprising memory storing at least a spatial configuration look up table.

5. The communication apparatus of claim 1 or claim 2, wherein the signaling subfield indicates an MCS index and a spatial configuration index.

6. The communication apparatus of claim 5, wherein the spatial configuration index corresponds to entries in the spatial configuration look up table.

7. The communication apparatus of claim 5, wherein a bit length of the spatial configuration index is variable and two or more bits of the signaling subfield are used to indicate the bit length of the spatial configuration index.

8. The communication apparatus of claim 5, wherein a location of the MCS index in the signaling subfield is variable and two or more bits of the signaling subfield are used to indicate the location of the MCS index in the signaling subfield.

9. The communication apparatus of claim 7 or claim 8, wherein the two or more bits that are used to indicate a bit length of the spatial configuration index are the same two or more bits that are used to indicate the location of the MCS index.

10. The communication apparatus of claim 5, wherein the MCS index and spatial configuration index are directly derivable from the signaling subfield and the spatial configuration information is derivable using the spatial configuration index in conjunction with the spatial configuration look up table.

11. The communication apparatus of claim 5, wherein there are two to four reserved spatial configuration indexes.

12. The communication apparatus of claim 1 or claim 2, wherein resource allocation information is used to enable one or more of Orthogonal Frequency Division Multiple Access (OFDMA) and MU-MIMO transmission in a data field of the PPDU .

13. The communication apparatus of claim 1 or claim 2, wherein a configuration of the signaling subfield is determined according to a value of a predetermined portion of the signaling subfield.

14. The communication apparatus of claim 13, wherein the configuration of the signaling subfield indicates a bit position of the MCS index in the signaling subfield.

15. The communication apparatus of claim 13, wherein the configuration of the signaling subfield indicates whether a first encoding method or a second encoding method for the spatial configuration index is used in the signaling subfield, the first encoding method directly indicating the spatial configuration index and the second encoding method indicating the spatial configuration index minus a predetermined offset.

16. The communication apparatus of claim 1 or claim 2, wherein the signaling subfield contains spatial configuration and Modulation and Coding Scheme (MCS) information for up to eight users, up to sixteen spatial streams and up to four spatial streams per user in an MU-MIMO allocation.

17. A communication method for transmitting data, the communication method comprising:

determining resource allocation information; and

generating a Physical Layer Protocol Data Unit (PPDU) that includes a plurality of signaling fields that are associated with a Multi-User Multiple Input Multiple Output (MU-MIMO) allocation, each comprising a signaling subfield, based on the determined resource allocation information, containing spatial configuration and Modulation and Coding Scheme (MCS) information; and

transmitting the PPDU.

18. A communication method for receiving data, the communication method comprising:

receiving a Physical Layer Protocol Data Unit (PPDU);

obtaining a plurality of signaling fields that contains per-user allocation information;

determining one of the plurality of signaling fields specific to the communication apparatus and spatial configuration and modulation and coding scheme (MCS) information from a signaling subfield of the determined one of the plurality of signaling fields if the determined one of the plurality of signaling fields is associated with a Multi-user Multiple Input Multiple Output (MU-MIMO) allocation; and

demodulating and decoding data contained in the PPDU according to the spatial configuration and MCS information.

