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(54) Title: METHODS, WIRELESS COMMUNICATION STATION, AND SYSTEM FOR WLAN CHANNEL SELECTION THROUGH BEACON REQUESTS

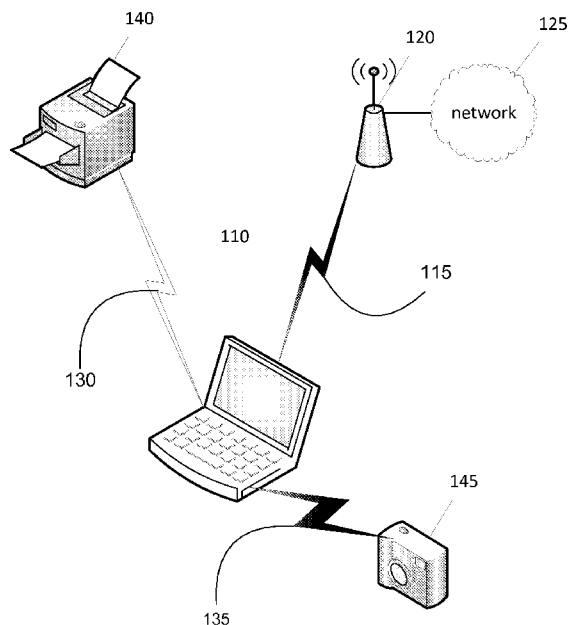


FIG. 1

(57) Abstract: Embodiments of a user station (STA) and methods for WLAN channel selection through beacon requests are generally described herein. In some embodiments, a STA requests that an access point (AP) transmit a beacon signal on a first sub-band. The first sub-band may include a channel of interest to the STA. The STA may determine that the AP supports the first sub-band if the AP transmits the requested beacon signal.



TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, **Published:**
KM, ML, MR, NE, SN, TD, TG).

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

5 METHOD, WIRELESS COMMUNICATION STATION, AND SYSTEM FOR
WLAN CHANNEL SELECTION THROUGH BEACON REQUESTS

PRIORITY APPLICATION

10 **[0001]** This application claims the benefit of priority to U.S. Application
Serial No. 13/712,243, filed December 12, 2012, which is incorporated herein by
reference in its entirety.

TECHNICAL FIELD

15 **[0002]** Embodiments pertain to communication networks. Some
embodiments pertain to wireless devices operating in wireless local area
networks (WLANs) in accordance with Institute of Electrical and Electronics
Engineers (IEEE) 802.11 family of standards.

20 BACKGROUND

[0003] The IEEE has adopted a set of standards for WLANs, known as 802.11. Under 802.11, a user device, also known as a user station (STA), may access a WLAN through an access point (AP). The user STA may transmit in those sub-bands of the regulatory WLAN frequency spectrum in which the user STA has already received signaling from the AP. Therefore, sub-band use may be limited according to the signaling provided by the AP.

30 **[0004]** Accordingly, there is a general need for a user STA to perform methods to switch sub-bands for transmission based on the needs of the user STA.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] FIG. 1 illustrates a wireless local area network (WLAN) in which
35 example embodiments are implemented;

[0006] FIG. 2 is a flow diagram of a procedure performed by a user STA for operation in a wireless communication network, in accordance with some embodiments;

5 [0007] FIG. 3 illustrates a beacon request frame in accordance with some embodiments;

[0008] FIG. 4 illustrates a functional block diagram of a communication station (STA), in accordance with some embodiments;

[0009] FIG. 5 is a flow diagram of a procedure for switching from a first sub-band to a second sub-band in a wireless communication network in
10 accordance with some embodiments; and

[0010] FIG. 6 is a flow diagram of a procedure performed by an access point (AP) for operating in a wireless communication network in accordance with some embodiments.

15 DETAILED DESCRIPTION

[0011] The following description and the drawings sufficiently illustrate specific embodiments to enable those skilled in the art to practice them. Other embodiments may incorporate structural, logical, electrical, process, and other
20 changes. Portions and features of some embodiments may be included in, or substituted for, those of other embodiments. Embodiments set forth in the claims encompass all available equivalents of those claims.

[0012] FIG. 1 illustrates a user wireless communication station (STA) 110. The user STA 110 may be, for example, a laptop computer, a smart phone, a tablet computer, or any other wireless device. In an example, the user STA
25 110 has a wireless connection 115 through a second STA 120 to the network 125. The second STA 120 may be a more stationary communication unit such as a wireless access point (AP) and will hereinafter be referred to as the AP 120. The network 125 may be a home network, an enterprise network, the Internet, or
30 any other suitable network. In some embodiments, the user STA 110 and the AP 120 may transmit and/or receive communications in accordance with specific communication standards, such as the IEEE 802.11 standards although user STA

110 and the AP 120 may also be suitable to transmit and/or receive communications in accordance with other techniques.

