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Method, apparatus, and computer readable media for acknowledgement in wireless networks

Abstract

Embodiments of a system and method for communicating acknowledgments in a wireless network are generally described herein. In some embodiments, a method of wirelessly communicating acknowledgements includes receiving a first signal on a first subchannel from a second wireless device. The method may include transmitting a block acknowledgement of the first signal on a subchannel. The first wireless communication device may not receive a block acknowledgement request to transmit the block acknowledgement. In some embodiments, a method of communicating block acknowledgements includes transmitting a first transmission to a first wireless device on a first subchannel and a second transmission to a second wireless device on a second subchannel The method may include receiving a first block acknowledgement from the first wireless device and a second block acknowledgement from second wireless device. The first and second block acknowledgement may be received on one of the first and second subchannels.

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Background/Summary

PRIORITY CLAIM (1) This application is a continuation of U.S. application Ser. No. 16/256,842 filed on Jan. 24, 2019, which is a continuation of U.S. patent application Ser. No. 14/498,385, filed Sep. 26, 2014 (abandoned), which claims priority under 35 U.S.C. 119(e) to United States Provisional Patent Application Ser. No. 61/990,414, filed May 8, 2014, each of which is incorporated herein by reference in its entirety.

TECHNICAL FIELD
(1) Embodiments pertain to wireless communications. Some embodiments relate to block acknowledgements in wireless networks.
BACKGROUND
(2) One issue with communicating data over a wireless network is acknowledging received data. Often acknowledging received data consumes bandwidth. Moreover, with the use of some protocols, a large number of stations may be transmitting simultaneously in both the spatial domain and time domain. Additionally, consumers often demand more and more bandwidth for their

applications.
(3) Thus, there are general needs for systems, apparatus, and methods that reduce signaling, bandwidth, and delay associated with communicating smaller amounts of data.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** illustrates a wireless network, in accordance with some embodiments;
(2) FIG. **2** illustrates a time sequence diagram of an acknowledgement, in accordance with some example embodiments;
(3) FIG. **3** illustrates a time sequence diagram of an acknowledgement, in accordance with some example embodiments;
(4) FIG. **4** illustrates a time sequence diagram of an acknowledgement, in accordance with some example embodiments;
(5) FIG. **5** illustrates a time sequence diagram of an acknowledgement, in accordance with some example embodiments;
(6) FIG. **6** illustrates a time sequence diagram of an acknowledgement, in accordance with some example embodiments;
(7) FIG. **7** illustrates a frame with a field for acknowledgement, in wireless networks according to example embodiments;
(8) FIG. **8** illustrates a frame with a field for acknowledgement, in wireless networks according to example embodiments;
(9) FIG. **9** illustrates a frame with a field for acknowledgement, in wireless networks according to example embodiments; and
(10) FIG. **10** illustrates a high-efficiency wireless HEW device, in accordance with some embodiments.
DETAILED DESCRIPTION
(11) The following description and the drawings sufficiently illustrate specific embodiments to enable those skilled in the art to practice them. Other embodiments may incorporate structural, logical, electrical, process, and other changes. Portions and features of some embodiments may be included in, or substituted for, those of other embodiments. Embodiments set forth in the claims encompass all available equivalents of those claims.
(12) FIG. **1** illustrates a wireless network, in accordance with some embodiments. The wireless network may comprise a basis service set (BSS) **50** that may include an access point (AP) **104**, a plurality of high-efficiency wireless or Wi-Fi (HEW) (e.g., Institute of Electrical and Electronics Engineers IEEE 802.11ax) devices, and a plurality of legacy (e.g., IEEE 802.11n/ac) devices **106**.
(13) The AP **104** may be an AP and use 802.11 to transmit and receive. The AP **104** may be a base station. The AP **104** may use other communications protocols as well as the 802.11 protocol. The 802.11 protocol may be 802.11ax. The 802.11 protocol may include using Orthogonal Frequency-Division Multiple Access (OFDMA). The 802.11 may include using multi-user multiple-input and multiple-output (MU-MIMO).
(14) The HEW devices **102** may be wireless transmit and receive devices such as cellular telephones, handheld wireless devices, wireless glasses, wireless watches, wireless personal devices, tablets, or another devices that may be transmitting and receiving using an 802.11 protocol such as 802.11ax or another wireless protocol.
(15) The BSS **50** may operate on a primary channel and one or more secondary channels or sub-channels. The BSS **50** may include one or more APs **104**. In accordance with embodiments, the AP **104** may communicate with one or more of the HEW devices **102** on one or more of the secondary channels or sub-channels or the primary channel. In example embodiments, the AP **104**

communicates with the legacy devices **106** on the primary channel. In example embodiments, the AP **104** may be configured to communicate concurrently with one or more of the HEW devices **102** on one or more of the secondary channels and a legacy device **106** utilizing only the primary channel and not utilizing any of the secondary channels.

(16) The AP **104** may communicate with legacy devices **106** in accordance with legacy IEEE 802.11 communication techniques. In example embodiments, the AP **104** may also be configured to communicate with HEW devices **102** in accordance with legacy IEEE 802.11 communication techniques. Legacy IEEE 802.11 communication techniques may refer to any IEEE 802.11 communication technique prior to IEEE 802.11ax.

(17) In some embodiments, HEW frames may be configurable to have the same bandwidth or different bandwidths, and the bandwidth may be one of 20 MHz, 40 MHz, 80 MHz or 160 MHz contiguous bandwidths or an 80+80 MHz non-contiguous bandwidth. In some embodiments, a 320 MHz contiguous bandwidth may be used. In some embodiments, bandwidths of 1 MHz, 1.25 MHz, 2.5 MHz, 5 MHz and 10 MHz or a combination thereof may also be used. In these embodiments, a HEW frame may be configured for transmitting a number of spatial streams.

(18) In example embodiments, referring to FIGS. **2** through **9**, the AP **104** is configured to transmit and/or receive signal fields (SIGs) **120**, **220**, **320**, **420**, and **520**; DATA **122**, **222**, **322**, **422**, and **522**; (multi-user block acknowledgment requests (MU BAR) **323**, **423**, and **523**; block acknowledgement request (BAR) **223**; (block acknowledgement) BACK **226**, **326**, **426**, and **526**; frames **600** and **700**; and, BACK **126**.

(19) In example embodiments the HEW device **102** is configured to transmit and/or receive SIGs **120**, **220**, **320**, **420**, and **520**; DATA **122**, **222**, **322**, **422**, and **522**; MU BAR **323**, **423**, and **523**; BAR **223**; BACK **226**, **326**, **426**, and **526**; frames **600** and **700**; and, ACK **126**. In example embodiments, the HEW device **102** is station (STA) in 802.11.