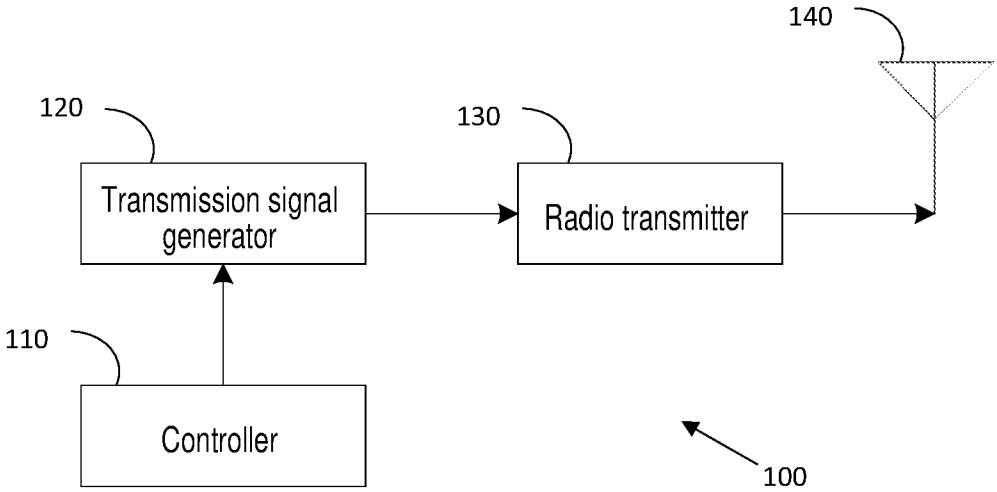


FIGURE 1

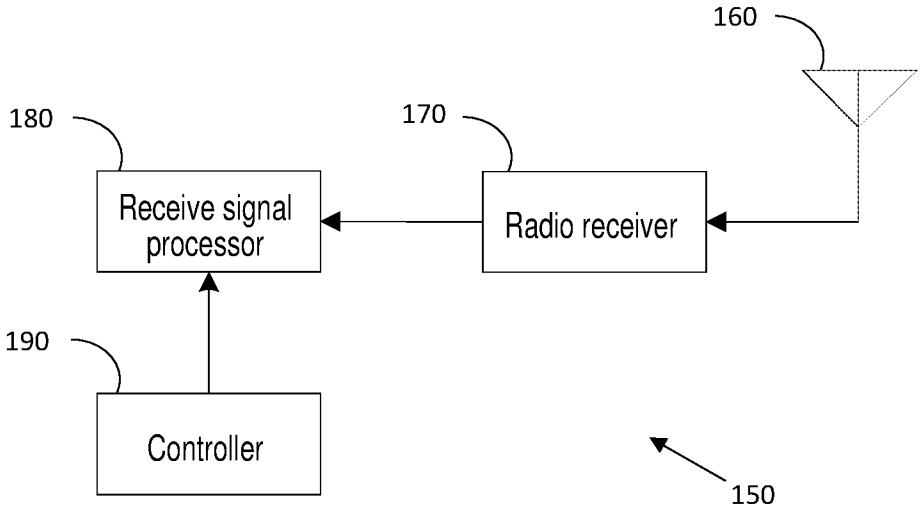


FIGURE 2

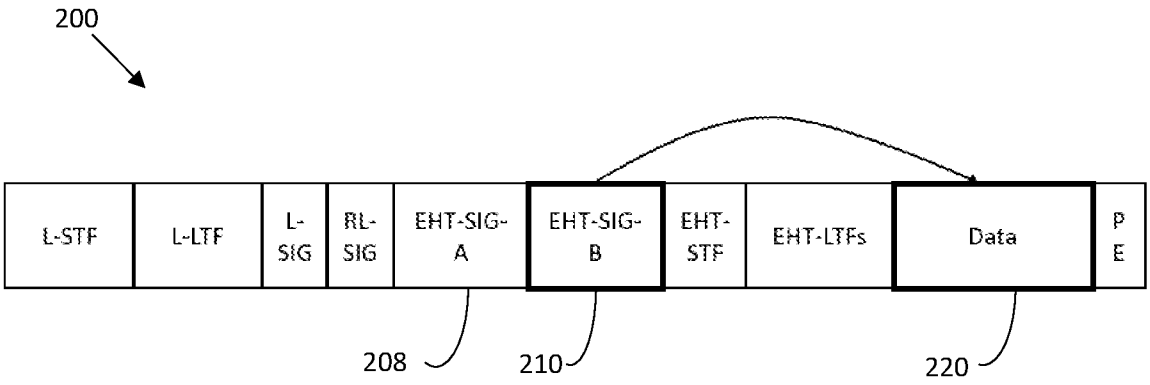


FIGURE 3

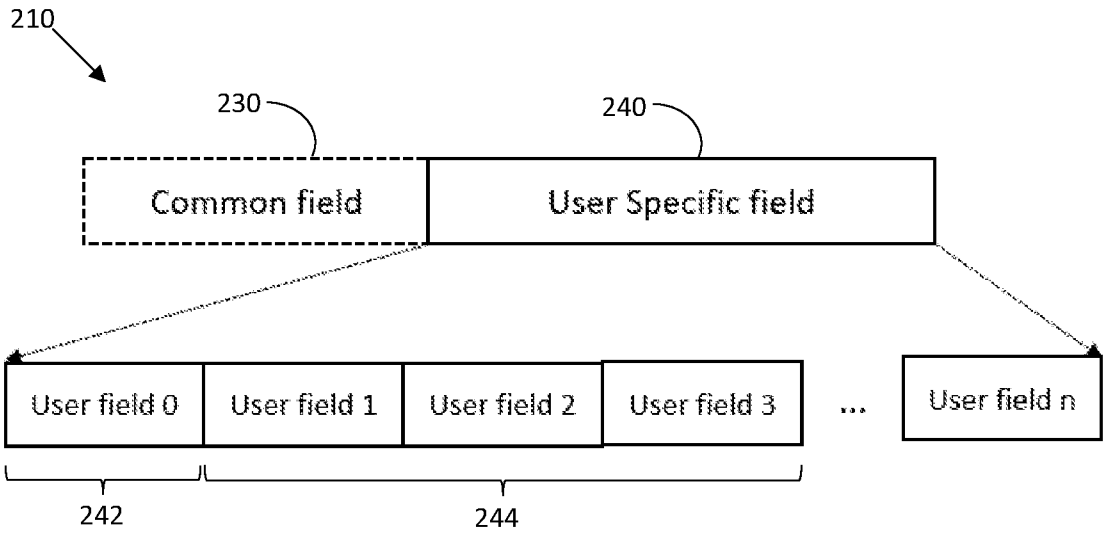
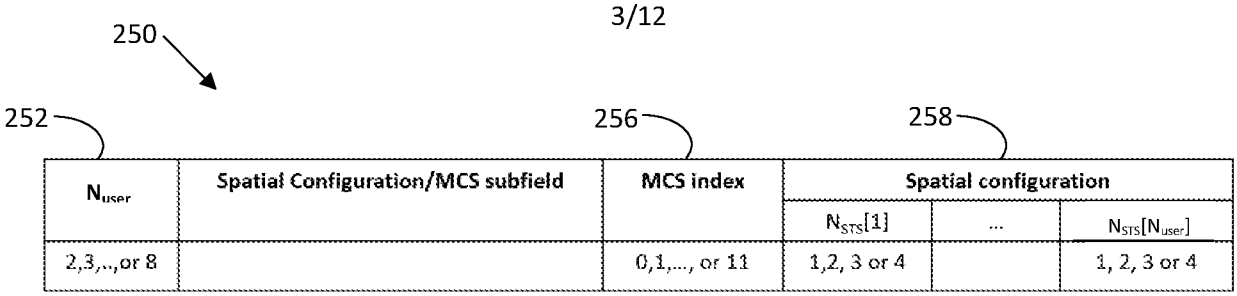


