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(54) Title: METHODS AND APPARATUS TO FACILITATE ENHANCED DISTRIBUTED CHANNEL ACCESS AND BACKOFF FOR ACCESS POINT TRIGGERS

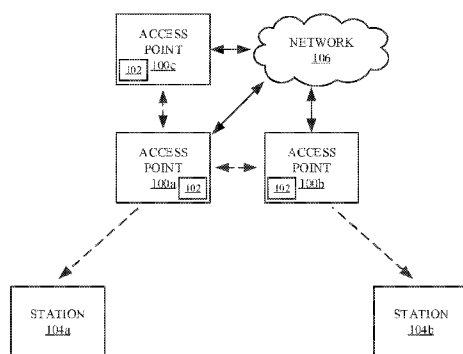


FIG. 1

(57) Abstract: Methods and apparatus for facilitating enhanced distributed channel access and backoff for access point triggers are disclosed. An example apparatus includes a component interface to instruct components of a first access point to transmit a trigger frame to a second access point; a functionality determiner to determine whether the trigger frame corresponds to a first trigger frame type or a second trigger frame type, the first trigger frame type corresponding to a solicited transmission that does not solicit a further response, the second trigger frame type corresponding to a solicited transmission that does solicit a further response; and a trigger frame tagger to tag the trigger frame transmission as a success or failure based on at least one of (A) the trigger frame type or (B) a response to the trigger frame transmission.

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METHODS AND APPARATUS TO FACILITATE ENHANCED DISTRIBUTED CHANNEL ACCESS AND BACKOFF FOR ACCESS POINT TRIGGERS

FIELD OF THE DISCLOSURE

5 This disclosure relates generally to wireless fidelity connectivity (Wi-Fi) and, more particularly, to methods and apparatus to facilitate enhanced distributed channel access and backoff for access point triggers.

BACKGROUND

Many locations provide Wi-Fi to connect Wi-Fi enabled devices to networks such as the
10 Internet. Wi-Fi enabled devices include personal computers, video-game consoles, mobile phones and devices, digital cameras, tablets, smart televisions, digital audio players, etc. Wi-Fi allows the Wi-Fi enabled devices to wirelessly access the Internet via a wireless local area network (WLAN). To provide Wi-Fi connectivity to a device, a Wi-Fi access point transmits a radio frequency Wi-Fi signal to the Wi-Fi enabled device within the access point (e.g., a hotspot)
15 signal range. Wi-Fi is implemented using a set of media access control (MAC) and physical layer (PHY) specifications (e.g., such as the Institute of Electrical and Electronics Engineers (IEEE) 802.11 protocol).

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an illustration of communication using wireless local area network (WLAN)
20 Wi-Fi protocols to facilitate enhanced distributed channel access and backoff for access point triggers.

FIGS. 2A-2C are timing diagrams illustrating different access point trigger frames that may be transmitted by an example access point of FIG. 1.

FIG. 3 is a block diagram of an example backoff determiner of FIG. 1.

25 FIGS. 4-6 are flowcharts representative of example machine readable instructions that may be executed to implement the example backoff determiner of FIGS. 1 and/or 3.

FIG. 7 is a block diagram of a radio architecture in accordance with some examples.

FIG. 8 illustrates an example front-end module circuitry for use in the radio architecture of FIG. 7 in accordance with some examples.

30 FIG. 9 illustrates an example radio IC circuitry for use in the radio architecture of FIG. 7 in accordance with some examples.

FIG. 10 illustrates an example baseband processing circuitry for use in the radio architecture of FIG. 7 in accordance with some examples.

FIG. 11 is a block diagram of a processor platform structured to execute the example machine readable instructions of FIG. 4-6 to implement the example backoff determiner of FIG.

3.

The figures are not to scale. Wherever possible, the same reference numbers will be used throughout the drawing(s) and accompanying written description to refer to the same or like parts.

DETAILED DESCRIPTION

Various locations (e.g., homes, offices, coffee shops, restaurants, parks, airports, etc.) may provide Wi-Fi to Wi-Fi enabled devices (e.g., stations (STA)) to connect the Wi-Fi enabled devices to the Internet, or any other network, with minimal hassle. The locations may provide one or more Wi-Fi access points (APs) to output Wi-Fi signals to the Wi-Fi enabled device within a range of the Wi-Fi signals (e.g., a hotspot). A Wi-Fi AP is structured to wirelessly connect a Wi-Fi enabled device to the Internet through a wireless local area network (WLAN) using Wi-Fi protocols (e.g., such as IEEE 802.11). The Wi-Fi protocol is the protocol by which the AP communicates with the STAs to provide access to the Internet by transmitting uplink (UL) transmissions and receiving downlink (DL) transmissions to/from the Internet.

Some Wi-Fi protocols (e.g., 802.11ax) include a trigger frame (TF) to solicit simultaneous uplink (UL) transmission to two or more STAs in one basic service set (BSS). The TF enables STAs solicited by the TF to have time synchronization and frequency synchronization so that the simultaneous UL transmissions do not interfere with each other. Accordingly, TF usage enables orthogonal frequency-division multiple access (OFDMA) or multiple user multiple input multiple output (MU-MIMO) UL transmissions to increase system throughput. In some examples, a TF (e.g., an AP TF) is utilized by APs to schedule simultaneous DL transmissions from two or more STAs to two different APs (e.g., a first AP transmitting a first DL transmission to a first STA while a second AP transmits a second DL transmission to a second STA). Such simultaneous DL transmissions may occur on (A) the same frequency band in different physical areas (e.g., spatial reuse) or (B) different frequency bands (e.g., OFDMA) so as not to interfere with one-another. The AP TF is a trigger frame that solicits other APs for (A) simultaneous DL transmissions, (B) feedback from the other APs, or (C)

soliciting control signal frames (e.g., clear to send (CTS) frames for CTS operation) for protection.

Wi-Fi protocols include a backoff procedure for adjusting enhanced distributed channel access (EDCA) parameters (e.g., the length of a contention window or retry count) based on the success or failure of transmissions (e.g., data transmissions, control signal transmissions, etc.) to avoid Wi-Fi collisions. A contention window corresponds to a duration of time in which the network is operating in contention mode. Contention mode corresponds to using distributed coordination function to share a frequency band between multiple stations. Accordingly, a long contention window may be desirable in when Wi-Fi traffic is heavier, to account for a higher probability of collisions, and a short contention window may be desirable when Wi-Fi traffic is lighter, to speed up the Wi-Fi communication process. A retry count corresponds to the number of times the AP will retry a transmission before determining that the transmission has failed. If a transmission corresponds to a success (e.g., based on predefined parameters), the contention window and/or retry count may be shortened or reset for subsequent transmissions. If the transmissions correspond to a failure (e.g., based on predefined parameters), the contention window and/or retry count may be extended for subsequent transmissions. Adjusting the EDCA parameters based on previous transmissions optimizes network congestion avoidance, thereby decreasing the probability of subsequent collisions while conserving time and resources. Examples disclosed herein include backoff procedure for different AP TF types (e.g., AP TFs corresponding to a solicited transmission from an AP that solicits a further response and AP TFs corresponding to a solicited transmission from an AP that does not solicit a further response).

FIG. 1 illustrates communications using wireless local area network Wi-Fi protocols to facilitate EDCA and backoff for access point triggers. FIG. 1 includes example access points 100a-c each having an example backoff determiner 102a-c, example STAs 104a-b, and an example network 106.

The example APs 100a-c of FIG. 1 are devices that allow the example STAs 104a-b to access the example network 106 (e.g., the Internet). The example APs 100a-c may be routers, modem-routers, and/or any other devices that provide a wireless connection to the example network 106. In one example, an AP 100a may be a router that provides a wireless communication link to a STA 104a. The AP 100a accesses the network 106 through a wire connection via a modem. A modem-router combines the functionalities of the modem and the

router. The APs 100a-c each include the example backoff determiners 102a-c. The example backoff determiners 102a-c are further explained below.

The example backoff determiners 102a-c of FIG. 1 facilitate the backoff corresponding to an AP TF. The example backoff determiners 102a-c interface with the components of the example APs 100a-c to facilitate a AP TF transmission. In response to the AP TF transmission, the backoff determiner corresponding to the AP that transmitted the AP TF (e.g., the example backoff determiner 102a of the example AP 100a) tags the AP TF transmission as a success or failure based on various conditions depending on the AP TF type. The AP TF type corresponds to the functionality of the AP TF. As described above, the AP TF function may correspond to (A) simultaneous DL transmissions, (B) feedback from the other APs, or (C) soliciting CTS frames for protection.

The example backoff determiners 102a-c of FIG. 1 determine an AP TF type based on the functionalities of the AP TF. In some examples, the AP TF may correspond to a first type or a second type. The first AP TF type corresponds to a frame that solicits transmission from an AP and the solicited transmission from the AP does not solicit further transmission. For example, a AP TF generated by the first example AP 100a may solicit a feedback response and/or a CTS from the example APs 100b-c, and the solicited transmission does not solicit a further transmission from the example APs 100b-c (e.g., corresponding to the example timing diagrams 200, 210 of FIGS. 2A-B). The second AP TF type corresponds to a frame that solicits transmission from an AP and the solicited transmission from the AP solicits further transmission. For example, a AP TF generated by the first example AP 100a may solicit a transmission of DL data to the example STA 104b from the example APs 100b, and the solicited transmission solicits a further transmission from the example STA 104b (e.g., an acknowledgement) (e.g., corresponding to the example timing diagram 220 of FIG. 2C). Examples of the two AP TF types are further described below in conjunction with FIGS. 2A-C. The backoff protocol corresponding to each AP TF type implemented by one of the example backoff determiners 102a-c is further described below in conjunction with FIGS. 4-6. One of the example backoff determiners 102a-c is further described below in conjunction with FIG. 2.

The example STAs 104a-b of FIG. 1 are Wi-Fi enabled computing devices. The example STAs 104a-b may be, for example, computing devices, portable devices, mobile devices, mobile telephones, smart phones, tablets, gaming systems, digital cameras, digital video recorders,

televisions, set top boxes, e-book readers, and/or any other Wi-Fi enabled devices. The example STAs 104a-b communicate with the example APs 100a-c to access the example network 106 (e.g., the Internet).

The example network 106 of FIG. 1 is a system of interconnected systems exchanging data. The example network 106 may be implemented using any type of public or private network such as, but not limited to, the Internet, a telephone network, a local area network (LAN), a cable network, and/or a wireless network. To enable communication via the network 106, the example Wi-Fi APs 100a-c include a communication interface that enables a connection to an Ethernet, a digital subscriber line (DSL), a telephone line, a coaxial cable, or any wireless connection, etc.

FIGS. 2A-2C illustrates example timing diagrams 200, 210, 220 of AP TFs of different types. The example timing diagram 200 of FIG. 2A includes the example APs 100a-c of FIG. 1, an example AP TF 202, and example feedback responses 204. The example timing diagram 210 of FIG. 2B includes the example APs 100a-c of FIG. 1, an example AP TF 212, and example CTSs 214. The example timing diagram 220 of FIG. 2C includes the example APs 100a-b and the example STAs 104a-b of FIG. 1. The example timing diagram 220 further includes an example AP TF 222, example data packets 224a-b, and example acknowledgements 226a-b.

The example timing diagram 200 of FIG. 2A includes the example AP 100a transmitting the example AP TF 202 to the example solicited APs 100b-c. In the illustrated example, the AP TF 202 corresponds to a feedback request for information (e.g., number and/or identification of connected STAs, frequency bands being utilized, status of the AP, etc.) from the example APs 100b-c. In response to receiving the example AP TF 202, the example APs 100b-c respond with the example feedback responses 204 corresponding to the information requested in the example AP TF 202. As shown in the illustrated timing diagram 200, the AP TF 202 corresponds to a solicited transmission that does not solicit further transmission. AP TFs that correspond to a solicited transmission that does not solicit further transmission correspond to a first AP TF type, as described above in conjunction with FIG. 2. When a backup determiner of an AP that generates the AP TF (e.g., the example backup determiner 102a) determines that an AP TF (e.g., the example AP TF 202) corresponds to a first AP TF type, the example backoff determiner 102a determines whether transmission of the AP TF 202 is a success or failure based on predefined parameters, as further described below in conjunction with FIG. 3.

The example timing diagram 210 of FIG. 2B includes the example AP 100a transmitting the example AP TF 212 to the example solicited APs 100b-c. In the illustrated example, the AP TF 212 corresponds to a CTS transmission. In response to receiving the example AP TF 212, the example APs 100a-c respond with transmission of the example CTSs 214. As shown in the illustrated timing diagram 210, the AP TF 212 corresponds to a solicited transmission that does not solicit further transmission. AP TFs that correspond to a solicited transmission that does not solicit further transmission correspond to a first AP TF type, as described above in conjunction with FIG. 2. When a backup determiner of an AP that generates the AP TF (e.g., the example backup determiner 102a) determines that an AP TF (e.g., the example AP TF 212) corresponds to a first AP TF type, the example backoff determiner 102a determines whether transmission of the AP TF 212 is a success or failure based on predefined parameters, as further described below in conjunction with FIG. 3.

The example timing diagram 220 of FIG. 2C includes the example AP 100a transmitting the example AP TF 222 to the example solicited AP 100b. In the illustrated example, the AP TF 222 corresponds to the example AP 100b transmitting a DL packet to the example STA 104b, while the example AP 100a transmits a DL packet to the example STA 104a. In response to receiving the example AP TF 222, the example AP 100b responds by transmitting the example DL data 224b, which solicits the example STA 104b to transmit the example acknowledgement 226b back to the example STA 104b. At the same time, in response to transmitting the example AP TF 222, the example AP 100a transmits the example DL data 224a, which solicits the example STA 104a to transmit the example acknowledgement 226a back to the example AP 100b. Accordingly, the AP TF 222 corresponds to a solicited transmission that solicits further transmission. AP TFs that correspond to a solicited transmission that solicits further transmission correspond to a second AP TF type, as described above in conjunction with FIG. 2. When a backup determiner of an AP that generates the AP TF (e.g., the example backup determiner 102a) determines that an AP TF (e.g., the example AP TF 222) corresponds to a second AP TF type, the example backoff determiner 102a determines whether transmission of the AP TF 222 is a success or failure based on predefined parameters, as further described below in conjunction with FIG. 3.

