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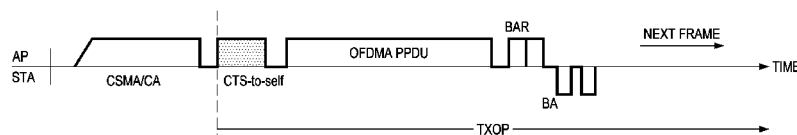


FIG. 2

(57) **Abstract:** Embodiments are provided for WLAN OFDMA operations in uplink and downlink transmissions. For OFDMA downlink transmission, an access point (AP) sends a signaling requesting protection of a transmission channel from access by stations (STAs) associated with the AP. The AP then sends an OFDMA physical layer Protocol Data Unit (PPDU) and a Block Acknowledgement Request (BAR) to the STAs, and receives a Block Acknowledgement (BA) from each one of the STAs. For OFDMA uplink transmissions, an STA sends a signaling requesting protection of a transmission channel from access by the AP. The STA then sends, to the AP, a frame indicating start of OFDMA transmission by the STA, and receives, from the AP, an OFDMA Begin Receive (OBR) frame, which is sent by the AP to participating STAs. The STA then sends an OFDMA PPDU and a BAR to the AP, and receives a BA in return.



System and Method for WLAN OFDMA Design of Uplink and Downlink Transmissions

This application claims the benefit of U.S. Provisional Application Serial No. 61/917,791, filed on December 18, 2013, and to U.S. Non-Provisional Patent Application No. 14/340,058 filed on July 24, 2014, which are hereby incorporated herein by reference as if reproduced in their entirety.

5 TECHNICAL FIELD

The present invention relates to network communications, and, in particular embodiments, to a system and method for WLAN OFDMA design of uplink and downlink transmissions.

BACKGROUND

10 Wireless Local Area Networks (WLANs) commonly operate in unlicensed spectrum bands. Rules for operation in these bands force competing devices to share the available resources and defer their intended transmissions when the medium is sensed busy. The medium refers to the transmission channel or bandwidth shared by multiple components of the WLAN to transmit uplink and downlink signals. The bandwidth (or
15 frequency range) is shared for uplink and downlink transmissions. Typically, a WLAN uses an Orthogonal Frequency-Division Multiplexing (OFDM) transmission format in which all transmission resources are assigned to a single device. Random assignment is commonly achieved using carrier sense multiple access with collision avoidance (CSMA/CA). With CSMA/CA a device wins access to the medium, transmits its data up
20 to a pre-defined period of time, and then gives up the medium for other devices to compete for transmission. In contrast, Orthogonal Frequency Division Multiple Access (OFDMA) is a transmission and access mechanism that accommodates multiple-user transmissions simultaneously. OFDMA is commonly implemented in wireless infrastructures operating in the licensed bands in order to meet timing information in
25 terms of frame structure and the scheduling of resources among a subset of users. There is a need for efficient schemes for implementing OFDMA in WLANs.

SUMMARY OF THE INVENTION

In accordance with an embodiment, a method by an access point (AP) for Orthogonal Frequency Division Multiple Access (OFDMA) downlink transmission in a Wireless Local Area Network (WLAN) includes sending a signaling requesting
5 protection of a transmission channel for downlink transmissions from access by stations (STAs) associated with the AP. The method further includes sending an OFDMA physical layer Protocol Data Unit (PPDU) to the STAs, and sending a Block Acknowledgement Request (BAR) to the STAs. In return, a Block Acknowledgement (BA) is received from each one of the STAs.

10 In accordance with another embodiment, a method by an STA for OFDMA downlink transmission in a WLAN includes detecting a signaling from an AP. The signaling indicates the AP requesting protection of a transmission channel from access by a plurality of STAs associated with the AP including the STA. The method further includes receiving, from the AP an OFDMA PPDU, and receiving, from the AP, a BAR.
15 The BAR is sent to all participating STAs. In return, the STA sends a BA to the AP.

In accordance with another embodiment, a method by a STA for OFDMA uplink transmissions in a WLAN includes sending a signaling requesting protection of a transmission channel from access by an AP of the STA. The method further includes sending, to the AP, a frame indicating start of OFDMA transmission by the STA, and
20 receiving, from the AP, an OFDMA Begin Receive (OBR) frame. The OBR frame is sent by the AP to a plurality of STAs associated with the AP including the STA. The STA then sends, to the AP, an OFDMA PPDU and a BAR after the OFDMA PPDU. In return, the STA receives a BA from the AP.

In accordance with another embodiment, a method by an AP for OFDMA uplink
25 transmission in a WLAN includes detecting a signaling from a STA. The signaling indicates the STA requesting protection of a transmission channel from access by the AP. The method further includes receiving, from the STA, a frame indicating start of OFDMA transmission by the STA, and sending, to a plurality of STAs associated with the AP including the STA, an OBR frame. The AP then receives, from the STA, an OFDMA
30 PPDU followed by a BA, and sends to the STA with a BA.

In accordance with another embodiment, an AP supporting OFDMA transmission in a WLAN comprises a processor and a computer readable storage medium storing

programming for execution by the processor. The programming includes instructions to send a signaling requesting protection of a transmission channel from access by STAs associated with the AP, and send an OFDMA PPDU to the STAs. The programming includes further instructions to send a BAR to the STAs, and receive a BA from each one
5 of the STAs.

In accordance with yet another embodiment, a user station supporting OFDMA transmission in a WLAN comprises a processor and a computer readable storage medium storing programming for execution by the processor. The programming includes instructions to send a signaling requesting protection of a transmission channel from
10 access by an AP of the user station, and send, to the AP, a frame indicating start of OFDMA transmission by the STA. The programming includes further instructions to receive, from the AP, an OBR frame which is sent by the AP to a plurality of STAs associated with the AP, and send, to the AP, an OFDMA PPDU. The programming further configure the user station to send a BAR to the AP, and receive a BA from the AP.

15 The foregoing has outlined rather broadly the features of an embodiment of the present invention in order that the detailed description of the invention that follows may be better understood. Additional features and advantages of embodiments of the invention will be described hereinafter, which form the subject of the claims of the invention. It should be appreciated by those skilled in the art that the conception and
20 specific embodiments disclosed may be readily utilized as a basis for modifying or designing other structures or processes for carrying out the same purposes of the present invention. It should also be realized by those skilled in the art that such equivalent constructions do not depart from the spirit and scope of the invention as set forth in the appended claims.