(20) In other embodiments, the AP **104**, HEW device **102**, and/or legacy device **106** may implement different technologies such as code-division multiple access (CDMA) 2000, CDMA2000 IX, CDMA2000 EV-DO, Interim Standard 2000 (IS-2000), Interim Standard 95 (IS-95), Interim Standard 856 (IS-856), Global System for Mobile communications (GSM), Enhanced Data rates for GSM Evolution (EDGE), GSM EDGE (GERAN), Long Term Evolution (LTE), IEEE 802.15.1, 802.11ac, IEEE 802.16 (i.e., Worldwide Interoperability for Microwave Access (WiMAX)).

(21) In an OFDMA system (e.g. 802.11ax), an associated HEW device **104** may operate on any 20 MHz sub-channel of the BSS **50** (that can operate, for example, at 80 MHz).

(22) Embodiments pertain to wireless communications. Some embodiments relate to high-efficiency wireless communications including high-efficiency Wi-Fi/wireless local-area network (WEAN) and HEW communications. Some embodiments relate to wireless communications in accordance with one of the IEEE 802.11 standards including the High Efficiency WEAN Study Group (HEW SG) that is now IEEE 802.11ax Task Group.

(23) In accordance with some IEEE 802.11ax (High-Efficiency Wi-Fi) embodiments, AP **104** may operate as a master station, which may be arranged to contend for a wireless medium (e.g., during a contention period) to receive exclusive control of the medium for a HEW control period (i.e., a transmission opportunity (TXOP)). The master station may transmit an HEW master-sync transmission at the beginning of the HEW control period. During the HEW control period, HEW stations may communicate with the master station in accordance with a non-contention based multiple access technique. This is unlike conventional Wi-Fi communications in which devices communicate in accordance with a contention-based communication technique, rather than a multiple access technique. During the HEW control period, the master station may communicate with HEW stations using one or more HEW frames. During the HEW control period, legacy stations refrain from communicating. In some embodiments, the master-sync transmission may be referred to as an HEW control and schedule transmission.

(24) In some embodiments, the multiple-access technique used during the HEW control period may be a scheduled OFDMA technique, although this is not a requirement. In some embodiments, the multiple access technique may be a time-division multiple access (TDMA) technique or a frequency division multiple access (FDMA) technique. In some embodiments, the multiple access technique may be a space-division multiple access (SDMA) technique.
(25) The master station may also communicate with legacy stations in accordance with legacy IEEE 802.11 communication techniques. In some embodiments, the master station may also be configurable to communicate with HEW stations outside the HEW control period in accordance with legacy IEEE 802.11 communication techniques, although this is not a requirement.
(26) FIG. **2** illustrates a time sequence diagram **100** of an acknowledgement, in accordance with some example embodiments. Illustrated in FIG. **1** is a time sequence diagram **100**, AP **104**, STAs **108**, SIG **120**, DATA **122**, and BACK **126**. In example embodiments, the STAs **108** are HEW devices **102**. The time sequence diagram **100** illustrates time **160** along the horizontal axis and frequency **150** along the vertical axis. The transmitter is indicated along the top.
(27) The frequency **150** may be divided into four subchannels **1**, **2**, **3**, **4**. In example embodiments, each subchannel **1**, **2**, **3**, **4** may have a bandwidth of 5 MHz. In example embodiments, each subchannel has a bandwidth, and the bandwidths may be different. For example, subchannels **1** and **2** may have a bandwidth of 5 MHz, subchannel **3** may have a bandwidth of 10 MHz, and subchannel **4** may have a bandwidth of 20 MHz. In example embodiments, the subchannels **1**, **2**, **3**, **4** may be in accordance with a wireless standard. As illustrated, there is one AP **104** and four STAs **108**. In example embodiments, there may be more or fewer STAs **108** and more or fewer APs **104**.
(28) In example embodiments, the STAs **108** and AP **104** may be using OFDMA to communicate. In example embodiments, the STAs **108** and AP **104** may be using uplink and downlink multiple-user multiple-input multiple-out (UL MU-MIMO) to communicate. In MU-MIMO, two or more spatial streams may be used that utilize the same frequency. In example embodiments, the STAs **108** and AP **104** may communicate according to a wireless communication standard. In example embodiments, the wireless standard may be 802.11, 802.11a, 802.11b, 802.11g, 802.11n, 802.11ac, 802.11ad, 802.11af, 802.11ah, 802.11ai, 802.11aj, 802.11aq, 802.11ax, Bluetooth, or another wireless standard.
(29) In example embodiments, the STAs **108** are mobile devices. In example embodiments, the STAs **108** are wireless mobile devices. In example embodiments, the AP **104** is an AP. In example embodiments, the AP **104** is a mobile device. In example embodiments, the AP **104** is a wireless device. In example embodiments, the AP **104** is a STA **108**.
(30) In example embodiments, the SIG **120** is a signal that may include information regarding the data **122**. In example embodiments, the SIG **120** may include information regarding the AP **104**. In example embodiments, the SIG **120** may include information regarding an acknowledgement policy. In example embodiments, the SIG **120** may comprise a frame that complies with a wireless standard. In example embodiments, the SIG **120** comprises a control or management frame that complies with a wireless standard.
(31) In example embodiments, the data **122** may be a signal that comprises a data frame that complies with a wireless standard. In example embodiments, the BACK **126** may be a signal that comprises an acknowledgement frame in accordance with a wireless standard. In example embodiments, the BACK **126** may be a block acknowledgment in accordance with a wireless standard. In example embodiments, the data **122** includes an indication of an acknowledgement policy.
(32) The time sequence diagram **100** begins at **162** with the AP **104** transmitting the SIG **120** to the STAs **108**. In an example embodiment, the AP **104** may determine, based on the acknowledge policy being used, to include a bit in the SIG **120** that indicates to the STAs **108** to use an acknowledgement policy where the STAs **108** transmit an BACK **126** to the AP **104** without waiting for a request to transmit the BACK **126**. In example embodiments, the AP **104** may