FIGURE 4



N_{user}	Spatial Configuration/MCS subfield	MCS index	Spatial configuration		
			$N_{STS}[1]$	...	$N_{STS}[N_{user}]$
2,3,..,or 8		0,1,..., or 11	1,2, 3 or 4		1, 2, 3 or 4

FIGURE 5

N_{user}	Number of entries in MCS/spatial configuration look-up table	Bits per entry	MCS/spatial configuration look-up table size (bits)
2	10*12	4 (MCS index) +2*2 (spatial configuration)	960
3	20*12	4 (MCS index) +2*3 (spatial configuration)	2400
4	34*12	4 (MCS index) +2*4 (spatial configuration)	4896
5	38*12	4 (MCS index) +2*5 (spatial configuration)	6384
6	37*12	4 (MCS index) +2*6 (spatial configuration)	7104
7	37*12	4 (MCS index) +2*7 (spatial configuration)	7992
8	34*12	4 (MCS index) +2*8 (spatial configuration)	8160

FIGURE 6

N_{user}	Number of entries in spatial configuration look-up table	Bits per entry	Spatial configuration look-up table size (bits)
2	10	2*2 (spatial configuration)	40
3	20	2*3 (spatial configuration)	120
4	34	2*4 (spatial configuration)	272
5	38	2*5 (spatial configuration)	380
6	37	2*6 (spatial configuration)	444
7	37	2*7 (spatial configuration)	518
8	34	2*8 (spatial configuration)	544

FIGURE 7

B8	B7	B6	B5	B4	B3	B2	B1	B0	
0	0	x	x	y	y	y	y	y	262
0	1	x	x	y	y	y	y	y	
1	0	x	x	y	y	y	y	y	
1	1	x	x	x	x	y	y	y	264

FIGURE 8

B8	B7	B6	B5	B4	B3	B2	B1	B0	
0	0	x	x	y	y	y	y	y	272
0	1	x	x	y	y	y	y	y	
1	0	x	x	y	y	y	y	y	
1	1	0	0	x	x	y	y	y	274
1	1	0	1	x	x	y	y	y	
1	1	1	0	x	x	y	y	y	
1	1	1	1	x	x	x	x	y	276

FIGURE 9

N_{user}	Number of entries in spatial configuration look-up table	Bits per entry	Spatial configuration look-up table size (bits)
2	10	2*2 (spatial configuration)	40
3	20	2*3 (spatial configuration)	120
4	34	2*4 (spatial configuration)	272
5	38	2*5 (spatial configuration)	380
6	37	2*6 (spatial configuration)	444
7	37	2*7 (spatial configuration)	518
8	34	2*8 (spatial configuration)	544