25

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawing, in which:

5 Figure 1 illustrates a WLAN basic service set (BSS);

 Figure 2 illustrates embodiment of events during a downlink (DL) OFDMA TXOP;

 Figure 3 illustrates a Block Acknowledgement Request (BAR) frame format;

 Figure 4 illustrates a BAR control field format;

10 Figure 5 illustrates embodiment of events during an uplink (UL) OFDMA TXOP;

 Figure 6 illustrates an embodiment of UL OFDMA transmissions;

 Figure 7 illustrates an embodiment method of AP and STAs operations during the DL OFDMA TXOP;

 Figure 8 illustrates an embodiment method of AP and STAs operations during the
15 UL OFDMA TXOP; and

 Figure 9 is a diagram of a processing system that can be used to implement various embodiments.

 Corresponding numerals and symbols in the different figures generally refer to corresponding parts unless otherwise indicated. The figures are drawn to clearly illustrate
20 the relevant aspects of the embodiments and are not necessarily drawn to scale.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

The making and using of the presently preferred embodiments are discussed in detail below. It should be appreciated, however, that the present invention provides many applicable inventive concepts that can be embodied in a wide variety of specific contexts.

- 5 The specific embodiments discussed are merely illustrative of specific ways to make and use the invention, and do not limit the scope of the invention.

Disclosed herein are system and method embodiments for WLAN OFDMA operations in uplink and downlink transmissions. Figure 1 shows an example of a WLAN basic service set (BSS) including an access point (AP) and one or more stations (STAs).

- 10 The AP is a communication device that allows the STAs to access and communicate with the WLAN. The STAs are any user communication devices allowing users or subscribers to communicate with the AP and hence the WLAN. Examples of STAs include smartphones, tablet computers, laptop computers, desktop computers, sensor devices (e.g., smartwatch), and other mobile or communication devices with WLAN (e.g., WiFi)
- 15 capability.

- The STAs and the AP compete for access to a shared medium, e.g., shared wireless channel bandwidth, symbols, or subcarriers. Access to the medium may be based on random access mechanisms such as carrier sense multiple access with collision avoidance (CSMA/CA) or using a scheduling mechanism that allows the STAs and AP
- 20 access to the medium at specified or predetermined times. Irrespective of how access to the medium is obtained, a downlink (DL) OFDMA transmission opportunity (TXOP) is obtained when the AP has the right to access the medium and communicates with multiple STAs in a single OFDMA transmission. An uplink (UL) OFDMA TXOP is obtained when a STA gains access to the medium and is ready to start an UL OFDMA
- 25 TXOP by inviting other STAs to share the available transmission resources, e.g. the subcarriers.

- In general, an OFDMA system consists of an integer N_{sc} of subcarriers defined in a channel of certain bandwidth, W Megahertz (MHz). For example in WLAN, the bandwidth W is usually set to 20 MHz. The subcarrier separation Δf is given by $\Delta f =$
- 30 W/N_{sc} . The OFDMA symbol duration T_s is given by $1/\Delta f$. The quantity N_{sc} is set at 64 in WLAN OFDM implementation. With the introduction of OFDMA to WLAN, N_{sc} may be set to a higher value, such as 256 or 512 to achieve finer granularity. During each

OFDMA transmission (uplink or downlink), a number of subcarriers are allocated to each of the users participating in the transmission.

Figure 2 shows a sequence of events during a DL OFDMA TXOP according to an embodiment of the disclosure. Using CSMA/CA, a DL OFDMA TXOP starts when the AP gains access to the medium. The first action that the AP performs is to protect the medium. The protection of the medium can be performed by a signaling mechanism to request protection of the medium from access by other entities. In an embodiment, the signaling mechanism is sending a clear-to-send (CTS). As such, a CTS frame is sent by the AP using a non-High Throughput (non-HT) format and comprises a time value in a Legacy Signal Field (L-SIG) in the CTS frame for the legacy STAs, or in a Duration/ID field of the CTS frame for non-OFDMA STAs (e.g., high throughput (HT) and very high throughput (VHT) STAs). The time value allows all STAs to defer their transmissions by an amount of time. In various embodiments, the CTS sent by the AP does not require a reply back to the AP from other entities (STAs) receiving this CTS.

Alternatively, the AP can protect the medium by sending a request-to-send (RTS) message to one of its associated STAs. The STA then responds with a CTS message back to the AP. The RTS and CTS messages are sent using non-HT format. The AP then generates an OFDMA physical layer (PHY) Protocol Data Unit (PPDU) that includes frames destined to a number of STAs. For instance, the recipient STAs can be identified by a group ID (GrpID) in the OFDMA SIG field. The OFDMA resource allocation portion in the SIG field may be determined by any previous suitable packet transmission from the AP to the STAs, instead of using any separate channel sounding for the channel response information per each STA. For example, packets that were used for the contention to access the medium by each STA can also be used to get the channel response of each STA and to determine OFDMA resource allocation portion in the SIG field.

When the transmission of the OFDMA PPDU is finished, the AP requests acknowledgements from those STAs participating in the OFDMA transmission. Specifically, the AP sends Block Acknowledgement Request (BAR) frames using OFDMA, one frame for each of the participating STAs. Each STA responds with a Block ACK (BA) frame according to one of the following scenarios. If UL OFDMA is supported, then the participating STAs use OFDMA to send their BAs in the uplink direction. In this case, timing information for synchronizing the uplink transmissions needs to be propagated from the AP to the STAs. The timing information may be

included in the BAR frame by extending the BAR information field. Figure 3 shows a BAR frame format. The BAR information field in the frame is of variable length and suitable for adding timing information at the start or at the end of the field.

Alternatively, if UL OFDMA is not supported, then the participating STAs need
5 to send their BA frames in sequence. One way to determine the sequence for sending the BA frames is for the AP to transmit the BAR frames one after the other using non-HT format (e.g., without using OFDMA format). However, this approach produces some overhead. Instead, the AP can send an explicit sequence using some of the reserved bits in the BAR control field in the BAR frame. Figure 4 shows a BAR control field format. The
10 number of bits needed to indicate the sequence depends on the maximum number of STAs that are allowed to participate in the OFDMA transmission. For example, in the case of 4 STAs, 2 bits are needed for the AP to communicate to the STAs the expected sequence of BA frames.

Figure 5 shows a sequence of events during an UL OFDMA TXOP according to
15 an embodiment of the disclosure. The UL OFDMA TXOP starts when an OFDMA-capable STA (non-AP STA) acquires the medium. Similar to the DL OFDMA TXOP, the first action of the STA is to protect the medium by a signaling mechanism. The signaling mechanism requests protection of the medium from access by the AP. The signaling comprises sending an RTS frame to the AP and wait for the CTS response. The STAs
20 defer their transmissions based on information included in the RTS/CTS frames.