[0013] The user STA 110 may further have connections 130 and 135 to other wireless devices such as, for example, a printer 140 and a camera 145.

5 However, any number of wireless devices, or no wireless devices, may have connections to the user STA 110. The user STA 110 may act or be capable of acting as a peer-to-peer (P2P) group owner (GO) of the group comprised of the printer 140, the user STA 110, the camera 145 or other wireless devices (not shown).

10 [0014] The user STA 110 may be arranged to operate on a first set of one or more sub-bands within a WLAN spectrum. The AP 120 may be arranged to operate on a second set of one or more sub-bands within the WLAN spectrum. The WLAN spectrum may include channels within frequency ranges specified in accordance with a standard of the 802.11 family of standards. For example, the
15 WLAN spectrum may include channels or sub-bands within a 2.4-gigahertz (GHz) band, a 5-GHz band, or a 60-GHz band. The first set of sub-bands, supported by the user STA 110, may include the same sub-bands that are included in the second set of sub-bands supported by the AP 120. Alternatively, the first set may include more sub-bands than the second set, or the second set
20 may include more sub-bands than the first set.

[0015] The allowable WLAN spectrum may vary based on geographic considerations. For example, national regulations may permit spectrum usage at 5.8 GHz in the United States, while the 5.8 GHz band may not be used in the European Union. Some equipment manufacturers therefore may provide
25 different STAs for usage in different geographical locations. Other equipment manufacturers may provide a “worst-case scenario” STA that can function in any geographical location, on a reduced set of sub-bands or with reduced functionality. Accordingly, logistical supply complications may be introduced, or the user experience may be degraded.

30 [0016] Under some reduced functionalities, a user STA 110 may not transmit on a sub-band or channel unless or until the user STA 110 has observed or received a beacon signal from an AP 120 on that sub-band. Accordingly, the user STA 110 is limited to transmissions on particular sub-bands for which the

AP 120 has transmitted a beacon signal. However, either or both of the AP 120 and the user STA 110 may support communications on other sub-bands.

Additionally, conditions may be advantageous to the user STA 110 on other sub-bands besides those sub-bands on which the AP 120 is transmitting beacon
5 signals. For example, other sub-bands may have reduced or no traffic or provide better channel quality.

[0017] In accordance with example embodiments, therefore, the user STA 110 may request that the AP 120 transmit a beacon signal on a given sub-band, so that the user STA 110 may thereafter communicate over that sub-band.
10 FIG. 2 illustrates a method, performed by the user STA 110, for operating in a wireless network.

[0018] Referring to FIG. 2, in operation 200, the user STA 110 may request that an AP 120 transmit a beacon signal on a first sub-band. The first sub-band may include a channel of interest to the user STA 110. The user STA
15 110 may request the beacon signal by transmitting a beacon request frame to the AP 120. The user STA 110 may transmit the beacon request frame on a second sub-band. The second sub-band may be a sub-band on which the AP 120 has already transmitted a beacon signal, thus permitting user STA 110 transmissions on the second sub-band. A beacon request frame in accordance with example
20 embodiments is shown in FIG. 3.

[0019] Referring to FIG. 3, the beacon request frame may include a sub-field 300 indicating the identity of the first sub-band for which the user STA 110 is requesting a beacon signal. The beacon request frame may include additional fields in accordance with a standard of the IEEE 802.11 family of standards.

25 **[0020]** Referring again to FIG. 2, in operation 210, the user STA 110 may determine that the AP 120 supports the first sub-band if the AP 120 transmits the requested beacon signal. The user STA 110 may determine that the AP 120 does not support the first sub-band if the AP 120 indicates that the AP 120 does not support the first sub-band or if no response is received to the
30 beacon request frame within a time duration. Upon determining that the AP 120 does not support the first sub-band, the user STA 110 may transmit a beacon request frame to request a beacon signal on a different sub-band. The different sub-band may include a different channel of interest to the user STA 110.

[0021] The user STA 110 may determine a sub-band for which to request transmission of the beacon signal based on geographically specific signaling from the AP 120. The geographically specific signaling may be, for example, country information signaling according to a standard of the IEEE 802.11 family of standards.

[0022] FIG. 4 illustrates a functional block diagram of a STA 400, in accordance with some embodiments. The STA 400 may be suitable as a user STA 110 (FIG. 1) or as an AP 120 (FIG. 1). The STA 400 may support methods for operating in a wireless communication network, in accordance with embodiments. The STA 400 may include a processor 402, which uses a chipset 404 to access on-chip state memory 406, as well as a communications interface 408. In one embodiment the memory 406 includes, but is not limited to, random access memory (RAM), dynamic RAM (DRAM), static RAM (SRAM), synchronous DRAM (SDRAM), double data rate (DDR) SDRAM (DDR-SDRAM), or any device capable of supporting high-speed buffering of data.