transmit an indication to the STAs **108** of an acknowledgement policy in a previous frame.
(33) The time sequence diagram **100** continues at **164** with the AP **104** transmitting data **122** to the STAs **108**. For example, the AP **104** may transmit data **122.2** to STA**2** **108.2** on subchannel **3**.
(34) In an example embodiment, the AP **104** may determine not to transmit a schedule (SCH)/SIG after the data **122** based on the acknowledgement policy of the AP **104**. In an example embodiment, the AP **104** may include an indication of an acknowledge policy in frames of the data **122**.
(35) The time sequence diagram **100** continues at **166** with the STAs **108** waiting to transmit ACKs **126**. In some embodiments, the STAs **108** may wait a short interframe space (SIFS) **166** before transmitting the BACKs **126**. In example embodiments, the STAs **108** may determine to not wait for a SCH and/or a SIG and/or an ACK request from the AP **104** based on an acknowledgement policy. In example embodiments, the STAs **108** may wait SIFs **166** before transmitting the ACKs **126** based on receiving an indication of an acknowledgement policy from the AP **104**. In example embodiments, the STAs **108** may wait a period of time greater than the SIFS **166**. In example embodiments, the AP **104** may transmit to the STAs **108** a pre-determined amount of time the STAs **108** should wait before transmitting. In example embodiments, an indication of the acknowledgement policy may have been sent to the STAs **108** in an earlier frame such as a beacon or other management frame, or in a control or data frame. For example, an indication of the acknowledgement policy may have been sent in the SIG **120** or DATA **122** frames.
(36) The time sequence diagram **100** continues at **168** with the STAs **108** transmitting ACKs **126** to the AP **104**. In example embodiments, the STAs **108** use the same subchannel on which they received the data **122** to transmit the ACK **126**. For example, STA**3** **108.3** received data **122.3** on subchannel **2** and transmitted an ACK **126.3** to the AP **104** on subchannel **2**. In example embodiments, the ACKs **126** are ACKs **126**. In example embodiments, the STAs **108** are configured to send the BACKs **126** in response to the DATA **122** without receiving a SCH and/or a (SIG and/or an BACK request from the AP **104** based on an acknowledgement policy.
(37) In example embodiments, the BACKs **126** are transmitted to the AP **104** in response to an implicit request from the AP **104** that is part of an acknowledgement policy. In example embodiments, the STAs **108** may transmit data (not illustrated) prior to or after transmitting the BACKs **126**. In example embodiments, one of the SIG **120** or the DATA **122** includes a schedule, and the STAs transmit data according to the schedule. In example embodiments, the BACK **126** may be part of a data frame (not illustrated).
(38) The STAs **108** transmitting BACKs **126** without receiving additional frames from the AP **104** may have the technical effect of saving time since transmitting a scheduling and/or SIG frame takes time. The scheduling and/or SIG frame may take 100 microseconds.
(39) In some embodiments, the MU-MIMO may be used where one or more subchannels **1**, **2**, **3**, **4** may be shared by more than one STA **108**. For example, subchannel **4** may be shared by a MU-MIMO group such as STA**1** **108.1** and STA**5** **108.5** (not illustrated). In example embodiments, the acknowledgement policy may be based on a pre-determined rule. In example embodiments, the STA **108** may determine when to transmit a BACK **126** based on a spatial stream associated with the STA **108**. In example embodiments, the STA **108** from the MU-MIMO group that the first spatial stream is intended for may be the first STA **108** to transmit the BACK **126** after the data **122** transmission is received.
(40) FIG. **3** illustrates a time sequence diagram **200** of an acknowledgement, in accordance with some example embodiments. Illustrated in FIG. **3** is a time sequence diagram **200**, AP **104**, STAs **108**, SIG **220**, DATA **222**, block acknowledgement request (BAR) **223**, and BACK **226**. The time sequence diagram illustrates time **260** along the horizontal axis and frequency **250** along the vertical axis. The transmitter is indicated along the top.
(41) In example embodiments, the BAR **223** may be a signal that is a block acknowledgement request **223** according to a wireless standard. In example embodiments, the block acknowledgement (BACK) **226** may be a signal that is a block acknowledgement according to a

wireless standard.
(42) The time sequence diagram **200** begins at **262** with the AP **104** transmitting the SIG **220** to the STAs **108**. The time sequence diagram **200** continues at **264** with the AP **104** transmitting data **222** to the STAs **108**. For example, the AP **104** may transmit data **222**.**2** to STA**2** **108**.**2** on subchannel **3**.
(43) The time sequence diagram **200** continues at **266** with the AP **104** transmitting BAR **223** to the STAs **108**. The BAR **223** may include an indication that the STAs **108** are to use an acknowledgement policy that indicates that the BACKs **226** are to be transmitted on the same subchannel **1**, **2**, **3**, **4** in which the BAR **223** and/or DATA **222** was transmitted to the STAs **108**. In example embodiments, the indication of the acknowledgement policy may have been sent to the STAs **108** in an earlier frame such as a beacon or other management frame, or in a control or data frame:
(44) The time sequence diagram **200** may continue at **268** with the STAs **108** waiting to transmit BACKs **226**. In example embodiments, the STAs **108** may wait a SIFS **268** before transmitting the BACKs **226**. In example embodiments, the STAs **108** may determine to not wait for a SCH/SIG and wait SIFs **268** before transmitting the BACKs **226**. In example embodiments, the STAs **108** may determine to not wait for a SCH/SIG and wait SIFs **268** before transmitting the BACKs **226** based on receiving an indication from the AP **104** that the SCH/SIG would not be sent. In example embodiments, the STAs **108** may wait a different period of time before transmitting the BACK **226**.
(45) The time sequence diagram **200** continues at **270** with the STAs **108** transmitting BACKs **226** to the AP **104**. In some embodiments, the STAs **108** use the same subchannel on which they received the data **222** and/or BAR **223** to transmit the BACK **226**. For example, STA**3** **108**.**3** received BAR **223**.**3** on subchannel **2** and transmitted a BACK **226**.**3** to the AP **104** on subchannel **2**. In some embodiments, the STAs **108** are configured to send the BACKs **226** in response to the BAR **223** without receiving a SCH and/or a SIG based on receiving an indication to implement this acknowledgement policy from the AP **104**.
(46) In example embodiments, the MU-M IMO may be used where one or more subchannels **1**, **2**, **3**, **4** may be shared by more than one STA **108**. For example, subchannel **4** may be shared by a MU-MIMO group such as STA**1** **108**.**1** and SIA**5** **108**.**5** (not illustrated). In example embodiments, the acknowledgement policy may be based on a pre-determined rule. In example embodiments, the STA **108** may determine when to transmit a BACK **226** based on a spatial stream associated with the STA **108**. In example embodiments, the STA **108** from the MU-MIMO group that the first spatial stream is intended for may be the first STA **108** to transmit the BACK **226** after the DATA **222** transmission is received.
(47) FIG. **4** illustrates a time sequence diagram **300** of an acknowledgement, in accordance with some example embodiments. Illustrated in FIG. **4** is a time sequence diagram **300**, AP **104**, STAs **108**, SIG **320**, DATA **322**, multi-user block acknowledgement request (MU BAR) **323**, and BACK **326**. The time sequence diagram illustrates time **360** along the horizontal axis and frequency **350** along the vertical axis. The transmitter is indicated along the top.
(48) In example embodiments, the MU BAR **323** may be a signal that is a multi-user BACK request according to a wireless standard. In example embodiments, the MU BAR **323** is a BACK request transmitted on subchannels **1**, **2**, **3**, **4** to the STAs **108**. In an example embodiment, the MU-BAR **323** may be a multicast/broadcast frame addressing multiple STAs **108**. In example embodiments, the MU BAR **323** may include an indication that the STAs **108** are to use an acknowledgement policy that indicates on which subchannel **1**, **2**, **3**, **4** that the BACKs **326** are to be transmitted.
(49) The time sequence diagram **300** begins at **362** with the AP **104** transmitting the SIG **320** to the STAs **108**. The time sequence diagram **300** continues at **364** with the AP **104** transmitting data **322** to the STAs **108**. For example, the AP **104** may transmit data **322**.**2** to STA**2** **108**.**2** on subchannel **3**.
(50) The time sequence diagram **300** continues at **366** with the AP **104** transmitting MU-BAR **323** to the STAs **108**. In example embodiments, the MU BAR **323** may be transmitted on a band of the