The STA then sends an OFDMA Begin Transmission (OBX) frame to the AP. The reception of the OBX frame by the AP is an indication that the STA wishes to start an UL OFDMA TXOP by sharing the medium with other STAs. The AP selects other STAs to participate in the UL OFDMA, e.g., STAx and STAy in Figure 5, based on
25 knowledge available at the AP on traffic requirements and frame availability. The AP then responds with an OFDMA Begin Receive (OBR) frame to participating STAs. In addition to the identities of stations participating in the UL TXOP, the OBR frame may include information such as timing information, the allocation of subcarriers to STAs using, for example, GrpID and subcarrier group index, the maximum PPDU length that
30 STAs must adhere to, and/or any other relevant information. The OBR frame acts as a trigger to start the UL transmissions by participating stations. Each STA may compensate the timing offset and carrier frequency offset using Legacy STFs and LTFs appended in the OBR frame. Before the participating STAs, e.g., STAx and STAy in Figure 5, transmit the UL frame, OFDMA PPDU, a time delay is needed after the OBR reception to

allow enough processing time for each participating STA to switch from receiving mode to transmitting mode. For instance, each STA waits at least a 30 microseconds to establish an Inter Frame Spacing between the OBR reception and the OFDMA PPDU transmission. The Inter Frame Spacing avoids transient frequency agitation which can occur during the STA switching from the receiving mode to transmitting mode.

Figure 6 shows UL OFDMA transmissions according to an embodiment of the disclosure. After performing the synchronization during the OBX/OBR exchange of the UL OFDMA TXOP, the STAs start their OFDMA transmissions of PPDU's, as described above. The participating STAs transmit their corresponding PPDU's simultaneously on the uplink to the AP using their allocated subcarriers. After the successful transmission of the PPDU's by participating STAs, the AP can send BA frames after receiving BAR frames transmitted by the participating STAs using OFDMA format. The BA frames may be sent by the AP using the OFDMA format or can be sent sequentially as shown in Figure 5.

Figure 7 shows an embodiment method 700 of AP operations during a DL OFDMA TXOP. At step 710, the AP gains access to the medium, e.g., using CSMA/CA. At step 720, the AP sends a signaling requesting protection of the medium from access by the STAs. The signaling is sent using a CTS frame or using a RTS message to each STA. The CTS frame allows all STAs to defer their transmissions by an amount of time. In various embodiments, the CTS sent by the AP does not require a reply back to the AP from other entities (STAs) receiving this CTS. If a RTS message is sent, the STA responds by a CTS message back to the AP. At step 730, the AP sends an OFDMA PPDU to STAs, e.g., identified by a GrpID in an OFDMA SIG field. At step 740, the AP sends a BAR for the STAs using OFDMA. At step 750, the AP receives a BA frame from each STA using OFDMA or in sequence (e.g., as determined by the BARs).

Figure 8 shows an embodiment method of STAs operations during an UL OFDMA TXOP. At step 810, the STA gains access to the medium, e.g., using CSMA/CA. At step 820, the STA sends a signaling requesting protection of the medium from access by the AP. The signaling is sent using a RTS message to the AP. At step 830, the STA receives a CTS from the AP. At step 840, the STA sends an OBX frame to the AP. At step 850, the STA receives, with other STAs selected by the AP to share the medium for OFDMA uplink transmissions, an OBR from the AP. At step 860, the STAs send OFDMA PPDU's to the AP. At step 870, each STA sends a BAR to the AP. At step 880, the STAs receive BAs from the AP.

Figure 9 is a block diagram of a processing system 900 that can be used to implement various embodiments. For instance the processing system 900 can be part of a AP, a STA, or a controller in a WLAN. Specific devices may utilize all of the components shown, or only a subset of the components, and levels of integration may vary from device to device. Furthermore, a device may contain multiple instances of a component, such as multiple processing units, processors, memories, transmitters, receivers, etc. The processing system 900 may comprise a processing unit 901 equipped with one or more input/output devices, such as a speaker, microphone, mouse, touchscreen, keypad, keyboard, printer, display, and the like. The processing unit 901 may include a central processing unit (CPU) 910, a memory 920, a mass storage device 930, a video adapter 940, and an I/O interface 960 connected to a bus. The bus may be one or more of any type of several bus architectures including a memory bus or memory controller, a peripheral bus, a video bus, or the like.

The CPU 910 may comprise any type of electronic data processor. The memory 920 may comprise any type of system memory such as static random access memory (SRAM), dynamic random access memory (DRAM), synchronous DRAM (SDRAM), read-only memory (ROM), a combination thereof, or the like. In an embodiment, the memory 920 may include ROM for use at boot-up, and DRAM for program and data storage for use while executing programs. In embodiments, the memory 920 is non-transitory. The mass storage device 930 may comprise any type of storage device configured to store data, programs, and other information and to make the data, programs, and other information accessible via the bus. The mass storage device 930 may comprise, for example, one or more of a solid state drive, hard disk drive, a magnetic disk drive, an optical disk drive, or the like.

The video adapter 940 and the I/O interface 960 provide interfaces to couple external input and output devices to the processing unit. As illustrated, examples of input and output devices include a display 990 coupled to the video adapter 940 and any combination of mouse/keyboard/printer 970 coupled to the I/O interface 960. Other devices may be coupled to the processing unit 901, and additional or fewer interface cards may be utilized. For example, a serial interface card (not shown) may be used to provide a serial interface for a printer.

The processing unit 901 also includes one or more network interfaces 950, which may comprise wired links, such as an Ethernet cable or the like, and/or wireless links to access nodes or one or more networks 980. The network interface 950 allows the

processing unit 901 to communicate with remote units via the networks 980. For example, the network interface 950 may provide wireless communication via one or more transmitters/transmit antennas and one or more receivers/receive antennas. In an embodiment, the processing unit 901 is coupled to a local-area network or a wide-area
5 network for data processing and communications with remote devices, such as other processing units, the Internet, remote storage facilities, or the like.

While several embodiments have been provided in the present disclosure, it should be understood that the disclosed systems and methods might be embodied in many other specific forms without departing from the spirit or scope of the present
10 disclosure. The present examples are to be considered as illustrative and not restrictive, and the intention is not to be limited to the details given herein. For example, the various elements or components may be combined or integrated in another system or certain features may be omitted, or not implemented.

In addition, techniques, systems, subsystems, and methods described and
15 illustrated in the various embodiments as discrete or separate may be combined or integrated with other systems, modules, techniques, or methods without departing from the scope of the present disclosure. Other items shown or discussed as coupled or directly coupled or communicating with each other may be indirectly coupled or communicating through some interface, device, or intermediate component whether electrically,
20 mechanically, or otherwise. Other examples of changes, substitutions, and alterations are ascertainable by one skilled in the art and could be made without departing from the spirit and scope disclosed herein.