[0023] In at least one embodiment, the communications interface 408 is, for example, a wireless Physical Layer (PHY), which operates according to a multiple input/multiple output (MIMO) operation. The communications interface 408 may receive geographical information. The geographical information may be received from the AP 120. When the STA 400 acts as a user STA 110 (FIG. 1), the communications interface 408 may use a first sub-band to transmit the beacon request frame to a second STA. As discussed above, the second STA may be the AP 120. The beacon request frame may request that the AP 120 transmit a beacon signal on a second sub-band. The communications interface 408 may receive, on the second sub-band, a beacon signal in response to the beacon request frame. The communications interface 408 may receive geographical information. The geographical information may be received from the AP 120. The communications interface 408 may receive an acknowledgement (ACK) from the AP 120 in response to the beacon request frame.

[0024] The chipset 404 may incorporate therein Beacon Request Logic 412 to, for example, configure a beacon request frame or to configure a response to a beacon request frame. In an embodiment, the chipset 404 provides MAC

layer functionality. For example, the chipset 404 may provide MAC layer functionality to configure a beacon request frame or to configure a response to a beacon request frame.

5 [0025] When the STA 400 operates as a user STA 120, the processor 402 may be arranged to determine the sub-band for which to transmit the beacon request frame based on a channel of interest of the STA 400. The processor 402 may be arranged to select the channel of interest based on geographical information received through the communications interface 408. The processor 402 may determine that the requested sub-band is not supported if the
10 communications interface 408 does not receive the requested beacon signal within a time duration. The processor 402 may determine that the requested sub-band is not supported if the communications interface 408 does not receive the requested beacon signal within a time duration after the communications interface 408 received the ACK to the beacon request frame.

15 [0026] When the STA 400 operates as an AP 120 (FIG. 1), the communications interface 408 may receive, on a first sub-band, a beacon request frame requesting transmission of a beacon signal on a second sub-band. The communications interface 408 may transmit the beacon signal on the second sub-band upon determining whether to support communication on the second sub-
20 band. The communications interface 408 may transmit, on the second sub-band, an acknowledgement (ACK) message in response to the beacon request frame. The communications interface 408 may transmit, on the first sub-band, a response denying service on the second sub-band.

[0027] When the STA 400 operates as an AP 120, the processor 402 may
25 determine whether to support communication in the second sub-band. The communications interface 408 may transmit the beacon signal within a time duration of the transmission of the ACK message upon determination by the processor 402 to support communication in the second sub-band.

[0028] Embodiments may be implemented in one or a combination of
30 hardware, firmware and software. Embodiments may also be implemented as instructions 414 stored on a computer-readable storage device, which may be read and executed by at least one processor 402 to perform the operations described herein. In some embodiments, the instructions 414 are stored on the

processor 402 or the memory 406 such that the processor 402 and the memory 406 act as computer-readable mediums. A computer-readable storage device may include any non-transitory mechanism for storing information in a form readable by a machine (e.g., a computer). For example, a computer-readable
5 storage device may include ROM, RAM, magnetic disk storage media, optical storage media, flash-memory devices, and other storage devices and media.

[0029] Although the STA 400 is illustrated as having several separate functional elements, one or more of the functional elements may be combined and may be implemented by combinations of software-configured elements,
10 such as processing elements including digital signal processors (DSPs) and/or other hardware elements. For example, some elements may comprise one or more microprocessors, DSPs, application specific integrated circuits (ASICs), radio-frequency integrated circuits (RFICs), and combinations of various hardware and logic circuitry for performing at least the functions described
15 herein. In some embodiments, the functional elements of the STA 400 may refer to one or more processes operating on one or more processing elements.

[0030] The STA 400 may include multiple transmit and receive antennas 410-1 through 410-N, where N is a natural number. Antennas 410-1 through 410-N may comprise one or more directional or omnidirectional antennas,
20 including, for example, dipole antennas, monopole antennas, patch antennas, loop antennas, microstrip antennas, or other types of antennas suitable for transmission of RF signals. In some embodiments, instead of two or more antennas, a single antenna with multiple apertures may be used. In these embodiments, each aperture may be considered a separate antenna. In some
25 MIMO embodiments, antennas 410-1 through 410-N may be effectively separated to take advantage of spatial diversity and the different channel characteristics that may result between each of antennas 410-1 through 410-N and the antennas of an originator STA. In some MIMO embodiments, antennas 410-1 through 410-N may be separated by up to 1/10 of a wavelength or more.

