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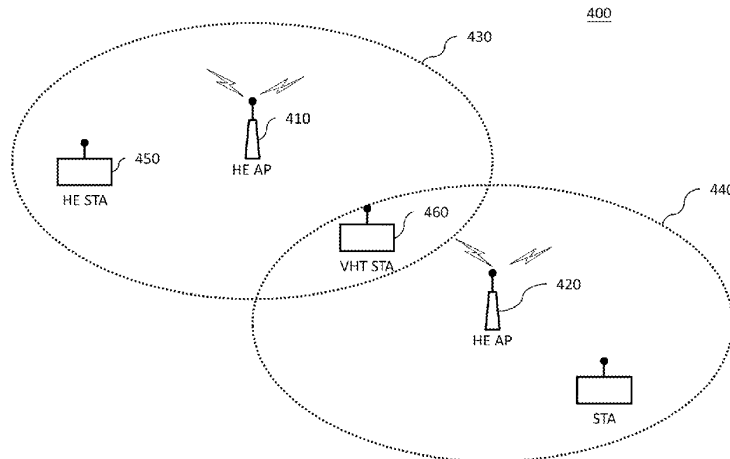


FIG. 4

(57) Abstract: A method for identifying source BSS in WLAN is proposed. A high efficiency (HE) access point (AP) sends a packet containing a basic service set (BSS) color to a HE station. The HE AP also sends a packet containing an assigned association identification (AID) to a very high throughput (VHT) station. The assigned AID comprises at least part of the BSS color information. The VHT station therefore sends a packet containing the at least part of the BSS color information such that any AP or station that receives the packet can determine the BSS the VHT station is in.

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Since AID and BSSID are inserted into the MAC header or as a management element and therefore belongs to data portion of a packet, they are mostly modulated by high modulation and coding scheme (MCS). Therefore, whether AID and BSSID are correctly received can only be found out until the whole packet is decoded. If a STA receives a packet that is not destined to itself, which means the STA is not the destination of the received packet, the STA needs to decode the whole packet to know it. In many cases, a STA wastes a lot of power decoding packets that are not sent to itself.

To avoid or reduce the frequency of unnecessary decoding of the whole packet, partial AID is introduced in the IEEE 802.11ac standard. A system based on IEEE 802.11ac standard is known as Very High Throughput (VHT) system. IEEE 802.11ac also introduce Partial AID that is a non-unique STA ID assigned by AP or STA. Partial AID is included in VHT_SIG-A1 symbol (the first symbol of VHT-SIG-A symbols), as shown in Figure 1.

Because VHT-SIG-A symbols are Pre-VHT-modulated fields and include an 8-bit CRC check, the symbols can be easily decoded. When a STA receives a VHT (Very High Throughput) PLCP (PHY Layer Convergence Procedure) protocol data unit (PPDU) with a format shown in Figure 2, it can determine whether the PPDU is sent to itself or another STA by checking the partial AID after decoding the VHT_SIG-A. If the PPDU is not for itself, the STA can turn off receiver for the rest of the PPDU or discard the rest of the PPDU to save power.

In VHT WLAN, the partial AID is defined as shown in Table 1.

Condition	GROUP_ID	PARTIAL_AID
Addressed to AP	0	BSSID[39:47]
Addressed to Mesh STA	0	RA[39:47]
Sent by an AP and addressed to a STA associated with that AP or sent by a DL S or TDLS STA in a direct path to a DL S or TDLS peer STA	63	$(dec(AID[0:8]) + dec(BSSID[44:47]) \oplus BSSID[40:43]) \cdot 2^8 \pmod{2^9}$ <p>where</p> <ul style="list-style-type: none"> \oplus is a bitwise exclusive OR operation \pmod{X} indicates the X-modulo operation $dec(A[b:c])$ is the cast to decimal operator where b is scaled by 2^0 and c by 2^{c-b}
Otherwise (see NOTE)	63	0
NOTE---The last row covers the following cases: ----- A PPDU sent to an IBSS STA ----- A PPDU sent by an AP to a non-associated STA ----- Any other condition not explicitly listed elsewhere in the table		

5

Table 1

The Group ID is 0 or 63 to indicate the PPDU is for single user (SU) transmission. For an infrastructure BSS, the Group ID is set to 0 to indicate an uplink transmission and to 63 to indicate a downlink transmission.