WHAT IS CLAIMED IS:

1. A method by an access point (AP) for Orthogonal Frequency Division Multiple Access (OFDMA) downlink transmission in a Wireless Local Area Network (WLAN), the method comprising:
 - 5 sending a signaling requesting protection of a transmission channel for downlink transmissions from access by stations (STAs) associated with the AP;
sending an OFDMA physical layer Protocol Data Unit (PPDU) to the STAs;
sending a Block Acknowledgement Request (BAR) to the STAs; and
receiving a Block Acknowledgement (BA) from each one of the STAs.
- 10 2. The method of claim 1 further comprising gaining access to the transmission channel before sending the signaling.
3. The method of claim 1, wherein sending the signaling requesting protection of the transmission channel from access by the STAs includes sending by the AP a clear-to-send (CTS) frame, wherein the CTS frame is sent using a non-High Throughput (non-HT) format
15 and comprises timing information allowing the STAs to defer their transmissions by an amount of time.
4. The method of claim 3, wherein the timing information is sent in one of a Legacy Signal Field (L-SIG) of the CTS frame for legacy STAs and a Duration/ID field of the CTS frame for non-OFDMA STAs.
- 20 5. The method of claim 1, wherein sending the signaling requesting protection of the transmission channel from access by stations (STAs) includes:
sending a request-to-send (RTS) message to the STAs, wherein the RTS message comprises timing information allowing the STAs to defer their transmissions by an amount of time; and
25 receiving a clear-to-send (CTS) message from the STAs.

6. The method of claim 5, wherein the RTS message and the CTS message are sent using non-High Throughput (non-HT) format.

7. The method of claim 1, wherein the OFDMA PPDU comprises a Signaling (SIG) field including a group ID that identifies recipient STAs for the OFDMA PPDU, wherein
5 OFDMA resource allocation in the SIG field is determined by a previous packet transmission from the AP.

8. The method of claim 1, wherein the STAs support OFDMA uplink transmission, wherein the BAR comprises a BAR information field of variable length, the BAR information field including timing information for synchronizing OFDMA uplink
10 transmissions from the STAs, and wherein the BA is sent by the STAs simultaneously using OFDMA.

9. The method of claim 1, wherein the STAs do not support OFDMA uplink transmission, wherein the BAR is sent using non-High Throughput (non-HT) format and comprises a BAR control field of variable number of bits according to a maximum number of
15 the STAs, the BAR control field indicating a sequence of transmissions to the STAs, and wherein the BA is sent by the STAs according to the sequence of transmissions.

10. A method by a station (STA) for Orthogonal Frequency Division Multiple Access (OFDMA) downlink transmission in a Wireless Local Area Network (WLAN), the method comprising:

detecting a signaling from an access point (AP), the signaling indicating the AP

5 requesting protection of a transmission channel from access by a plurality of STAs associated with the AP including the STA;

receiving, from the AP an OFDMA physical layer Protocol Data Unit (PPDU);

receiving, from the AP, a Block Acknowledgement Request (BAR), wherein the BAR is sent to the STAs; and

10 sending, to the AP, a Block Acknowledgement (BA).

11. The method of claim 10, wherein detecting the signaling from the AP comprises detecting a clear-to-send (CTS) frame by the AP, wherein the CTS frame is sent using a non-High Throughput (non-HT) format and comprises timing information allowing the STAs to defer transmission by an amount of time.

15 12. The method of claim 10 wherein detecting the signaling from the AP comprises receiving from the AP, a request-to-send (RTS) message that is sent to the STAs, wherein the RTS message comprises timing information allowing the STAs to defer transmission by an amount of time, and wherein the method further comprises sending, to the AP, a clear-to-send (CTS) message in response to the RTS message.

13. A method by a station (STA) for Orthogonal Frequency Division Multiple Access (OFDMA) uplink transmissions in a Wireless Local Area Network (WLAN), the method comprising:

5 sending a signaling requesting protection of a transmission channel for uplink transmissions from access by an access point (AP) of the STA;
sending, to the AP, a frame indicating start of OFDMA transmission by the STA;
receiving, from the AP, an OFDMA Begin Receive (OBR) frame, wherein the OBR frame is sent by the AP to a plurality of STAs associated with the AP including the STA;
10 sending, to the AP, an Orthogonal Frequency Division Multiple Access (OFDMA) physical layer Protocol Data Unit (PPDU);
sending a Block Acknowledgement Request (BAR) to the AP; and
receiving a Block Acknowledgement (BA) from the AP.

14. The method of claim 13 further comprising gaining access to the transmission channel before sending the signaling.

15 15. The method of claim 13, wherein sending the signaling requesting protection of the transmission channel from the AP includes:
sending, to the AP, a request-to-send (RTS) message, wherein the RTS message comprises time information allowing the AP to defer transmission by an amount of time; and
receiving, from the AP, a clear-to-send (CTS) message, wherein the CTS message is
20 sent by the AP to the STAs.

16. The method of claim 15, wherein the OBR frame includes identities of STAs selected for OFDMA uplink transmissions and optionally at least one of timing information for the STAs for synchronizing OFDMA transmissions from the STAs, allocation of a plurality of subcarrier groups to the STAs for OFDMA transmissions, and a maximum PPDU length for
25 the STAs.

17. The method of claim 16, wherein the OBR comprises a group ID designating the STAs, and a plurality of subcarrier group indices indicating the subcarrier groups.

18. The method of claim 16, wherein the OFDMA PPDU is sent to the AP on one or more subcarriers from the subcarrier groups allocated to the STA.

19. The method of claim 13, before sending the OFDMA PPDU, waiting an amount of time providing an Inter Frame Spacing between receiving the OBR frame and sending the
5 OFDMA PPDU, wherein the Inter Frame Spacing allows the STA to switch from receiving mode to transmitting mode.

20. A method by an access point (AP) for Orthogonal Frequency Division Multiple Access (OFDMA) uplink transmission in a Wireless Local Area Network (WLAN), the method comprising:

detecting a signaling from a station (STA), the signaling indicating the STA

5 requesting protection of a transmission channel from access by the AP;

receiving, from the STA, a frame indicating start of OFDMA transmission by the STA;

sending, to a plurality of STAs associated with the AP including the STA, an OFDMA Begin Receive (OBR) frame;

10 receiving, from the STA, an OFDMA physical layer Protocol Data Unit (PPDU);

receiving, from the STA, a Block Acknowledgement Request (BAR); and

sending, to the STA, a Block Acknowledgement (BA).