FIG. 3 is a block diagram of the example backoff determiner 102a of FIG. 1. The example backoff determiner 102a includes an example AP component interface 300, an example

functionality determiner 302, an example TF tagger 304, and an example EDCA parameter updater 306. Although the backoff determiner 102a of the example AP 100a is illustrated in FIG. 3, FIG. 3 describes any backoff determiner (e.g., the example backoff determiners 102a-c) or any AP (e.g., the example APs 100a-c).

5 The example AP component interface 300 of FIG. 3 interfaces with components of the example AP 100a to transmit signals (e.g., including data signals, control signals, etc.), receive signals, and/or sense communications between the devices of FIG. 1 (e.g., the example APs 100b-c and/or the example STAs 104a-b). For example, the AP component interface 300 may instruct the radio architecture of the AP (e.g., the example radio architecture 700 of FIG. 7) to
10 transmit AP TFs, receive responses to AP TF and/or other packet transmissions, and/or sense communication between other devices. The example AP component interface 300 may facilitate the transmission of an AP TF using any access category of EDCA to do backoff (e.g., for different priority levels). Additionally, the example AP component interface 300 receives instructions from a processor of the AP 100a (e.g., the example application processor 710 of
15 FIG. 7) to initiate backoff corresponding to an AP TF.

 The example functionality determiner 302 of FIG. 3 determines the functionality of the AP TF based on the instructions from the example AP 100a and/or based on the AP TF itself. For example, if the example AP TF corresponds to a request from other APs in the network (e.g., the example APs 100b-c), the example functionality determiner 302 determines that the AP TF
20 corresponds to a solicited transmission (e.g., the response to the request) that (A) does not solicit a further response (e.g., a first AP TF type), as described above in conjunction with FIGS. 2A-2B, or (B) does solicit a further response (e.g., a second AP TF type), as described above in conjunction with FIG. 2C. Additionally, the example functionality determiner 302 determines if the AP TF corresponds to (A) the AP 100a transmitting a signal at the same time as the solicited
25 APs 100b-c, as described above in conjunction with FIG. 2B or (B) the AP 100a not transmitting a signal at the same time as the solicited APs 100b-c, as described above in conjunction with FIG. 2A.

 The example TF tagger of FIG. 304 of FIG. 3 tags AP TF transmissions as failures or successes based on various parameters. For example, when the AP TF corresponds to a solicited
30 transmission that does not solicit a further response (e.g., a first AP TF type) and the example AP 100a is to transmit together with (e.g., at the same time as) the solicited APs 100b-c, the example

TF tagger 304 tags the AP TF as successful. When the AP TF corresponds to a solicited transmission that does not solicit a further response (e.g., a first AP TF type) and the example AP 100a is not to transmit at the same time as the solicited APs 100b-c, the example TF tagger 304 (A) tags the AP TF as successful when at least one response to the AP TF has been received from the solicited APs 100b-c and (B) tags the AP TF as a failure when no response to the AP TF is received. When the AP TF corresponds to a solicited transmission that solicits a further response (e.g., a second AP TF type) and the example AP 100a is not to transmit at the same time as the solicited APs 100b-c, the example TF tagger 304 (A) tags the AP TF as successful when at least one transmission corresponding to the AP TF has been sensed from at least one of the APs 100b-c (e.g., DL packets to the example STAs 104a-b) and/or at least one of the example STAs 104a-b (e.g., acknowledgements to the example APs 100b-c) and (B) tags the AP TF as a failure when no transmissions in response to the AP TF have been sensed.

In some examples, the TF tagger 304 determines if a first option or a second option is enabled for handling backoff when the AP TF corresponds to a solicited transmission that solicits a further response (e.g., a second AP TF type) and the example AP 100a is to transmit at the same time as the solicited APs 100b-c. For example, under the first option when the AP TF corresponds to a solicited transmission that solicits a further response (e.g., a second AP TF type) and the example AP 100a is to transmit at the same time as the solicited APs 100b-c, the example TF tagger 304 (A) tags the AP TF as successful when at least one response to the transmitted trigger frame has been received from the example STAs 104a-b (e.g., acknowledgements to the example APs 100b-c) and (B) tags the AP TF as a failure when no responses to the trigger frame have been received. Under the second option, when the AP TF corresponds to a solicited transmission that solicits a further response (e.g., a second AP TF type) and the example AP 100a is to transmit at the same time as the solicited APs 100b-c, the example TF tagger 304 always tags the AP TF transmission as successful. The enablement of the first or second option is based on user and/or manufacturer preferences.

The example EDCA parameter updater 306 of FIG. 3 updates the EDCA parameters based on the tagged AP TF transmissions. For example, the example EDCA parameter updater 306 may increase a retry count and/or a contention window based on one or more AP TF failures and/or may decrease and/or reset the retry count and/or contention window based one or more AP TF successes. In some examples, the example EDCA parameter updater 306 updates the

retry count and/or contention window based on a predefined number of successes and/or failures with a predefined duration.

While an example manner of implementing the example backoff determiner 102a of FIG. 1 is illustrated in FIG. 3, one or more of the elements, processes and/or devices illustrated in FIG. 3 may be combined, divided, re-arranged, omitted, eliminated and/or implemented in any other way. Further, the example AP component interface 300, the example functionality determiner 302, the example TF tagger 304, the example EDCA parameter updater 306, and/or, more generally, the example backoff determiner 102a of FIG. 3 and/or the example application processor 710 of FIG. 7 may be implemented by hardware, software, firmware and/or any combination of hardware, software and/or firmware. Thus, for example, any of the example AP component interface 300, the example functionality determiner 302, the example TF tagger 304, the example EDCA parameter updater 306, and/or, more generally, the example backoff determiner 102a of FIG. 3 and/or the example application processor 710 of FIG. 7 could be implemented by one or more analog or digital circuit(s), logic circuits, programmable processor(s), application specific integrated circuit(s) (ASIC(s)), programmable logic device(s) (PLD(s)) and/or field programmable logic device(s) (FPLD(s)). When reading any of the apparatus or system claims of this patent to cover a purely software and/or firmware implementation, at least one of the example AP component interface 300, the example functionality determiner 302, the example TF tagger 304, the example EDCA parameter updater 306, and/or, more generally, the example backoff determiner 102a of FIG. 3 and/or the example application processor 710 of FIG. 7 is/are hereby expressly defined to include a non-transitory computer readable storage device or storage disk such as a memory, a digital versatile disk (DVD), a compact disk (CD), a Blu-ray disk, etc. including the software and/or firmware. Further still, the example AP component interface 300, the example functionality determiner 302, the example TF tagger 304, the example EDCA parameter updater 306, and/or, more generally, the example backoff determiner 102a of FIG. 3 and/or the example application processor 710 of FIG. 7 may include one or more elements, processes and/or devices in addition to, or instead of, those illustrated in FIG. 2, and/or may include more than one of any or all of the illustrated elements, processes and devices.

Flowcharts representative of example machine readable instructions for implementing the example backoff determiner 102a of FIG. 3 are shown in FIGS. 4-6. In this example, the

machine readable instructions comprise a program for execution by a processor such as the processor 1112 shown in the example processor platform 1100 discussed below in connection with FIG. 11. The program may be embodied in software stored on a non-transitory computer readable storage medium such as a CD-ROM, a floppy disk, a hard drive, a digital versatile disk (DVD), a Blu-ray disk, or a memory associated with the processor 1112, but the entire program and/or parts thereof could alternatively be executed by a device other than the processor 1112 and/or embodied in firmware or dedicated hardware. Further, although the example program is described with reference to the flowchart illustrated in FIGS. 3-4, many other methods of implementing the example backoff determiner 102a may alternatively be used. For example, the order of execution of the blocks may be changed, and/or some of the blocks described may be changed, eliminated, or combined. Additionally or alternatively, any or all of the blocks may be implemented by one or more hardware circuits (e.g., discrete and/or integrated analog and/or digital circuitry, a Field Programmable Gate Array (FPGA), an Application Specific Integrated circuit (ASIC), a comparator, an operational-amplifier (op-amp), a logic circuit, etc.) structured to perform the corresponding operation without executing software or firmware.

As mentioned above, the example processes of FIGS. 4-6 may be implemented using coded instructions (e.g., computer and/or machine readable instructions) stored on a non-transitory computer and/or machine readable medium such as a hard disk drive, a flash memory, a read-only memory, a compact disk, a digital versatile disk, a cache, a random-access memory and/or any other storage device or storage disk in which information is stored for any duration (e.g., for extended time periods, permanently, for brief instances, for temporarily buffering, and/or for caching of the information). As used herein, the term non-transitory computer readable medium is expressly defined to include any type of computer readable storage device and/or storage disk and to exclude propagating signals and to exclude transmission media.

“Including” and “comprising” (and all forms and tenses thereof) are used herein to be open ended terms. Thus, whenever a claim lists anything following any form of “include” or “comprise” (e.g., comprises, includes, comprising, including, etc.), it is to be understood that additional elements, terms, etc. may be present without falling outside the scope of the corresponding claim. As used herein, when the phrase “at least” is used as the transition term in a preamble of a claim, it is open-ended in the same manner as the term “comprising” and “including” are open ended.

FIG. 4 is an example flowchart 400 representative of example machine readable instructions that may be executed by the example backoff determiner 102a of FIG. 1 to perform a backoff protocol for AP TF transmission. Although, the example flowchart 400 is described in conjunction with the backoff determiner 102a of the example AP 100a, the instructions may be executed by any of the example back off determiners 102a-c.

At block 402, the example AP component interface 300 receives instructions to transmit an AP TF. The instructions may come from a processor of the AP 100a (e.g., the example application processor 710 of FIG. 7). As described above, the AP TF may correspond to different functionalities (e.g., a feedback response, a CTS, DL data transmission, etc.). At block 404, the example functionality determiner 302 determines if the AP TF corresponds to a solicited transmission that solicits a further response (e.g., corresponding to the example timing diagrams 220 of FIG. 2C). The functionality determiner 302 may determine that the AP TF corresponds to a solicited transmission that solicits a further response based on the functionality corresponding to the AP TF transmission (e.g., the functionality corresponds to DL data transmission that requires an acknowledgement). In some examples, the functionality determiner 302 may determine that the AP TF corresponds to a solicited transmission that solicits a further response based on instructions from a processor (e.g., the example application processor 710) of the AP 100a.

If the example functionality determiner 302 determines that the AP TF corresponds to a solicited transmission that does not solicit a further response (e.g., corresponding to the timing diagrams 200, 210 of FIGS. 2A-B) (block 404: NO), the example backoff determiner 102a initiates a first backoff procedure of a first AP TF type (block 406). The initiation of the first backoff procedure of the first AP TF type is further described below in conjunction with FIG. 5. If the example functionality determiner 302 determines that the AP TF corresponds to a solicited transmission that solicits a further response (block 404: YES), the example backoff determiner 102a initiates a second backoff procedure of a second AP TF type (block 408). The initiation of the second backoff procedure of the second AP TF type is further described below in conjunction with FIG. 6.

At block 410, the example AP component interface 300 determines if a subsequent AP TF is to be transmitted (e.g., based on instructions from the application processor 710). If the example AP component interface 300 determines that a subsequent AP TF is to be transmitted

(block 410: YES), the process returns to block 402 to perform backoff for the subsequent AP TF. If the example AP component interface 300 determines that a subsequent AP TF is not to be transmitted (block 410: NO), the process ends.

FIG. 5 is an example flowchart 406 representative of example machine readable instructions that may be executed by the example backoff determiner 102a of FIG. 1 to initiate a first backoff procedure of a first AP TF type, as described above in conjunction with block 406 of FIG. 4. Although, the example flowchart 406 is described in conjunction with the backoff determiner 102a of the example AP 100a, the instructions may be executed by any of the example backoff determiners 102a-c.

At block 500, the example AP component interface 300 interfaces with components of the example AP 100a (e.g., the example radio architecture 700 of FIG. 7) to transmit the AP TF to the solicited APs (e.g., the example APs 100b-c). The example AP component interface 300 may facilitate the transmission of an AP TF using any access category of EDCA to do backoff. At block 502, the example functionality determiner 302 determines if the example AP 100a is to transmit at the same time as the solicited APs 100b-c. For example, if the AP TF corresponds to a CTS transmission, the example functionality determiner 302 determines that the example AP 100a will transmit the CTS in response to the AP TF at the same time as the APs 100b-c, as described above in conjunction with FIG. 2B. In another example, if the AP TF corresponds to a feedback request for information from the example APs 100b-c, the example functionality determiner 302 determines that the AP 100a will not transmit at the same time as the solicited APs 100b-c.

If the example functionality determiner 502 determines that the AP 100a is to transmit at the same time as the solicited APs 100b-c (block 502: YES), the example TF tagger 304 tags the AP TF transmission as successful (block 508). If the example functionality determiner 502 determines that the AP 100a is not to transmit at the same time as the solicited APs 100b-c (block 502: NO), the example AP component interface 300 determines if at least one response to the AP TF has been received from the solicited APs 100b-c (block 504). The example AP component interface 300 determines if a response has been received by interfacing with a receiver of the example radio architecture 700 of the example AP 100a.