In dense networks with overlapped BSS (OBSS), a tradeoff between receive sensitivity and spatial reuse should be considered. In current WLAN, when a STA receives a packet on its primary channel, the STA decodes the pre-VHT-modulation parts and backs off for at least the duration of the received packet. However, this reduces the chance to perform spatial reuse because if the packet is from OBSS, the STA may still be able to transmit if the received packet from OBSS is below a certain signal strength level, e.g., a given clear channel assessment (CCA) level. On the other hand, if the packet is from its own BSS, the STA shall back off even if the signal strength is low.

In VHT WLAN, uplink traffic can be identified using partial AID since it is basically partial BSSID. Contrarily, in current WLAN based on IEEE 802.11a/b/g/n/ac standards, there's no feasible way to identify whether the downlink traffic (AP to non-AP STAs) is from its own BSS or from OBSS and therefore spatial reuse opportunities are reduced.

It is desirable to have a solution to increase the chance to perform spatial reuse VHT stations.

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SUMMARY

A method for identifying source BSS in WLAN is proposed. A high efficiency (HE) access point (AP) sends a packet containing a basic service set (BSS) color to a HE station. The HE AP also sends a packet containing an assigned association identification (AID) to a very high throughput (VHT) station. The assigned AID comprises at least part of the BSS color information. The VHT station therefore sends a packet containing the at least part of the BSS color information such that any AP or station that receives the packet can determine the BSS the VHT station is in.

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BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates a VHT_SIG-A1 Structure according to IEEE 802.11ac standard.

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Figure 2 illustrates a VHT PPDU Format.

Figure 3 illustrates a SIG-1 structure of IEEE 802.11ah non-1MHz PPDU.

Figure 4 is a wireless communications system in accordance with one novel aspect.

30

Figure 5 illustrates a flowchart in accordance with one novel aspect.

Figure 6 illustrates a flowchart in accordance with one novel aspect.

DETAILED DESCRIPTION

Reference will now be made in detail to some embodiments of the invention, examples of which are illustrated in the accompanying drawings.

5 In the IEEE 802.11ah standard, in the sub-1GHz band, BSS color is introduced for identification of which BSS the packet is from. For a non-1MHz PPDU, the IEEE 802.11ah standard implements a 1-bit UPLINK field and a 9-bit ID field in the SIG-1 symbol, as shown in Figure 3. If the field UPLINK
10 is not presented or set to 1, the ID field represents the 9-bit PARTIAL BSSID. If the UPLINK field is set to 0, B7-B9 of the ID field are set to the value of the BSS color and B10-B15 are set as 6-bit PARTIAL_AID. In this case, the source BSS of a downlink packet can be identified by checking the UPLINK
15 field and BSS color in the ID field. Therefore the high spatial reuse can be achieved when a downlink communication is performed.

 However, in the WLAN that is operated in the 2.4GHz or 5.8GHz bands, VHT STAs and the next generation High
20 Efficiency (HE) STAs could co-exist in the same BSS. In dense network scenarios, identifying packets from OBSS and packets of its own BSS is crucial to perform spatial reuse such that the network throughput can be improved. The next generation HE STA here can be referred to as STAs that are compatible
25 with the high efficiency standard or any later standards. And the VHT STAs can be referred to as non-HE STAs or the STAs compatible with IEEE 802.11ac standard.

 In next generation HE WLAN that is operated in 2.4GHz or 5.8GHz band, BSS color should be introduced to identify
30 the source BSS of a packet.

 Please refer to Figure 4, which illustrates a wireless communications system 400 according to an embodiment of the present invention. In the wireless communications system 400, there are two access points (AP) 410 and 420, which

respectively form two basic service sets (BSSs) 430 and 440 that overlap each other. Therefore, the BSS 430 and 440 form overlapped basic service set (OBSS). The APs 410 and 420, for example, can be High Efficiency (HE) APs. The station (STA) 5 450 is a HE STA within the BSS 430, and the STA 460 is a Very High Throughput (VHT) STA that locates in the overlapped area of the two BSSs 430 and 440. In the current example, the VHT STA 460 is serviced by the HE AP 410.

The HE AP 410 first chooses or determines basic service 10 set (BSS) color information and inserts the BSS color information in all the HE packets sent by the HE AP 410 to the HE STA 450. The HE STA 450 adds the BSS color information into the packets it sends out. Any HE AP and HE stations that receives the packet from the HE STA 450 can extract the BSS 15 color information to determine whether the packet sent from HE STA 450 is within the AP's BSS.