21. The method of claim 20, wherein detecting the signaling from the STA includes:

receiving, from the STA, a request-to-send (RTS) message, wherein the RTS message

15 comprises time information allowing the AP to defer transmission by an amount of time; and

sending, to the STAs, a clear-to-send (CTS) message.

22. The method of claim 20, wherein the OBR frame includes allocation of a plurality of subcarrier groups to the STAs for OFDMA transmissions, and wherein the method further comprises receiving from the STAs simultaneously a plurality of OFDMA PPDU's on

20 respective subcarriers of the STAs according to the allocation of the subcarrier groups to the STAs.

23. The method of claim 20 further comprising, upon receiving the OBR frame from the STA, selecting other STAs to participate with the STA in the OFDMA uplink transmission.

24. An access point (AP) supporting Orthogonal Frequency Division Multiple Access (OFDMA) transmission in a Wireless Local Area Network (WLAN), the AP comprising:

a processor; and

a computer readable storage medium storing programming for execution by the

5 processor, the programming including instructions to:

send a signaling requesting protection of a transmission channel from access by stations (STAs) associated with the AP;

send an Orthogonal Frequency Division Multiple Access (OFDMA) physical layer Protocol Data Unit (PPDU) to the STAs;

10 send a Block Acknowledgement Request (BAR) to the STAs; and

receive a Block Acknowledgement (BA) from each one of the STAs.

25. The AP of claim 24, wherein the programming includes further instructions to:

detect a signaling from a STA, the signaling indicating the STA requesting protection of a transmission channel for uplink transmissions from access by the AP;

15 receive, from the STA, a frame indicating start of OFDMA transmission by the STA;

send, to the STAs including the STA, an OFDMA Begin Receive (OBR) frame;

receive, from the STAs, OFDMA physical layer Protocol Data Units (PPDUs);

receive, from the STAs, Block Acknowledgement Requests (BARs); and

send, to the STAs, Block Acknowledgements (BAs).

26. A user station supporting Orthogonal Frequency Division Multiple Access (OFDMA) transmission in a Wireless Local Area Network (WLAN), the user station comprising:
- a processor; and
 - a computer readable storage medium storing programming for execution by the
- 5 processor, the programming including instructions to:
- send a signaling requesting protection of a transmission channel from access by an access point (AP) of the user station;
 - send, to the AP, a frame indicating start of OFDMA transmission by the STA;
 - receive, from the AP, an OFDMA Begin Receive (OBR) frame, wherein the
- 10 OBR frame is sent by the AP to a plurality of STAs associated with the AP including the user station;
- send, to the AP, an OFDMA physical layer Protocol Data Unit (PPDU);
 - send a Block Acknowledgement Request (BAR) to the AP; and
 - receive a Block Acknowledgement (BA) from the AP.

27. The user station of claim 26, wherein the programming includes further instructions to:

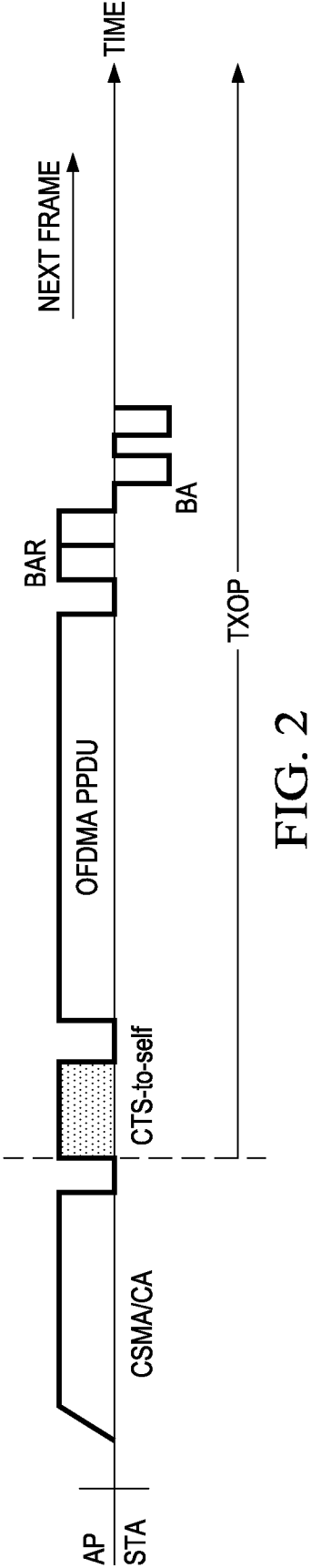
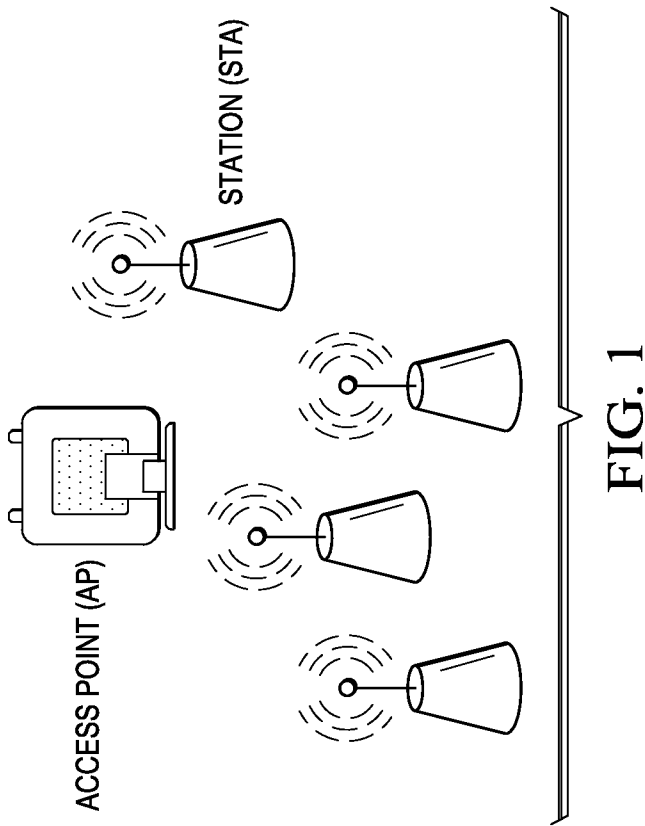
detect a signaling from the AP, the signaling indicating the AP requesting protection of a transmission channel for downlink transmissions from access by the STAs including the

