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Chu et al.

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(54) **BASIC SERVICE SET COLOR IDENTIFIER**

(71) Applicant: **Marvell International Ltd.**, Hamilton (BM)

(72) Inventors: **Liwen Chu**, San Ramon, CA (US); **Hongyuan Zhang**, Fremont, CA (US); **Lei Wang**, San Diego, CA (US); **Jinjing Jiang**, San Jose, CA (US); **Hui-Ling Lou**, Sunnyvale, CA (US)

(73) Assignee: **Marvell International Ltd.**, Hamilton (BM)

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H04W 84/12 (2009.01)
H04L 29/12 (2006.01)

(52) **U.S. Cl.**
CPC ***H04L 61/2038*** (2013.01); ***H04W 84/12*** (2013.01); *H04L 61/6072* (2013.01)

(58) **Field of Classification Search**
CPC . H04L 61/2038; H04L 61/6072; H04W 84/12
See application file for complete search history.

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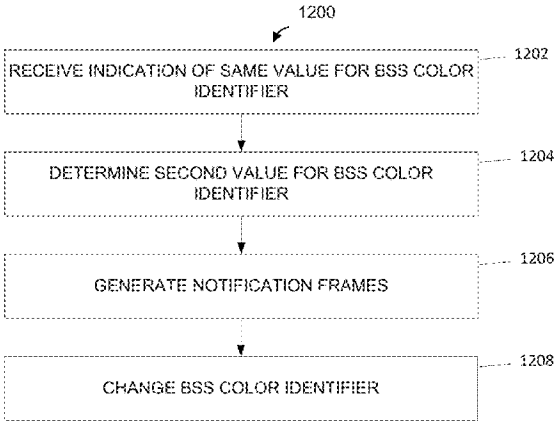
Primary Examiner — Alex Skripnikov
Assistant Examiner — Sharmin Chowdhury

(57) **ABSTRACT**

A method for changing a first basic service set (BSS) color identifier for a first communication device identifiable by the first BSS color identifier and a first basic service set identifier that is longer than the first BSS color identifier is described. An indication that the first BSS color identifier and a second BSS color identifier for a second communication device have a same first value is received by the first communication device. Respective service coverage areas of the first and second communication devices at least partially overlap. A second value of the first BSS color identifier is determined by the first communication device in response to the indication. A notification frame that indicates the second value and a start time are generated by the first communication device. The first BSS color identifier is changed by the first communication device to the second value based on the start time.

24 Claims, 9 Drawing Sheets



SAMSUNG 1029
Samsung v. Wilus
IPR2025-00936

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on Feb. 6, 2015, provisional application No. 62/140,393, filed on Mar. 30, 2015.

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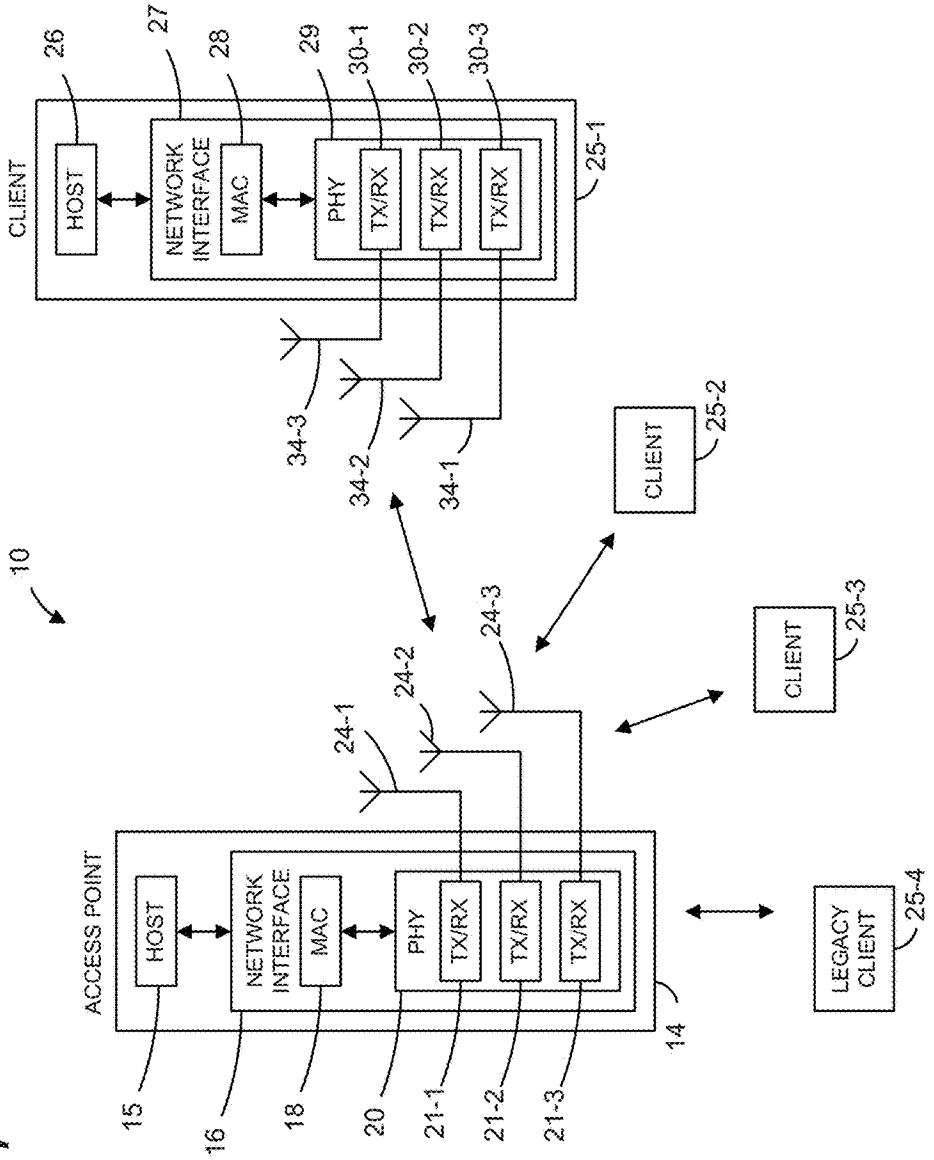

10
CLIENT
HOST
NETWORK INTERFACE
MAC
PHY
TX/RX
TX/RX
TX/RX
26
27
28
29
30-1
30-2
30-3
25-1
34-3
34-2
34-1
CLIENT
25-2
CLIENT
25-3
24-3
24-2
24-1
ACCESS POINT
HOST
NETWORK INTERFACE
MAC
PHY
TX/RX
TX/RX
TX/RX
LEGACY CLIENT
25-4
15
16
18
20
21-1
21-2
21-3
14