However, the HE APs and HE stations cannot identify the BSS of the packets sent from the VHT station 460 because there is no BSS color information inserted in VHT packets. 20 Therefore, according to an embodiment of the present invention, the HE AP 410 assigns an Association Identifier (AID) and inserts it into a packet sending to the VHT STA 460. The assigned AID is associated with the BSS color information chosen by HE AP 410. Since the assigned AID to VHT station 25 contains the BSS color information or partial BSS color information, the partial AID in the VHT packets sent by HE AP 410 to the VHT STA 460 contain the BSS color information or partial BSS color information.

According to an embodiment of the present invention, 30 N bits can be allocated as BSS color bits (BCB) in the HE-SIG symbols to indicate the BSS color. For example, N could be 1, 2, 3, or 4. BCB can be independent of partial AID bits or some part of partial AID bits. Considering an exemplary WLAN BSS which is composed of VHT STAs and HE STAs. The 9 LSBs (Least

Significant Bits) of AID can be decided differently. For example, the HE AP sets (8-N+1:8) bits in AID according to following equation when it assigns AID to the associated VHT STAs,

5

$$AID(8 - N + 1 : 8) = \text{bin}[(\text{dec}(\text{BCB}(0 : N - 1)) + \text{dec}(\text{BSSID}(47 - N + 1 : 47)) \oplus \text{BSSID}(43 - N + 1 : 43))] \bmod 2^N, N] \quad (1)$$

where $\text{bin}[x, N]$ is the cast to N-bit binary operator.

10

Hence, the (8-N+1:8) bit in PAID in VHT packets automatically becomes the BSS color. Using PAID (8-N+1:8) in VHT packets is better than using PAID (0:N-1) because VHT only BSS likely has one VHT device has the lower PAID bits that is same as BSS color bits. Fig. 5 therefore illustrates a flowchart to determine which BSS the packet is from according to AID information.

15

According to another embodiment of the present invention, when N (N=1, 2, 3, 4 or 5) BSS color bits (BCB), the HE AP sets (0: N-1) bits in AID according to following equation when it assigns AIDs to the associated STAs

20

$$AID(0 : N - 1) = \text{BCB}(0 : N - 1) \quad (2)$$

Then the PAID (0:N-1) bits in VHT packets sent from the HE AP automatically becomes the BSS color. Fig. 6 therefore illustrates a flowchart to determine which BSS the packet is from according to AID information.

25

For N>5, the above two methods can be combined to generate the AID or partial BSS color can be used for AID assignments.

After assigning the AID to VHT STA 460, the partial AID information which contains the BSS color or partial BSS color information is inserted into the packets sent to VHT STA 460. Therefore, when the HE AP 420 and the HE stations in its BSS receive the packet to the VHT STA 460, the HE AP

30

420 can extract the BSS color information from the partial AID and determines that the packet is sent from the OBSS that VHT STA 460 belongs to. The HE AP 420 and HE stations in its BSS can therefore begin spatial reuse process to efficiently
5 use the channel.

Although the present invention has been described in connection with certain specific embodiments for instructional purposes, the present invention is not limited thereto. Accordingly, various modifications, adaptations,
10 and combinations of various features of the described embodiments can be practiced without departing from the scope of the invention as set forth in the claims.

CLAIMS

What is claimed is:

1. A method, comprising:
 - 5 (a) sending by a high efficiency (HE) access point (AP) to a HE station a packet containing a basic service set (BSS) color;
 - (b) sending by the HE AP to a very high throughput (VHT) station a packet containing an assigned association
10 identification (AID), wherein the assigned AID comprises at least part of the BSS color information; and
 - (c) sending by the VHT station a packet containing the at least part of the BSS color information,
15 wherein the HE AP, the HE STA and the VHT STA are in the same BSS.
2. The method of claim 1, wherein the assigned AID comprises complete BSS color information.
- 20 3. The method of Claim 1, further comprising,
receiving by another HE AP the packet sent from the VHT station; and
discarding the packet by the another HE AP according to the BSS color information.
25
4. The method of claim 3, wherein the determining step comprises,
comparing (8-N+1:8) bits in the AID field with a BSS color information of the another HE AP,
30 wherein N is the number of bits of BSS color.
5. The method of claim 3, further comprising,
performing by the another HE AP a spatial reuse process.