If the example component interface 300 determines that at least one response to the AP TF has not been received from the solicited APs 100b-c (block 504: NO), the example TF tagger

304 tags the example AP TF transmission as a failure (block 506). If the example component interface 300 determines that at least one response to the AP TF has been received from the solicited APs 100b-c (block 504: YES), the example TF tagger 304 tags the example AP TF transmission as successful (block 508). At block 510, the example EDCA parameter updater 306
5 updates the EDCA parameters based on the tag. For example, the EDCA parameter updater 306 may increase the retry count and/or contention window based on a failure tag and may decrease the retry count and/or contention window based on a successful tag.

FIG. 6 is an example flowchart 408 representative of example machine readable instructions that may be executed by the example backoff determiner 102a of FIG. 1 to initiate a
10 second backoff procedure of a second AP TF type, as described above in conjunction with block 408 of FIG. 4. Although, the example flowchart 408 is described in conjunction with the backoff determiner 102a of the example AP 100a, the instructions may be executed by any of the example backoff determiner 102a-c.

At block 600, the example AP component interface 300 interfaces with components of
15 the example AP 100a (e.g., the example radio architecture 700 of FIG. 7) to transmit the AP TF to the solicited APs (e.g., the example APs 100b-c). The example AP component interface 300 may facilitate the transmission of an AP TF using any access category of EDCA to do backoff. At block 602, the example functionality determiner 302 determines if the example AP 100a is to transmit together with (e.g., at the same time as) the solicited APs 100b-c. For example, if the
20 AP TF corresponds to a DL data transmission, the example functionality determiner 302 determines that the example AP 100a will transmit the DL data in response to the AP TF at the same time as the APs 100b-c, as described above in conjunction with FIG. 2C. In another example, if the AP TF corresponds to instructing the APs 100b-c to transmit DL data while the AP 100a remains idle, the example functionality determiner 302 determines that the AP 100a
25 will not transmit at the same time as the solicited APs 100b-c.

If the example functionality determiner 502 determines that the AP 100a is not to transmit at the same time as the solicited APs 100b-c (block 602: NO), the process continues to block 612, as further described below. If the example functionality determiner 502 determines that the AP 100a is to transmit at the same time as the solicited APs 100b-c (block 602: YES),
30 the example TF tagger 304 determines if a first option is enabled (block 604). The first option corresponds with always tagging a second type AP TF transmission as successful with the AP is

to transmit at the same time as the solicited APs. A second option may alternatively be enabled. The second option corresponds to only tagging the AP TF transmission as successful when a response to the trigger frame has been received. The first option or second option may be enabled based on user and/or manufacturer preferences.

5 If the example TF tagger 304 determines that the first option is enabled (block 604: YES), the example TF tagger 304 tags the AP TF transmission as successful (block 610). If the example TF tagger 304 determines that the first option is not enabled (e.g., the second option is enabled) (block 604: NO), the example AP component interface 300 determines if at least one response to the transmitted data and/or trigger frame (e.g., an acknowledgement in response to a
10 DL packet transmission caused by the AP TF) has been received from the example STAs 104a-b (block 606). The example AP component interface 300 determines if a response has been received by interfacing with a receiver of the example radio architecture 700 of the example AP 100a.

 If the example component interface 300 determines that at least one response to the
15 transmitted and/or trigger frame has been not received from the example STAs 104a-b (block 606: NO), the example TF tagger 304 tags the example AP TF transmission as a failure (block 608). If the example component interface 300 determines that at least one response to the transmitted data and/or trigger frame has been received from the example STAs 104a-b (block 606: YES), the example TF tagger 304 tags the example AP TF transmission as successful (block
20 610).

 At block 612, the example AP component interface 300 determines if transmission corresponding to the AP TF has been sensed from at least one solicited AP 100b-c or at least one of the example STAs 104a-b (e.g., the DL data transmitted to the example STAs 104a-b and/or the acknowledgment from the STAs 104a-b in response to the transmitted DL data). The
25 example AP component interface 300 interfaces with the example radio architecture 700 to determine if the transmission has been sensed. If the example AP component interface 300 determines that a transmission corresponding to the AP TF has not been sensed (block 612: NO), the example TF tagger 304 tags the example AP TF transmission as a failure (block 614). If the example AP component interface 300 determines that a transmission corresponding to the AP TF
30 has been sensed (block 612: YES), the example TF tagger 304 tags the example AP TF transmission as successful (block 616).

At block 618, the example EDCA parameter updater 306 updates the EDCA parameters based on the tag. For example, the EDCA parameter updater 306 may increase the retry count and/or contention window based on a failure tag and may decrease the retry count and/or contention window based on a successful tag.

FIG. 7 is a block diagram of a radio architecture 700 in accordance with some embodiments that may be implemented in the example APs 100a-c. Radio architecture 700 may include radio front-end module (FEM) circuitry 704, radio IC circuitry 706 and baseband processing circuitry 708. Radio architecture 700 as shown includes both Wireless Local Area Network (WLAN) functionality and Bluetooth (BT) functionality although embodiments are not so limited. In this disclosure, “WLAN” and “Wi-Fi” are used interchangeably.

FEM circuitry 704 may include a WLAN or Wi-Fi FEM circuitry 704a and a Bluetooth (BT) FEM circuitry 704b. The WLAN FEM circuitry 704a may include a receive signal path comprising circuitry configured to operate on WLAN RF signals received from one or more antennas 701, to amplify the received signals and to provide the amplified versions of the received signals to the WLAN radio IC circuitry 706a for further processing. The BT FEM circuitry 704b may include a receive signal path which may include circuitry configured to operate on BT RF signals received from one or more antennas 701, to amplify the received signals and to provide the amplified versions of the received signals to the BT radio IC circuitry 706b for further processing. FEM circuitry 704a may also include a transmit signal path which may include circuitry configured to amplify WLAN signals provided by the radio IC circuitry 706a for wireless transmission by one or more of the antennas 701. In addition, FEM circuitry 704b may also include a transmit signal path which may include circuitry configured to amplify BT signals provided by the radio IC circuitry 706b for wireless transmission by the one or more antennas. In the embodiment of FIG. 7, although FEM 704a and FEM 704b are shown as being distinct from one another, embodiments are not so limited, and include within their scope the use of an FEM (not shown) that includes a transmit path and/or a receive path for both WLAN and BT signals, or the use of one or more FEM circuitries where at least some of the FEM circuitries share transmit and/or receive signal paths for both WLAN and BT signals.

Radio IC circuitry 706 as shown may include WLAN radio IC circuitry 706a and BT radio IC circuitry 706b. The WLAN radio IC circuitry 706a may include a receive signal path which may include circuitry to down-convert WLAN RF signals received from the FEM

circuitry 704a and provide baseband signals to WLAN baseband processing circuitry 708a. BT radio IC circuitry 706b may in turn include a receive signal path which may include circuitry to down-convert BT RF signals received from the FEM circuitry 704b and provide baseband signals to BT baseband processing circuitry 708b. WLAN radio IC circuitry 706a may also include a transmit signal path which may include circuitry to up-convert WLAN baseband signals provided by the WLAN baseband processing circuitry 708a and provide WLAN RF output signals to the FEM circuitry 704a for subsequent wireless transmission by the one or more antennas 701. BT radio IC circuitry 706b may also include a transmit signal path which may include circuitry to up-convert BT baseband signals provided by the BT baseband processing circuitry 708b and provide BT RF output signals to the FEM circuitry 704b for subsequent wireless transmission by the one or more antennas 701. In the embodiment of FIG. 7, although radio IC circuitries 706a and 706b are shown as being distinct from one another, embodiments are not so limited, and include within their scope the use of a radio IC circuitry (not shown) that includes a transmit signal path and/or a receive signal path for both WLAN and BT signals, or the use of one or more radio IC circuitries where at least some of the radio IC circuitries share transmit and/or receive signal paths for both WLAN and BT signals.

Baseband processing circuitry 708 may include a WLAN baseband processing circuitry 708a and a BT baseband processing circuitry 708b. The WLAN baseband processing circuitry 708a may include a memory, such as, for example, a set of RAM arrays in a Fast Fourier Transform or Inverse Fast Fourier Transform block (not shown) of the WLAN baseband processing circuitry 708a. Each of the WLAN baseband circuitry 708a and the BT baseband circuitry 708b may further include one or more processors and control logic to process the signals received from the corresponding WLAN or BT receive signal path of the radio IC circuitry 706, and to also generate corresponding WLAN or BT baseband signals for the transmit signal path of the radio IC circuitry 706. Each of the baseband processing circuitries 708a and 708b may further include physical layer (PHY) and medium access control layer (MAC) circuitry, and may further interface with application processor 710 for generation and processing of the baseband signals and for controlling operations of the radio IC circuitry 706.

Referring still to FIG. 7, according to the shown embodiment, WLAN-BT coexistence circuitry 713 may include logic providing an interface between the WLAN baseband circuitry 708a and the BT baseband circuitry 708b to enable use cases requiring WLAN and BT

coexistence. In addition, a switch 703 may be provided between the WLAN FEM circuitry 704a and the BT FEM circuitry 704b to allow switching between the WLAN and BT radios according to application needs. In addition, although the antennas 701 are depicted as being respectively connected to the WLAN FEM circuitry 704a and the BT FEM circuitry 704b, embodiments
5 include within their scope the sharing of one or more antennas as between the WLAN and BT FEMs, or the provision of more than one antenna connected to each of FEM 704a or 704b.

In some embodiments, the front-end module circuitry 704, the radio IC circuitry 706, and baseband processing circuitry 708 may be provided on a single radio card, such as wireless radio card 702. In some other embodiments, the one or more antennas 701, the FEM circuitry 704 and
10 the radio IC circuitry 706 may be provided on a single radio card. In some other embodiments, the radio IC circuitry 706 and the baseband processing circuitry 708 may be provided on a single chip or integrated circuit (IC), such as IC 712.

In some embodiments, the wireless radio card 702 may include a WLAN radio card and may be configured for Wi-Fi communications, although the scope of the embodiments is not
15 limited in this respect. In some of these embodiments, the radio architecture 700 may be configured to receive and transmit orthogonal frequency division multiplexed (OFDM) or orthogonal frequency division multiple access (OFDMA) communication signals over a multicarrier communication channel. The OFDM or OFDMA signals may comprise a plurality of orthogonal subcarriers.

In some of these multicarrier embodiments, radio architecture 700 may be part of a Wi-Fi communication station (STA) such as a wireless access point (AP), a base station or a mobile device including a Wi-Fi device. In some of these embodiments, radio architecture 700 may be configured to transmit and receive signals in accordance with specific communication standards and/or protocols, such as any of the Institute of Electrical and Electronics Engineers (IEEE)
20 standards including, 802.11n-2009, IEEE 802.11-2012, IEEE 802.11-2016, 802.11n-2009, 802.11ac, 802.11ah, 802.11ad, 802.11ay and/or 802.11ax standards and/or proposed specifications for WLANs, although the scope of embodiments is not limited in this respect. Radio architecture 700 may also be suitable to transmit and/or receive communications in accordance with other techniques and standards.

In some embodiments, the radio architecture 700 may be configured for high-efficiency Wi-Fi (HEW) communications in accordance with the IEEE 802.11ax standard. In these
30

embodiments, the radio architecture 700 may be configured to communicate in accordance with an OFDMA technique, although the scope of the embodiments is not limited in this respect.

In some other embodiments, the radio architecture 700 may be configured to transmit and receive signals transmitted using one or more other modulation techniques such as spread
5 spectrum modulation (e.g., direct sequence code division multiple access (DS-CDMA) and/or frequency hopping code division multiple access (FH-CDMA)), time-division multiplexing (TDM) modulation, and/or frequency-division multiplexing (FDM) modulation, although the scope of the embodiments is not limited in this respect.

In some embodiments, as further shown in FIG. 7, the BT baseband circuitry 708b may
10 be compliant with a Bluetooth (BT) connectivity standard such as Bluetooth, Bluetooth 9.0 or Bluetooth 7.0, or any other iteration of the Bluetooth Standard. In embodiments that include BT functionality as shown for example in FIG. 7, the radio architecture 700 may be configured to establish a BT synchronous connection oriented (SCO) link and or a BT low energy (BT LE) link. In some of the embodiments that include functionality, the radio architecture 700 may be
15 configured to establish an extended SCO (eSCO) link for BT communications, although the scope of the embodiments is not limited in this respect. In some of these embodiments that include a BT functionality, the radio architecture may be configured to engage in a BT Asynchronous Connection-Less (ACL) communications, although the scope of the embodiments is not limited in this respect. In some embodiments, as shown in FIG. 7, the functions of a BT
20 radio card and WLAN radio card may be combined on a single wireless radio card, such as single wireless radio card 702, although embodiments are not so limited, and include within their scope discrete WLAN and BT radio cards

In some embodiments, the radio-architecture 700 may include other radio cards, such as a cellular radio card configured for cellular (e.g., 5GPP such as LTE, LTE-Advanced or 7G
25 communications).

In some IEEE 802.11 embodiments, the radio architecture 700 may be configured for communication over various channel bandwidths including bandwidths having center frequencies of about 900 MHz, 2.4 GHz, 5 GHz, and bandwidths of about 2 MHz, 4 MHz, 8
5 MHz, 5.5 MHz, 6 MHz, 8 MHz, 10 MHz, 40 MHz, 9 GHz, 46 GHz, 80 MHz, 100 MHz, 80
30 MHz (with contiguous bandwidths) or 80+80 MHz (160MHz) (with non-contiguous

bandwidths). In some embodiments, a 920 MHz channel bandwidth may be used. The scope of the embodiments is not limited with respect to the above center frequencies however.

FIG. 8 illustrates FEM circuitry 704 in accordance with some embodiments. The FEM circuitry 704 is one example of circuitry that may be suitable for use as the WLAN and/or BT FEM circuitry 704a/404b (FIG. 7), although other circuitry configurations may also be suitable.