30 [0031] FIG. 5 illustrates a method, performed by the user STA 110, for switching from a first sub-band to a second sub-band in a wireless communication network. In operation 500, the user STA 110 may determine that a channel on the second sub-band is not in use. In operation 510, the user

STA 110 may request that a beacon signal be transmitted on the second sub-band. The request may include transmission, on the first sub-band, of a request signal as described above with respect to FIG. 3. In operation 520, the user STA 110 may transmit at least one frame on the channel in the second sub-band upon receiving the requested beacon signal in the second sub-band. The user STA 110 may further become a peer-to-peer (P2P) group owner (GO), over a group comprising, for example, the printer 140 (FIG. 1), the camera 145 (FIG. 1) or other wireless devices (not shown). The user STA 110 may become a GO by transmitting a beacon signal on the second sub-band to the printer 140, the camera 145, or to other wireless devices. As the GO, the user STA 110 may establish associations with and communications between the printer 140, the camera 145, or other wireless devices.

[0032] FIG. 6 illustrates a method, performed by the AP 120, of operating in a wireless communication network. In operation 600, the AP 120 may receive a request to transmit a beacon signal on a first sub-band. In operation 610, the AP 120 may determine whether the AP 120 can perform AP functions on the first sub-band. In operation 620, the AP 120 may transmit the requested beacon signal on the first sub-band if the AP 120 determines that the AP 120 might possibly perform AP functions on the first sub-band.

[0033] In at least one embodiment, if the AP 120 decides the AP 120 cannot support AP functions on the first sub-band, the AP 120 may transmit a response denying service on the first sub-band. The AP 120 may transmit this response on a sub-band at which the AP 120 is already providing service. For example, the AP 120 may transmit this response on the sub-band on which the AP 120 received the request for the beacon signal. In at least another embodiment, the AP 120 may ignore the request for the beacon signal if the AP 120 decides the AP 120 cannot support AP functions on the first sub-band. The AP 120 may limit determinations of whether to perform AP functions on the first sub-band. For example, the AP 120 may limit the number of determinations made to a certain maximum over a time interval. Further, or in addition, the AP 120 may limit transmissions of the requested beacon signal to a number of transmissions within a time interval. The AP 120 may transmit an acknowledgement (ACK) message upon receiving a request for a beacon signal.

[0034] The Abstract is provided to comply with 37 C.F.R. Section 1.72(b) requiring an abstract that will allow the reader to ascertain the nature and gist of the technical disclosure. It is submitted with the understanding that it will not be used to limit or interpret the scope or meaning of the claims. The

5 following claims are hereby incorporated into the detailed description, with each claim standing on its own as a separate embodiment.

CLAIMS

What is claimed is:

1. A wireless communication station (STA) comprising:
 - 5 a medium access control (MAC) layer to configure a beacon request frame;
 - physical layer (PHY) circuitry to
 - transmit, on a first sub-band, the beacon request frame to a second STA, and
 - 10 receive, on a second sub-band, a beacon signal in response to the beacon request frame; and
 - one or more processors to determine the second sub-band for which to transmit the beacon request frame based on a channel of interest of the STA.
- 15 2. The STA of claim 1, wherein
 - the PHY circuitry is further arranged to receive geographical information, and
 - the one or more processors are further arranged to select the channel of interest based on the geographical information.
- 20 3. The STA of claim 1, wherein the one or more processors determines that the second STA does not support the second sub-band if the PHY circuitry does not receive the beacon signal within a time duration.
- 25 4. The STA of claim 1, wherein the PHY circuitry is further arranged to receive an acknowledgement (ACK) in response to the beacon request frame.
5. The STA of claim 4, wherein the processor determines that the second STA does not support the second sub-band if the PHY circuitry does not receive the
- 30 beacon signal within a time duration after receiving the ACK.
6. A method, performed by a user station (STA), for operating in a wireless network, the method comprising:

requesting that an access point (AP) transmit a beacon signal on a first sub-band, the first sub-band including a channel of interest to the STA; and
determining that the AP supports the first sub-band if the AP transmits the requested beacon signal.

5

7. The method of claim 6, wherein the requesting comprises:

transmitting, on a second sub-band on which the AP has transmitted at least one beacon signal frame, a request signal including a field indicating the first sub-band.

10

8. The method of claim 6, further comprising:

determining that the AP does not support the sub-band if
the AP indicates that the AP does not support the sub-band or
if no response is received to the requesting within a time duration.

15

9. The method of claim 8, further comprising:

upon determining that the AP does not support the sub-band, requesting that the AP transmit a beacon signal on a second sub-band, the second sub-band including a second channel of interest to the STA

20

10. The method of claim 6, wherein the STA determines the sub-band for which to request transmission of the beacon signal based on geographically-specific signaling from the AP.

25 11. The method of claim 10, wherein the geographically-specific signaling is country information signaling according to a standard of the Institute of Electrical and Electronics Engineers (IEEE) 802.11 family of standards.