FIG. 1

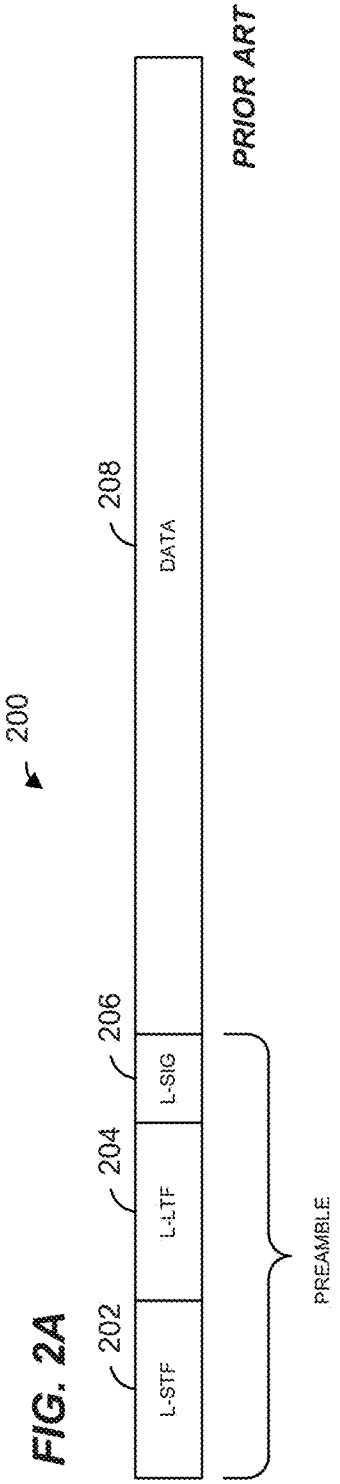


FIG. 2A

PRIOR ART

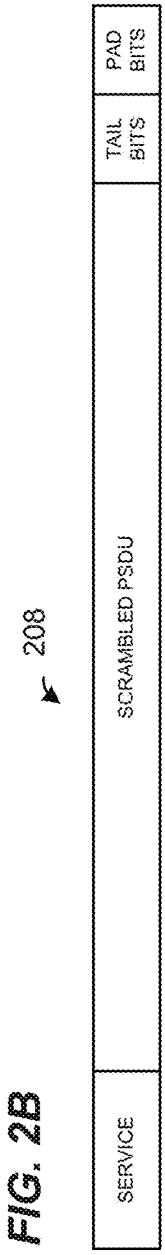


FIG. 2B

PRIOR ART

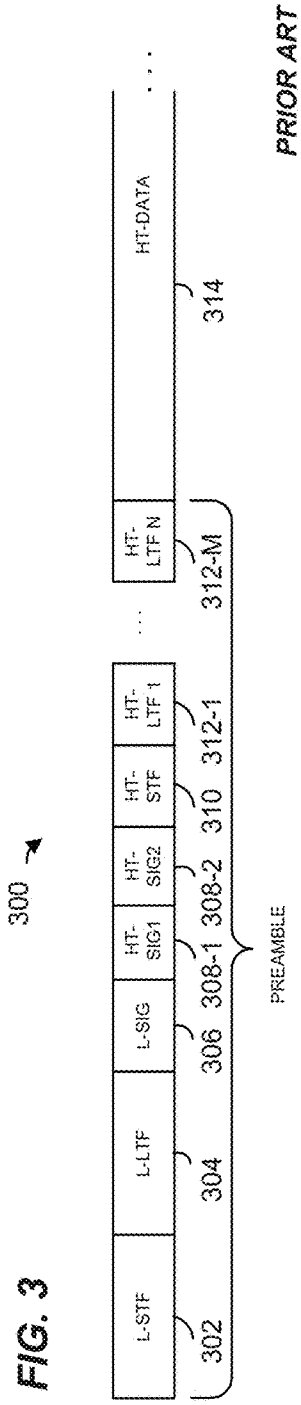


FIG. 3

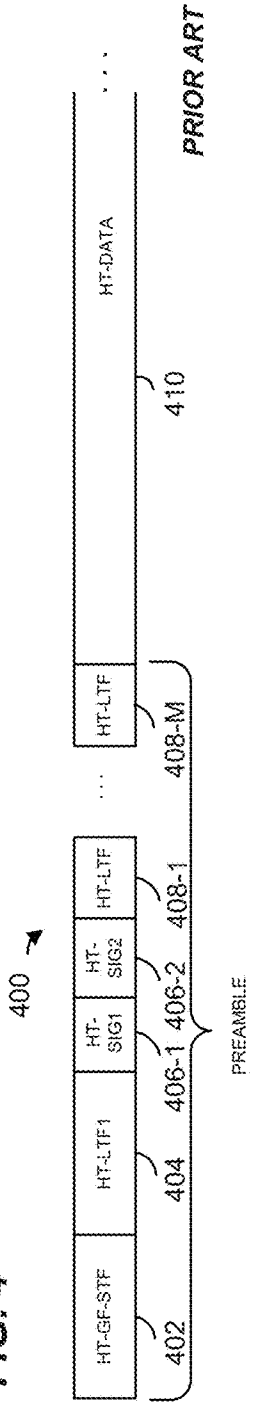


FIG. 4

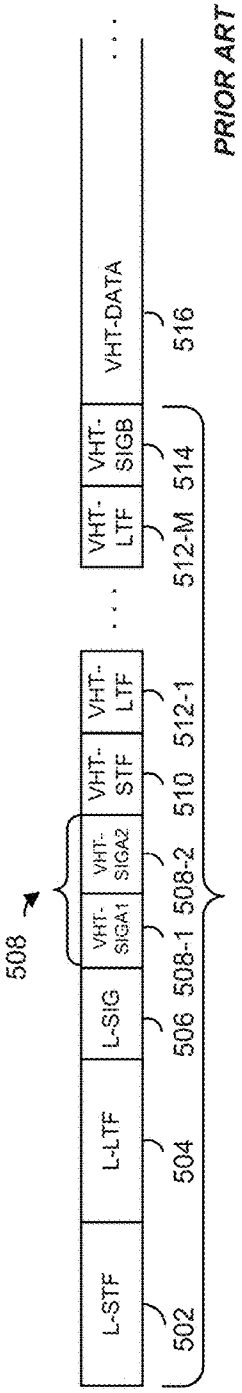


FIG. 5

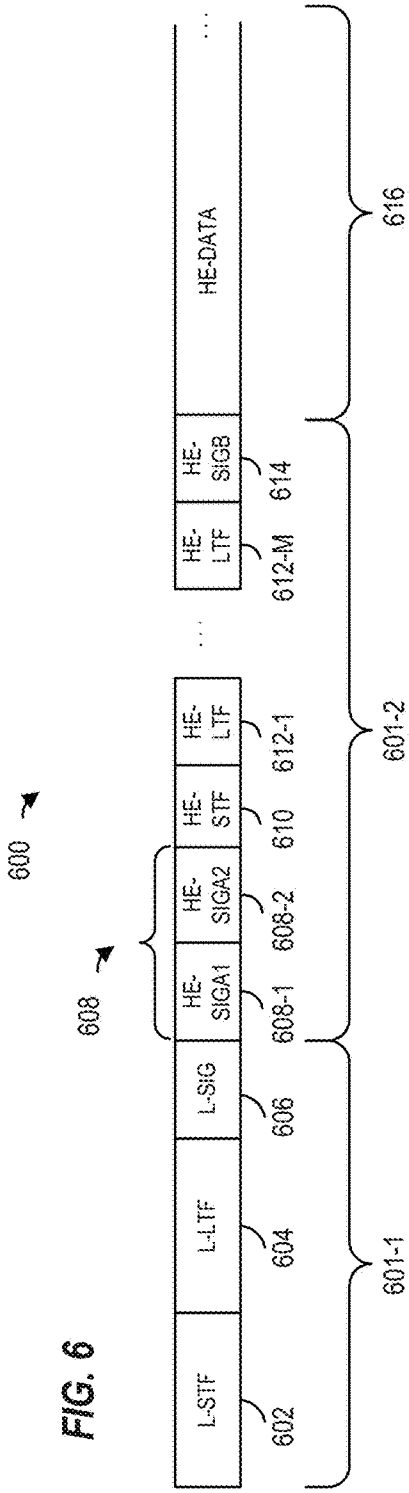

600
L-STF
602
L-LTF
604
L-SIG
606
608
HE-SIGA1
608-1
HE-SIGA2
608-2
HE-STF
610
HE-LTF
612-1
HE-LTF
612-M
HE-SIGB
614
HE-DATA
601-1
601-2
616

FIG. 6

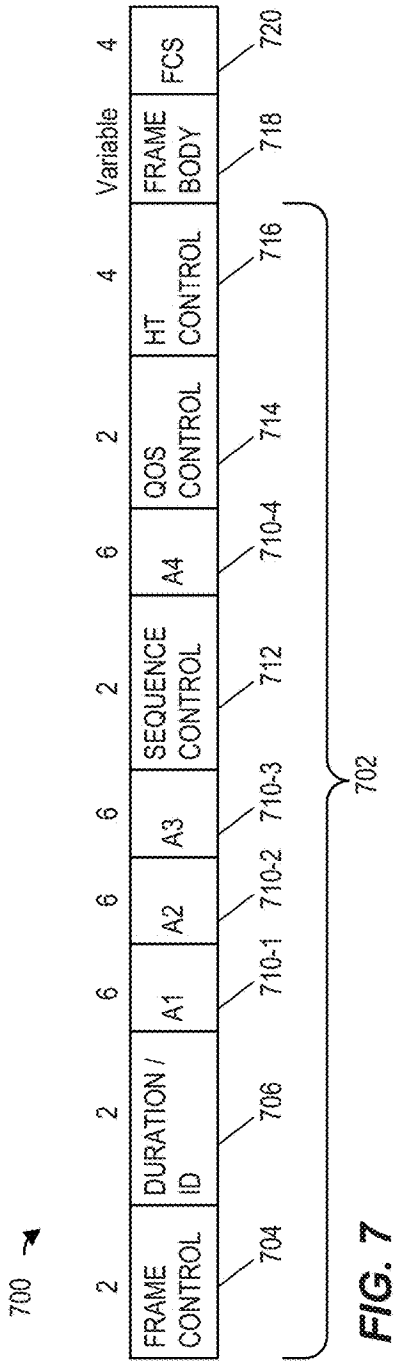

700
2
FRAME CONTROL
2
DURATION / ID
6
A1
6
A2
6
A3
2
SEQUENCE CONTROL
6
A4
2
QOS CONTROL
4
HT CONTROL
Variable
FRAME BODY
4
FCS
704
706
710-1
710-2
710-3
712
710-4
714
716
718
720
702

FIG. 7

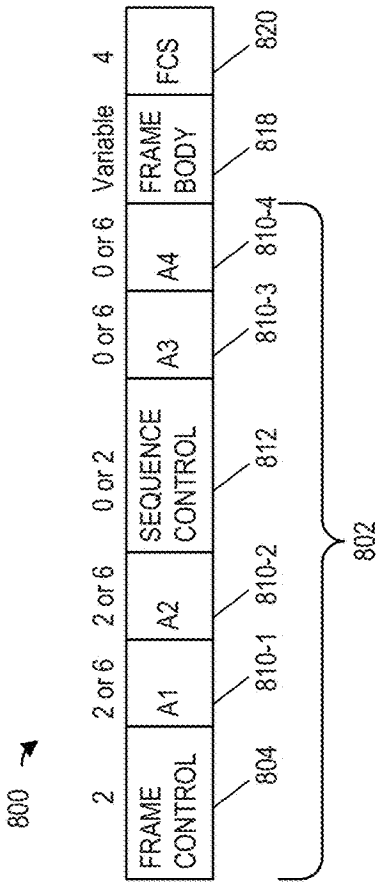

800
2
FRAME CONTROL
2 or 6
A1
2 or 6
A2
0 or 2
SEQUENCE CONTROL
0 or 6
A3
0 or 6
A4
Variable
FRAME BODY
4
FCS
804
810-1
810-2
812
810-3
810-4
818
820
802