subchannels **1**, **2**, **3**, **4** that polls two or more of the STAs **108** to transmit BACKs **326**.

(51) In example embodiments, the MU BAR **323** may include an indication that the STAs **108** are to use an acknowledgement policy that indicates that the BACKs **326** are to be transmitted on the same subchannel **1**, **2**, **3**, **4** in which the DATA **622** was transmitted to the STAs **108**. In example embodiments, the indication of the acknowledgement policy may have been sent to the STAs **108** in an earlier frame such as a management or control frame. In an example embodiment, MU-BAR **323** may include subchannel allocation for the uplink BACKs **326**. In example embodiments, the MU-BAR **323** includes one or more of the following information: association identification (AID) of the STAs **108**, subchannel for the STA **108** to use to transmit the BACK **326**, and legacy BAR information that may be included in one or more wireless standards.

(52) The time sequence diagram **300** continues at **368** with the STAs **108** waiting to transmit BACKs **326**. In some embodiments, the STAs **108** may wait a SIFS **368** before transmitting the ACKs **326**. In example embodiments, the STAs **108** may determine to not wait for a SCH/SIG and wait STAs **366** before transmitting the ACKs **326** based on receiving an indication of an acknowledgement policy in the SIG **320**.

(53) The time sequence diagram **300** continues at **370** with the STAs **108** transmitting BACKs **326** to the AP **104**. In example embodiments, the STAs **108** use the same subchannel on which they received the data **322** to transmit the BACK **326**. For example, STA**3** **108**.**3** received data **322**.**3** on subchannel **2** and transmitted a BACK **326**.**3** to the AP **104** on subchannel **2**. In example embodiments, the STAs **108** are configured to send the BACKs **326** in response to the MU BAR **323** without receiving a SCH and/or a SIG based on receiving an indication to implement this acknowledgement policy from the AP **104**. In example embodiments, the STAs **108** are configured to transmit the BACKs **326** on an allocated subchannel **1**, **2**, **3**, **4** based on a subchannel allocation in the MU-BAR **323**.

(54) In some embodiments, the MU-MIMO may be used where one or more subchannels **1**, **2**, **3**, **4** may be shared by more than one STA **108**. For example, subchannel **4** may be shared by a MU-MIMO group such as STA**1** **108**.**1** and STA**5** **108**.**5** (not illustrated). In example embodiments, the acknowledgement policy may be based on a pre-determined rule. In example embodiments, the STA **108** may determine when to transmit a BACK **326** based on a spatial stream associated with the STA **108**. In example embodiments, the STA **108** from the MU-MIMO group for which the first spatial stream is intended may be the first STA **108** to transmit the BACK **326** after the DATA **322** transmission is received.

(55) FIG. **5** illustrates a time sequence diagram **400** of an acknowledgement, in accordance with some example embodiments. Illustrated in FIG. **5** is a time sequence diagram **400**, AP **104**, STAs **108**, SIG **420**, DATA **422**, MU BAR **423**.**1**, MU BAR **423**.**2**, and BACK **426**. The time sequence diagram illustrates time **460** along the horizontal axis and frequency **450** along the vertical axis. The transmitter is indicated along the top. As illustrated, the AP **104** and two or more of the STAs **108** may be using MU-MIMO and OFDMA. As illustrated, the frequency **450** is illustrated twice (**450**.**1** and **450**.**2**), with **450**.**1** illustrating a first MU-MIMO group and **450**.**2** illustrating a second MU-MIMO group.

(56) The time sequence diagram **400** begins at **462** with the AP **104** transmitting the SIG **420**.**1** and SIG **420**.**2** to the STAs **108**. The time sequence diagram **400** continues at **464** with the AP **104** transmitting data **422** to the STAs **108**. For example, the AP **104** may transmit data **422**.**2** to STA**2** **108**.**2** in a first spatial stream and STA**6** **108**.**6** on subchannel **3** in a second spatial stream.

(57) The time sequence diagram **400** continues at **466** with the AP **104** MU-BAR **423**.**1** to the STAs **108**. In an example embodiment, the MU BAR **423**.**1** may be transmitted on a band that polls two or more of the STAs **108** to transmit BACKs **426**. For example, MU BAR **423**.**1** may poll STA**1** **108**.**1** through STA**4** **108**.**4** on subchannels **1**, **2**, **3**, **4** in MU-MIMO group. The MU BAR **423** may include an indication that the STAs **108** are to use an acknowledgement policy that indicates that the BACKs **426** are to be transmitted on the same subchannel **1**, **2**, **3**, **4** in which the DATA **422** was

transmitted to the STAs **108**.

(58) In example embodiments, the MU-BAR **423** may indicate which MU-MIMO group should respond. In example embodiments, the MU-BAR **423** may indicate that a MU-MIMO group should respond, and the STAs **108** may determine which group should respond based on a predetermined rule. In example embodiments, the indication of the acknowledgement policy may have been sent to the STAs **108** in an earlier frame such as a management or control frame. In example embodiments, the MU-BAR **423** may be a multicast/broadcast frame addressing multiple STAs **108**. In example embodiments, MU-BAR **423** may include subchannel allocation for the uplink BACKs **426**. The MU-BAR **423** may include one or more of the following information AID of the STAs **108**: subchannel for the STA **108** to use to transmit the BACK **426** and legacy BAR information that may be included in one or more wireless standards.