12. A method, performed by a user device station (STA), for switching from a
30 first sub-band to a second sub-band in a wireless communication network, the method comprising:

determining that a channel on the second sub-band is not in use;

requesting that a beacon signal be transmitted on the second sub-band;
and

transmitting at least one frame on the channel in the second sub-band
upon receiving the requested beacon signal in the second sub-band.

5

13. The method of claim 12, wherein the requesting comprises:

transmitting, on the first sub-band, a request including a field indicating
the second sub-band.

10 14. The method of claim 12, further comprising:

transmitting a beacon signal on the second sub-band, upon receiving the
requested beacon signal, to become a peer-to-peer (P2P) group owner (GO) on
the second sub-band.

15 15. A method, performed by a wireless access point (AP), of operating in a
wireless communication network, the method comprising:

receiving a request to transmit a beacon signal on a first sub-band;
determining whether the AP can support AP functions on the first sub-
band; and

20 transmitting the requested beacon signal on the first sub-band if the
determining determines that the AP can support AP functions on the first sub-
band.

16. The method of claim 15, further comprising:

25 transmitting, on a second sub-band, a response denying service if the
determining determines not supporting AP functions on the first sub-band.

17. The method of claim 15, further comprising:

30 ignoring the request if the determining determines not supporting AP
functions on the first sub-band.

18. The method of claim 15, further comprising:

limiting determination of whether the AP can support AP functions on the first sub-band to a number of determinations within a time interval.

19. The method of claim 15, further comprising:

- 5 limiting transmission of the requested beacon signal to a number of transmissions within a time interval.

20. A system comprising:

- an antenna arranged to receive transmissions from a second system on a
10 first sub-band; and
 a processor arranged to determine whether the second system supports a second sub-band based on whether a beacon signal is received from the second system, on the second sub-band, in response to a request for a beacon signal.
- 15 21. The system of claim 20, wherein the processor is further arranged to determine the second sub-band for which to request the beacon signal based on country information signaling received from the second system.

22. A wireless communication station (STA) comprising:

- 20 a medium access control (MAC) layer to configure a response to a beacon request frame;
 physical layer (PHY) circuitry to
 receive, on a first sub-band, a beacon request frame requesting
transmission of a beacon signal on a second sub-band, and
25 transmit a beacon signal on the second sub-band upon
determining whether the STA can support communication on the second sub-band; and
 one or more processors to
 determine whether the STA can support communication on the
30 second sub-band.

23. The STA of claim 22, wherein the PHY circuitry is further arranged to:

transmit, on the second sub-band, an acknowledgment (ACK) message in response to the beacon request frame; and

- transmit the beacon signal within a time duration of transmission of the ACK message upon the one or more processors determining the STA can
- 5 support communication in the second sub-band.

24. The wireless communication station of claim 22, wherein the PHY circuitry is further arranged to transmit, on the first sub-band, a response denying service on the second sub-band upon the one or more processors determining to not
- 10 support communication on the second sub-band.