FIG. 8

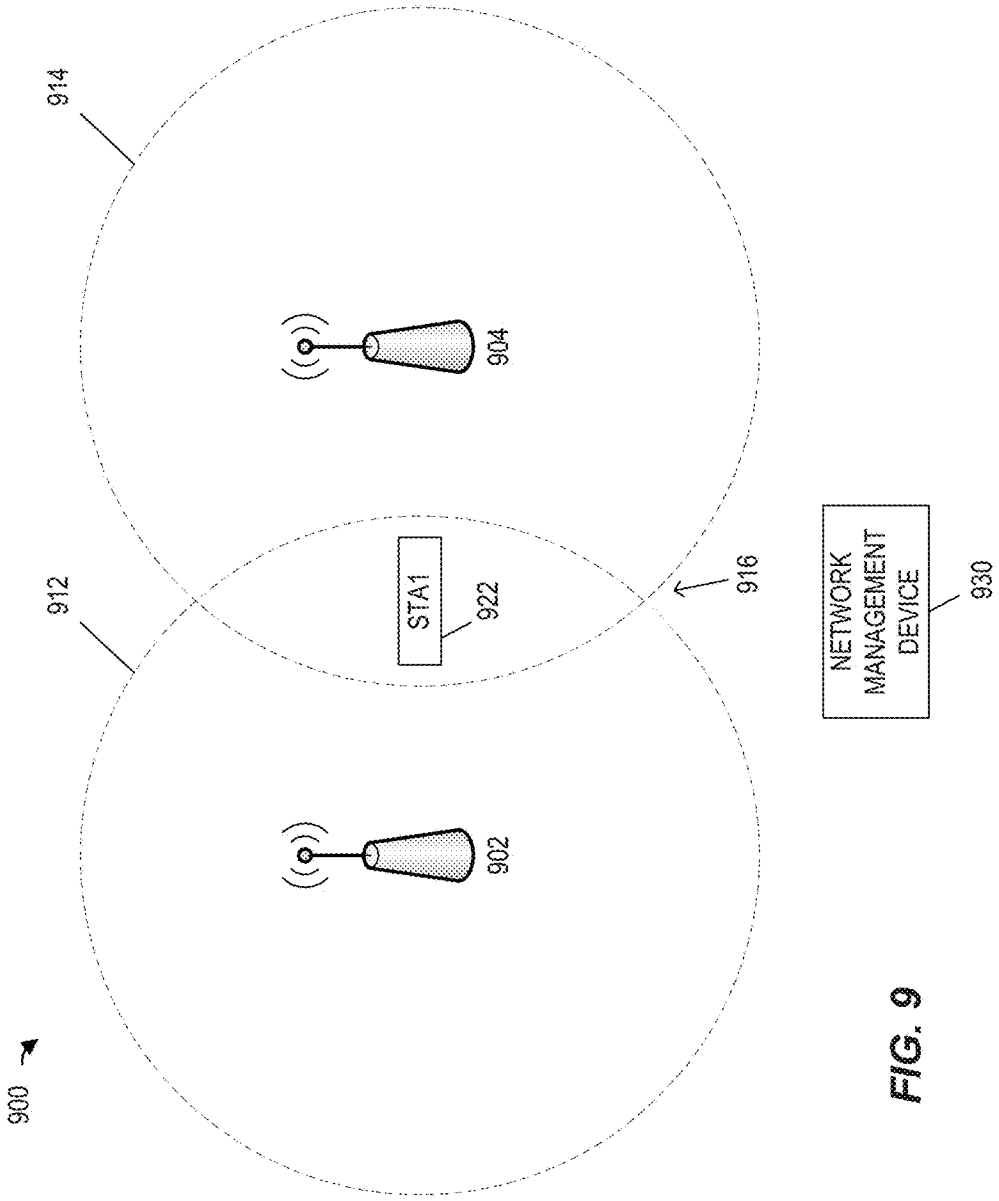

900
914
912
904
902
STA1
922
916
NETWORK MANAGEMENT DEVICE
930

FIG. 9

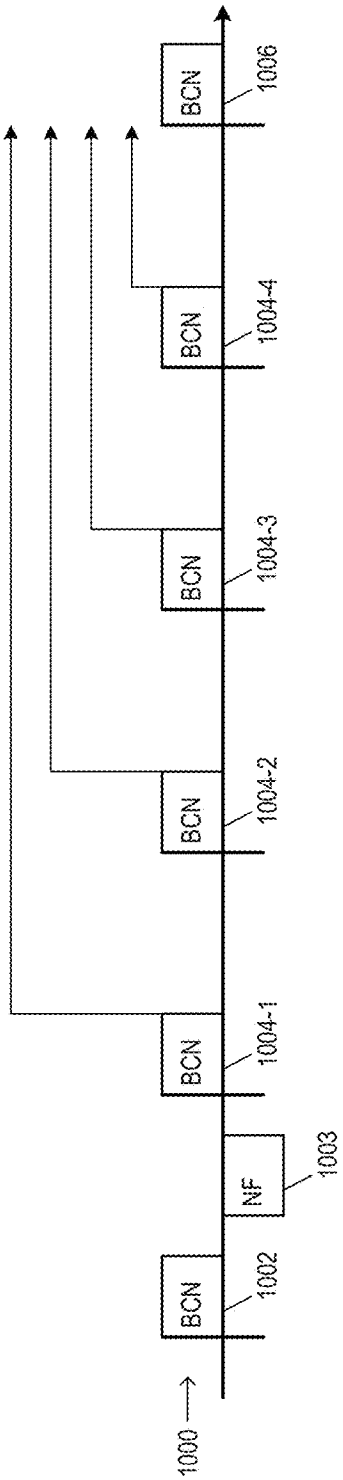

1000
BCN
1002
NF
1003
BCN
1004-1
BCN
1004-2
BCN
1004-3
BCN
1004-4
BCN
1006

FIG. 10

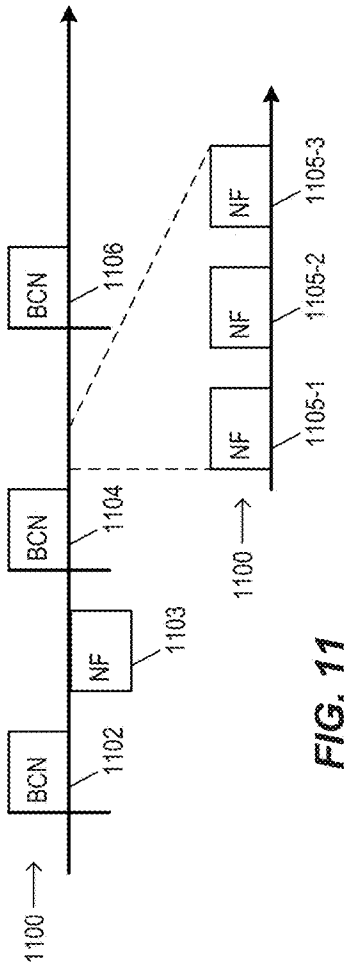

1100
BCN
1102
NF
1103
BCN
1104
BCN
1106
1100
NF
1105-1
NF
1105-2
NF
1105-3

FIG. 11

FIG. 12

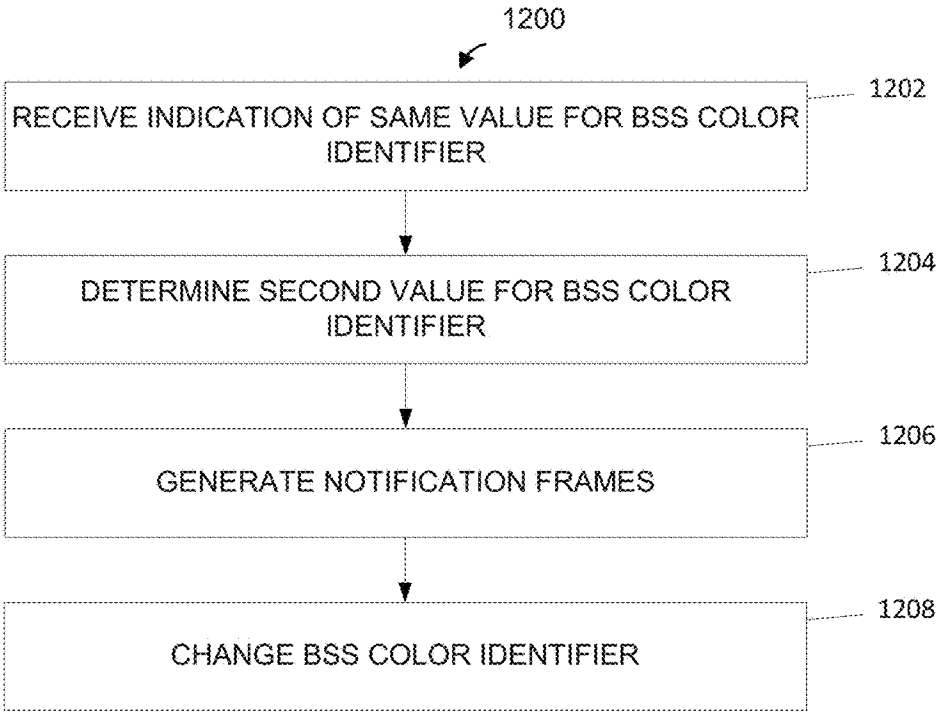
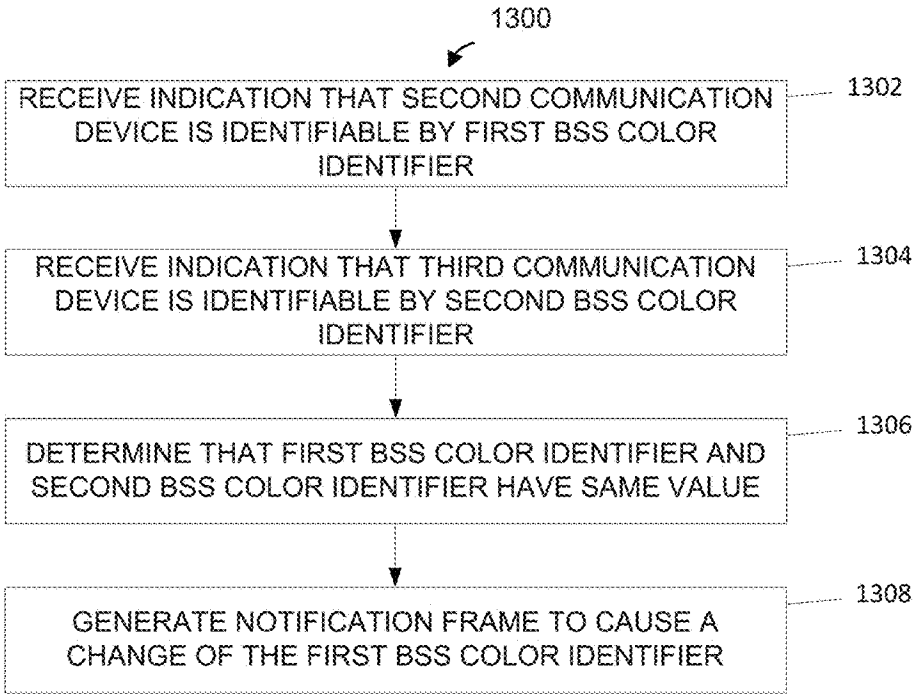

1200
RECEIVE INDICATION OF SAME VALUE FOR BSS COLOR IDENTIFIER
1202
DETERMINE SECOND VALUE FOR BSS COLOR IDENTIFIER
1204
GENERATE NOTIFICATION FRAMES
1206
CHANGE BSS COLOR IDENTIFIER
1208

FIG. 13


1300
RECEIVE INDICATION THAT SECOND COMMUNICATION DEVICE IS IDENTIFIABLE BY FIRST BSS COLOR IDENTIFIER
1302
RECEIVE INDICATION THAT THIRD COMMUNICATION DEVICE IS IDENTIFIABLE BY SECOND BSS COLOR IDENTIFIER
1304
DETERMINE THAT FIRST BSS COLOR IDENTIFIER AND SECOND BSS COLOR IDENTIFIER HAVE SAME VALUE
1306
GENERATE NOTIFICATION FRAME TO CAUSE A CHANGE OF THE FIRST BSS COLOR IDENTIFIER
1308

BASIC SERVICE SET COLOR IDENTIFIER

CROSS-REFERENCES TO RELATED APPLICATIONS

This disclosure claims the benefit of U.S. Provisional Patent Application No. 62/088,008, entitled "BSS Identifier and OFDMA Short Frame Format," filed on Dec. 5, 2014, U.S. Provisional Patent Application No. 62/112,967, entitled "BSS Identifier and OFDMA Short Frame Format," filed on Feb. 6, 2015, and U.S. Provisional Patent Application No. 62/140,393, entitled "BSS Identifier and OFDMA Short Frame Format," filed on Mar. 30, 2015, the disclosures of each of which are incorporated herein by reference in their entireties.