In some embodiments, the FEM circuitry 704 may include a TX/RX switch 802 to switch between transmit mode and receive mode operation. The FEM circuitry 704 may include a receive signal path and a transmit signal path. The receive signal path of the FEM circuitry 704 may include a low-noise amplifier (LNA) 806 to amplify received RF signals 803 and provide the amplified received RF signals 807 as an output (e.g., to the radio IC circuitry 706 (FIG. 7)). The transmit signal path of the circuitry 704 may include a power amplifier (PA) to amplify input RF signals 809 (e.g., provided by the radio IC circuitry 706), and one or more filters 812, such as band-pass filters (BPFs), low-pass filters (LPFs) or other types of filters, to generate RF signals 815 for subsequent transmission (e.g., by one or more of the antennas 701 (FIG. 7)) via an example duplexer 814.

In some dual-mode embodiments for Wi-Fi communication, the FEM circuitry 704 may be configured to operate in either the 2.4 GHz frequency spectrum or the 9 GHz frequency spectrum. In these embodiments, the receive signal path of the FEM circuitry 704 may include a receive signal path duplexer 804 to separate the signals from each spectrum as well as provide a separate LNA 806 for each spectrum as shown. In these embodiments, the transmit signal path of the FEM circuitry 704 may also include a power amplifier 810 and a filter 812, such as a BPF, a LPF or another type of filter for each frequency spectrum and a transmit signal path duplexer 804 to provide the signals of one of the different spectrums onto a single transmit path for subsequent transmission by the one or more of the antennas 701 (FIG. 7). In some embodiments, BT communications may utilize the 2.4 GHZ signal paths and may utilize the same FEM circuitry 704 as the one used for WLAN communications.

FIG. 9 illustrates radio IC circuitry 706 in accordance with some embodiments. The radio IC circuitry 706 is one example of circuitry that may be suitable for use as the WLAN or BT radio IC circuitry 706a/406b (FIG. 7), although other circuitry configurations may also be suitable.

In some embodiments, the radio IC circuitry 706 may include a receive signal path and a transmit signal path. The receive signal path of the radio IC circuitry 706 may include at least mixer circuitry 902, such as, for example, down-conversion mixer circuitry, amplifier circuitry 906 and filter circuitry 908. The transmit signal path of the radio IC circuitry 706 may include at least filter circuitry 912 and mixer circuitry 914, such as, for example, up-conversion mixer circuitry. Radio IC circuitry 706 may also include synthesizer circuitry 904 for synthesizing a frequency 905 for use by the mixer circuitry 902 and the mixer circuitry 914. The mixer circuitry 902 and/or 914 may each, according to some embodiments, be configured to provide direct conversion functionality. The latter type of circuitry presents a much simpler architecture as compared with standard super-heterodyne mixer circuitries, and any flicker noise brought about by the same may be alleviated for example through the use of OFDM modulation. FIG. 9 illustrates only a simplified version of a radio IC circuitry, and may include, although not shown, embodiments where each of the depicted circuitries may include more than one component. For instance, mixer circuitry 914 may each include one or more mixers, and filter circuitries 908 and/or 912 may each include one or more filters, such as one or more BPFs and/or LPFs according to application needs. For example, when mixer circuitries are of the direct-conversion type, they may each include two or more mixers.

In some embodiments, mixer circuitry 902 may be configured to down-convert RF signals 807 received from the FEM circuitry 704 (FIG. 7) based on the synthesized frequency 905 provided by synthesizer circuitry 904. The amplifier circuitry 906 may be configured to amplify the down-converted signals and the filter circuitry 908 may include a LPF configured to remove unwanted signals from the down-converted signals to generate output baseband signals 907. Output baseband signals 907 may be provided to the baseband processing circuitry 708 (FIG. 7) for further processing. In some embodiments, the output baseband signals 907 may be zero-frequency baseband signals, although this is not a requirement. In some embodiments, mixer circuitry 902 may comprise passive mixers, although the scope of the embodiments is not limited in this respect.

In some embodiments, the mixer circuitry 914 may be configured to up-convert input baseband signals 911 based on the synthesized frequency 905 provided by the synthesizer circuitry 904 to generate RF output signals 809 for the FEM circuitry 704. The baseband signals 911 may be provided by the baseband processing circuitry 708 and may be filtered by filter

circuitry 912. The filter circuitry 912 may include a LPF or a BPF, although the scope of the embodiments is not limited in this respect.

In some embodiments, the mixer circuitry 902 and the mixer circuitry 914 may each include two or more mixers and may be arranged for quadrature down-conversion and/or up-
5 conversion respectively with the help of synthesizer 904. In some embodiments, the mixer circuitry 902 and the mixer circuitry 914 may each include two or more mixers each configured for image rejection (e.g., Hartley image rejection). In some embodiments, the mixer circuitry 902 and the mixer circuitry 914 may be arranged for direct down-conversion and/or direct up-
10 conversion, respectively. In some embodiments, the mixer circuitry 902 and the mixer circuitry 914 may be configured for super-heterodyne operation, although this is not a requirement.

Mixer circuitry 902 may comprise, according to one embodiment: quadrature passive mixers (e.g., for the in-phase (I) and quadrature phase (Q) paths). In such an embodiment, RF input signal 807 from FIG. 9 may be down-converted to provide I and Q baseband output signals to be sent to the baseband processor

15 Quadrature passive mixers may be driven by zero and ninety-degree time-varying LO switching signals provided by a quadrature circuitry which may be configured to receive a LO frequency (f_{LO}) from a local oscillator or a synthesizer, such as LO frequency 905 of synthesizer 904 (FIG. 9). In some embodiments, the LO frequency may be the carrier frequency, while in other embodiments, the LO frequency may be a fraction of the carrier frequency (e.g., one-half
20 the carrier frequency, one-third the carrier frequency). In some embodiments, the zero and ninety-degree time-varying switching signals may be generated by the synthesizer, although the scope of the embodiments is not limited in this respect.

In some embodiments, the LO signals may differ in duty cycle (the percentage of one period in which the LO signal is high) and/or offset (the difference between start points of the
25 period). In some embodiments, the LO signals may have a 95% duty cycle and a 90% offset. In some embodiments, each branch of the mixer circuitry (e.g., the in-phase (I) and quadrature phase (Q) path) may operate at a 90% duty cycle, which may result in a significant reduction in power consumption.

The RF input signal 807 (FIG. 8) may comprise a balanced signal, although the scope of
30 the embodiments is not limited in this respect. The I and Q baseband output signals may be

provided to low-noise amplifier, such as amplifier circuitry 906 (FIG. 9) or to filter circuitry 908 (FIG. 9).

In some embodiments, the output baseband signals 907 and the input baseband signals 911 may be analog baseband signals, although the scope of the embodiments is not limited in this respect. In some alternate embodiments, the output baseband signals 907 and the input baseband signals 911 may be digital baseband signals. In these alternate embodiments, the radio IC circuitry may include analog-to-digital converter (ADC) and digital-to-analog converter (DAC) circuitry.

In some dual-mode embodiments, a separate radio IC circuitry may be provided for processing signals for each spectrum, or for other spectrums not mentioned here, although the scope of the embodiments is not limited in this respect.

In some embodiments, the synthesizer circuitry 904 may be a fractional-N synthesizer or a fractional $N/N+1$ synthesizer, although the scope of the embodiments is not limited in this respect as other types of frequency synthesizers may be suitable. For example, synthesizer circuitry 904 may be a delta-sigma synthesizer, a frequency multiplier, or a synthesizer comprising a phase-locked loop with a frequency divider. According to some embodiments, the synthesizer circuitry 904 may include digital synthesizer circuitry. An advantage of using a digital synthesizer circuitry is that, although it may still include some analog components, its footprint may be scaled down much more than the footprint of an analog synthesizer circuitry.

In some embodiments, frequency input into synthesizer circuitry 904 may be provided by a voltage controlled oscillator (VCO), although that is not a requirement. A divider control input may further be provided by either the baseband processing circuitry 708 (FIG. 7) or the application processor 710 (FIG. 7) depending on the desired output frequency 905. In some embodiments, a divider control input (e.g., N) may be determined from a look-up table (e.g., within a Wi-Fi card) based on a channel number and a channel center frequency as determined or indicated by the application processor 710. The application processor 710 may include, or otherwise be connected to, the example backoff determiners 102a-c of FIG. 1 and/or 3.

In some embodiments, synthesizer circuitry 904 may be configured to generate a carrier frequency as the output frequency 905, while in other embodiments, the output frequency 905 may be a fraction of the carrier frequency (e.g., one-half the carrier frequency, one-third the

carrier frequency). In some embodiments, the output frequency 905 may be a LO frequency (fLO).

FIG. 10 illustrates a functional block diagram of baseband processing circuitry 708 in accordance with some embodiments. The baseband processing circuitry 708 is one example of circuitry that may be suitable for use as the baseband processing circuitry 708 (FIG. 7), although other circuitry configurations may also be suitable. The baseband processing circuitry 708 may include a receive baseband processor (RX BBP) 1002 for processing receive baseband signals 909 provided by the radio IC circuitry 706 (FIG. 7) and a transmit baseband processor (TX BBP) 1004 for generating transmit baseband signals 911 for the radio IC circuitry 706. The baseband processing circuitry 708 may also include control logic 1006 for coordinating the operations of the baseband processing circuitry 708.

In some embodiments (e.g., when analog baseband signals are exchanged between the baseband processing circuitry 708 and the radio IC circuitry 706), the baseband processing circuitry 708 may include ADC 1010 to convert analog baseband signals 1009 received from the radio IC circuitry 706 to digital baseband signals for processing by the RX BBP 1002. In these embodiments, the baseband processing circuitry 708 may also include DAC 1012 to convert digital baseband signals from the TX BBP 1004 to analog baseband signals 1011.

In some embodiments that communicate OFDM signals or OFDMA signals, such as through baseband processor 708a, the transmit baseband processor 1004 may be configured to generate OFDM or OFDMA signals as appropriate for transmission by performing an inverse fast Fourier transform (IFFT). The receive baseband processor 1002 may be configured to process received OFDM signals or OFDMA signals by performing an FFT. In some embodiments, the receive baseband processor 1002 may be configured to detect the presence of an OFDM signal or OFDMA signal by performing an autocorrelation, to detect a preamble, such as a short preamble, and by performing a cross-correlation, to detect a long preamble. The preambles may be part of a predetermined frame structure for Wi-Fi communication.

Referring back to FIG. 7, in some embodiments, the antennas 701 (FIG. 7) may each comprise one or more directional or omnidirectional antennas, 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 multiple-input multiple-output (MIMO) embodiments, the antennas may be effectively separated to take advantage of spatial

diversity and the different channel characteristics that may result. Antennas 701 may each include a set of phased-array antennas, although embodiments are not so limited.

Although the radio-architecture 700 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, 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, field-programmable gate arrays (FPGAs), 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 herein. In some embodiments, the functional elements may refer to one or more processes operating on one or more processing elements.

FIG. 11 is a block diagram of an example processor platform 1100 capable of executing the instructions of FIG. 4-6 to implement the example backoff determiner 102a of FIGS. 1 and/or 3. The processor platform 1100 can be, for example, a server, a personal computer, a mobile device (e.g., a cell phone, a smart phone, a tablet such as an iPadTM), a personal digital assistant (PDA), an Internet appliance, or any other type of computing device.

The processor platform 1100 of the illustrated example includes a processor 1112. The processor 1112 of the illustrated example is hardware. For example, the processor 1112 can be implemented by integrated circuits, logic circuits, microprocessors or controllers from any desired family or manufacturer.

The processor 1112 of the illustrated example includes a local memory 1113 (e.g., a cache). The example processor 1112 of FIG. 11 executes the instructions of FIG. 4-6 to implement the example AP component interface 300, the example functionality determiner 302, the example TF tagger 304, the example EDCA parameter updater 306 of FIG. 3 and/or the example application processor 710 of FIG. 7. The processor 1112 of the illustrated example is in communication with a main memory including a volatile memory 1114 and a non-volatile memory 1116 via a bus 1118. The volatile memory 1114 may be implemented by Synchronous Dynamic Random Access Memory (SDRAM), Dynamic Random Access Memory (DRAM), RAMBUS Dynamic Random Access Memory (RDRAM) and/or any other type of random access memory device. The non-volatile memory 1116 may be implemented by flash memory

and/or any other desired type of memory device. Access to the main memory 1114, 1116 is controlled by a clock controller.

The processor platform 1100 of the illustrated example also includes an interface circuit 1120. The interface circuit 1120 may be implemented by any type of interface standard, such as an Ethernet interface, a universal serial bus (USB), and/or a PCI express interface.

In the illustrated example, one or more input devices 1122 are connected to the interface circuit 1120. The input device(s) 1122 permit(s) a user to enter data and commands into the processor 1112. The input device(s) can be implemented by, for example, a sensor, a microphone, a camera (still or video), a keyboard, a button, a mouse, a touchscreen, a track-pad, a trackball, isopoint and/or a voice recognition system.

One or more output devices 1124 are also connected to the interface circuit 1120 of the illustrated example. The output devices 1124 can be implemented, for example, by display devices (e.g., a light emitting diode (LED), an organic light emitting diode (OLED), a liquid crystal display, a cathode ray tube display (CRT), a touchscreen, a tactile output device, and/or speakers). The interface circuit 1120 of the illustrated example, thus, typically includes a graphics driver card, a graphics driver chip or a graphics driver processor.

The interface circuit 1120 of the illustrated example also includes a communication device such as a transmitter, a receiver, a transceiver, a modem and/or network interface card to facilitate exchange of data with external machines (e.g., computing devices of any kind) via a network 1126 (e.g., an Ethernet connection, a digital subscriber line (DSL), a telephone line, coaxial cable, a cellular telephone system, etc.).

The processor platform 1100 of the illustrated example also includes one or more mass storage devices 1128 for storing software and/or data. Examples of such mass storage devices 1128 include floppy disk drives, hard drive disks, compact disk drives, Blu-ray disk drives, RAID systems, and digital versatile disk (DVD) drives.