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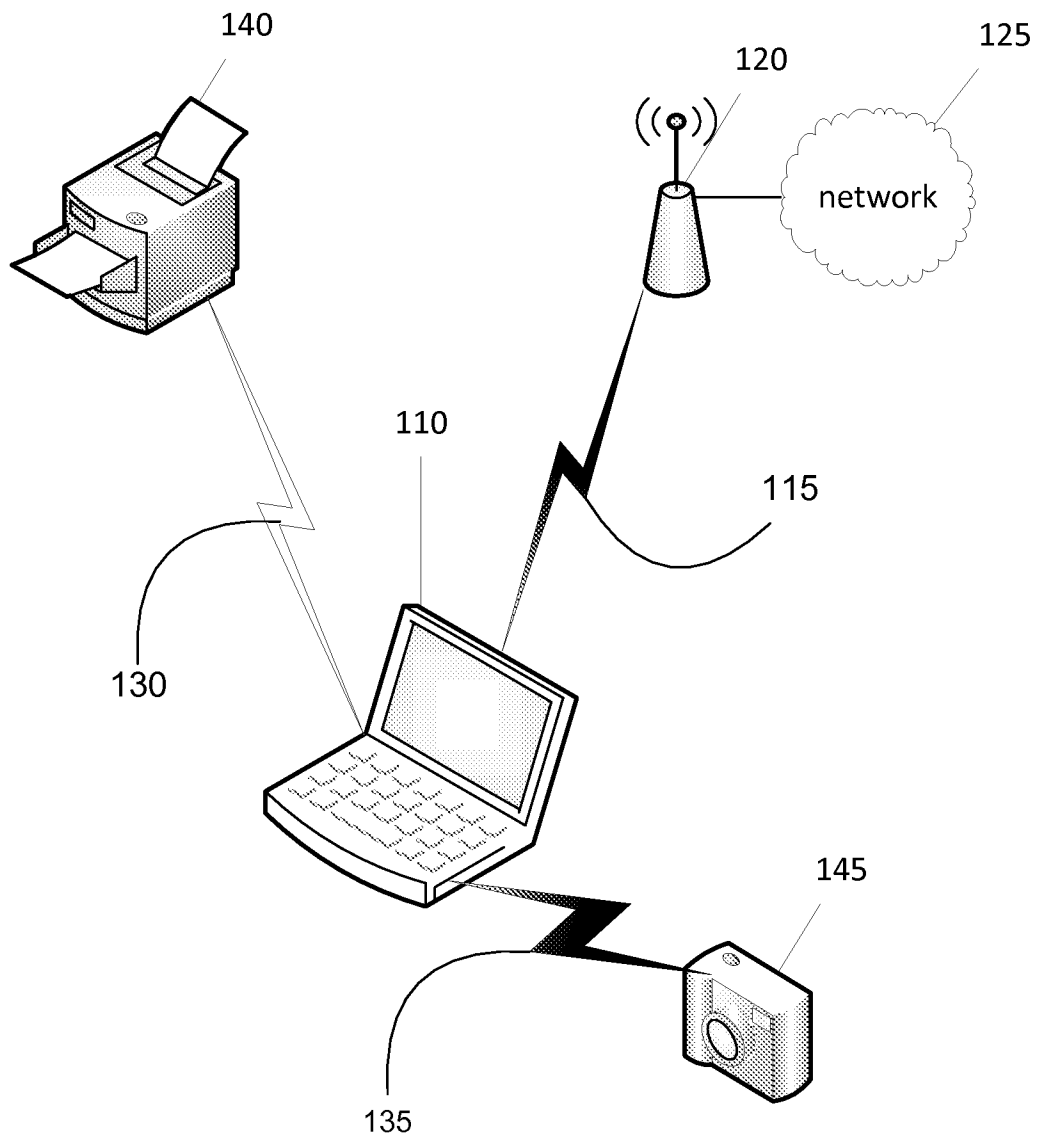


FIG. 1

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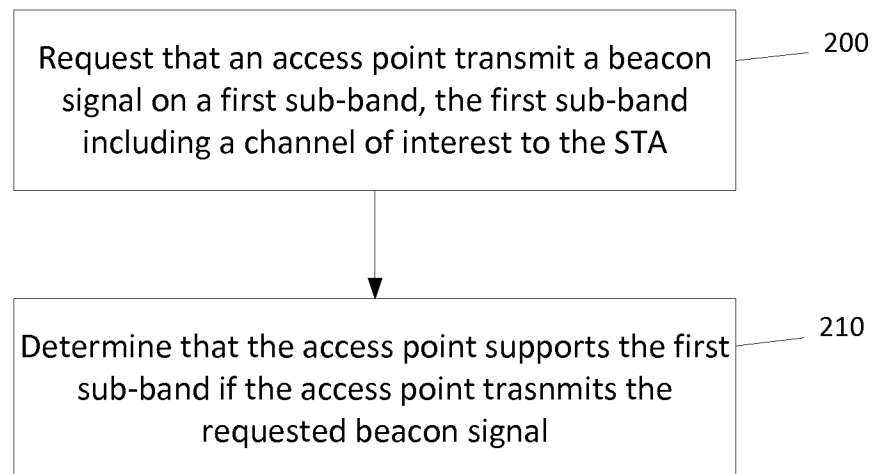