FIGURE 10

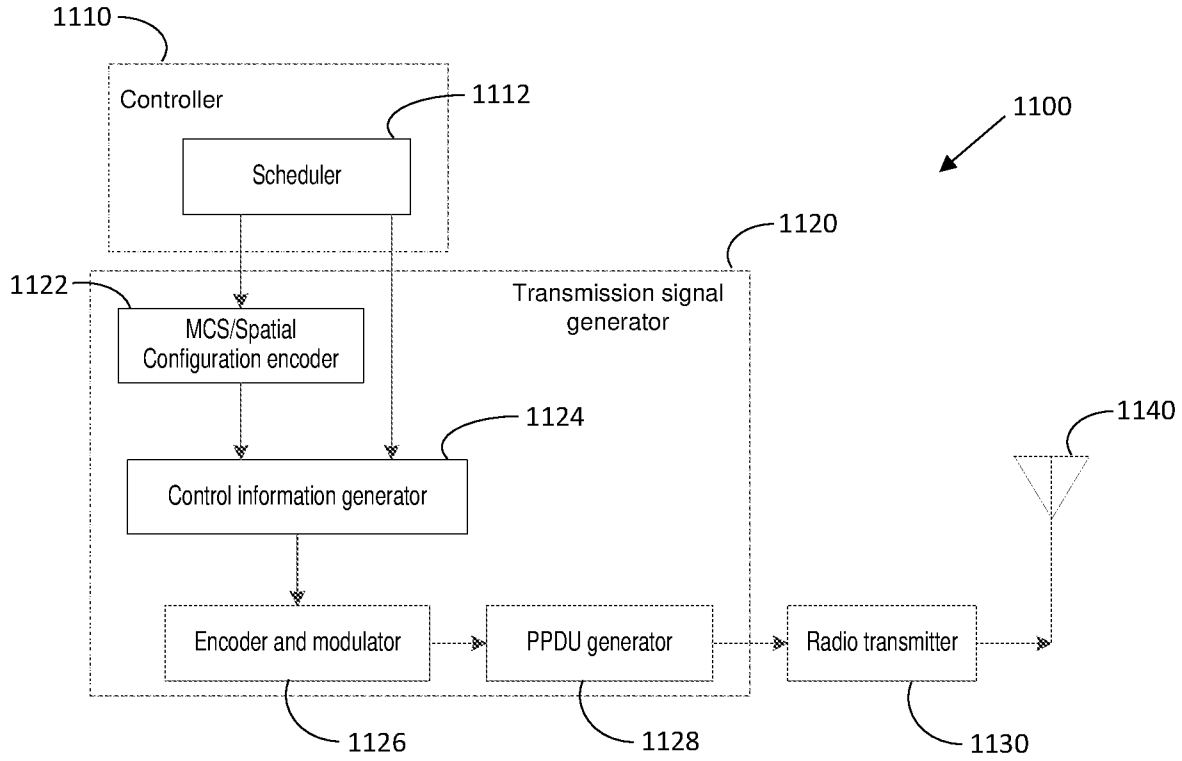


FIGURE 11

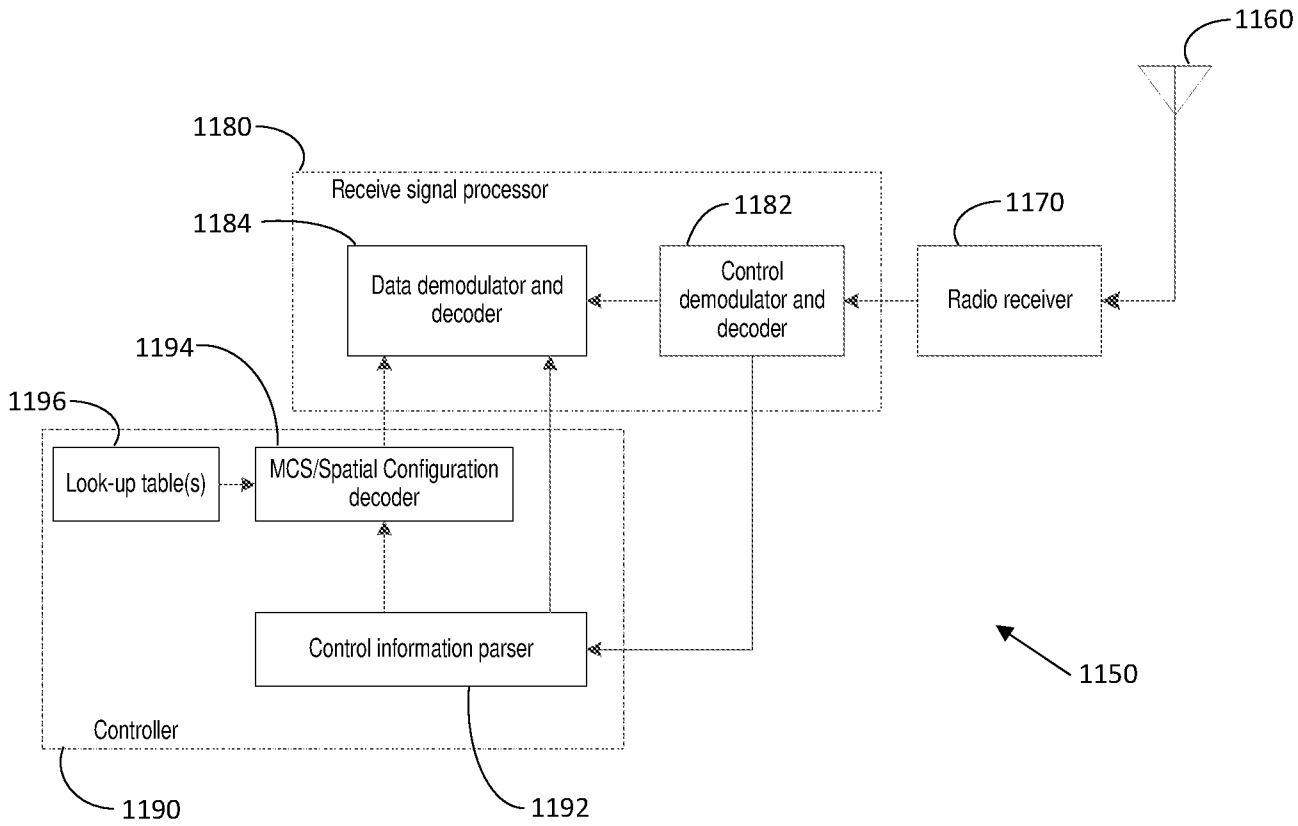


FIGURE 12

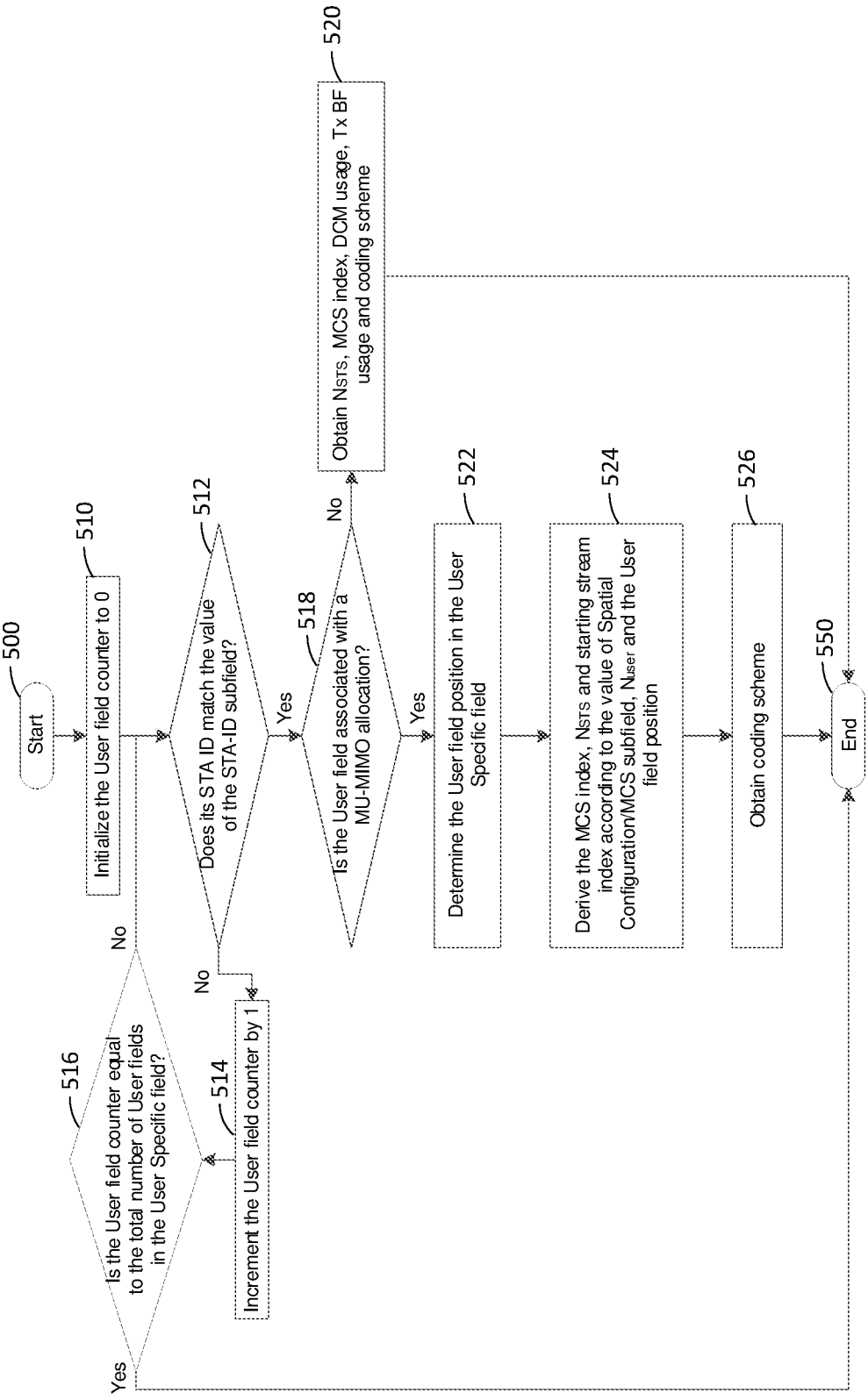

Start
500
Initialize the User field counter to 0
510
Does its STA ID match the value of the STA-ID subfield?
512
Yes
No
Is the User field associated with a MU-MIMO allocation?
518
Yes
No
Obtain NSTS, MCS index, DCM usage, Tx BF usage and coding scheme
520
Determine the User field position in the User Specific field
522
Derive the MCS index, NSTS and starting stream index according to the value of Spatial Configuration/MCS subfield, NUser and the User field position
524
Obtain coding scheme
526
End
550
Is the User field counter equal to the total number of User fields in the User Specific field?
516
Yes
No
Increment the User field counter by 1
514