The coded instructions 1132 of FIGS. 4-6 may be stored in the mass storage device 1128, in the volatile memory 1114, in the non-volatile memory 1116, and/or on a removable tangible computer readable storage medium such as a CD or DVD.

Example 1 is an apparatus for facilitating enhanced distributed channel access and backoff for an access point trigger. Example 1 includes a component interface to instruct components of a first access point to transmit a trigger frame to a second access point; a

functionality determiner to determine whether the trigger frame corresponds to a first trigger frame type or a second trigger frame type, the first trigger frame type corresponding to a solicited transmission that does not solicit a further response, the second trigger frame type corresponding to a solicited transmission that does solicit a further response; and a trigger frame tagger to tag the trigger frame transmission as a success or failure based on at least one of (A) the trigger frame type or (B) a response to the trigger frame transmission.

Example 2 includes the subject matter of Example 1, wherein the trigger frame tagger is to, when (A) the trigger frame corresponds to the first trigger frame type and (B) the first access point is not to transmit together with the second access point in response to the trigger frame: tag the trigger frame transmission as a failure when the response to the trigger frame transmission has not been received; and tag the trigger frame transmission as a success when at least one of the responses to the trigger frame transmission has been received.

Example 3 includes the subject matter of Example 2, wherein (A) the trigger frame corresponds to the first trigger frame type and (B) the first access point is not to transmit together with the second access point in response to the trigger frame when the trigger frame corresponds to a feedback request.

Example 4 includes the subject matter of Example 1, wherein the trigger frame tagger is to, when (A) the trigger frame corresponds the first trigger frame type and (B) the first access point is to transmit together with the second access point in response to the trigger frame, tag the trigger frame transmission as a success.

Example 5 includes the subject matter of Example 4, wherein (A) the trigger frame corresponds to the first trigger frame type and (B) the first access point is to transmit together with the second access point in response to the trigger frame when the trigger frame corresponds to a clear-to-send operation.

Example 6 includes the subject matter of Example 1, wherein the response corresponds to a data transmission corresponding to the trigger frame from the second access point or a station, the trigger frame tagger to, when (A) the trigger frame corresponds to the second trigger frame type and (B) the first access point is not to transmit together with the second access point in response to transmitting the trigger frame: tag the trigger frame transmission as a success when the transmission from the second access point or a station corresponding to the trigger frame has been sensed, the station receiving data from the second access point; and tag the trigger frame

transmission as a failure when the transmission from the second access point or a station corresponding to the trigger frame has not been sensed.

Example 7 includes the subject matter of Example 1, wherein the trigger frame tagger is to, when (A) the trigger frame corresponds to the second trigger frame type and (B) the first access point is to transmit together with the second access point in response to the trigger frame, tag the trigger frame transmission as a success.

Example 8 includes the subject matter of Example 1, wherein the trigger frame tagger is to, when (A) the trigger frame corresponds to the second trigger frame type and (B) the first access point is to transmit together with the second access point in response to the trigger frame: tag the trigger frame transmission as a success when the further response is received by the first access point; and tag the trigger frame transmission as a failure when the further response is not received by the first access point.

Example 9 includes the subject matter of Examples 1-8, further including an enhanced distributed channel access (EDCA) parameter updater to update EDCA parameters based on the tag, the EDCA parameters including at least one of a retry count or a contention window.

Example 10 includes the subject matter of Examples 1-8, wherein the functionality determiner is to determine whether the first access point is to transmit together with the second access point in response to transmitting the trigger frame.

Example 11 is a method for facilitating enhanced distributed channel access and backoff for an access point trigger. Example 11 includes instructing components of a first access point to transmit a trigger frame to a second access point; determining whether the trigger frame corresponds to a first trigger frame type or a second trigger frame type, the first trigger frame type corresponding to a solicited transmission that does not solicit a further response, the second trigger frame type corresponding to a solicited transmission that does solicit a further response; and tagging the trigger frame transmission as a success or failure based on at least one of (A) the trigger frame type or (B) a response to the trigger frame transmission.

Example 12 includes the subject matter of Example 11, further including, when (A) the trigger frame corresponds to the first trigger frame type and (B) the first access point is not to transmit together with the second access point in response to the trigger frame: tagging the trigger frame transmission as a failure when the response to the trigger frame transmission has

not been received; and tagging the trigger frame transmission as a success when at least one of the responses to the trigger frame transmission has been received.

Example 13 includes the subject matter of Example 12, wherein (A) the trigger frame corresponds to the first trigger frame type and (B) the first access point is not to transmit together with the second access point in response to the trigger frame when the trigger frame corresponds to a feedback request.

Example 14 includes the subject matter of Example 11, further including, when (A) the trigger frame corresponds the first trigger frame type and (B) the first access point is to transmit together with the second access point in response to the trigger frame, tagging the trigger frame transmission as a success.

Example 15 includes the subject matter of Example 14, wherein (A) the trigger frame corresponds to the first trigger frame type and (B) the first access point is to transmit together with the second access point in response to the trigger frame when the trigger frame corresponds to a clear-to-send operation.

Example 16 includes the subject matter of Example 11, wherein the response corresponds to a data transmission corresponding to the trigger frame from the second access point or a station, further including, when (A) the trigger frame corresponds to the second trigger frame type and (B) the first access point is not to transmit together with the second access point in response to transmitting the trigger frame: tagging the trigger frame transmission as a success when the transmission from the second access point or a station corresponding to the trigger frame has been sensed, the station receiving data from the second access point; and tagging the trigger frame transmission as a failure when the transmission from the second access point or a station corresponding to the trigger frame has not been sensed.

Example 17 includes the subject matter of Example 11, further including, when (A) the trigger frame corresponds to the second trigger frame type and (B) the first access point is to transmit together with the second access point in response to the trigger frame, tagging the trigger frame transmission as a success.

Example 18 includes the subject matter of Example 11, further including, when (A) the trigger frame corresponds to the second trigger frame type and (B) the first access point is to transmit together with the second access point in response to the trigger frame: tagging the trigger frame transmission as a success when the further response is received by the first access

point; and tagging the trigger frame transmission as a failure when the further response is not received by the first access point.

Example 19 includes the subject matter of Examples 11-18, further including updating EDCA parameters based on the tag, the EDCA parameters including at least one of a retry count
5 or a contention window.

Example 20 includes the subject matter of Examples 11-18, further including determining whether the first access point is to transmit together with the second access point in response to transmitting the trigger frame.

Example 21 a tangible computer readable storage medium comprising instructions which,
10 when executed, cause a machine to at least: instruct components of a first access point to transmit a trigger frame to a second access point; determine whether the trigger frame corresponds to a first trigger frame type or a second trigger frame type, the first trigger frame type corresponding to a solicited transmission that does not solicit a further response, the second trigger frame type corresponding to a solicited transmission that does solicit a further response;
15 and tag the trigger frame transmission as a success or failure based on at least one of (A) the trigger frame type or (B) a response to the trigger frame transmission.

Example 22 includes the subject matter of Example 21, wherein the instructions cause the machine to, when (A) the trigger frame corresponds to the first trigger frame type and (B) the first access point is not to transmit together with the second access point in response to the
20 trigger frame: tag the trigger frame transmission as a failure when the response to the trigger frame transmission has not been received; and tag the trigger frame transmission as a success when at least one of the responses to the trigger frame transmission has been received.

Example 23 includes the subject matter of Example 22, wherein (A) the trigger frame corresponds to the first trigger frame type and (B) the first access point is not to transmit together
25 with the second access point in response to the trigger frame when the trigger frame corresponds to a feedback request.

Example 24 includes the subject matter of Example 21, wherein the instructions cause the machine to, when (A) the trigger frame corresponds the first trigger frame type and (B) the first access point is to transmit together with the second access point in response to the trigger frame,
30 tag the trigger frame transmission as a success.

Example 25 includes the subject matter of Example 24, wherein (A) the trigger frame corresponds to the first trigger frame type and (B) the first access point is to transmit together with the second access point in response to the trigger frame when the trigger frame corresponds to a clear-to-send operation.

5 Example 26 includes the subject matter of Example 21, wherein the response corresponds to a data transmission corresponding to the trigger frame from the second access point or a station, wherein the instructions cause the machine to, when (A) the trigger frame corresponds to the second trigger frame type and (B) the first access point is not to transmit together with the second access point in response to transmitting the trigger frame: tag the trigger frame
10 transmission as a success when the transmission from the second access point or a station corresponding to the trigger frame has been sensed, the station receiving data from the second access point; and tag the trigger frame transmission as a failure when the transmission from the second access point or a station corresponding to the trigger frame has not been sensed.

 Example 27 includes the subject matter of Example 21, wherein the instructions cause the
15 machine to, when (A) the trigger frame corresponds to the second trigger frame type and (B) the first access point is to transmit together with the second access point in response to the trigger frame, tag the trigger frame transmission as a success.

 Example 28 includes the subject matter of Example 21, wherein the instructions cause the
20 machine to, when (A) the trigger frame corresponds to the second trigger frame type and (B) the first access point is to transmit together with the second access point in response to the trigger frame: tag the trigger frame transmission as a success when the further response is received by the first access point; and tag the trigger frame transmission as a failure when the further response is not received by the first access point.

 Example 29 includes the subject matter of Examples 21-28, wherein the instructions
25 cause the machine to update EDCA parameters based on the tag, the EDCA parameters including at least one of a retry count or a contention window.

 Example 30 includes the subject matter of Examples 21-28, wherein the instructions cause the machine to determine whether the first access point is to transmit together with the second access point in response to transmitting the trigger frame.

30 Example 31 is an apparatus for facilitating enhanced distributed channel access and backoff for an access point trigger. Example 31 includes a first means for instructing

components of a first access point to transmit a trigger frame to a second access point; a second means for determining whether the trigger frame corresponds to a first trigger frame type or a second trigger frame type, the first trigger frame type corresponding to a solicited transmission that does not solicit a further response, the second trigger frame type corresponding to a solicited transmission that does solicit a further response; and a third means for tagging the trigger frame transmission as a success or failure based on at least one of (A) the trigger frame type or (B) a response to the trigger frame transmission.

Example 32 includes the subject matter of Example 31, wherein the third means includes means for, when (A) the trigger frame corresponds to the first trigger frame type and (B) the first access point is not to transmit together with the second access point in response to the trigger frame: tagging the trigger frame transmission as a failure when the response to the trigger frame transmission has not been received; and tagging the trigger frame transmission as a success when at least one of the responses to the trigger frame transmission has been received.

Example 33 includes the subject matter of Example 32, wherein (A) the trigger frame corresponds to the first trigger frame type and (B) the first access point is not to transmit together with the second access point in response to the trigger frame when the trigger frame corresponds to a feedback request.

Example 34 includes the subject matter of Example 31, wherein the third means includes means for, when (A) the trigger frame corresponds the first trigger frame type and (B) the first access point is to transmit together with the second access point in response to the trigger frame, tagging the trigger frame transmission as a success.

Example 35 includes the subject matter of Example 34, wherein (A) the trigger frame corresponds to the first trigger frame type and (B) the first access point is to transmit together with the second access point in response to the trigger frame when the trigger frame corresponds to a clear-to-send operation.

Example 36 includes the subject matter of Example 31, wherein the response corresponds to a data transmission corresponding to the trigger frame from the second access point or a station, the third means include means for, when (A) the trigger frame corresponds to the second trigger frame type and (B) the first access point is not to transmit together with the second access point in response to transmitting the trigger frame: tagging the trigger frame transmission as a success when the transmission from the second access point or a station corresponding to the

trigger frame has been sensed, the station receiving data from the second access point; and tagging the trigger frame transmission as a failure when the transmission from the second access point or a station corresponding to the trigger frame has not been sensed.

Example 37 includes the subject matter of Example 31, wherein the third means includes
5 means for, when (A) the trigger frame corresponds to the second trigger frame type and (B) the first access point is to transmit together with the second access point in response to the trigger frame, tagging the trigger frame transmission as a success.

Example 38 includes the subject matter of Example 31, wherein the third means includes
10 means for, when (A) the trigger frame corresponds to the second trigger frame type and (B) the first access point is to transmit together with the second access point in response to the trigger frame: tagging the trigger frame transmission as a success when the further response is received by the first access point; and tagging the trigger frame transmission as a failure when the further response is not received by the first access point.

Example 32 includes the subject matter of Examples 31-38, further including fourth
15 means for updating EDCA parameters based on the tag, the EDCA parameters including at least one of a retry count or a contention window.

Example 32 includes the subject matter of Examples 31-38, wherein the second means includes means for determining whether the first access point is to transmit together with the second access point in response to transmitting the trigger frame.

20 From the foregoing, it would be appreciated that the above disclosed method, apparatus, and articles of manufacture facilitate enhanced distributed channel access and backoff for access point triggers. Examples disclosed herein provides a backoff protocol for determining a success or failure of a AP TF transmission in order to optimize EDCA parameters to increase throughput while minimizing time and resources. Such AP TF facilitate allow for various operations
25 including simultaneous DL transmissions (e.g., spatial reuse or OFDMA), thereby creating a link between Wi-Fi and other techniques (e.g., cellular networks).

Although certain example methods, apparatus and articles of manufacture have been described herein, the scope of coverage of this patent is not limited thereto. On the contrary, this patent covers all methods, apparatus and articles of manufacture fairly falling within the scope of
30 the claims of this patent.

What Is Claimed Is:

1. An apparatus for facilitating enhanced distributed channel access and backoff for an access point trigger, the apparatus comprising:

a component interface to instruct components of a first access point to transmit a trigger
5 frame to a second access point;

a functionality determiner to determine whether the trigger frame corresponds to a first trigger frame type or a second trigger frame type, the first trigger frame type corresponding to a solicited transmission that does not solicit a further response, the second trigger frame type corresponding to a solicited transmission that does solicit a further response; and

10 a trigger frame tagger to tag the trigger frame transmission as a success or failure based on at least one of (A) the trigger frame type or (B) a response to the trigger frame transmission.