FIG. 2

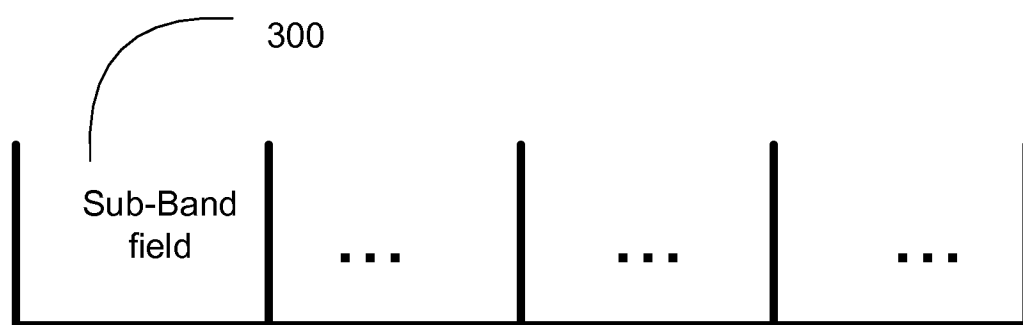


FIG. 3

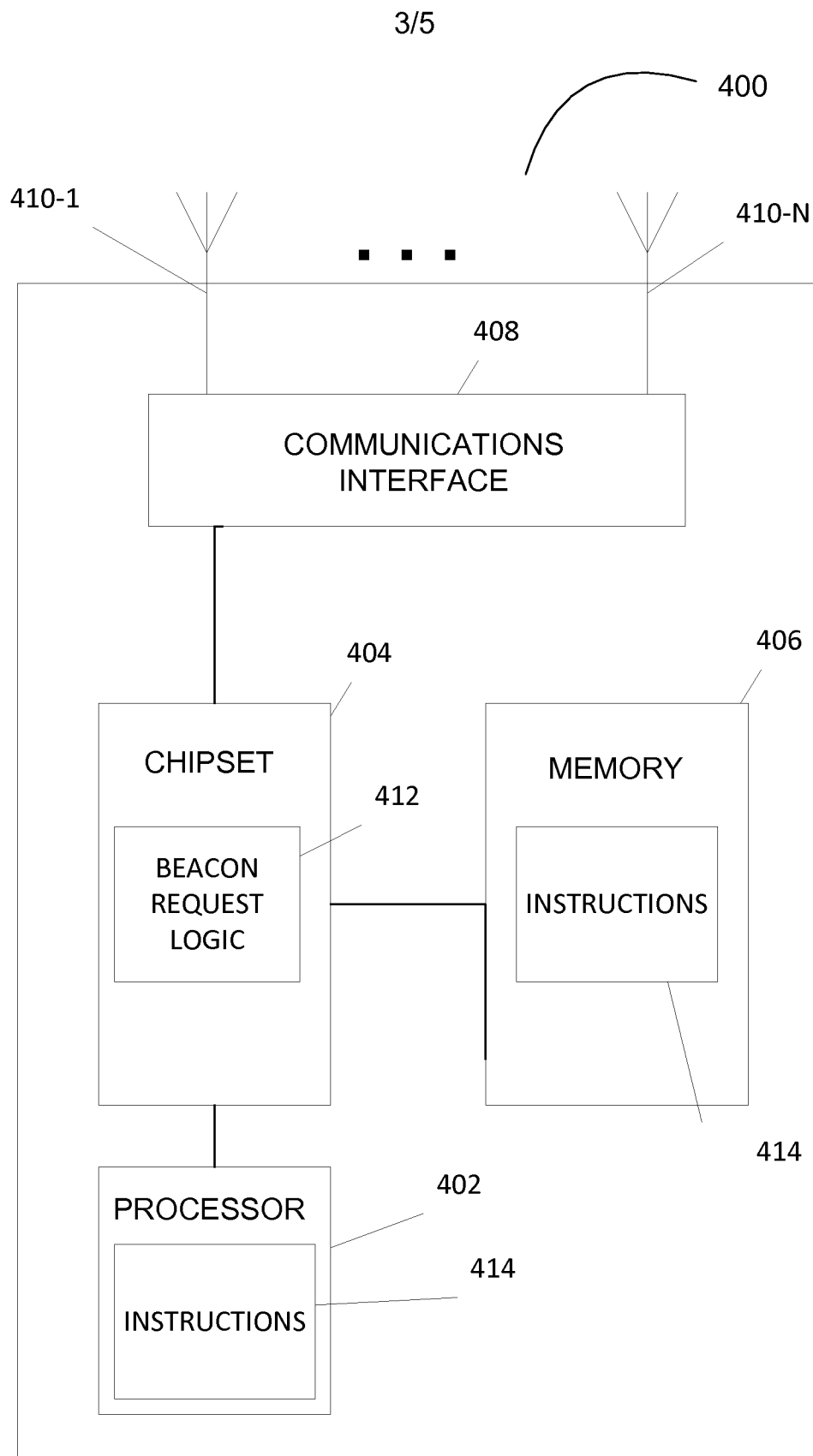


FIG. 4

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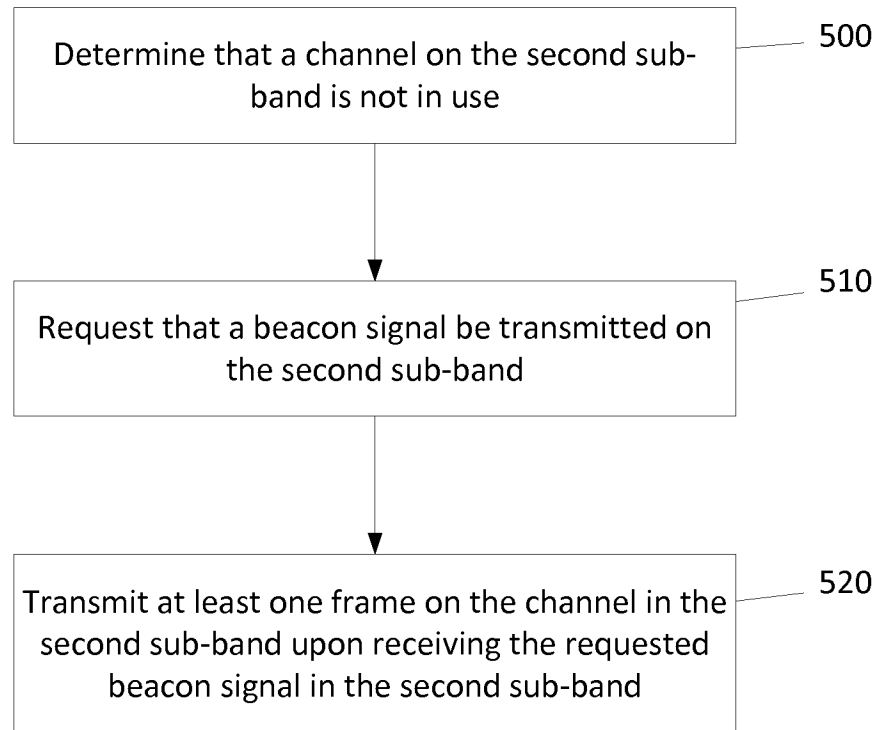


FIG. 5

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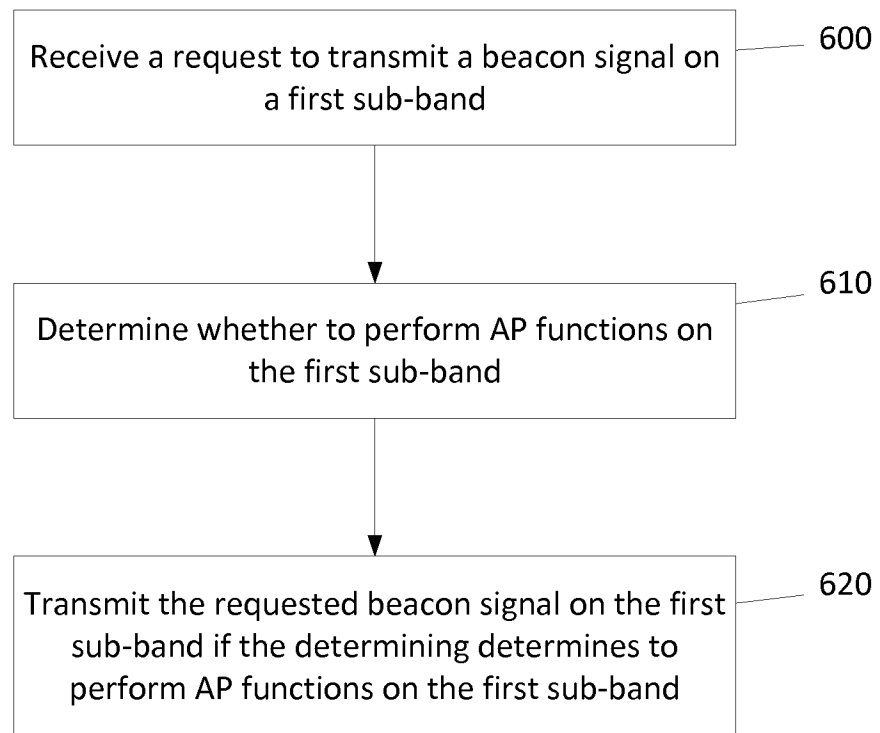


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/047915**A. CLASSIFICATION OF SUBJECT MATTER****H04W 74/08(2009.01)i, H04W 84/12(2009.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W 74/08; H04W 88/08; H04W 48/16; H04M 1/00; H04Q 7/20; H04W 72/00; H04W 84/12

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: IEEE 802.11, MAC, PHY, WLAN Spectrum, STA, AP, beacon, sub-band, request, response

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2007-0243888 A1 (STEFANO FACCIN) 18 October 2007 See paragraphs [0002], [0016], [0017], [0032]; and figure 1.	1-24
A	US 2010-0103844 A1 (HAN SOO KIM) 29 April 2010 See paragraphs [0035], [0038], [0059]; claim 9; and figure 1.	1-24
A	US 2006-0217147 A1 (ULISES OLVERA-HERNANDEZ et al.) 28 September 2006 See paragraphs [0027], [0028], [0033]; claim 1; and figure 1.	1-24
A	WO 2011-122884 A2 (LG ELECTRONICS INC.) 06 October 2011 See paragraphs [66], [92], [101]; and figure 1.	1-24
A	US 2010-0177718 A1 (DAVID HARLE et al.) 15 July 2010 See paragraphs [0007], [0014], [0022], [0023]; claim 1; and figure 1.	1-24



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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Date of the actual completion of the international search

21 October 2013 (21.10.2013)

Date of mailing of the international search report

21 October 2013 (21.10.2013)

Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2013/047915

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