FIGURE 13

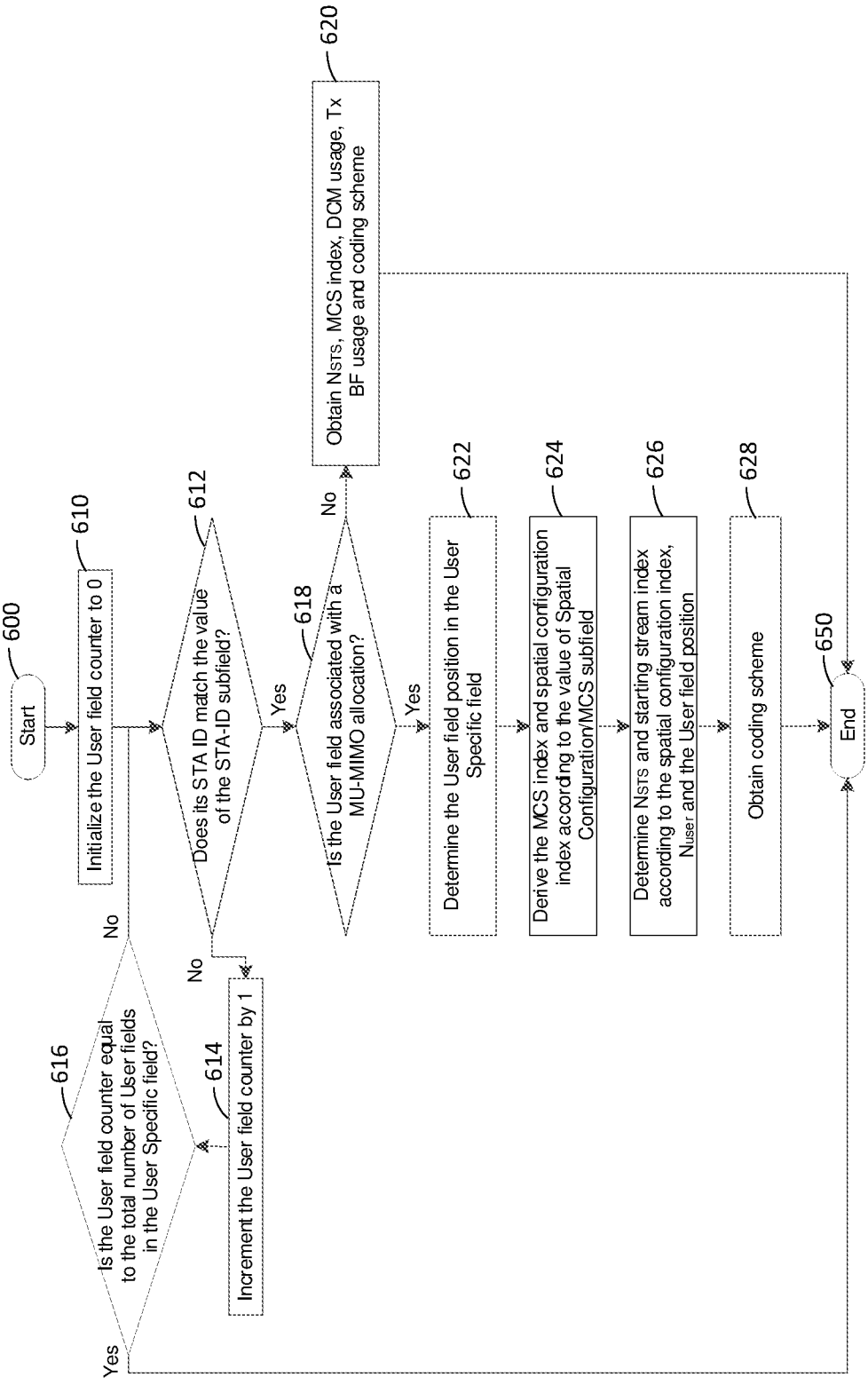

600
Start
610
Initialize the User field counter to 0
612
Does its STA ID match the value of the STA-ID subfield?
No
Yes
614
Increment the User field counter by 1
616
Is the User field counter equal to the total number of User fields in the User Specific field?
No
Yes
618
Is the User field associated with a MU-MIMO allocation?
No
Yes
620
Obtain NSTS, MCS index, DCM usage, Tx BF usage and coding scheme
622
Determine the User field position in the User Specific field
624
Derive the MCS index and spatial configuration index according to the value of Spatial Configuration/MCS subfield
626
Determine NSTS and starting stream index according to the spatial configuration index, NUser and the User field position
628
Obtain coding scheme
650
End