(59) The time sequence diagram **400** continues at **468** with the STAs **108** waiting to transmit BACKs **426**. In example embodiments, the STAs **108** may wait a short SIFS **468** before transmitting the BACKs **426**. En example embodiments, the STAs **108** may determine to not wait for a SCH/SIG and wait SIFs **466** before transmitting the BACKs **426**. In example embodiments, the STAs **108** may determine to not wait for a SCH/SIG and wait SIFs **466** before transmitting the BACKs **426** based on receiving an indication of an acknowledgement policy in the SIG **420**.

(60) The time sequence diagram **400** continues at **470** with the STAs **108** transmitting BACKs **426** to the AP **104**. In an example embodiment, the STAs **108** use the same subchannel on which they received the data **422** to transmit the BACK **426**. For example, STA**3 108.3** received data **423.3** on subchannel **2** and transmitted a BACK **426.3** to the AP **104** on subchannel **2**. In an example embodiment, the STAs **108** are configured to send the BACKs **426** in response to the MU-BAR **423** without receiving a SCH and/or a SIG based on receiving an indication to implement this acknowledgement policy from the AP **104**. In an example embodiment, the STAs **108** are configured to transmit the BACKs **426** on subchannels **1**, **2**, **3**, **4** based on a subchannel allocation in the MU-BAR **423**.

(61) The time sequence diagram **400** continues at **472** with the AP **104** transmitting a second MU-BAR **423.2**. In an example embodiment, the AP **104** transmits at least one MU-BAR **423** for each MU-MIMO group.

(62) The time sequence diagram **400** continues at **474** with the STAs **108** waiting to transmit BACKs **726**. The time sequence diagram **400** continues at **476** with the STAs **108** transmitting BACKs **426** to the AP **104**. In an example embodiment, the STAs **108** use the same subchannel on which they received the data **422** to transmit the BACK **426**. For example, STA**3 108.3** received data **422.3** on subchannel **2** and transmitted a BACK **426.3** to the AP **104** on subchannel **2**. In an example embodiment, the STAs **108** are configured to send the BACKs **426** in response to the MU-BAR **423** without receiving a SCH and/or a SIG based on receiving an indication to implement this acknowledgement policy from the AP **104**. In an example embodiment, the STAs **108** are configured to transmit the BACKs **426** on subchannels **1**, **2**, **3**, **4** based on a subchannel allocation in the MU-BAR **423**.

(63) As illustrated, STA**1 108.1** and STA**5 108.5** are in different MU-MIMO groups. STA**1 108.1** transmitted a BACK **426.1** to the AP **104** at **470** in response to MU-BAR **423.1** at **466**. STAS **108.5** transmitted a BACK **426.5** to the AP **104** at **476** in response to the MU-BAR **423.2** at **472**.

(64) FIG. **6** illustrates a time sequence diagram **500** of an acknowledgement, in accordance with some example embodiments. Illustrated in FIG. **6** is a time sequence diagram **500**, AP **104**, STAs **108**, SIG **520**, DATA **522**, MU BAR **523**, and BACK **526**. The time sequence diagram illustrates time **560** along the horizontal axis and frequency **550** along the vertical axis. The transmitter is indicated along the top. As illustrated, the AP **104** and two or more of the STAs **108** may be using MU-MIMO and OFDMA. As illustrated, the frequency **550** is illustrated twice (**550.1** and **550.2**), with **550.1** illustrating a first MU-MIMO group and **550.2** illustrating a second MU-MIMO group.

(65) The time sequence diagram **500** begins at **562** with the AP **104** transmitting the SIG **520** to the

STAs **108**. In example embodiments, the AP **104** transmits separate SIGS **520** for the two illustrated MU-MIMO groups.

(66) The time sequence diagram **500** continues at **564** with the AP **104** transmitting data **522** to the STAs **108**. For example, the AP **104** may transmit data **522.2** to STA**2** **108.2** and data **522.6** to STA**6** **108.6** on subchannel **3**. The data **522.2** and data **522.6** may be transmitted on different MU-MIMU groups.

(67) The time sequence diagram **500** continues at **566** with the AP **104** transmitting multi-user block acknowledgement requests (MU-BAR) **523** to the STAs **108**. In example embodiments, the MU BAR **523** may be transmitted on a band that polls two or more of the STAs **108** to transmit BACKs **526**. In example embodiments, the MU BAR **523** may poll multiple MU-MIMO groups.

(68) In example embodiments, the MU BAR **523** may include an indication that the STAs **108** are to use an acknowledgement policy that indicates that the BACKs **526** are to be transmitted on the same subchannels **1**, **2**, **3**, **4** in which the DATA **522** was received by the STAs **108**.

(69) In example embodiments, the MU-BAR **523** may indicate which MU-MIMO group should respond. In an example embodiment, the MU-BAR **523** may indicate that a particular MU-MIMO group should respond. In example embodiments, the STAs **108** may determine which group should respond based on a predetermined rule. In example embodiments, the indication of the acknowledgement policy may have been sent to the STAs **108** in an earlier frame such as a management, data, or control frame.

(70) In example embodiments, the MU-BAR **523** is a multicast/broadcast frame addressing multiple STAs **108**. In example embodiments, MU-BAR **523** may include subchannel allocation for the uplink BACKs **526**. In example embodiments, the MU-BAR **523** includes one or more of the following information AID of the STAs **108**: subchannel for the STA **108** to use to transmit the BACK **526**, order of the STAs **108** to transmit BACKs **826** in the MU group that are following the MU-BAR **823**, and legacy BAR information that may be included in one or more wireless standards. In example embodiments, the MU-BAR **523** is send once for each MU-MIMO group.

(71) The time sequence diagram **500** may continue at **568** with the STAs **108** waiting to transmit BACKs **526**. In some embodiments, the STAs **108** may wait a SIFS **568** before transmitting the BACKs **526**. In example embodiments, the STAs **108** may determine to not wait for a SCH/SIG and wait SIFs **568** before transmitting the BACKs **526** based on receiving an indication from the AP **104** that the SCH/SIG would not be sent. In example embodiments, the STAs **108** may wait another length of time.

(72) The time sequence diagram **500** continues at **570** with the STAs **108** transmitting BACKs **526** to the AP **104**. In an example embodiment, the STAs **108** use the same subchannel on which they received the data **522** to transmit the BACK **526**. For example, STA**3** **108.3** received BAR **523.3** on subchannel **2** and transmitted a BACK **526.3** to the AP **104** on subchannel **2**. In an example embodiment, the STAs **108** are configured to send the BACKs **526** in response to the MU-BAR **523** without receiving a SCH and/or a SIG based on receiving an indication to implement this acknowledgement policy from the AP **104**. In an example embodiment, the STAs **108** are configured to transmit the BACKs **526** on subchannels **1**, **2**, **3**, **4** based on a subchannel allocation in the MU-BAR **523**.