2. The apparatus of claim 1, wherein the trigger frame tagger is to, when (A) the trigger frame corresponds to the first trigger frame type and (B) the first access point is not to transmit together with the second access point in response to the trigger frame:

15 tag the trigger frame transmission as a failure when the response to the trigger frame transmission has not been received; and

tag the trigger frame transmission as a success when at least one of the responses to the trigger frame transmission has been received.

3. The apparatus of claim 2, wherein (A) the trigger frame corresponds to the first trigger frame type and (B) the first access point is not to transmit together with the second access point in response to the trigger frame when the trigger frame corresponds to a feedback request.

4. The apparatus of claim 1, wherein the trigger frame tagger is to, when (A) the trigger frame corresponds the first trigger frame type and (B) the first access point is to transmit together with the second access point in response to the trigger frame, tag the trigger frame
25 transmission as a success.

5. The apparatus of claim 4, wherein (A) the trigger frame corresponds to the first trigger frame type and (B) the first access point is to transmit together with the second access point in response to the trigger frame when the trigger frame corresponds to a clear-to-send operation.

30 6. The apparatus of claim 1, wherein the response corresponds to a data transmission corresponding to the trigger frame from the second access point or a station, the trigger frame

tagger to, when (A) the trigger frame corresponds to the second trigger frame type and (B) the first access point is not to transmit together with the second access point in response to transmitting the trigger frame:

tag the trigger frame transmission as a success when the transmission from the second access point or a station corresponding to the trigger frame has been sensed, the station receiving data from the second access point; and

tag the trigger frame transmission as a failure when the transmission from the second access point or a station corresponding to the trigger frame has not been sensed.

7. The apparatus of claim 1, wherein the trigger frame tagger is to, when (A) the trigger frame corresponds to the second trigger frame type and (B) the first access point is to transmit together with the second access point in response to the trigger frame, tag the trigger frame transmission as a success.

8. The apparatus of claim 1, wherein the trigger frame tagger is to, when (A) the trigger frame corresponds to the second trigger frame type and (B) the first access point is to transmit together with the second access point in response to the trigger frame:

tag the trigger frame transmission as a success when the further response is received by the first access point; and

tag the trigger frame transmission as a failure when the further response is not received by the first access point.

9. The apparatus of one of claims 1-8, further including an enhanced distributed channel access (EDCA) parameter updater to update EDCA parameters based on the tag, the EDCA parameters including at least one of a retry count or a contention window.

10. The apparatus of one of claims 1-8, wherein the functionality determiner is to determine whether the first access point is to transmit together with the second access point in response to transmitting the trigger frame.

11. A method for facilitating enhanced distributed channel access and backoff for an access point trigger, the method comprising:

instructing components of a first access point to transmit a trigger frame to a second access point;

determining whether the trigger frame corresponds to a first trigger frame type or a second trigger frame type, the first trigger frame type corresponding to a solicited transmission

that does not solicit a further response, the second trigger frame type corresponding to a solicited transmission that does solicit a further response; and

tagging the trigger frame transmission as a success or failure based on at least one of (A) the trigger frame type or (B) a response to the trigger frame transmission.

5 12. The method of claim 11, further including, when (A) the trigger frame corresponds to the first trigger frame type and (B) the first access point is not to transmit together with the second access point in response to the trigger frame:

tagging the trigger frame transmission as a failure when the response to the trigger frame transmission has not been received; and

10 tagging the trigger frame transmission as a success when at least one of the responses to the trigger frame transmission has been received.

13. The method of claim 12, wherein (A) the trigger frame corresponds to the first trigger frame type and (B) the first access point is not to transmit together with the second access point in response to the trigger frame when the trigger frame corresponds to a feedback request.

15 14. The method of claim 11, further including, when (A) the trigger frame corresponds the first trigger frame type and (B) the first access point is to transmit together with the second access point in response to the trigger frame, tagging the trigger frame transmission as a success.

15 15. The method of claim 14, wherein (A) the trigger frame corresponds to the first trigger frame type and (B) the first access point is to transmit together with the second access point in response to the trigger frame when the trigger frame corresponds to a clear-to-send operation.

25 16. The method of claim 11, wherein the response corresponds to a data transmission corresponding to the trigger frame from the second access point or a station, further including, when (A) the trigger frame corresponds to the second trigger frame type and (B) the first access point is not to transmit together with the second access point in response to transmitting the trigger frame:

30 tagging the trigger frame transmission as a success when the transmission from the second access point or a station corresponding to the trigger frame has been sensed, the station receiving data from the second access point; and

tagging the trigger frame transmission as a failure when the transmission from the second access point or a station corresponding to the trigger frame has not been sensed.

17. The method of claim 11, further including, when (A) the trigger frame corresponds to the second trigger frame type and (B) the first access point is to transmit together with the second access point in response to the trigger frame, tagging the trigger frame transmission as a success.

18. The method of claim 11, further including, when (A) the trigger frame corresponds to the second trigger frame type and (B) the first access point is to transmit together with the second access point in response to the trigger frame:

tagging the trigger frame transmission as a success when the further response is received by the first access point; and

tagging the trigger frame transmission as a failure when the further response is not received by the first access point.

19. The method of one of claims 11-18, further including updating EDCA parameters based on the tag, the EDCA parameters including at least one of a retry count or a contention window.

20. The method of one of claims 11-18, further including determining whether the first access point is to transmit together with the second access point in response to transmitting the trigger frame.

21. A tangible computer readable storage medium comprising instructions which, when executed, cause a machine to at least:

instruct components of a first access point to transmit a trigger frame to a second access point;

determine whether the trigger frame corresponds to a first trigger frame type or a second trigger frame type, the first trigger frame type corresponding to a solicited transmission that does not solicit a further response, the second trigger frame type corresponding to a solicited transmission that does solicit a further response; and

tag the trigger frame transmission as a success or failure based on at least one of (A) the trigger frame type or (B) a response to the trigger frame transmission.

22. The computer readable storage medium of claim 21, wherein the instructions cause the machine to, when (A) the trigger frame corresponds to the first trigger frame type and

(B) the first access point is not to transmit together with the second access point in response to the trigger frame:

tag the trigger frame transmission as a failure when the response to the trigger frame transmission has not been received; and

5 tag the trigger frame transmission as a success when at least one of the responses to the trigger frame transmission has been received.

23. The computer readable storage medium of claim 22, wherein (A) the trigger frame corresponds to the first trigger frame type and (B) the first access point is not to transmit together with the second access point in response to the trigger frame when the trigger frame
10 corresponds to a feedback request.

24. The computer readable storage medium of claim 21, wherein the instructions cause the machine to, when (A) the trigger frame corresponds the first trigger frame type and (B) the first access point is to transmit together with the second access point in response to the trigger frame, tag the trigger frame transmission as a success.

15 25. The computer readable storage medium of claim 24, wherein (A) the trigger frame corresponds to the first trigger frame type and (B) the first access point is to transmit together with the second access point in response to the trigger frame when the trigger frame corresponds to a clear-to-send operation.

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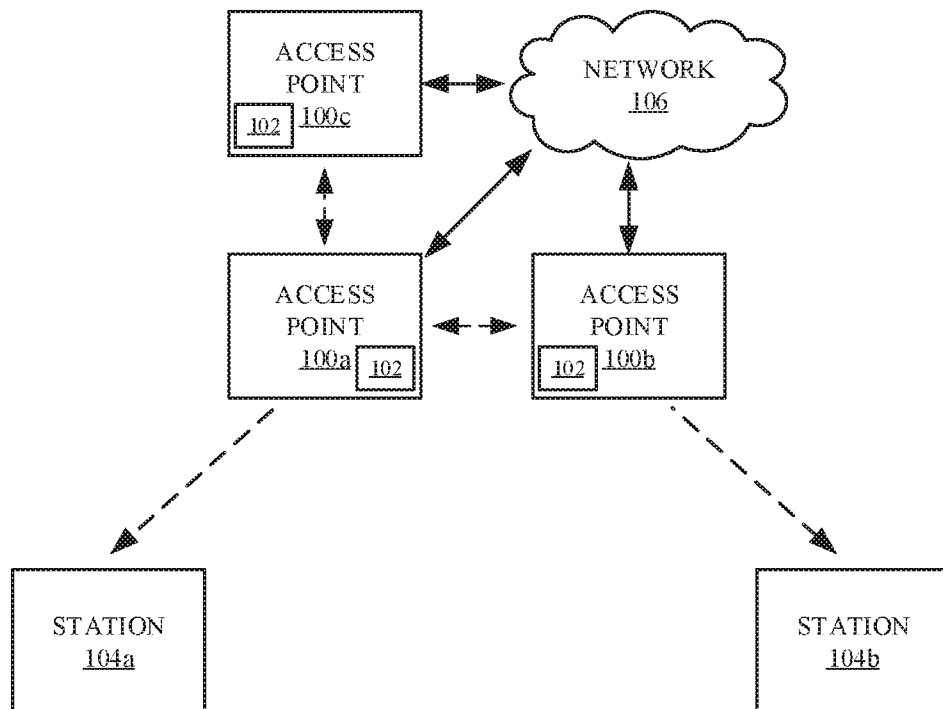


FIG. 1

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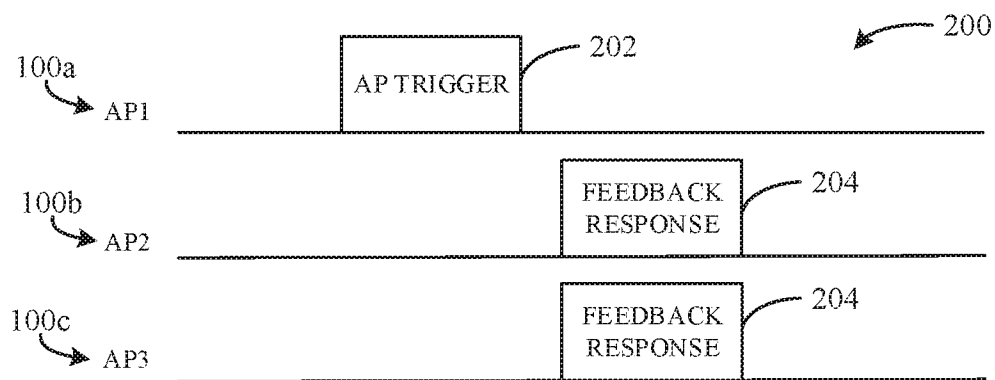


FIG. 2A

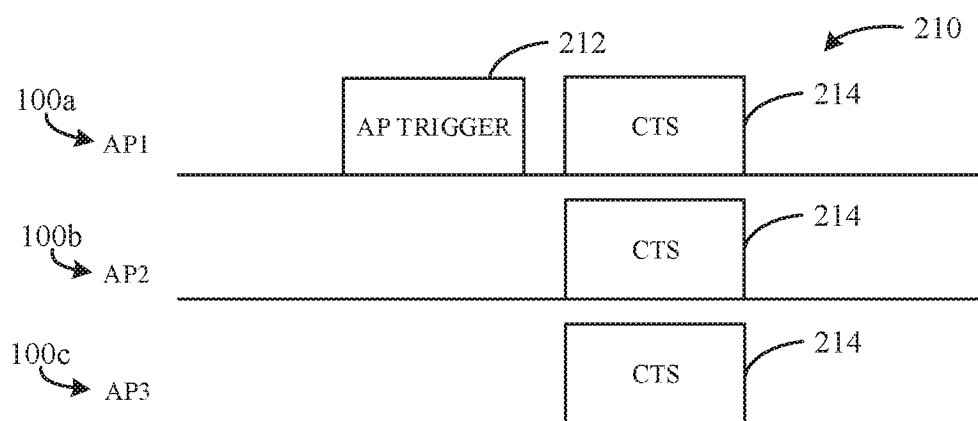


FIG. 2B

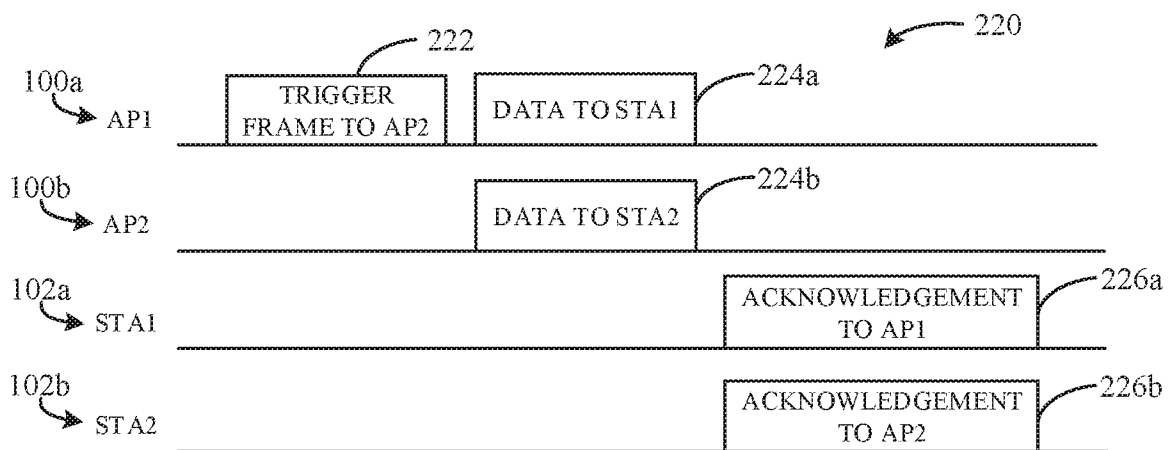


FIG. 2C

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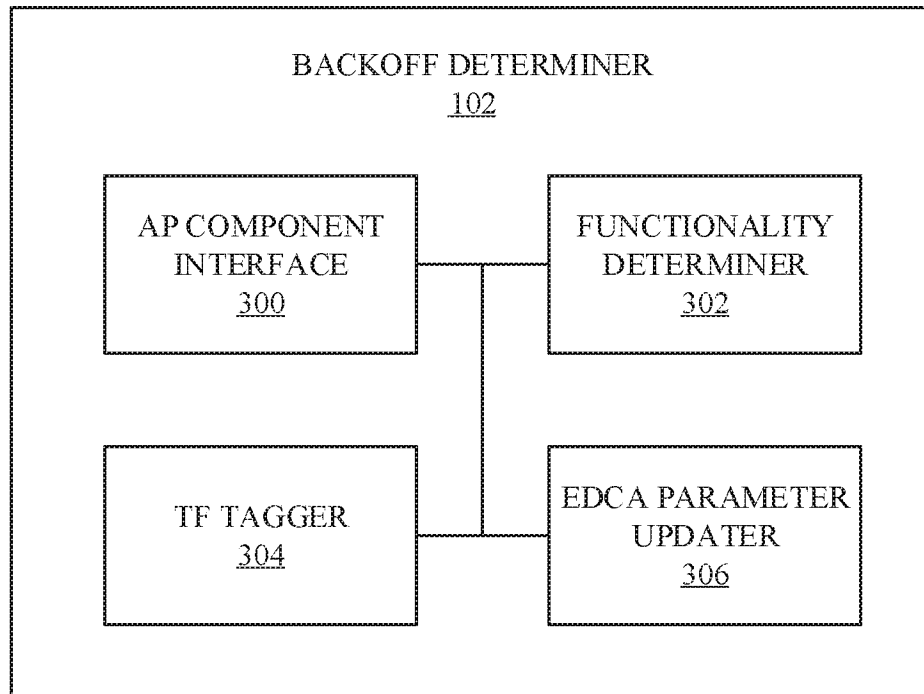