FIGURE 14

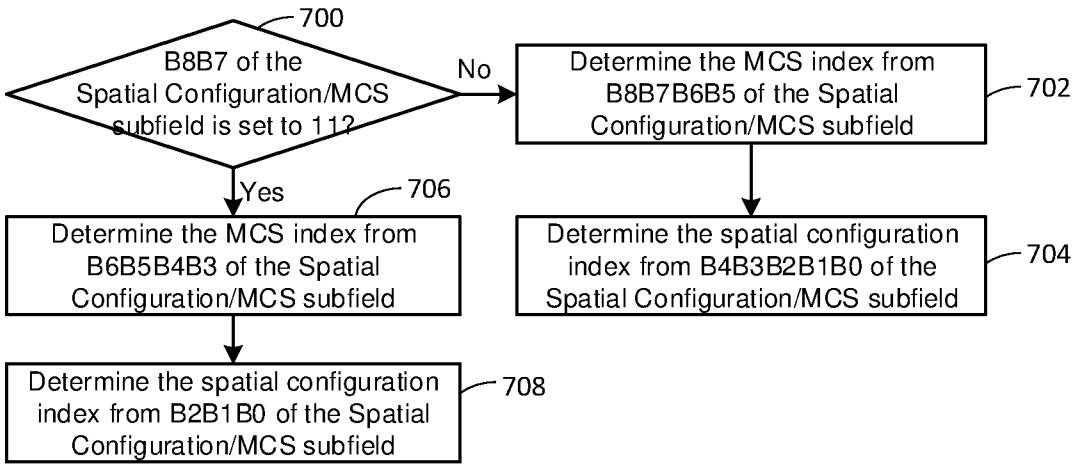


FIGURE 15

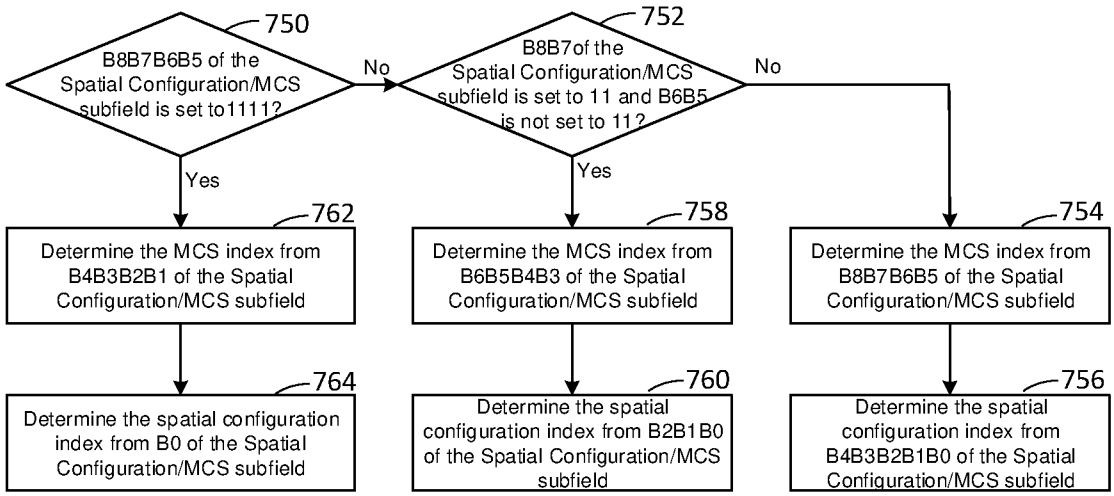


FIGURE 16

MCS/Spatial Configuration subfield value	MCS Index	Spatial Configuration Index	MCS/Spatial Configuration subfield value	MCS Index	Spatial Configuration Index
0–11	0–11	0	228–239	0–11	19
12–23	0–11	1	240–251	0–11	20
24–35	0–11	2	252–263	0–11	21
36-47	0–11	3	264-275	0–11	22
48–59	0–11	4	276–287	0–11	23
60–71	0–11	5	288–299	0–11	24
72–83	0–11	6	300–311	0–11	25
84-95	0–11	7	312-323	0–11	26
96–107	0–11	8	324–335	0–11	27
108-119	0–11	9	336-347	0–11	28
120-131	0–11	10	348-359	0–11	29
132-143	0–11	11	360-371	0–11	30
144-155	0–11	12	372-383	0–11	31
156-167	0–11	13	384-395	0–11	32
168-179	0–11	14	396-407	0–11	33
180-191	0–11	15	408-419	0–11	34
192-203	0–11	16	420-431	0–11	35
204-215	0–11	17	432-443	0–11	36
216-227	0–11	18	444-455	0–11	37

FIGURE 17

N_{user}	Spatial Configuration Index	$N_{STS}[1]$	$N_{STS}[2]$	$N_{STS}[3]$	Total N_{STS}
2	0–3	1–4	1		2–5
	4–6	2–4	2		4–6
	7–8	3–4	3		6–7
	9	4	4		8
3	0–3	1–4	1	1	3–6
	4–6	2–4	2	1	5–7
	7–8	3–4	3	1	7–8
	9	4	4	1	9
	10–12	2–4	2	2	6–8
	13-14	3-4	3	2	8-9
	15	4	4	2	10
	16-17	3-4	3	3	9-10
	18	4	4	3	11
	19	4	4	4	12

FIGURE 18

N_{user}	Spatial Configuration Index	$N_{STS}[1]$	$N_{STS}[2]$	$N_{STS}[3]$	$N_{STS}[4]$	Total N_{STS}
4	0-3	1–4	1	1	1	4–7
	4-6	2–4	2	1	1	6–8
	7-8	3-4	3	1	1	8-9
	9	4	4	1	1	10
	10–12	2–4	2	2	1	7–9
	13-14	3-4	3	2	1	9-10
	15	4	4	2	1	11
	16-17	3-4	3	3	1	10-11
	18	4	4	3	1	12
	19	4	4	4	1	13
	20-22	2-4	2	2	2	8-10
	23-24	3-4	3	2	2	10-11
	25	4	4	2	2	12
	26-27	3-4	3	3	2	11-12
	28	4	4	3	2	13
	29	4	4	4	2	14
	30-31	3-4	3	3	3	12-13
	32	4	4	4	3	15
	33	4	4	4	4	16

FIGURE 19

N_{user}	Spatial Configuration Index	$N_{STS}[1]$	$N_{STS}[2]$	$N_{STS}[3]$	$N_{STS}[4]$	$N_{STS}[5]$	Total N_{STS}
5	0-3	1–4	1	1	1	1	5–8
	4-6	2–4	2	1	1	1	7–9
	7-8	3-4	3	1	1	1	9-10
	9	4	4	1	1	1	11
	10-12	2-4	2	2	1	1	8-10
	13-14	3-4	3	2	1	1	10-11
	15	4	4	2	1	1	12
	16-17	3-4	3	3	1	1	11-12
	18	4	4	3	1	1	13
	19	4	4	4	1	1	14
	20-22	2-4	2	2	2	1	9-11
	23-24	3-4	3	2	2	1	11-12
	25	4	4	2	2	1	13
	26-27	3-4	3	3	2	1	12-14
	28	4	4	3	2	1	14
	29-30	3-4	3	3	3	1	13-14
	31-33	2-4	2	2	2	2	10-12
	34-35	3-4	3	3	3	2	14-15
	36-37	3-4	3	3	3	3	15-16