(73) The time sequence diagram **500** may continue at **572** with the STAs **108** waiting to transmit BACKs **526**. In some embodiments, the STAs **108** may wait a SIFS **572** before transmitting the BACKs **526**. In an example embodiments, the STAs **108** may determine to not wait for a SCH/SIG and wait SIFs **572** before transmitting the BACKs **526** based on receiving an indication from the AP **104** that the SCH/SIG would not be sent. In example embodiments, the STAs **108** may wait another length of time.

(74) The time sequence diagram **500** continues at **574** with the STAs **108** transmitting BACKs **526** to the AP **104**. In an example embodiment, the STAs **108** use the same subchannel on which they received the data **522** to transmit the BACK **526**. For example, STA**3** **108.3** received BAR **523.3** on

subchannel **2** and transmitted a BACK **526**.**3** to the AP **104** on subchannel **2**. In an example embodiment, the STAs **108** are configured to send the BACKs **526** in response to the MU-BAR **523** without receiving a SCFI and/or a SIG based on receiving an indication to implement this acknowledgement policy from the AP **104**. In an example embodiment, the STAs **108** are configured to transmit the BACKs **526** on subchannel **1**, **2**, **3**, **4** based on a subchannel allocation in the MU-BAR **523**.

(75) As illustrated, STA**1** **108**.**1** and STA**5** **108**.**5** are in different MU-MIMO groups. STA**1** **108**.**1** transmitted a BACK **526**.**1** to the AP **104** at **570** in response to MU-BAR **523** at **566**. STA**5** **108**.**5** transmitted a BACK **526**.**5** to the AP **104** at **574** in response to the MU-BAR **523** at **566**.

(76) In example embodiments, the technical effect is achieved of reducing the time to receive BACKs by requesting that BACK be sent in parallel. In example embodiments, the technical effect is achieved of reducing the time to receive BACK by not including a schedule subchannel allocation in a BAR.

(77) FIG. **7** illustrates a frame **600** with a field **602** for acknowledgement in wireless networks, according to example embodiments. In example embodiments, the frame **600** is a signal that is a management, control, or data frame. In example embodiments, the frame **600** is a SIG frame, beacon frame, data frame, or MU BAR frame. In example embodiments, the field **602** may indicate an acknowledgement policy indicating how a STA **108** should acknowledge frames.

(78) In example embodiments, the STA **108** is communicating in accordance with OFDMA and MU-MIMO. In example embodiments, the field **602** may indicate that the STA **108** should use a same subchannel or channel to acknowledge a frame as the frame was received on. In example embodiments, the STA **108** may be configured to use block acknowledgements. In example embodiments, the field **602** may be a single hit indicating that an OFDMA MU-MIMO acknowledgment policy should be used. The acknowledgment policy may be a block acknowledgment policy.

(79) In example embodiments, the frame **600** is a frame transmitted prior to data frames, and the frame **600** includes an indication that data frames should be acknowledged using block acknowledgment on subchannels that were used to transmit the data frames.

(80) In example embodiments, the field **602** may indicate an acknowledgement policy for groups in MU-MIMO. In example embodiments, the field **602** indicates that a STA should block acknowledge based on the order of the MU-MIMO group. In example embodiments, the field **602** indicates that the STA should acknowledge frames in the order of their MU-MIMO group. In example embodiments, the field **602** indicates that the STA should acknowledge frames according to their MU-MIMO group and wait a SIFS before transmitting the block acknowledgement.

(81) In example embodiment, the field **602** may indicate that the STA should wait a SIFS after receiving a block acknowledgement request to transmit a block acknowledgment.

(82) In example embodiments, the field **602** indicates that the STA should use a predetermined rule for a subchannel to transmit a block acknowledgment on and/or a predetermined rule for an order of a MU-MIMO group to transmit a block acknowledgement.

(83) In example embodiments, the frame **600** is a SIG frame and the field **602** indicates that the STAs should acknowledge data frames transmitted after the SIG frame without waiting for an acknowledgement request.

(84) FIG. **8** illustrates a frame **700** with a field **702** for acknowledgement in wireless networks, according to example embodiments. In example embodiments, the frame **700** is a MU BAR signal and the field **702** indicates a subchannel allocation for a STA to use to transmit block acknowledgement of frames transmitted to the STA. In example embodiments, the frame **700** may be used for communications in OFDMA and MU-MIMO. In example embodiments, the frame **700** is a signal that is a block acknowledgement request for OFDMA and MU-MIMO. In example embodiments, the frame **700** is transmitted to poll multiple STAs at once to transmit multiple BACK in parallel back.

(85) FIG. **9** illustrates a frame **800** with a field **802** for acknowledgement in wireless networks, according to example embodiments. The frame **800** may be a signal that is part of a management frame transmitted by the STA where the field **802** indicates one or more acknowledgement policies that are supported by the STA as disclosed herein.
(86) FIG. **10** illustrates a HEW device, in accordance with some embodiments. HEW device **1000** may be an HEW compliant device that may be arranged to communicate with one or more other HEW devices, such as HEW devices **104** (FIG. **1**) or AP **104** (FIG. **1**) as well as communicate with legacy devices **106** (FIG. **1**). HEW devices **104** and legacy devices **106** may also be referred to as HEW STAs and legacy STAs, respectively. HEW device **1000** may be suitable for operating as AP **104** (FIG. **1**) or an HEW device **104** (FIG. **1**). In accordance with embodiments, HEW device **1000** may include, among other things, physical layer (PHY) circuitry **1002** and medium-access control layer circuitry (MAC) **1004**. PHY circuitry **1002** and MAC **1004** may be HEW compliant layers and may also be compliant with one or more legacy IEEE 802.11 standards. MAC **1004** may be arranged to configure physical layer convergence procedure protocol data unit PPDUs and arranged to transmit and receive PPDUs, among other things. HEW device **1000** may also include other hardware processing circuitry **1006** and memory **1008** configured to perform the various operations described herein.
(87) In some embodiments, the MAC **1004** may be arranged to contend for a wireless medium during a contention period to receive control of the medium for the HEW control period and configure an HEW PPDU. The PHY circuitry **1002** may be arranged to transmit the HEW PPDU. The PHY circuitry **1002** may include circuitry for modulation/demodulation, upconversion/downconversion, filtering, amplification, and the like. In some embodiments, the hardware processing circuitry **1006** may include one or more processors. The hardware processing circuitry **1006** may be configured to perform functions based on instructions being stored in a random access memory (RAM) or read-only memory (ROM), or based on special purpose circuitry. In some embodiments, two or more antennas may be coupled to the PHY circuitry **1002** and arranged for sending and receiving signals including transmission of the HEW packets. The HEW device **1000** may include a transceiver (not shown) to transmit and receive data such as HEW PPDU. The memory **1008** may store information for configuring the other circuitry to perform operations for configuring and transmitting HEW packets and performing the various operations described herein including the reception of and transmission of SIGs **120**, **220**, **320**, **420**, and **520**; DATA **122**, **222**, **322**, **422**, and **522**; MU BAR **323**, **423**, and **523**; BAR **223**; BACK **226**, **326**, **426**, and **526**; frames **600** and **700**; and, ACK **126**. In example embodiments, the circuitry of one or more of the antenna, transceiver, PHY circuitry **1002**, MAC **1.004**, and processing **1006** may be configured to perform operations for configuring and transmitting HEW packets and performing the various operations described herein including the reception of and transmission of SIGs **120**, **220**, **320**, **420**, and **520**; DATA **122**, **222**, **322**, **422**, and **522**; MU BAR **323**, **423**, and **523**; BAR **223**; BACK **226**, **326**, **426**, and **526**; frames **600** and **700**; and, ACK **126**.
(88) In some embodiments, the HEW device **1000** may be configured to communicate using OFDM communication signals over a multicarrier communication channel. In some embodiments, HEW device **1000** may be configured to communicate in accordance with one or more specific communication standards, such as the IEEE standards including IEEE 802.11-2012, 802.11n-2009, 802.11ac-2013, 802.11ax, standards and/or proposed specifications for WLANs, although the scope of the example embodiments is not limited in this respect as they may also be suitable to transmit and/or receive communications in accordance with other techniques and standards.
(89) In some embodiments, an HEW device **1000** may be part of a portable wireless communication device, such as a PDA) a laptop or portable computer with wireless communication capability, a web tablet, a wireless telephone, a smartphone, a wireless headset, a pager, an instant messaging device, a digital camera, an AP, a television, a medical device (e.g., a heart rate monitor, a blood pressure monitor, etc.), a base station, a transmit/receive device for a wireless standard such