Additionally, this application is related to U.S. patent application Ser. No. 14/961,512, entitled "ORTHOGONAL FREQUENCY DIVISION MULTIPLE ACCESS SHORT FRAME FORMAT," filed on the same day as the present application, the disclosure of which is incorporated herein by reference in its entirety.

FIELD OF THE DISCLOSURE

The present disclosure relates generally to communication networks and, more particularly, to wireless local area networks that utilize multiple basic service set identifiers having different lengths.

BACKGROUND

Wireless local area networks (WLANs) have evolved rapidly over the past decade. Development of WLAN standards such as the Institute for Electrical and Electronics Engineers (IEEE) 802.11a, 802.11b, 802.11g, and 802.11n Standards has improved single-user peak data throughput. For example, the IEEE 802.11b Standard specifies a single-user peak throughput of 11 megabits per second (Mbps), the IEEE 802.11a and 802.11g Standards specify a single-user peak throughput of 54 Mbps, the IEEE 802.11n Standard specifies a single-user peak throughput of 600 Mbps, and the IEEE 802.11ac Standard specifies a single-user peak throughput in the gigabits per second (Gbps) range. Future standards promise to provide even greater throughputs, such as throughputs in the tens of Gbps range.

SUMMARY

In an embodiment, a method for changing a first basic service set (BSS) color identifier for a first communication device identifiable by i) the first BSS color identifier, and ii) a first basic service set identifier (BSSID) having a length that is longer than a length of the first BSS color identifier includes receiving, by the first communication device, an indication that the first BSS color identifier for the first communication device and a second BSS color identifier for a second communication device have a same first value. A first service coverage area of the first communication device at least partially overlaps a second service coverage area of the second communication device. The method includes determining, by the first communication device, a second value of the first BSS color identifier in response to the indication. The method includes generating, by the first communication device, one or more notification frames that indicate i) the second value of the first BSS color identifier, and ii) a start time at which the second value will supersede the first value of the first BSS color identifier. The method also includes changing, by the first communication device, the first BSS color identifier to the second value based on the start time.

In another embodiment, a first communication device that is identifiable by i) a first basic service set (BSS) color identifier, and ii) a first basic service set identifier (BSSID) having a length that is longer than a length of the first BSS color identifier includes a network interface device having one or more integrated circuits. The one or more integrated circuits are configured to: receive an indication that the first BSS color identifier for the first communication device and a second BSS color identifier for a second communication device have a same first value, wherein a first service coverage area of the first communication device at least partially overlaps a second service coverage area of the second communication device, determine a second value of the first BSS color identifier in response to the indication, generate one or more notification frames that indicate i) the second value of the first BSS color identifier, and ii) a start time at which the second value will supersede the first value of the first BSS color identifier, and change the first BSS color identifier to the second value based on the start time.

In yet another embodiment, a method for causing a change of a first basic service set (BSS) color identifier for a first communication device identifiable by i) the first BSS color identifier, and ii) a first basic service set identifier (BSSID) having a length that is longer than a length of the first BSS color identifier includes receiving, from a second communication device and by a third communication device, a first indication that the second communication device is identifiable by i) the first BSS color identifier, and ii) a second BSSID. The method includes receiving, from the first communication device and by the third communication device, a second indication that the first communication device is identifiable by i) the first BSS color identifier, and ii) the first BSSID. A first service coverage area of the first communication device at least partially overlaps a second service coverage area of the second communication device. The method also includes determining, by the third communication device, that the first BSS color identifier for the first communication device and the second BSS color identifier for the second communication device have a same first value. The method also includes generating, by the third communication device, a notification frame for the first communication device to cause the change of the first BSS color identifier, wherein the notification frame includes i) an indication that the first BSS color identifier for the first communication device and the second BSS color identifier for the second communication device have the same first value, and ii) the second BSSID.

In another embodiment, a first communication device includes a network interface device having one or more integrated circuits. The one or more integrated circuits are configured to: receive, from a second communication device, a first indication that the second communication device is identifiable by i) a first basic service set (BSS) color identifier, and ii) a first basic service set identifier (BSSID) having a length that is longer than a length of the first BSS color identifier, receive, from a third communication device, a second indication that the third communication device is identifiable by i) the first BSS color identifier, and ii) a second BSSID, wherein a first service coverage area of the second communication device at least partially overlaps a second service coverage area of the third communication device, determine that the first BSS color identifier for the second communication device and the second BSS color identifier for the third communication device have a same

first value, and generate a notification frame for the second communication device to cause a change of the first BSS color identifier, wherein the notification frame includes i) an indication that the first BSS color identifier for the second communication device and the second BSS color identifier for the third communication device have the same first value, and ii) the second BSSID.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of an example wireless local area network (WLAN), according to an embodiment.

FIGS. **2**A and **2**B are diagrams of a prior art data unit format.

FIG. **3** is a diagram of another prior art data unit format.

FIG. **4** is a diagram of another prior art data unit format.

FIG. **5** is a diagram of another prior art data unit format.

FIG. **6** is a diagram of an orthogonal frequency division multiplexing (OFDM) data unit, according to an embodiment.

FIG. **7** is a diagram of a medium access control (MAC) protocol data unit (MPDU), according to an embodiment.

FIG. **8** is a diagram of an MPDU, according to another embodiment.

FIG. **9** is a diagram of an example system having a first access point, a second access point, and a network management device, according to an embodiment.

FIG. **10** is a diagram of a sequence of OFDM data units transmitted by an access point for a change in the BSS color identifier of the access point, according to an embodiment.

FIG. **11** is a diagram of a sequence of OFDM data units transmitted by the access point for a change in the BSS color identifier of the access point, according to another embodiment.

FIG. **12** is a flow diagram illustrating an example method for changing a first basic service set (BSS) color identifier for a first communication device, according to an embodiment.

FIG. **13** is a flow diagram illustrating an example method for causing a change of a first BSS color identifier for a first communication device, according to an embodiment.

DETAILED DESCRIPTION

In embodiments described below, a wireless network device such as an access point (AP) of a wireless local area network (WLAN) is identifiable by a basic service set identifier (BSSID) and a basic service set (BSS) color identifier. In an embodiment, the BSSID is an identifier that uniquely identifies the access point, while the BSS color identifier has a shorter length than the BSSID but does not uniquely identify the access point. For example, the BSS color identifier is a short, local address that is unique within a wireless network associated with the device but is not unique with respect to other wireless networks, in an embodiment. The shorter length of the BSS color identifier helps to reduce signaling overhead for transmissions to the access point (e.g., uplink frames) and/or transmissions from the access point (e.g., downlink frames). In some scenarios, one or more "collisions" occur when a first access point and a second access point are located proximately to each other and have a same value for their respective BSS color identifiers. For example, a client station or other communication device that receives a downlink frame that includes the BSS color identifier, but omits the BSSID, cannot readily determine which access point transmitted the downlink frame. In an embodiment, a communication device that detects a collision transmits a suitable indication of the collision to the first access point to cause a change in a value of the BSS color identifier for the first access point.

FIG. **1** is a block diagram of an example wireless local area network (WLAN) **10**, according to an embodiment. An AP **14** includes a host processor **15** coupled to a network interface **16**. In an embodiment, the network interface **16** includes one or more integrate circuits (ICs) configured to operate as discussed below. The network interface **16** includes a medium access control (MAC) processing unit **18** and a physical layer (PHY) processing unit **20**. The PHY processing unit **20** includes a plurality of transceivers **21**, and the transceivers **21** are coupled to a plurality of antennas **24**. Although three transceivers **21** and three antennas **24** are illustrated in FIG. **1**, the AP **14** includes other suitable numbers (e.g., 1, 2, 4, 5, etc.) of transceivers **21** and antennas **24** in other embodiments. In some embodiments, the AP **14** includes a higher number of antennas **24** than transceivers **21**, and antenna switching techniques are utilized.

In one embodiment, the MAC processing unit **18** and the PHY processing unit **20** are configured to operate according to a first communication protocol (e.g., the HE communication protocol), including at least a first transmission mode and a second transmission mode of the first communication protocol. In some embodiments, the first transmission mode corresponds to a use of a BSS color identifier instead of a BSSID for transmissions to and/or from an access point, while the second transmission mode corresponds to a use of the BSSID for transmissions to and/or from the access point. The first transmission mode is configured to reduce signaling overhead as compared to the second transmission mode, which corresponds to an identifier for the access point that has a shorter length than for the second transmission mode. In another embodiment, the MAC processing unit **18** and the PHY processing unit **20** are also configured to operate according to a second communication protocol (e.g., according to the IEEE 802.11ac Standard). In yet another embodiment, the MAC processing unit **18** and the PHY processing unit **20** are additionally configured to operate according to the second communication protocol, a third communication protocol, and/or a fourth communication protocol (e.g., according to the IEEE 802.11a Standard and/or the IEEE 802.11n Standard).

The WLAN **10** includes a plurality of client stations **25**. Although four client stations **25** are illustrated in FIG. **1**, the WLAN **10** includes other suitable numbers (e.g., 1, 2, 3, 5, 6, etc.) of client stations **25** in various scenarios and embodiments. At least one of the client stations **25** (e.g., client station **25-1**) is configured to operate at least according to the first communication protocol. In some embodiments, at least one of the client stations **25** is not configured to operate according to the first communication protocol but is configured to operate according to at least one of the second communication protocol, the third communication protocol, and/or the fourth communication protocol (referred to herein as a "legacy client station").