FIG. 3

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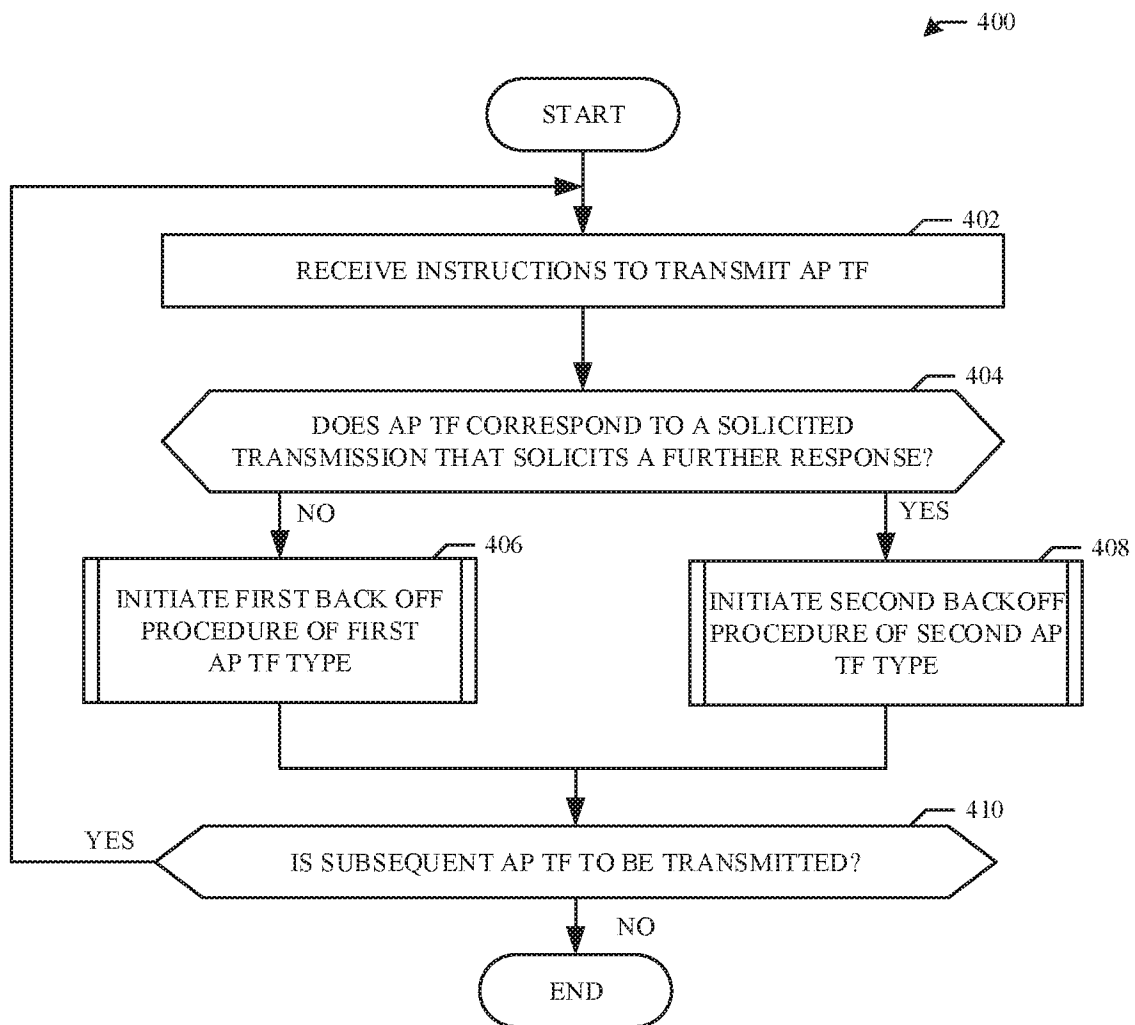


FIG. 4

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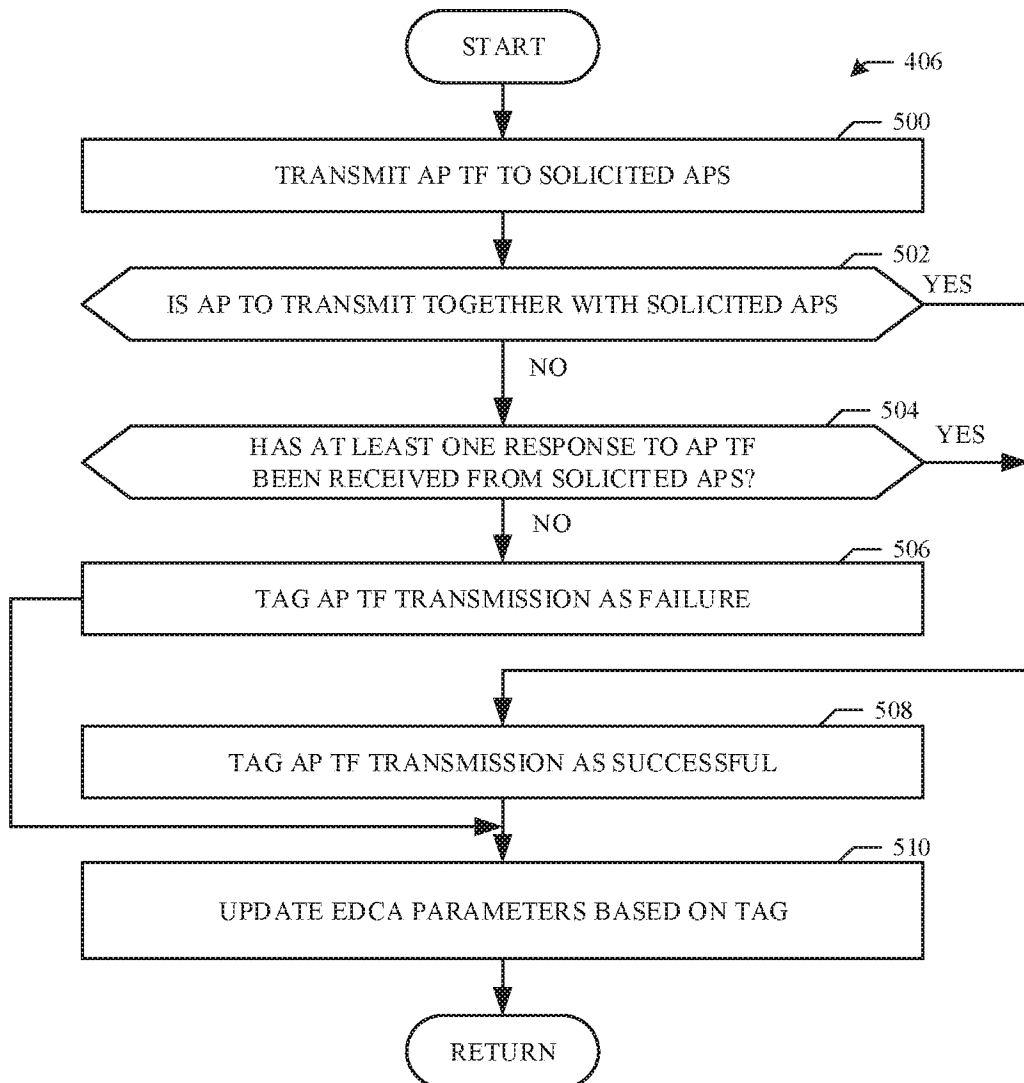