6. The method of claim 1, wherein the step (b) comprises,
 assigning (8-N+1:8) bits in the AID with the at least
 part of the BSS color information according to,

$$\begin{aligned} \text{AID}(8-N+1:8) \\ &= \text{bin}[\{\text{dec}(\text{BCB}(0:N-1)) \\ &\quad + \text{dec}(\text{BSSID}(47-N+1:47) \oplus \text{BSSID}(43-N+1:43))\} \bmod 2^N, N] \end{aligned}$$

5 wherein N is the number of bits of BSS color, BCB is BSS color
 bits, and BSSID is the BSS identification assigned by the HE
 AP.

7. The method of claim 1, wherein the step (b) comprises,
 10 assigning (0:N-1) bits in the AID with the at least part
 of the BSS color information according to,

$$\text{AID}(0:N-1) = \text{BCB}(0:N-1)$$

wherein BCB is BSS color bits, and N is the number of bits
 of BSS color.

15

8. The method of claim 1, wherein the step (b) comprises,
 assigning (0:N-1) bits and (8-N+1:8) bits in the AID
 according to the BSS color information or partial BSS color
 information,

20 wherein N is the number of bits of BSS color.

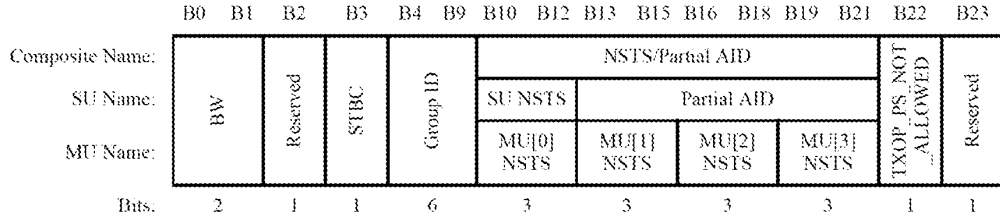


FIG. 1

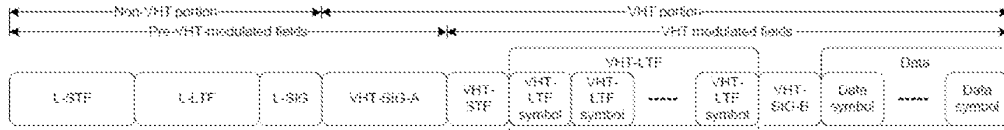


FIG. 2

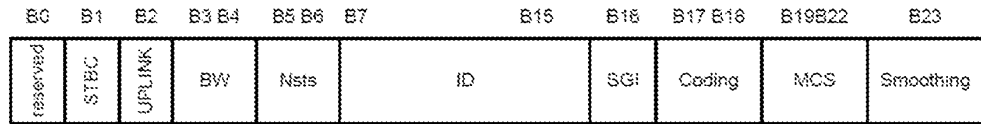


FIG. 3

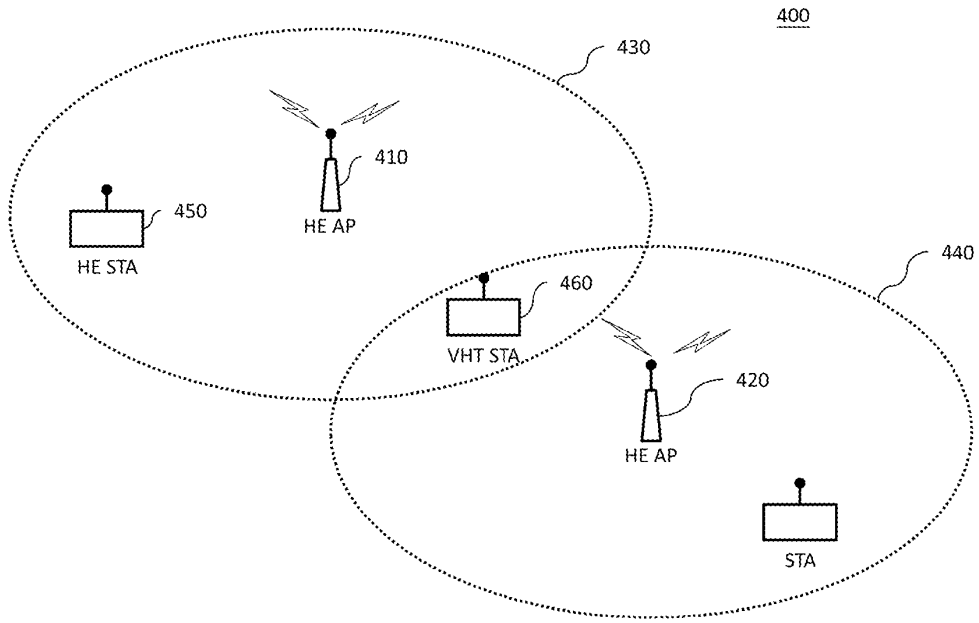


FIG. 4

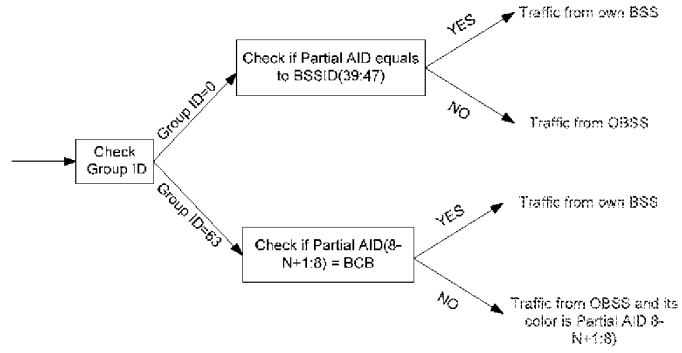


FIG. 5

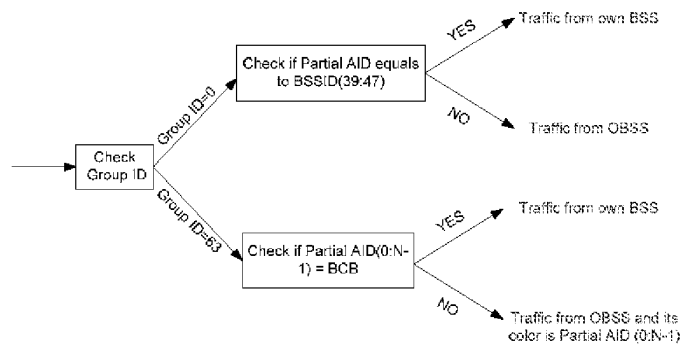


FIG. 6

INTERNATIONAL SEARCH REPORT

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International application No.
PCT/US2015/015293

<p>A. CLASSIFICATION OF SUBJECT MATTER IPC(8) - H04W 72/04 (2015.01) CPC - H04W 74/06 (2015.01) According to International Patent Classification (IPC) or to both national classification and IPC</p>																	