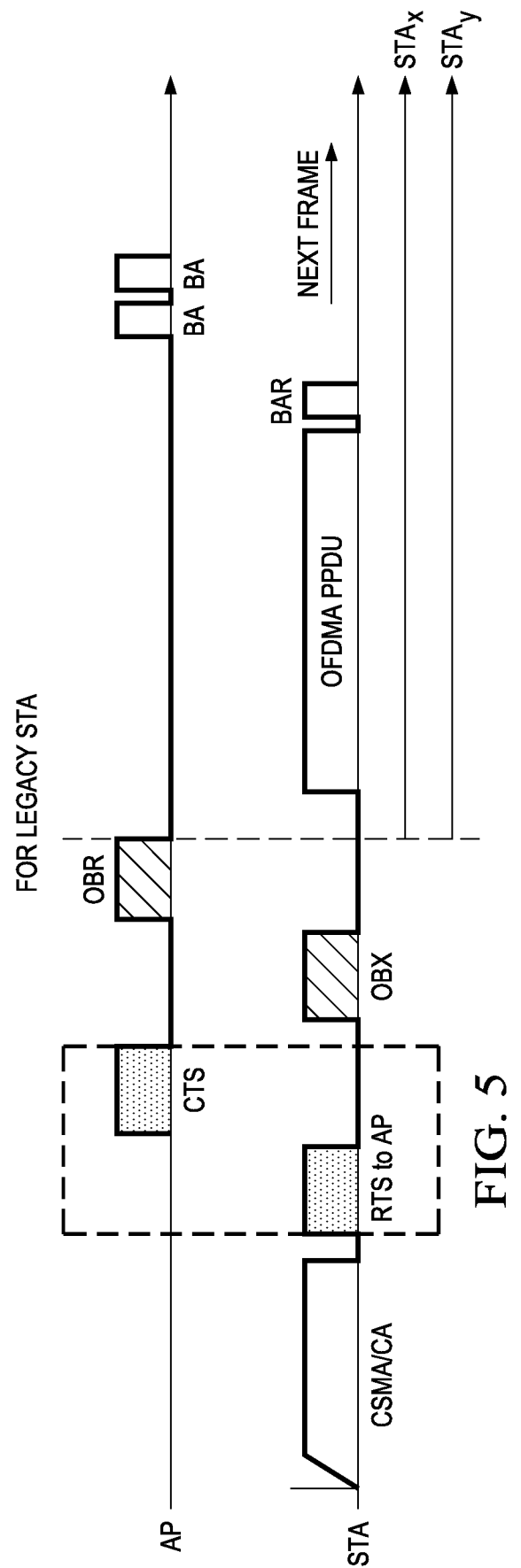
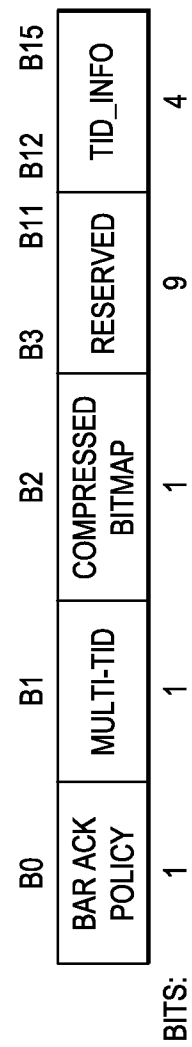
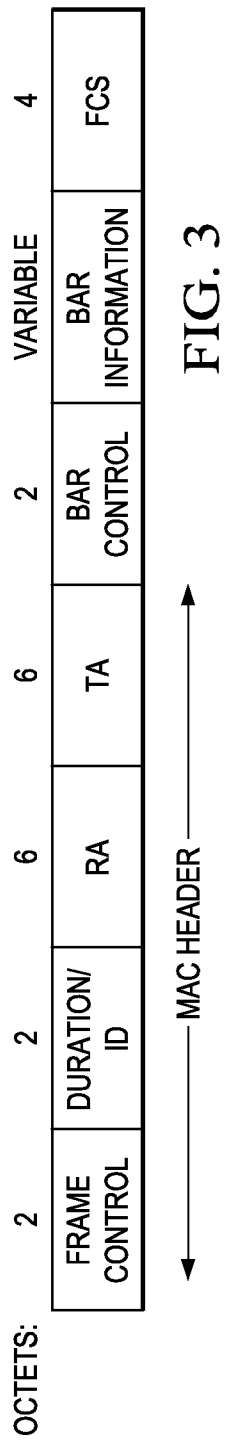
5 user station;

receive, from the AP an OFDMA PPDU;

receive, from the AP, a BAR, wherein the BAR is sent to the STAs; and

send, to the AP, a BA.