The client station **25-1** includes a host processor **26** coupled to a network interface **27**. In an embodiment, the network interface **27** includes one or more ICs configured to operate as discussed below. The network interface **27** includes a MAC processing unit **28** and a PHY processing unit **29**. The PHY processing unit **29** includes a plurality of transceivers **30**, and the transceivers **30** are coupled to a plurality of antennas **34**. Although three transceivers **30** and three antennas **34** are illustrated in FIG. **1**, the client station **25-1** includes other suitable numbers (e.g., 1, 2, 4, 5, etc.) of transceivers **30** and antennas **34** in other embodiments. In

some embodiments, the client station **25-1** includes a higher number of antennas **34** than transceivers **30**, and antenna switching techniques are utilized.

According to an embodiment, the client station **25-4** is a legacy client station, i.e., the client station **25-4** is not enabled to receive and fully decode a data unit that is transmitted by the AP **14** or another client station **25** according to the first communication protocol. Similarly, according to an embodiment, the legacy client station **25-4** is not enabled to transmit data units according to the first communication protocol. On the other hand, the legacy client station **25-4** is enabled to receive and fully decode and transmit data units according to the second communication protocol, the third communication protocol, and/or the fourth communication protocol.

In an embodiment, one or both of the client stations **25-2** and **25-3**, has a structure that is the same as or similar to the client station **25-1**. In an embodiment, the client station **25-4** has a structure similar to the client station **25-1**. In these embodiments, the client stations **25** structured the same as or similar to the client station **25-1** have the same or a different number of transceivers and antennas. For example, the client station **25-2** has only two transceivers and two antennas (not shown), according to an embodiment.

In various embodiments, the PHY processing unit **20** of the AP **14** is configured to generate data units conforming to the first communication protocol and having formats described herein. The transceiver(s) **21** is/are configured to transmit the generated data units via the antenna(s) **24**. Similarly, the transceiver(s) **21** is/are configured to receive data units via the antenna(s) **24**. The PHY processing unit **20** of the AP **14** is configured to process received data units conforming to the first communication protocol and having formats described hereinafter and to determine that such data units conform to the first communication protocol, according to various embodiments.

In various embodiments, the PHY processing unit **29** of the client device **25-1** is configured to generate data units conforming to the first communication protocol and having formats described herein. The transceiver(s) **30** is/are configured to transmit the generated data units via the antenna(s) **34**. Similarly, the transceiver(s) **30** is/are configured to receive data units via the antenna(s) **34**. The PHY processing unit **29** of the client device **25-1** is configured to process received data units conforming to the first communication protocol and having formats described hereinafter and to determine that such data units conform to the first communication protocol, according to various embodiments.

In various embodiments, the client device **25-1** is configured to receive OFDM data units from access points that are identifiable by a basic service set (BSS) color identifier and a basic service set identifier (BSSID) having a length that is longer than a length of the BSS color identifier. In an embodiment, the client device **25-1** maintains an association of the BSSID with the BSS color identifier such that the client device **25-1** can generally identify which access point has transmitted an OFDM data unit when the OFDM data unit includes the BSS color identifier but omits the BSSID. In an embodiment, the client device **25-1** stores and/or maintains a list of BSS color identifiers that have been received or detected.

FIG. **2**A is a diagram of a prior art orthogonal frequency division multiplexing (OFDM) data unit **200** that the AP **14** is configured to transmit to the legacy client station **25-4** via orthogonal frequency division multiplexing (OFDM) modulation, according to an embodiment. In an embodiment, the legacy client station **25-4** is also configured to transmit the data unit **200** to the AP **14**. The data unit **200** conforms to the IEEE 802.11a Standard and occupies a 20 Megahertz (MHz) bandwidth. The data unit **200** includes a preamble having a legacy short training field (L-STF) **202**, generally used for packet detection, initial synchronization, and automatic gain control, etc., and a legacy long training field (L-LTF) **204**, generally used for channel estimation and fine synchronization. The data unit **200** also includes a legacy signal field (L-SIG) **206**, used to carry certain physical layer (PHY) parameters with the data unit **200**, such as modulation type and coding rate used to transmit the data unit, for example. The data unit **200** also includes a data portion **208**. FIG. **2**B is a diagram of example data portion **208** (not low density parity check encoded), which includes a service field, a scrambled physical layer service data unit (PSDU), tail bits, and padding bits, if needed. The data unit **200** is designed for transmission over one spatial or space-time stream in a single input single output (SISO) channel configuration. In various embodiments, the data portion **208** includes a MAC protocol data unit (MPDU), for example, the MPDU **700** (FIG. **7**) or the MPDU **800** (FIG. **8**).

FIG. **3** is a diagram of a prior art OFDM data unit **300** that the AP **14** is configured to transmit to the legacy client station **25-4** via OFDM modulation, according to an embodiment. In an embodiment, the legacy client station **25-4** is also configured to transmit the data unit **300** to the AP **14**. The data unit **300** conforms to the IEEE 802.11n Standard, occupies a 20 MHz bandwidth, and is designed for mixed mode situations, i.e., when the WLAN includes one or more client stations that conform to the IEEE 802.11a Standard but not the IEEE 802.11n Standard. The data unit **300** includes a preamble having an L-STF **302**, an L-LTF **304**, an L-SIG **306**, a high throughput signal field (HT-SIG) **308**, a high throughput short training field (HT-STF) **310**, and M data high throughput long training fields (HT-LTFs) **312**, where M is an integer generally based on the number of spatial streams used to transmit the data unit **300** in a multiple input multiple output (MIMO) channel configuration. In particular, according to the IEEE 802.11n Standard, the data unit **300** includes two HT-LTFs **312** if the data unit **300** is transmitted using two spatial streams, and four HT-LTFs **312** is the data unit **300** is transmitted using three or four spatial streams. An indication of the particular number of spatial streams being utilized is included in the HT-SIG field **308**. The data unit **300** also includes a data portion **314**. In various embodiments, the data portion **314** includes an MPDU, for example, the MPDU **700** (FIG. **7**) or the MPDU **800** (FIG. **8**).

FIG. **4** is a diagram of a prior art OFDM data unit **400** that the AP **14** is configured to transmit to the legacy client station **25-4** via OFDM modulation, according to an embodiment. In an embodiment, the legacy client station **25-4** is also configured to transmit the data unit **400** to the AP **14**. The data unit **400** conforms to the IEEE 802.11n Standard, occupies a 20 MHz bandwidth, and is designed for "Greenfield" situations, i.e., when the WLAN does not include any client stations that conform to the IEEE 802.11a Standard, and only includes client stations that conform to the IEEE 802.11n Standard. The data unit **400** includes a preamble having a high throughput Greenfield short training field (HT-GF-STF) **402**, a first high throughput long training field (HT-LTF**1**) **404**, a HT-SIG **406**, and M data HT-LTFs **408**. The data unit **400** also includes a data portion **410**. In various embodiments, the data portion **410** includes an MPDU, for example, the MPDU **700** (FIG. **7**) or the MPDU **800** (FIG. **8**).

FIG. **5** is a diagram of a prior art OFDM data unit **500** that the AP **14** is configured to transmit to the legacy client station **25-4** via OFDM modulation, according to an embodiment. In an embodiment, the legacy client station **25-4** is also configured to transmit the data unit **500** to the AP **14**. The data unit **500** conforms to the IEEE 802.11ac Standard and is designed for "Mixed field" situations. The data unit **500** occupies a 20 MHz bandwidth. In other embodiments or scenarios, a data unit similar to the data unit **500** occupies a different suitable bandwidth, such as a 40 MHz, an 80 MHz, or a 160 MHz bandwidth. The data unit **500** includes a preamble having an L-STF **502**, an L-LTF **504**, an L-SIG **506**, two first very high throughput signal fields (VHT-SIGAs) **508** including a first very high throughput signal field (VHT-SIGA**1**) **508-1** and a second very high throughput signal field (VHT-SIGA**2**) **508-2**, a very high throughput short training field (VHT-STF) **510**, M very high throughput long training fields (VHT-LTFs) **512**, and a second very high throughput signal field (VHT-SIG-B) **514**. The data unit **500** also includes a data portion **516**. In various embodiments, the data portion **516** includes an MPDU, for example, the MPDU **700** (FIG. **7**) or the MPDU **800** (FIG. **8**).

In an embodiment, the data unit **500** occupies a bandwidth that is an integer multiple of 20 MHz and the L-STF **502** is duplicated within each 20 MHz sub-band. In an embodiment, the VHT-STF **510** has a duration of 4.0 microseconds and uses a same frequency sequence as the L-STF **502**. For example, in an embodiment, the VHT-STF **510** uses the frequency sequence defined in equation 22-29 of the IEEE 802.11ac standard. In at least some embodiments, the VHT-STF **510** occupies a whole bandwidth for the data unit **500** (e.g., 20 MHz, 40 MHz, 80 MHz, etc.) and is mapped to multiple antennas for multiple input, multiple output (MIMO) or beamforming in a manner similar to the data portion **516**.

FIG. **6** is a diagram of an OFDM data unit **600** that the AP **14** is configured to transmit to the client station **25-1** via orthogonal frequency domain multiplexing (OFDM) modulation, according to an embodiment. In an embodiment, the client station **25-1** is also configured to transmit the data unit **600** to the AP **14**. The data unit **600** conforms to the first communication protocol and occupies a 20 MHz bandwidth. Data units that conform to the first communication protocol similar to the data unit **600** may occupy other suitable bandwidths such as 40 MHz, 80 MHz, 160 MHz, 320 MHz, 640 MHz, etc., for example, or other suitable bandwidths, in other embodiments. The data unit **600** is suitable for "mixed mode" situations, i.e., when the WLAN **10** includes a client station (e.g., the legacy client station **25-4**) that conforms to a legacy communication protocol, but not the first communication protocol. The data unit **600** is utilized in other situations as well, in some embodiments.