as 802.11 or 802.16, or other device that may receive and/or transmit information wirelessly. In some embodiments, the mobile device may include one or more of a keyboard, a display, a non-volatile memory port, multiple antennas, a graphics processor, an application processor, speakers, and other mobile device elements. The display may be an LCD screen including a touch screen.

(90) The antennas may 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 MIMO embodiments, the antennas may be effectively separated to take advantage of spatial diversity and the different channel characteristics that may result.

(91) Although the device **1000** 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 DSPs, and/or other hardware elements. For example, some elements may comprise one or more microprocessors, DSPs, FPGAs, ASICs, transmitters, receivers, transceivers, 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.

(92) Embodiments may be implemented in one or a combination of hardware, firmware and software. Embodiments may also be implemented as instructions stored on a computer-readable storage device, which may be read and executed by at least one processor to perform the operations described herein. A computer-readable storage device may include any non-transitory mechanism for storing information in a form readable by a machine (e.g., a computer). For example, a computer-readable storage device may include ROM, RAM, magnetic disk storage media, optical storage media, flash-memory devices, and other storage devices and media. Some embodiments may include one or more processors and may be configured with instructions stored on a computer-readable storage device.

(93) The following examples pertain to further embodiments. Example 1 is a station (STA) including hardware processing circuitry configured to: receive data frames on a subchannel from an access point (AP) in accordance with down link (DL) multi-user multiple input and multiple output (MU-MIMO) and orthogonal frequency division multiple access (OFDMA). The hardware circuitry may be configured to: transmit a block acknowledgement of the data frames in accordance with uplink (UL) MU-MIMO and OFDMA, in response to the data frames.

(94) In Example 2, the subject matter of Example 1 can optionally include: where the hardware processing circuitry is further configured to: transmit the block acknowledgement of the data frames on the subchannel.

(95) In Example 3, the subject matter of Examples 1 and 2 can optionally include: where the hardware processing circuitry is further configured to: transmit the block acknowledgement of the data frames when a block acknowledgement request has not been received by the STA.

(96) In Example 4, the subject matter of Examples 1 through 3 can optionally include: where the hardware processing circuitry is further configured to: receive an indication of an acknowledgment policy from the AP.

(97) In Example 5, the subject matter of Examples 1 through 4 can optionally include: where the hardware processing circuitry is further configured to wait a short interframe space (SIFS) time before the transmit.

(98) In Example 6, the subject matter of Examples 1 through 5 can optionally include: where the hardware processing circuitry is further configured to wait a predetermined time before the transmit, where the predetermined time is longer than a short interframe space (SIFS) time.

(99) In Example 7, the subject matter of Examples 1 through 6 can optionally include: where the hardware processing circuitry is further configured to transmit the block acknowledgement at a time based on a MU-MIMO group identification of the wireless device.

(100) In Example 8, the subject matter of Examples 1 through 7 can optionally include: where the hardware processing circuitry is further configured to: transmit second data frames in accordance with UL MU-MIMO and OFDMA, wherein the second data frames comprises the block acknowledgement of the data frames, in response to the data frames.
(101) In Example 9, the subject matter of Examples 1 through 8 can optionally include: where the hardware processing circuitry is further configured to: transmit second data frames on the subchannel, and transmit the block acknowledgement of the data frames on the subchannel in accordance with UL MU-MIMO and OFDMA, in response to the data frames.
(102) In Example 10, the subject matter of Examples 1 through 9 can optionally include: where the hardware processing circuitry is further configured to: receive a signal frame from the AP prior to the data frames.
(103) In Example 11, the subject matter of Examples 1 through 10 can optionally include: where the data frames or the signal frame comprise an indication of a schedule; and where the second data frames are transmitted according to the schedule.
(104) In Example 12, the subject matter of Examples 1 through 11 can optionally include: where the data frames or the signal frame comprise an indication to transmit the block acknowledgement of the data on the subchannel.
(105) In Example 13, the subject matter of Examples 1 through 8 can optionally include: memory and a transceiver coupled to the processing circuitry.
(106) In Example 14, the subject matter of Example 13 can optionally include: one or more antennas coupled to the transceiver.
(107) Example 15 is a method on a station (STA). The method including receiving data frames on a subchannel from an access point (AP) using multi-user multiple-input multiple-output (MU MIMO). The method may further include transmitting a block acknowledgement of the data frames, wherein the block acknowledgement is transmitted without receiving a block acknowledgement request, in response to receiving the data frames.
(108) In Example 16, the subject matter of Example 15 can optionally include: transmitting the block acknowledgement of the data frames on the subchannel.
(109) In Example 17, the subject matter of Examples 15 and 16 can optionally include: waiting a short interframe space (SIFS) time before transmitting.
(110) In Example 18 is an access point (AP). The AP may include hardware processing circuitry configured to: transmit first data frames to a first station (STA) on a first subchannel and concurrently transmit second data frames to a second STA on a second subchannel in accordance with down link (DL) multi-user multiple input and multiple output (MU-MIMO) and orthogonal frequency division multiple access (OFDMA). The hardware processing circuitry may be further configured to receive a first block acknowledgement from the first STA and concurrently receive a second block acknowledgement from the second STA in accordance with uplink (UL) MU-MIMO and OFDMA, where the first block acknowledgement is received on one of the first and second subchannels, and the second block acknowledgement is received on the other of the first and second subchannels.
(111) In Example 19, the subject matter of Example 18 can optionally include: where the first subchannel and the second subchannel have a first bandwidth and a second bandwidth, respectively; and where the first bandwidth and the second bandwidth are each one of the following group: 1 MHz, 1.25 MHz, 2.5 MHz, 5 MHz, 10 MHz, 20 MHz, 40 Mhz, 80 MHz, and 160 MHz; and where the first subchannel and the second subchannel are different portions of a radio spectrum.
(112) In Example 20, the subject matter of Examples 18 and 19 can optionally include where the hardware processing circuitry is further configured to: transmit the first transmission to the first STA on the first subchannel and a third transmission to a third STA on the first subchannel.
(113) In Example 21, the subject matter of Examples 18 through 20 may option include where the