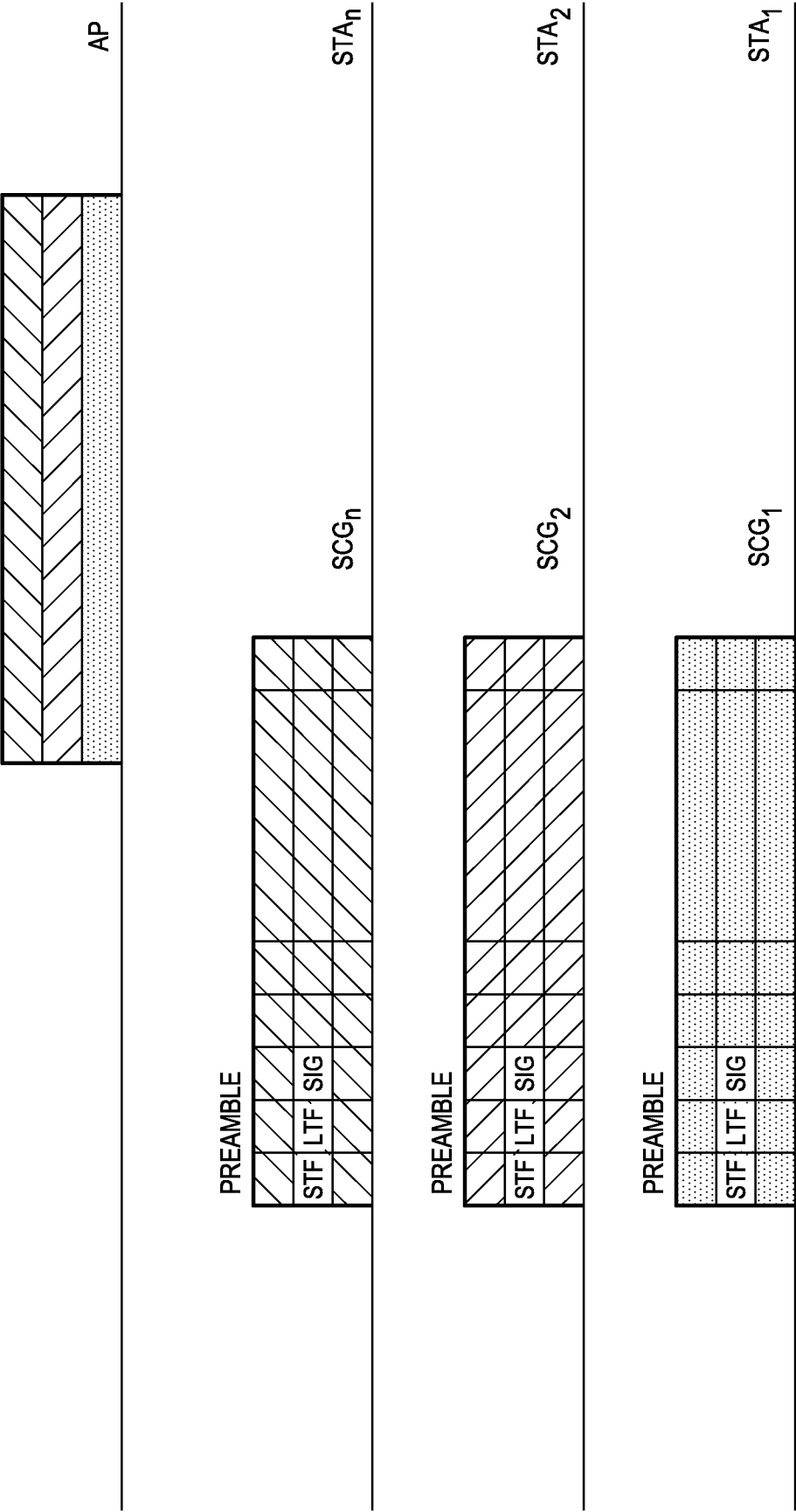


FIG. 6

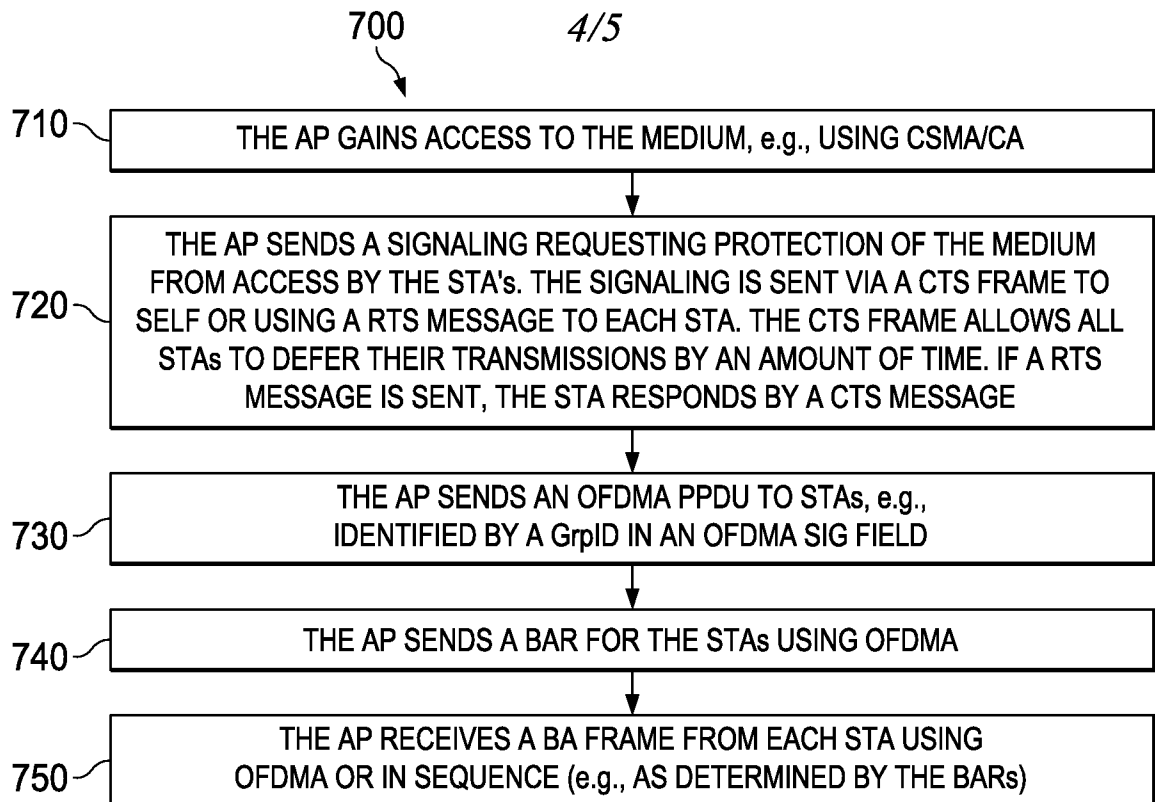


FIG. 7

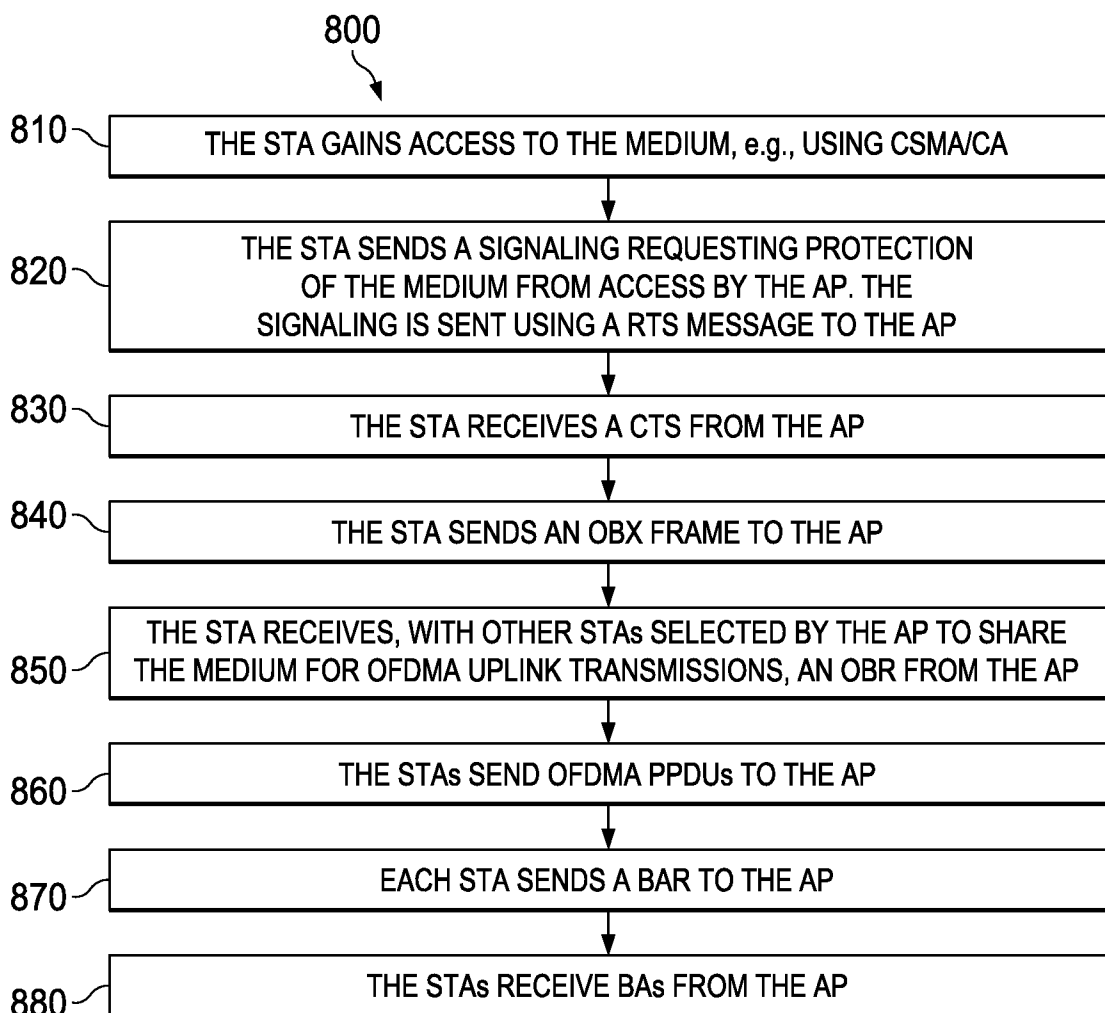


FIG. 8

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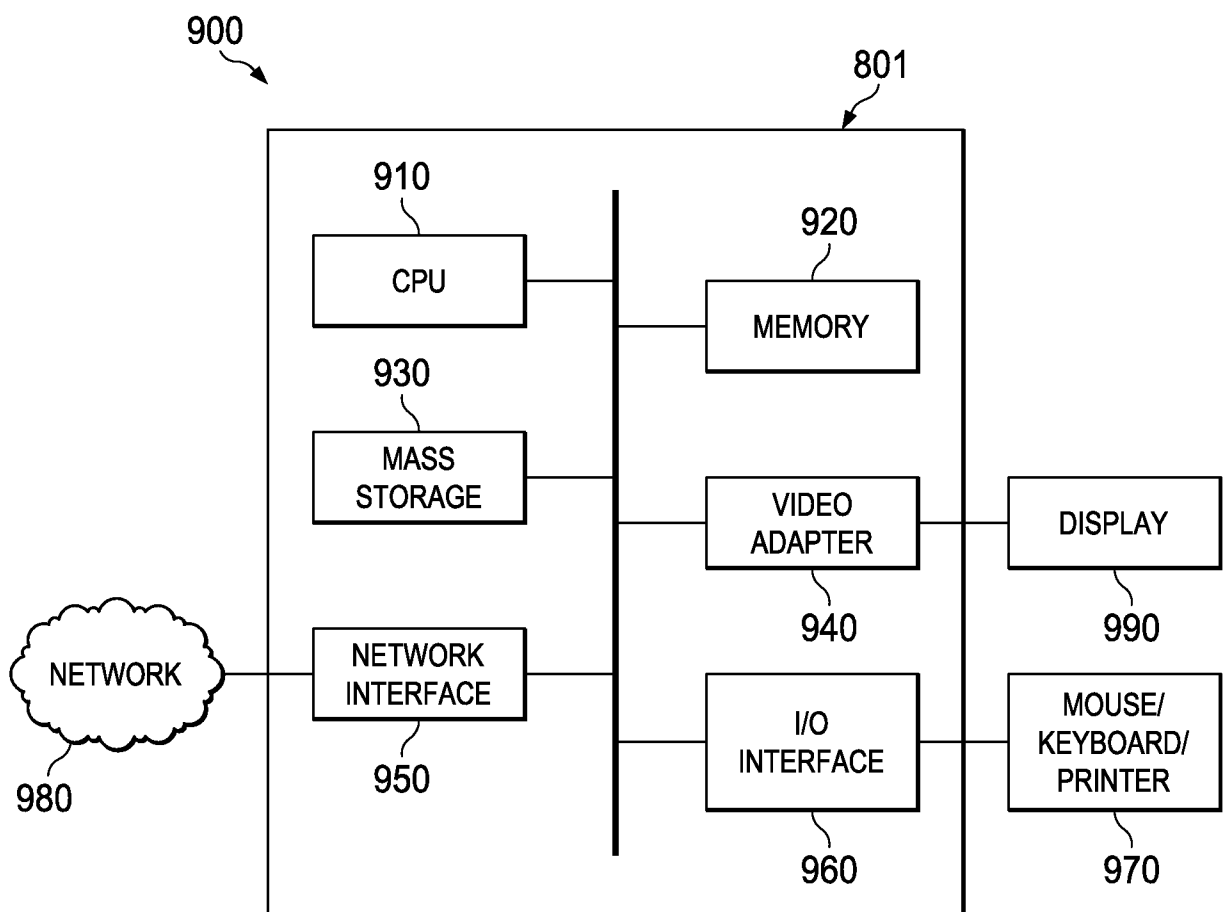


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 14/70543

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - H04W 4/00 (2015.01)

CPC - H04W 84/12, H04W 84/18, H04W 80/04

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8): H04W 4/00 (2015.01)

CPC: H04W 84/12, H04W 84/18, H04W 80/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC: 370/338 (keyword limited - see terms below)

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

PatBase; GOOGLE; GoogleScholar; GooglePatents

Search Terms: access point, OFDMA, downlink, transmission, WLAN, physical layer, block acknowledgment, protocol, throughput, access, duration, ID, delay, defer, latency, CTS, RTS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2013/0286959 A1 (Lou et al.) 31 October 2013 (31.10.2013), entire document, especially; abstract, para. [0066], [0101], [0111], [0213], [0359]	1 - 27
A	US 2008/0049690 A1 (Kuchibhotla et al.) 28 February 2008 (28.02.2008), entire document	1 - 27
A	US 2013/0223210 A1 (Asterjadhi et al.) 29 August 2013 (29.08.2013), entire document	1 - 27

☐ Further documents are listed in the continuation of Box C.

* Special categories of cited documents:

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

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"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

14 February 2015 (14.02.2015)

Date of mailing of the international search report

18 MAR 2015

Name and mailing address of the ISA/US

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