FIGURE 20

N_{user}	Spatial Configuration Index	$N_{STS}[1]$	$N_{STS}[2]$	$N_{STS}[3]$	$N_{STS}[4]$	$N_{STS}[5]$	$N_{STS}[6]$	Total N_{STS}
6	0-3	1–4	1	1	1	1	1	6–9
	4-6	2-4	2	1	1	1	1	8-10
	7-8	3-4	3	1	1	1	1	10-11
	9	4	4	1	1	1	1	12
	10-12	2-4	2	2	1	1	1	9-11
	13-14	3-4	3	2	1	1	1	11-12
	15	4	4	2	1	1	1	13
	16-17	3-4	3	3	1	1	1	12-13
	18	4	4	3	1	1	1	14
	19	4	4	4	1	1	1	15
	20-22	2-4	2	2	2	1	1	10-12
	23-24	3-4	3	3	2	1	1	13-14
	25	4	4	4	2	1	1	16
	26-27	3-4	3	3	3	1	1	14-15
	28-30	2-4	2	2	2	2	1	11-13
	31-32	3-4	3	3	3	2	1	15-16
	33	3	3	3	3	3	1	16
	34-36	2-4	2	2	2	2	2	12-14

FIGURE 21

N_{user}	Spatial Configuration Index	$N_{STS}[1]$	$N_{STS}[2]$	$N_{STS}[3]$	$N_{STS}[4]$	$N_{STS}[5]$	$N_{STS}[6]$	$N_{STS}[7]$	Total N_{STS}
7	0-3	1–4	1	1	1	1	1	1	7–10
	4-6	2-4	2	1	1	1	1	1	9-11
	7-8	3-4	3	1	1	1	1	1	11-12
	9	4	4	1	1	1	1	1	13
	10-12	2-4	2	2	1	1	1	1	10-12
	13-14	3-4	3	2	1	1	1	1	12-13
	15	4	4	2	1	1	1	1	14
	16-17	3-4	3	3	1	1	1	1	13-14
	18	4	4	3	1	1	1	1	15
	19	4	4	4	1	1	1	1	16
	20-22	2-4	2	2	2	1	1	1	11-13
	23-24	3-4	3	3	2	1	1	1	14-15
	25-26	3-4	3	3	3	1	1	1	15-16
	27-29	2-4	2	2	2	2	1	1	12-14
	30	3	3	3	3	2	1	1	16
	31-33	2-4	2	2	2	2	2	1	13-15
	34-36	2-4	2	2	2	2	2	2	14-16

FIGURE 22

N_{user}	Spatial Configuration Index	$N_{STS}[1]$	$N_{STS}[2]$	$N_{STS}[3]$	$N_{STS}[4]$	$N_{STS}[5]$	$N_{STS}[6]$	$N_{STS}[7]$	$N_{STS}[8]$	Total N_{STS}
8	0-3	1-4	1	1	1	1	1	1	1	8-11
	4-6	2-4	2	1	1	1	1	1	1	10-12
	7-8	3-4	3	1	1	1	1	1	1	12-13
	9	4	4	1	1	1	1	1	1	14
	10-12	2-4	2	2	1	1	1	1	1	11-13
	13-14	3-4	3	2	1	1	1	1	1	13-14
	15	4	4	2	1	1	1	1	1	15
	16-17	3-4	3	3	1	1	1	1	1	14-15
	18	4	4	3	1	1	1	1	1	16
	19-21	2-4	2	2	2	1	1	1	1	12-14
	22-23	3-4	3	3	2	1	1	1	1	15-16
	24	3	3	3	3	1	1	1	1	16
	25-27	2-4	2	2	2	2	1	1	1	13-15
	28-30	2-4	2	2	2	2	2	1	1	14-16
	31-32	2-3	2	2	2	2	2	2	1	15-16
	33	2	2	2	2	2	2	2	2	16

FIGURE 23

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SG2019/050386

A. CLASSIFICATION OF SUBJECT MATTER

See Supplemental Box

According to International Patent Classification (IPC)

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W; H04B; H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

FamPat and Internet: SIG-B, SIG-A, signal B field, signal A field, signal field, per-user, user-specific, user-block, PPDU, preamble, pilot, MCS, NSTS, space configuration, space-time stream, spatial stream, encode, joint, structural, combine, integrate, together, single, one, unified, same, sole, field, subfield, MU-MIMO, 802.11, WLAN, WIFI, HEW, EHT, VHT, 多用户, 多入多出, 多输入多输出, 物理层协议单元, 调制与编码策略, 空分, 信令, 字段, 一个, 单个, 同一, 统一 and the related terms

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2017/0311302 A1 (ZHANG H.) 26 October 2017 Figs. 5, 14 and Paras. [0072], [0052], [0076], [0103]-[0104]	1-8, 10-14, 16-18
A	US 2013/0208606 A1 (MERLIN S. ET AL.) 15 August 2013 Paras. [0039]-[0043]	
A	IEEE 802.11ax Technology Introduction. 16 May 2017 [Retrieved on 2019-10-10 from https://www.rohde-schwarz.com/lt/applications/ieee-802.11ax-technology-introduction-application-note_56280-345664.html?rusprivacypolicy=0] The whole document especially Table 4-6	
A	US 2018/0132109 A1 (LIM D. ET AL.) 10 May 2018 The whole document	

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SG2019/050386

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SG2019/050386

Supplemental Box
(Classification of Subject Matter)

Int. Cl.
H04W 72/04 (2009.01)
H04B 7/0452 (2017.01)
H04W 28/06 (2009.01)
H04L 5/00 (2006.01)
H04W 84/12 (2009.01)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/SG2019/050386

Note: This Annex lists known patent family members relating to the patent documents cited in this International Search Report. This Authority is in no way liable for these particulars which are merely given for the purpose of information.

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