hardware processing circuitry is further configured to: transmit a multi-user (MU) block acknowledgement request (BAR).
(114) In Example 22, the subject matter of Example 21 may optionally include where the MU-BAR comprises a scheduling subchannel allocation.
(115) In Example 23, the subject matter of Example 21 may optionally include where the hardware processing circuitry is further configured to: receive a third block acknowledgement from the third STA after the first block acknowledgement from the first STA is received, wherein the third subchannel and the first subchannel occupy the same portion of the radio spectrum.
(116) Example 24 is a non-transitory computer-readable storage medium that stores instructions for execution by one or more processors to perform operations for block acknowledgement. The instructions configure the one or more processors to: receive data frames on a subchannel from an access point (AP) in accordance with down link (DL) multi-user multiple input and multiple output (MU-MIMO) and orthogonal frequency division multiple access (OFDMA); and transmit a block acknowledgement of the data frames on a subchannel in accordance with uplink (UL) MU-MIMO and OFDMA, in response to the data frames. In Example 25, the subject matter of Example 24 may optionally include where the instructions further configure the one or more processors to: transmit the block acknowledgement when a block acknowledgement request has not been received.
(117) The Abstract is provided to comply with 37 C.F.R. Section 1.72(b) requiring an abstract that will allow the reader to ascertain the nature and gist of the technical disclosure. It is submitted with the understanding that it will not be used to limit or interpret the scope or meaning of the claims. The following claims are hereby incorporated into the detailed description, with each claim standing on its own as a separate embodiment.

Claims

1. A method performed by a first station, the method comprising: receiving a signal field from an access point, the signal field including a first schedule; receiving a first downlink data frame from the access point on a first sub-channel according to the first schedule, wherein a second downlink data frame from the access point is received by a second station on a second sub-channel simultaneously according to downlink multi-user multiple input multiple output (DL MU-MIMO) and/or orthogonal frequency division multiple access (OFDMA), wherein the first station is included in a first group and the second station is included in a second group; receiving a multi-user block acknowledgement request (MU BAR) from the access point, wherein the MU BAR polls a first response of one or more stations in the first group and a second response of one or more stations in the second group with different response timing, and wherein the MU BAR indicates a resource allocation for a first uplink block acknowledgement for the first downlink data frame to be transmitted by the first station, and transmitting, to the access point, the first uplink block acknowledgement for the first downlink data frame at a first response timing in response to the MU BAR based on the resource allocation, while a second uplink block acknowledgement for the second downlink data frame being transmitted to the access point from the second station at a second response timing after a short inter-frame space (SIFS) interval following the first response timing, in response to the MU BAR.
2. The method of claim 1, wherein the MU BAR is a group based request for the first group and the second group.
3. The method of claim 1 further comprising: waiting for the SIFS interval before transmitting the first uplink block acknowledgement for the first downlink data frame.
4. The method of claim 1 further comprising: waiting for a predetermined time before transmitting the first uplink block acknowledgement for the first downlink data frame, wherein the predetermined time is longer than the SIFS interval.
5. The method of claim 1, wherein the first uplink block acknowledgement is transmitted by being

included in a first uplink data frame.

6. The method of claim 1, wherein a bandwidth for each of the first sub-channel and the second sub-channel is one of the following bandwidths: 1 MHz, 1.25 MHZ, 2.5 MHz, 5 MHz, 10 MHz, 20 MHz, 40 MHz, 80 MHz, and 160 MHz.

7. A method performed by an access point, the method comprising: transmitting a signal field to a first station and a second station, the signal field including a first schedule and a second schedule; transmitting a first downlink data frame to the first station on a first sub-channel according to the first schedule and simultaneously transmitting a second downlink data frame to the second station on a second sub-channel according to the second schedule, the first downlink data frame and the second downlink data frame are transmitted based on downlink multi-user multiple input multiple output (DL MU-MIMO) and/or orthogonal frequency division multiple access (OFDMA), wherein the first station is included in a first group and the second station is included in a second group; transmitting a multi-user block acknowledgement request (MU BAR) to the first station and the second station, wherein the MU BAR polls a first response of one or more stations in the first group and a second response of one or more stations in the second group with different response timing, and wherein the MU BAR indicates a resource allocation for a first uplink block acknowledgement for the first downlink data frame to be transmitted from the first station, and receiving the first uplink block acknowledgement for the first downlink data frame at a first response timing in response to the MU BAR and receiving a second uplink block acknowledgement for the second downlink data frame at a second response timing after a short inter-frame space (SIFS) interval following the first response timing, in response to the MU BAR.

8. The method of claim 7, wherein the MU BAR is a group based request for the first group and the second group.

9. The method of claim 7 further comprising: waiting for the SIFS interval before receiving the first uplink block acknowledgement for the first downlink data frame.

10. The method of claim 7 further comprising: waiting for a predetermined time before receiving the first uplink block acknowledgement for the first downlink data frame, wherein the predetermined time is longer than the SIFS interval.

11. The method of claim 7, wherein the first uplink block acknowledgement is received by being included in a first uplink data frame.

12. The method of claim 7, wherein a bandwidth for each of the first sub-channel and the second sub-channel is one of the following bandwidths: 1 MHz, 1.25 MHZ, 2.5 MHz, 5 MHz, 10 MHz, 20 MHz, 40 MHz, 80 MHz, and 160 MHz.