FIG. 5

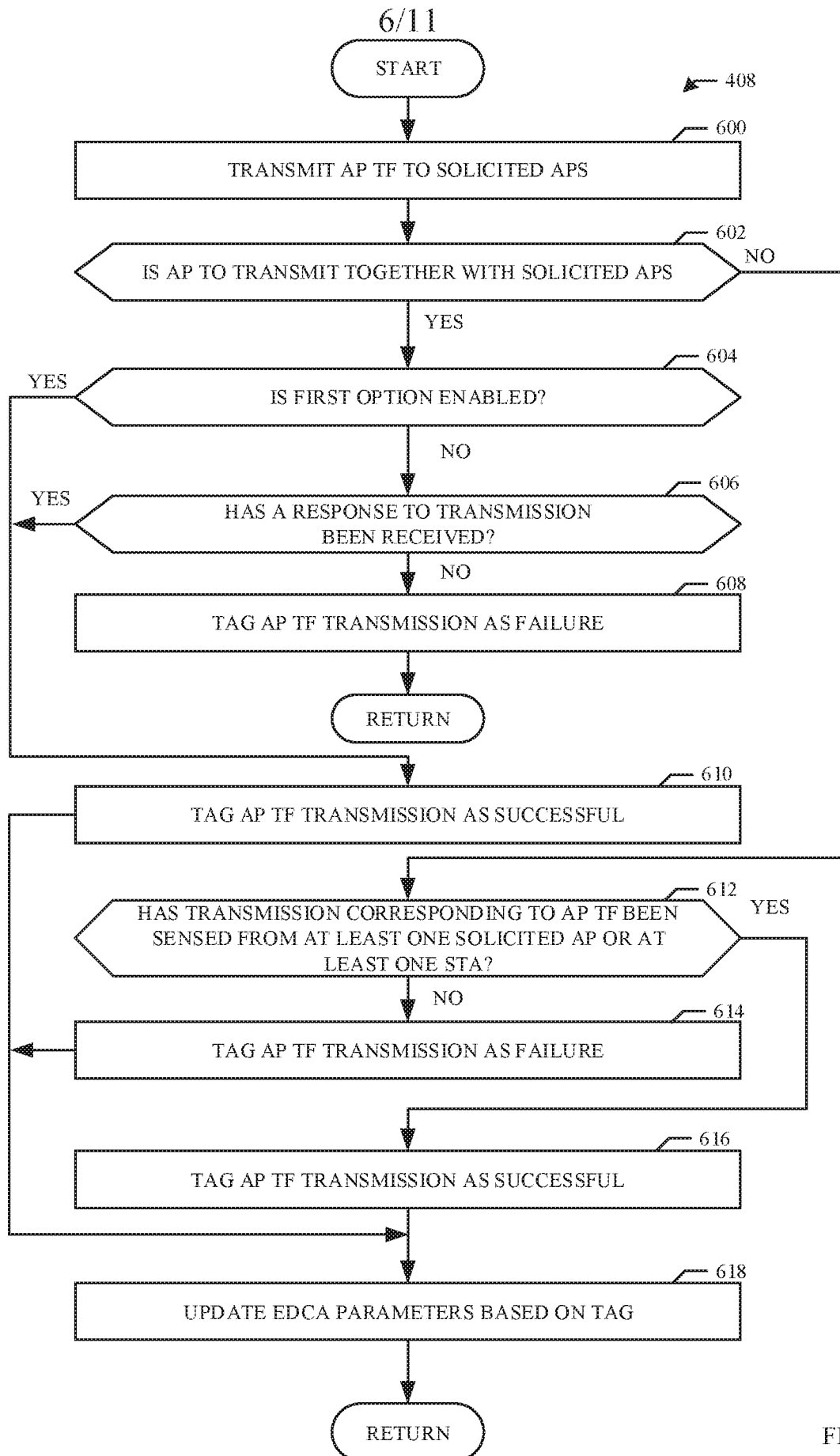


FIG. 6

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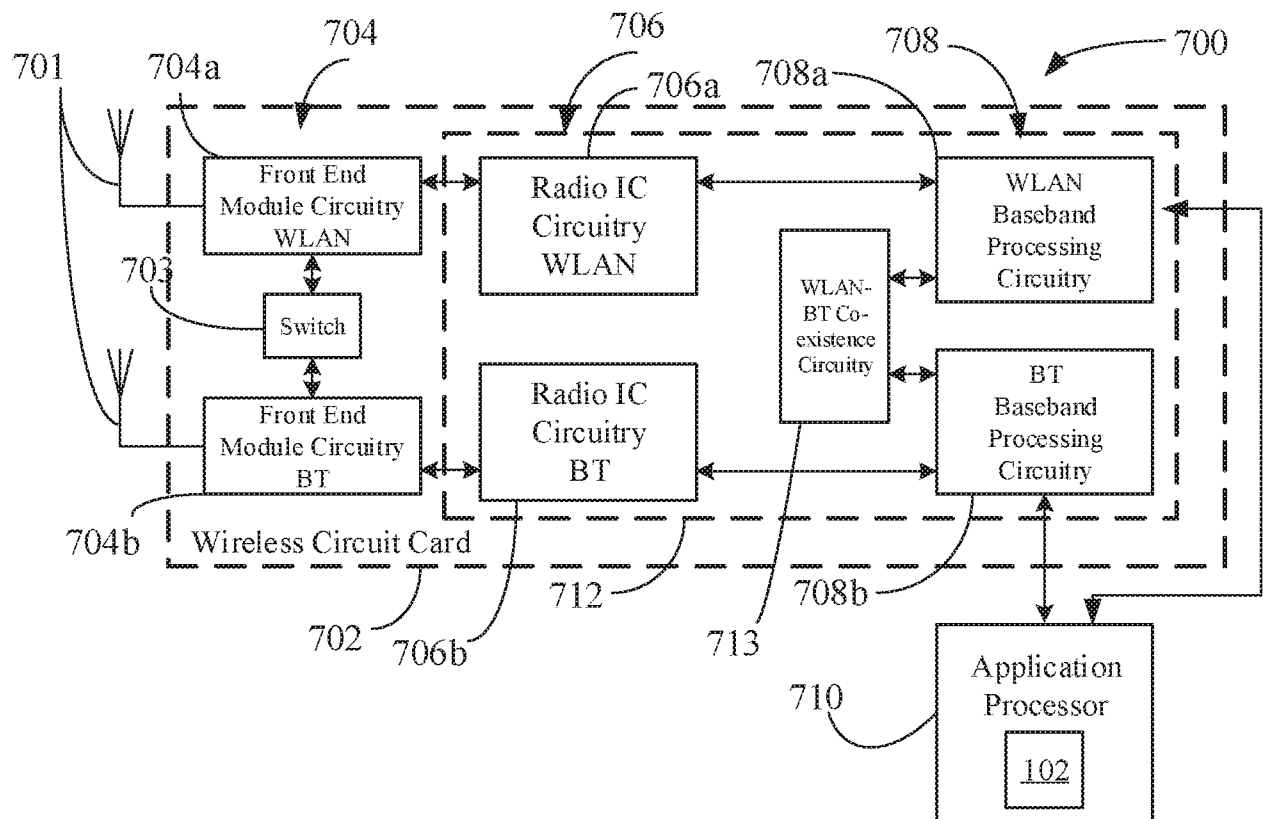


FIG. 7

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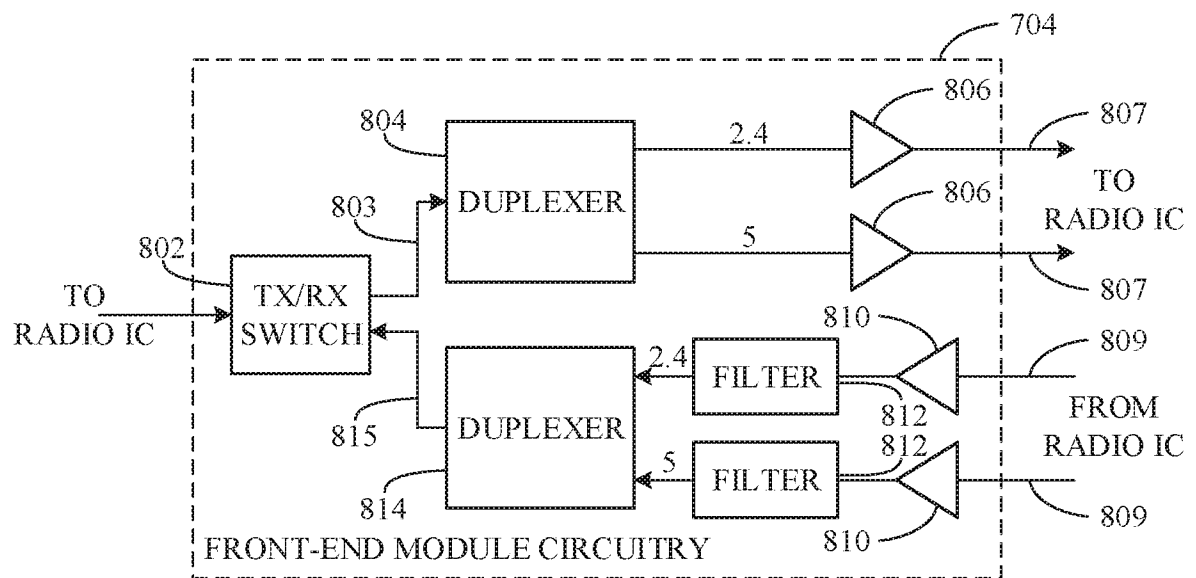


FIG. 8

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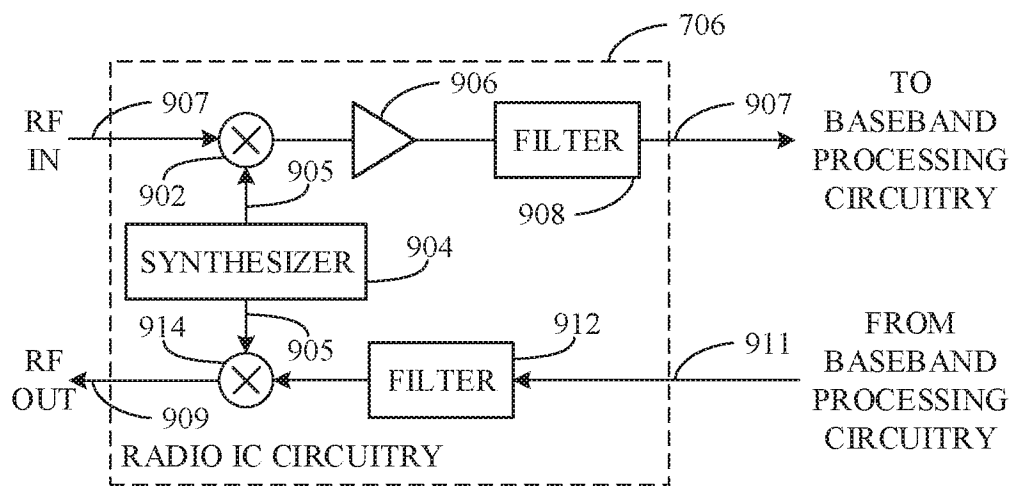


FIG. 9

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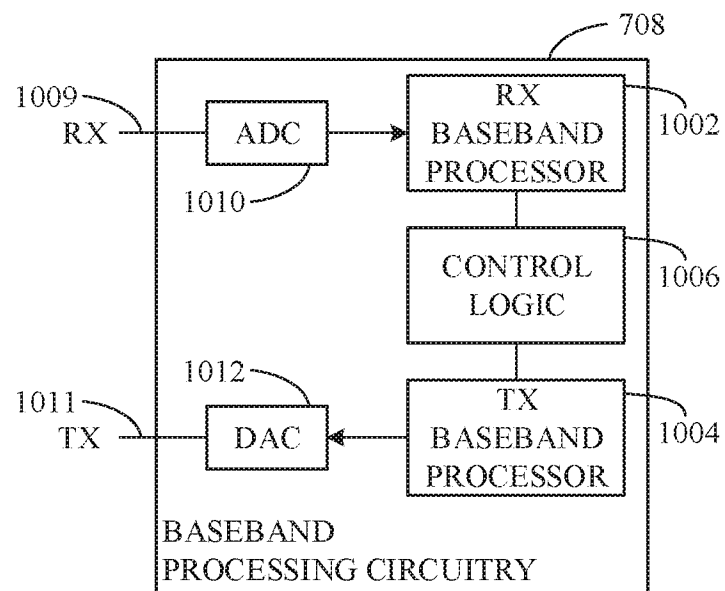


FIG. 10

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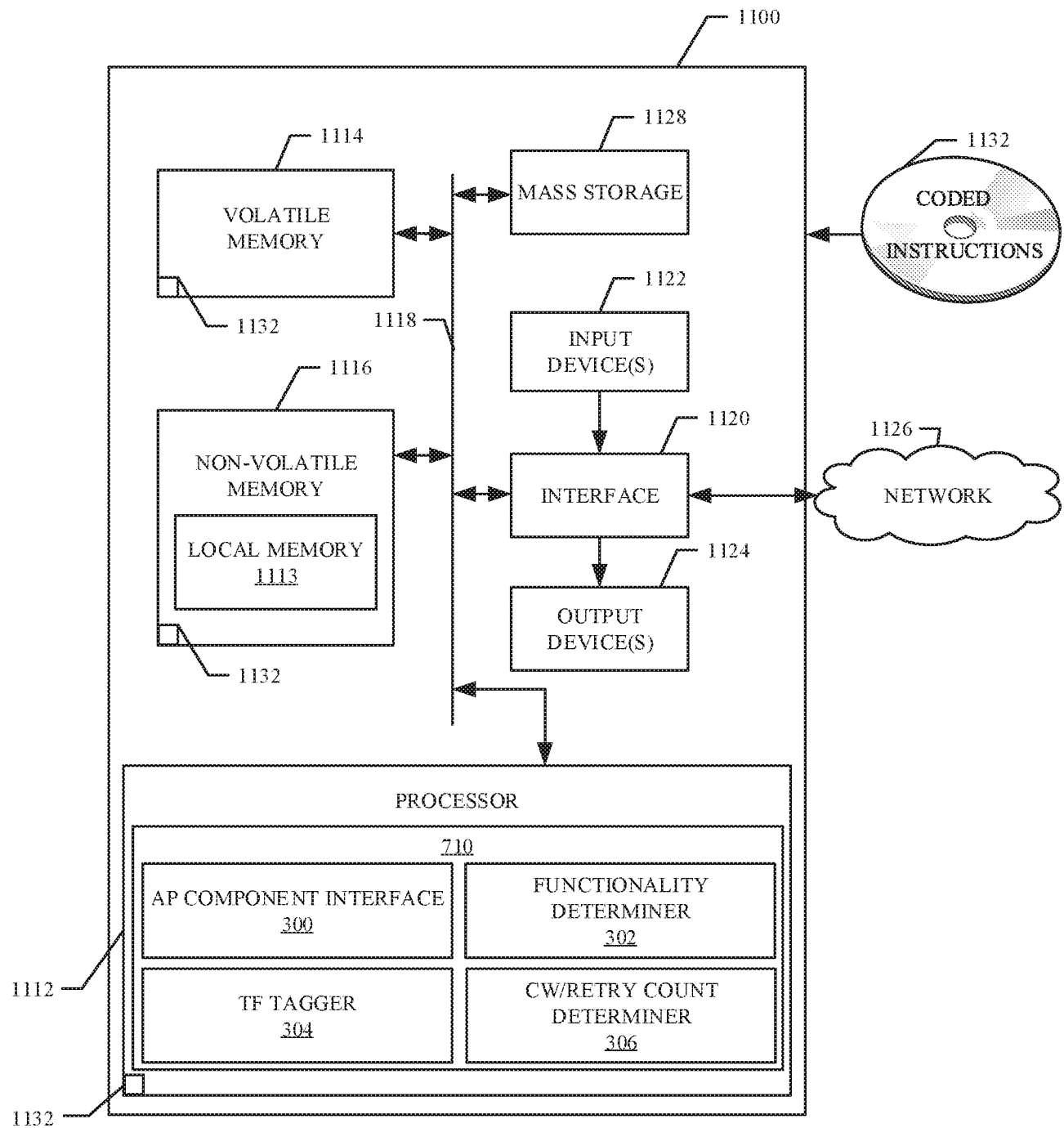


FIG. 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/054015**A. CLASSIFICATION OF SUBJECT MATTER****H04W 74/00(2009.01)i, 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 SEARCHEDMinimum documentation searched (classification system followed by classification symbols)
H04W 74/00; H04L 5/00; H04L 1/18; H04W 28/04; H04B 7/015; H04W 74/08; H04W 84/12Documentation 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 modelsElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: first access point, second access point, trigger frame type, response, backoff**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2006-107886 A2 (INTERDIGITAL TECHNOLOGY CORPORATION) 12 October 2006 See paragraph [0022]; and figure 2.	1-25
A	WO 2017-061797 A1 (LG ELECTRONICS INC.) 13 April 2017 See claims 14-15; and figure 16.	1-25
A	SEBASTIAN SPEICHER et al., 'Fast MAC-Layer Scanning in IEEE 802.11 Fixed Relay Radio Access Networks', In: ICN/ICONS/MCL 2006. International Conference on, 08 May 2006 See section 4.2.	1-25
A	US 2006-0009246 A1 (PAUL MARINIER et al.) 12 January 2006 See paragraph [0023]; and figure 1.	1-25
A	WO 2014-048402 A1 (HUAWEI TECHNOLOGIES CO., LTD.) 03 April 2014 See paragraph [0024]; and figure 3.	1-25



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

19 June 2018 (19.06.2018)

Date of mailing of the international search report

19 June 2018 (19.06.2018)

Name and mailing address of the ISA/KR

International Application Division

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2017/054015

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2006-107886 A2	12/10/2006	AR 053707 A1	16/05/2007
		AR 072164 A2	11/08/2010
		AU 2006-232543 A1	12/10/2006
		AU 2006-232543 B2	18/02/2010
		AU 2010-201957 A1	03/06/2010
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		CA 2603975 C	04/11/2014
		CN 101502032 A	05/08/2009
		CN 105743620 A	06/07/2016
		CN 105827373 A	03/08/2016
		CN 2930122 Y	01/08/2007
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