In an embodiment, the data unit **600** includes a preamble **601** having an L-STF **602**, an L-LTF **604**, an L-SIG **606**, two first HE signal fields (HE-SIGAs) **608** including a first HE signal field (HE-SIGA**1**) **608-1** and a second HE signal field (HE-SIGA**2**) **608-2**, a HE short training field (HE-STF) **610**, M HE long training fields (HE-LTFs) **612**, and a third HE signal field (HE-SIGB) **614**. In an embodiment, the preamble **601** includes a legacy portion **601-1**, including the L-STF **602**, the L-LTF **604**, and the L-SIG **606**, and a non-legacy portion **601-2**, including the HE-SIGAs **608**, HE-STF **610**, M HE-LTFs **612**, and HE-SIGB **614**.

Each of the L-STF **602**, the L-LTF **604**, the L-SIG **606**, the HE-SIGAs **608**, the HE-STF **610**, the M HE-LTFs **612**, and the HE-SIGB **614** are included in an integer number of one or more OFDM symbols. For example, in an embodiment, the HE-SIGAs **608** correspond to two OFDM symbols, where the HE-SIGA**1** **608-1** field is included in the first OFDM symbol and the HE-SIGA**2** is included in the second OFDM symbol. In another embodiment, for example, the preamble **601** includes a third HE signal field (HE-SIGA**3**, not shown) and the HE-SIGAs **608** correspond to three OFDM symbols, where the HE-SIGA**1** **608-1** field is included in the first OFDM symbol, the HE-SIGA**2** is included in the second OFDM symbol, and the HE-SIGA**3** is included in the third OFDM symbol. In at least some examples, the HE-SIGAs **608** are collectively referred to as a single HE signal field (HE-SIGA) **608**. In some embodiments, the data unit **600** also includes a data portion **616**. In other embodiments, the data unit **600** omits the data portion **616** (e.g., the data unit **600** is a null-data packet). In various embodiments, the data portion **616** includes an MPDU, for example, the MPDU **700** (FIG. **7**) or the MPDU **800** (FIG. **8**).

In the embodiment of FIG. **6**, the data unit **600** includes one of each of the L-STF **602**, the L-LTF **604**, the L-SIG **606**, and the HE-SIGA**1**s **608**. In other embodiments in which an OFDM data unit similar to the data unit **600** occupies a cumulative bandwidth other than 20 MHz, each of the L-STF **602**, the L-LTF **604**, the L-SIG **606**, the HE-SIGA**1**s **608** is repeated over a corresponding number of 20 MHz-wide sub-bands of the whole bandwidth of the data unit, in an embodiment. For example, in an embodiment, the OFDM data unit occupies an 80 MHz bandwidth and, accordingly, includes four of each of the L-STF **602**, the L-LTF **604**, the L-SIG **606**, and the HE-SIGA**1**s **608** in four 20 MHz-wide sub-bands that cumulatively span the 80 MHz bandwidth, in an embodiment. In some embodiments, the modulation of different 20 MHz-wide sub-bands signals is rotated by different angles. For example, in one embodiment, a first sub-band is rotated 0-degrees, a second sub-band is rotated 90-degrees, a third sub-band is rotated 180-degrees, and a fourth sub-band is rotated 270-degrees. In other embodiments, different suitable rotations are utilized. The different phases of the 20 MHz-wide sub-band signals result in reduced peak to average power ratio (PAPR) of OFDM symbols in the data unit **600**, in at least some embodiments. In an embodiment, if the data unit that conforms to the first communication protocol is an OFDM data unit that occupies a cumulative bandwidth such as 20 MHz, 40 MHz, 80 MHz, 160 MHz, 320 MHz, 640 MHz, etc., the HE-STF, the HE-LTFs, the HE-SIGB and the HE data portion occupy the corresponding whole bandwidth of the data unit.

FIG. **7** is a diagram of an MPDU **700**, according to an embodiment. The MPDU **700** includes a MAC header **702**, a frame body **704**, and a frame check sequence field **720**. The number above each field in FIG. **7** indicates the number of octets occupied by the corresponding field. Accordingly, the MAC header **702** includes a frame control field **704** (2 octets), a duration/ID field **706** (2 octets), a first address (A**1**) field **710-1** (6 octets), a second address (A**2**) field **710-2** (6 octets), a third address (A**3**) field (6 octets) **710-3**, a sequence control field **712** (2 octets), a fourth address (A**4**) field **710-4** (6 octets), a QoS control field **714** (2 octets), and an HT control field **716** (4 octets). The data unit **700** also includes the frame body **718** and a four-octet frame check sequence (FCS) field **720**. In some embodiments and/or scenarios, the frame body **718** is omitted (e.g., a null data frame). Each of the address fields **710** is a 48 bit (6 octet) field that includes a globally unique MAC address of a device associated with the data unit **700**, such as a trans-

mitting device of the data unit **700**, a receiving device of the data unit **700**, etc. In general, the MAC header **702** occupies 36 octets of the MPDU **700**.

FIG. **8** is a diagram of an MPDU **800**, according to another embodiment. The MPDU **800** includes a MAC header **802**, a frame body **804**, and a frame check sequence field **806**. The number above each field in FIG. **8** indicates the number of octets occupied by the corresponding field. Accordingly, the MAC header **802** includes a frame control field **804** (2 octets), a first address (A**1**) field **810-1** (2 or 6 octets), a second address (A**2**) field **810-2** (2 or 6 octets), a third address (A**3**) field (0 or 6 octets) **810-3**, a sequence control field **812** (0 or 2 octets), and a fourth address (A**4**) field **810-4** (0 or 6 octets). The data unit **800** also includes the frame body **818** and a four-octet frame check sequence (FCS) field **820**. In some embodiments and/or scenarios, the frame body **818** is omitted (e.g., a null data frame).

As compared to the MPDU **700**, the MPDU **800** has a "short frame format" having a reduced length of the MAC header **802**. In some embodiments and/or scenarios, one or more of the address fields **810-1** or **810-2** is a 48 bit (6 octet) field that includes a globally unique MAC address of a device associated with the data unit **800**, such as a transmitting device of the data unit **800**, a receiving device of the data unit **800**, etc. In other embodiments and/or scenarios, one or more of the address fields **810-1** or **810-2** is a 16 bit (2 octet) field that includes a BSS color identifier, partial association identification (PAID or partial AID), or other suitable address having a reduced length as compared to a MAC address (i.e., less than 6 octets). In various embodiments, the BSS color identifier occupies 6 bits, 7 bits, 10 bits, or another suitable number of bits. In some embodiments and/or scenarios, one or more of the sequence control field **812**, the address field **810-3**, or the address field **810-4** are optional and omitted from the MAC header **802**. In general, the MAC header **802** occupies 6 octets, or up to 28 octets, of the MPDU **800**.

FIG. **9** is a diagram of an example system **900** having a first access point **902**, a second access point **904**, and a client station (STA**1**) **922**, according to an embodiment. While only two access points and a single client station are shown in FIG. **9**, in other embodiments, the system **900** includes other suitable numbers of access points and other suitable numbers of client stations. In an embodiment, the first access point **902** and the second access point **904** are implemented as instances of the access point **14** described above with reference to FIG. **1**. In an embodiment, the client station **922** is implemented as an instance of the client station **25**. The first access point **902** and the second access point **904** communicate with client stations by transmitting and/or receiving OFDM data units, for example, OFDM data unit **200**, OFDM data unit **300**, OFDM data unit **400**, OFDM data unit **500**, or OFDM data unit **600**. In some embodiments and/or scenarios, the OFDM data units include an MPDU having a reduced header length using a BSS color identifier or other suitable non-unique identifier for the corresponding access point, for example, the MPDU **800**. In an embodiment, for example, the OFDM data units include scheduling frames for uplink orthogonal frequency division multiple access (OFDMA). In some embodiments and/or scenarios, the OFDM data unit includes the BSS color identifier in a PHY field, for example, the HE signal field **608** of the data unit **600**.

The first access point **902** and the second access point **904** provide service coverage area **912** and service coverage area **914**, respectively. The service coverage area **912** and service coverage area **914** each represent respective physical regions within which a client station may receive and decode transmissions from the corresponding access point, for example, broadcast management frames or downlink data frames provided by the access point. In the example embodiment shown in FIG. **9**, the service coverage area **912** at least partially overlaps with the service coverage area **914**, the client station **922** is located within an overlapping region **916**, and the client station **922** is associated with a wireless local area network provided by the first access point **902**.

In some scenarios, the client station **922** receives an OFDM data unit that includes the BSS color identifier to indicate the transmitter of the OFDM data unit. In one such scenario, the client station **922** cannot readily determine which access point transmitted the OFDM data unit if both the first access point **902** and the second access point **904** have a same value for their respective BSS color identifiers (e.g., a "color collision"). In an embodiment, the client station **922** determines that the first access point **902** and the second access point **904** have the same value for their respective BSS color identifiers and generates a notification frame for the first access point **902** to cause a change in the BSS color identifier of the first access point **902**. In an embodiment, the first access point **902** determines a new value for its BSS color identifier and changes the BSS color identifier, as described below.

In some embodiments, the system **900** also includes a network management device **930**. In an embodiment, the network management device **930** is implemented as an instance of the access point **14** described above with reference to FIG. **1**. In another embodiment, the network management device **930** is a network server or other suitable computing device. The network management device **930**, when present in the system **900**, manages the allocation of BSS color identifiers to access points within the system **900**. In an embodiment, the first access point **902** sends an indication of a color collision to the network management device **930**. In this embodiment, the network management device **930** determines a new value for the BSS color identifier for the first access point **902**. In other embodiments, the network management device **930** selects a new value for the BSS color identifier for the second access point **904**.

FIG. **10** is a diagram of a sequence of OFDM data units **1000** transmitted by the first access point **902** for a change in the BSS color identifier of the first access point **902**, according to an embodiment. In some embodiments, the OFDM data units **1000** are notification frames. In an embodiment, at least some of the notification frames are beacon management frames transmitted at predetermined beacon intervals. In various embodiments, a current value of the BSS color identifier is included in the frame body of the beacon management frame, for example, within the frame body **718** or frame body **818**. In an embodiment, for example, the BSS color identifier is included in an HE Operation element of the beacon management frame. In other embodiments, a suitable location other than the HE Operation element includes the BSS color identifier.