<p>B. FIELDS SEARCHED</p> <p>Minimum documentation searched (classification system followed by classification symbols) IPC(8) - H04W 72/04, H04W 28/06, H04L 12/28 (2015.01) USPC - 370/329, 343, 449</p> <p>Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched CPC - H04W 74/06, H04W 72/0453, H04W 28/065 (2015.01) (keyword delimited)</p> <p>Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) Orbit, Google Patents, Google. Search terms used: high efficiency, access points, BSS, VHT, AID, BSS color bits.</p>																	
<p>C. DOCUMENTS CONSIDERED TO BE RELEVANT</p> <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>Y -- A</td> <td>US 2011/0310834 A1 (SEOK) 22 December 2011 (22.12.2011) entire document</td> <td>1-5, 7-8 ---- 6</td> </tr> <tr> <td>Y -- A</td> <td>US 2006/0252443 A1 (SAMMOUR et al) 09 November 2006 (09.11.2006) entire document</td> <td>1-5, 7-8 ---- 6</td> </tr> <tr> <td>Y</td> <td>US 2008/0259936 A1 (HUSSAIN et al) 23 October 2008 (23.10.2008) entire document</td> <td>3-5</td> </tr> <tr> <td>A</td> <td>US 2005/0070270 A1 (AKIYAMA) 31 March 2005 (31.03.2005) entire document</td> <td>1-8</td> </tr> </tbody> </table>			Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	Y -- A	US 2011/0310834 A1 (SEOK) 22 December 2011 (22.12.2011) entire document	1-5, 7-8 ---- 6	Y -- A	US 2006/0252443 A1 (SAMMOUR et al) 09 November 2006 (09.11.2006) entire document	1-5, 7-8 ---- 6	Y	US 2008/0259936 A1 (HUSSAIN et al) 23 October 2008 (23.10.2008) entire document	3-5	A	US 2005/0070270 A1 (AKIYAMA) 31 March 2005 (31.03.2005) entire document	1-8
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