In the embodiment illustrated in FIG. **10**, the sequence of OFDM data units **1000** includes a beacon management frame **1002**, one or more notification frames **1004**, and a beacon management frame **1006**. The first access point **902** transmits the beacon management frame **1002**, which includes a first value of the BSS color identifier of the first access point **902** and a first BSSID of the first access point **902**. In an embodiment, the client station **922** associates with the first access point **902**. In an embodiment, the client station **922** receives and decodes the beacon management

frame from the second access point **904** and determines that the first access point **902** and the second access point **904** have the same value for their respective BSS color identifiers (e.g., a color collision). In an embodiment, for example, the client station **922** receives an OFDM data unit or beacon management frame (not shown), transmitted by the second access point **904**, that indicates a BSSID of the second access point **904** and the BSS color identifier of the second access point **904**.

In some embodiments, the client station **922** generates a BSS color collision notification frame **1003** for the first access point **902** in response to the determination of the color collision. In an embodiment, the BSS color collision notification frame **1003** provides a report of neighboring BSS color identifiers and/or neighboring BSSIDs. In an embodiment, the BSS color collision notification frame **1003** includes an indication that the BSS color identifier for the first access point **902** and the BSS color identifier for the second access point **904** have the same first value (e.g., a color collision indication). In an embodiment, the BSS color collision notification frame **1003** includes the color collision indication and the BSSID of the second access point **904**. In an embodiment, the BSS color collision notification frame **1003** includes the color collision indication and a set of BSS color identifier values detected by the client station **922**, for example, an "occupied" set of values. The client station **922** transmits the BSS color collision notification frame **1003** to the first access point **902**. In some embodiments, the access point **902** itself detects that the BSS color identifier for the second access point **904** has the same first value as the access point **902**.

In various embodiments, the first access point **902** determines a second value for its BSS color identifier in response to the BSS color collision notification frame **1003**. In some embodiments, the first access point **902** selects a second value that is different from the first value. For example, the first access point **902** selects a random value that is different from the first value, adds a predetermined offset to the first value, or selects another suitable value, in various embodiments. In another embodiment, the first access point **902** selects a second value that is not within the set of BSS color identifier values detected by the client station **922** or the access point **902** itself. In yet another embodiment, the first access point **902** transmits the first value and the set of BSS color identifier values to the network management device **930** and receives the second value from the network management device **930**.

After the determination of the second value, the first access point **902** generates one or more notification frames **1004** that indicate i) the second value of the first BSS color identifier, and ii) a start time at which the second value will supersede the first value (e.g., a subsequent changeover to the second value), in various embodiments. The notification frames **1004** generally indicate to client stations associated with the first access point **902** that a changeover will occur, while still using the first value of the BSS color identifier.

In some embodiments, the start time corresponds to a predetermined integer number of beacon intervals (BIs). In an embodiment, the start time is based on a backoff or delay to reduce the likelihood of a simultaneous change in the BSS color identifier for multiple access points. In the embodiment shown in FIG. **10**, the first access point **902** generates four beacon management frames **1004-1**, **1004-2**, **1004-3**, and **1004-4** to notify client stations of the change of the BSS color identifier and the number of BIs before the new BSS color is used. Each of the beacon management frames **1004** i) identifies the first value of the first BSS color identifier as the transmitter of beacon management frame, ii) indicates the second value, and iii) indicates the start time at which the second value will supersede the first value for subsequent beacon management frames. On or after the start time, the first access point **902** transmits a beacon management frame **1006** that identifies the second value of the first BSS color identifier as the transmitter of beacon management frame **1006**. In some embodiments, the start time is immediately after the determination of the second value. In an embodiment, for example, the predetermined integer number of beacon intervals indicated by the beacon management frame is zero.

As discussed above, in an embodiment, the first value of the BSS color identifier is included in the HE Operation element of the beacon management frames **1004**. In an embodiment, the second value is included in a Color Change element within the frame body of the beacon management frames **1004**. In various embodiments, the Color Change element includes a new color field that indicates the second value and a start time field. In an embodiment, the start time field indicates an effective target beacon transmission time for the beacon management frame **1006**. In an embodiment, for example, the start time field of each of the beacon management frames **1004** indicates an integer number of remaining beacon intervals until the second value supersedes the first value (e.g., beacon management frame **1004-1** indicates an integer value of 4, beacon management frame **1004-2** indicates an integer value of 3, beacon management frame **1004-3** indicates an integer value of 2, and beacon management frame **1004-4** indicates an integer value of 1). In another embodiment, the start time field indicates a timing synchronization function (TSF) time.

FIG. **11** is a diagram of a sequence of OFDM data units **1100** transmitted by the first access point **902** for a change in the BSS color identifier of the first access point **902**, according to another embodiment. In some embodiments, the OFDM data units **1100** include beacon management frames **1102**, **1104**, and **1106** and an integer number of BSS color change notification frames **1105**. The beacon management frames **1102**, **1104**, and **1106** are transmitted at predetermined beacon intervals. In various embodiments, a current value of the BSS color identifier is included in the frame body of the beacon management frames **1102**, **1104**, and **1106**, for example, within the frame body **718** or frame body **818**.

The first access point **902** transmits the beacon management frame **1102**, which includes a first value of the BSS color identifier of the first access point **902** and a first BSSID of the first access point **902**. In an embodiment, the client station associates with the first access point **902**. In an embodiment, the client station **922** receives and decodes the beacon management frame from the second access point **904** and determines that the first access point **902** and the second access point **904** have the same value for their respective BSS color identifiers (e.g., a color collision). In some embodiments, the client station **922** generates and transmits a BSS color collision notification frame **1103** for the first access point **902** in response to the determination of the color collision, as described above with respect to FIG. **10**.

In various embodiments, the first access point **902** determines a second value for its BSS color identifier in response to the BSS color collision notification frame **1103**, as described above with respect to FIG. **10**. In the embodiment shown in FIG. **11**, after determining the second value for the BSS color identifier, the first access point **902** performs a changeover to the second value and begins generating beacon management frames with the second value. For

example, after the determination of the second value, the first access point **902** generates the beacon management frame **1104**, which identifies the second value of the first BSS color identifier as the transmitter of beacon management frame **1104**. Accordingly, a first beacon management frame, generated at a beacon interval that occurs first after the determination of the second value, indicates that the first access point **902** is identifiable by the second value.

The first access point **902** generates one or more BSS color change notification frames that indicate the changeover from the first value to the second value, in various embodiments. In some embodiments, the first access point **902** generates a plurality of BSS color change notification frames within one or more beacon intervals after the changeover. In an embodiment, the first access point **902** transmits each of the plurality of BSS color change notification frames **1105** between i) the beacon interval of the predetermined beacon intervals that occurs first after the determining of the second value of the first BSS color identifier (e.g., the beacon interval corresponding to the beacon management frame **1104**), and ii) a beacon interval of the predetermined beacon intervals that occurs second after the determining of the second value of the first BSS color identifier (e.g., the beacon interval corresponding to the beacon management frame **1106**). In the embodiment shown in FIG. **11**, the first access point **902** generates three BSS color change notification frames **1105-1**, **1105-2**, and **1105-3** and transmits each of the BSS color change notification frames within a single beacon interval. The first access point **902** uses other suitable numbers of BSS color change notification frames and other suitable numbers of beacon intervals, in various embodiments.

FIG. **12** is a flow diagram illustrating an example method **1200** for changing a first basic service set (BSS) color identifier for a first communication device, according to an embodiment. With reference to FIG. **1**, the method **1200** is implemented by the network interface **16**, in an embodiment. For example, in one such embodiment, the PHY processing unit **20** is configured to implement the method **1200**. According to another embodiment, the MAC processing **18** is also configured to implement at least a part of the method **1200**. With continued reference to FIG. **1**, in yet another embodiment, the method **1200** is implemented by the network interface **27** (e.g., the PHY processing unit **29** and/or the MAC processing unit **28**). In other embodiments, the method **1200** is implemented by other suitable network interfaces.

At block **1202**, an indication that the first BSS color identifier for the first communication device and a second BSS color identifier for a second communication device have a same first value is received. In an embodiment, the indication comprises the BSS color collision notification frame **1003**, as described above with respect to FIG. **10**. In an embodiment, the indication is received by the first access point **902**, the second access point **904**, or another suitable communication device. As described above, the first access point **902** is identifiable by i) the first BSS color identifier, and ii) the first BSSID having a length that is longer than a length of the first BSS color identifier. In an embodiment, a first service coverage area of the first communication device at least partially overlaps a second service coverage area of the second communication device.

At block **1204**, a second value of the first BSS color identifier is determined in response to the indication received in block **1202**. In an embodiment, the determination corresponds to the determination of the second value by the first access point **902**, as described above with respect to FIG. **10**.

At block **1206**, one or more BSS color change notification frames are generated that indicate i) the second value of the first BSS color identifier, and ii) a start time at which the second value will supersede the first value of the first BSS color identifier. In an embodiment, the BSS color change notification frames include the beacon management frames **1004**, as described above with respect to FIG. **10**. In another embodiment, the BSS color change notification frames include the notification frames **1105**, as described above with respect to FIG. **11**.

At block **1208**, the first BSS color identifier is changed to the second value based on the start time.

FIG. **13** is a flow diagram illustrating an example method **1300** for causing a change of a first BSS color identifier for a first communication device, according to an embodiment. With reference to FIG. **1**, the method **1300** is implemented by the network interface **16**, in an embodiment. For example, in one such embodiment, the PHY processing unit **20** is configured to implement the method **1300**. According to another embodiment, the MAC processing **18** is also configured to implement at least a part of the method **1300**. With continued reference to FIG. **1**, in yet another embodiment, the method **1300** is implemented by the network interface **27** (e.g., the PHY processing unit **29** and/or the MAC processing unit **28**). In other embodiments, the method **1300** is implemented by other suitable network interfaces.

At block **1302**, a first indication is received from a second communication device and by a third communication device. The first indication indicates that the second communication device is identifiable by i) a first BSS color identifier, and ii) a second BSSID. In an embodiment, the first indication is a beacon management frame received by the client station **922**, for example, a beacon management frame **1002** transmitted by the second access point **904**.

At block **1304**, a second indication is received from a first communication device and by the third communication device. The second indication indicates that the second communication device is identifiable by i) a first BSS color identifier, and ii) a second BSSID. In an embodiment, the second indication is a beacon management frame received by the client station **922**, for example, a beacon management frame **1002** transmitted by the first access point **902**. In an embodiment, a first service coverage area of the first communication device at least partially overlaps a second service coverage area of the second communication device.

At block **1306**, it is determined that the first BSS color identifier for the first communication device and the second BSS color identifier for the second communication device have a same first value.

At block **1308**, a notification frame is generated for the first communication device to cause a change of the first BSS color identifier. In an embodiment, the notification frame includes i) an indication that the first BSS color identifier for the first communication device and the second BSS color identifier for the second communication device have the same first value, and ii) the second BSSID. In an embodiment, the notification frame is the BSS color collision notification frame **1003**, as described above with respect to FIG. **10**. In another embodiment, the notification frame is the BSS color collision notification frame **1103**, as described above with respect to FIG. **11**.

At least some of the various blocks, operations, and techniques described above may be implemented utilizing

hardware, a processor executing firmware instructions, a processor executing software instructions, or any combination thereof. When implemented utilizing a processor executing software or firmware instructions, the software or firmware instructions may be stored in any computer readable memory such as on a magnetic disk, an optical disk, or other storage medium, in a RAM or ROM or flash memory, processor, hard disk drive, optical disk drive, tape drive, etc. Likewise, the software or firmware instructions may be delivered to a user or a system via any known or desired delivery method including, for example, on a computer readable disk or other transportable computer storage mechanism or via communication media. Communication media typically embodies computer readable instructions, data structures, program modules or other data in a modulated data signal such as a carrier wave or other transport mechanism. The term "modulated data signal" means a signal that has one or more of its characteristics set or changed in such a manner as to encode information in the signal. By way of example, and not limitation, communication media includes wired media such as a wired network or direct-wired connection, and wireless media such as acoustic, radio frequency, infrared and other wireless media. Thus, the software or firmware instructions may be delivered to a user or a system via a communication channel such as a telephone line, a DSL line, a cable television line, a fiber optics line, a wireless communication channel, the Internet, etc. (which are viewed as being the same as or interchangeable with providing such software via a transportable storage medium). The software or firmware instructions may include machine readable instructions that, when executed by the processor, cause the processor to perform various acts.

When implemented in hardware, the hardware may comprise one or more of discrete components, an integrated circuit, an application-specific integrated circuit (ASIC), etc.

While the present invention has been described with reference to specific examples, which are intended to be illustrative only and not to be limiting of the invention, changes, additions and/or deletions may be made to the disclosed embodiments without departing from the scope of the invention.

What is claimed is:

1. A method for changing a first basic service set (BSS) color identifier for a first communication device identifiable by i) the first BSS color identifier, and ii) a first basic service set identifier (BSSID) having a length that is longer than a length of the first BSS color identifier, the method comprising:

receiving, by the first communication device, an indication that the first BSS color identifier for the first communication device and a second BSS color identifier for a second communication device have a same first value, wherein a first service coverage area of the first communication device at least partially overlaps a second service coverage area of the second communication device;

determining, by the first communication device, a second value of the first BSS color identifier in response to the indication;

generating, by the first communication device, one or more notification frames that indicate i) the second value of the first BSS color identifier, and ii) a start time at which the second value will supersede the first value of the first BSS color identifier, wherein the start time corresponds to a backoff delay after receiving the indication and before using the second value; and

changing, by the first communication device, the first BSS color identifier to the second value based on the start time.

2. The method of claim **1**, wherein the one or more notification frames comprise one or more first beacon management frames that i) identify the first value of the first BSS color identifier as corresponding to a transmitter of the corresponding beacon management frame, ii) indicate the second value of the first BSS color identifier, and iii) indicate the start time at which the second value will supersede the first value for subsequent beacon management frames.

3. The method of claim **2**, wherein:

the one or more first beacon management frames comprise a predetermined integer number of first beacon management frames; and

the method further comprises:

transmitting, by the first communication device, each of the predetermined integer number of first beacon management frames at predetermined beacon intervals,

generating, by the first communication device, a second beacon management frame that indicates i) the second value of the first BSS color identifier as a transmitter of the second beacon management frame, and

transmitting, by the first communication device, the second beacon management frame based on the start time indicated by the one or more first beacon management frames.

4. The method of claim **1**, wherein the start time at which the second value will supersede the first value of the first BSS color identifier is an effective target beacon transmission time (TBTT).

5. The method of claim **1**, wherein the start time at which the second value will supersede the first value of the first BSS color identifier is a timing synchronization function (TSF) time.

6. The method of claim **1**, further comprising generating, by the first communication device, beacon management frames for transmission by the first communication device at predetermined beacon intervals;

wherein:

a first beacon management frame, generated at a beacon interval of the predetermined beacon intervals that occurs first after the determining of the second value of the first BSS color identifier, indicates that the first communication device is identifiable by the second value of the first BSS color identifier; and

generating the one or more notification frames comprises generating one or more notification frames that indicate a changeover by the first communication device from the first value to the second value.

7. The method of claim **6**, wherein:

the one or more notification frames comprise a plurality of notification frames; and

the method further comprises transmitting each of the plurality of notification frames between i) the beacon interval of the predetermined beacon intervals that occurs first after the determining of the second value of the first BSS color identifier, and ii) a beacon interval of the predetermined beacon intervals that occurs second after the determining of the second value of the first BSS color identifier.

8. The method of claim **1**, wherein:

the indication that the first BSS color identifier for the first communication device and the second BSS color identifier for the second communication device have the

same first value comprises a set of BSS color identifier values detected by a third communication device associated with the first communication device; and

determining the second value for the first BSS color identifier comprises determining the second value to be a value that is not within the set of BSS color identifier values detected by the third communication device.

9. The method of claim **1**, wherein:

the indication that the first BSS color identifier for the first communication device and the second BSS color identifier for the second communication device have the same first value comprises a set of BSS color identifier values detected by a third communication device associated with the first communication device; and

determining the second value for the first BSS color identifier comprises:

transmitting the first value and the set of BSS color identifier values to a network management device, and

receiving the second value from the network management device.

10. The method of claim **1**, wherein the start time indicates an integer number of remaining beacon management frames until the second value supersedes the first value.

11. The method of claim **1**, wherein the start time corresponds to an effective target beacon transmission time for a beacon management frame to be transmitted by the first communication device and that identifies the second value of the first BSS color identifier as the transmitter of the beacon management frame.

12. The method of claim **1**, wherein the one or more notification frames indicate to client stations associated with the first communication device that a changeover, from the first value to the second value, will occur while still using the first value of the BSS color identifier.

13. A first communication device that is identifiable by i) a first basic service set (BSS) color identifier, and ii) a first basic service set identifier (BSSID) having a length that is longer than a length of the first BSS color identifier, the first communication device comprising:

a network interface device having one or more integrated circuits configured to:

receive an indication that the first BSS color identifier for the first communication device and a second BSS color identifier for a second communication device have a same first value, wherein a first service coverage area of the first communication device at least partially overlaps a second service coverage area of the second communication device,

determine a second value of the first BSS color identifier in response to the indication,

generate one or more notification frames that indicate i) the second value of the first BSS color identifier, and ii) a start time at which the second value will supersede the first value of the first BSS color identifier, wherein the start time corresponds to a backoff delay after receiving the indication and before using the second value, and

change the first BSS color identifier to the second value based on the start time.

14. The first communication device of claim **13**, wherein the one or more notification frames comprise one or more first beacon management frames that i) identify the first value of the first BSS color identifier as corresponding to a transmitter of the corresponding beacon management frame, ii) indicate the second value of the first BSS color identifier, and iii) indicate the start time at which the second value will supersede the first value for subsequent beacon management frames.

15. The first communication device of claim **14**, wherein:

the one or more first beacon management frames comprise a predetermined integer number of first beacon management frames; and

the one or more integrated circuits configured to:

transmit each of the predetermined integer number of first beacon management frames at predetermined beacon intervals,

generate a second beacon management frame that indicates i) the second value of the first BSS color identifier as a transmitter of the second beacon management frame, and

transmit the second beacon management frame based on the start time indicated by the one or more first beacon management frames.

16. The first communication device of claim **13**, wherein the start time at which the second value will supersede the first value of the first BSS color identifier is an effective target beacon transmission time (TBTT).

17. The first communication device of claim **13**, wherein the start time at which the second value will supersede the first value of the first BSS color identifier is a timing synchronization function (TSF) time.

18. The first communication device of claim **13**, wherein:

the one or more integrated circuits are configured to generate beacon management frames for transmission by the first communication device at predetermined beacon intervals;

a first beacon management frame, generated at a beacon interval of the predetermined beacon intervals that occurs first after the second value of the first BSS color identifier is determined, indicates that the first communication device is identifiable by the second value of the first BSS color identifier; and

the one or more integrated circuits are configured to generate one or more notification frames that indicate a changeover by the first communication device from the first value to the second value.

19. The first communication device of claim **18**, wherein:

the one or more notification frames comprise a plurality of notification frames; and

the one or more integrated circuits are configured to transmit each of the plurality of notification frames between i) the beacon interval of the predetermined beacon intervals that occurs first after the second value of the first BSS color identifier is determined, and ii) a beacon interval of the predetermined beacon intervals that occurs second after the second value of the first BSS color identifier is determined.

20. The first communication device of claim **13**, wherein:

the indication that the first BSS color identifier for the first communication device and the second BSS color identifier for the second communication device have the same first value comprises a set of BSS color identifier values detected by a third communication device associated with the first communication device; and

the one or more integrated circuits are configured to determine the second value to be a value that is not within the set of BSS color identifier values detected by the third communication device.

21. The first communication device of claim **13**, wherein:

the indication that the first BSS color identifier for the first communication device and the second BSS color identifier for the second communication device have the

same first value comprises a set of BSS color identifier values detected by a third communication device associated with the first communication device; and

the one or more integrated circuits are configured to:

transmit the first value and the set of BSS color identifier values to a network management device, and

receive the second value from the network management device.

22. The first communication device of claim **13**, wherein the start time indicates an integer number of remaining beacon management frames until the second value supersedes the first value.

23. The first communication device of claim **13**, wherein the start time corresponds to an effective target beacon transmission time for a beacon management frame to be transmitted by the first communication device and that identifies the second value of the first BSS color identifier as the transmitter of the beacon management frame.

24. The first communication device of claim **13**, wherein the one or more notification frames indicate to client stations associated with the first communication device that a changeover, from the first value to the second value, will occur while still using the first value of the BSS color identifier.

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