



(51) International Patent Classification:

H04W 74/00 (2009.01) *H04W* 84/12 (2009.01)
H04W 74/08 (2009.01) *H04L* 27/26 (2006.01)

(21) International Application Number:

PCT/US2016/039774

(22) International Filing Date:

28 June 2016 (28.06.2016)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

62/267,037 14 December 2015 (14.12.2015) US

(71) Applicant: INTEL IP CORPORATION [US/US]; 2200 Mission College Blvd., Santa Clara, California 95054 (US).

(72) Inventor; and

(71) Applicant: LI, Qinghua [CN/US]; 5117 Chiltern Lane, San Ramon, California 94582 (US).

(72) Inventors: HUANG, Po-Kai; 213 Halsey Dr., Apt 7, West Lafayette, Indiana 47906 (US). CARIU, Laurent; 5714 SW miles court, Portland, Oregon 97219 (US). CHEN, Xiaogang; Raycom Building A 8F, Ke Xue Yuan Nan Lu 2#, Haidian District, Beijing 100080 (CN).

(74) Agents: PERDOK, Monique M. et al.; Schwegman Lundberg & Woessner, P.A., c/o CPA Global, 900 Second Av-

enue South, Suite 600, Minneapolis, Minnesota 55402 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

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

(54) Title: CHANNEL AVAILABILITY REPORTS

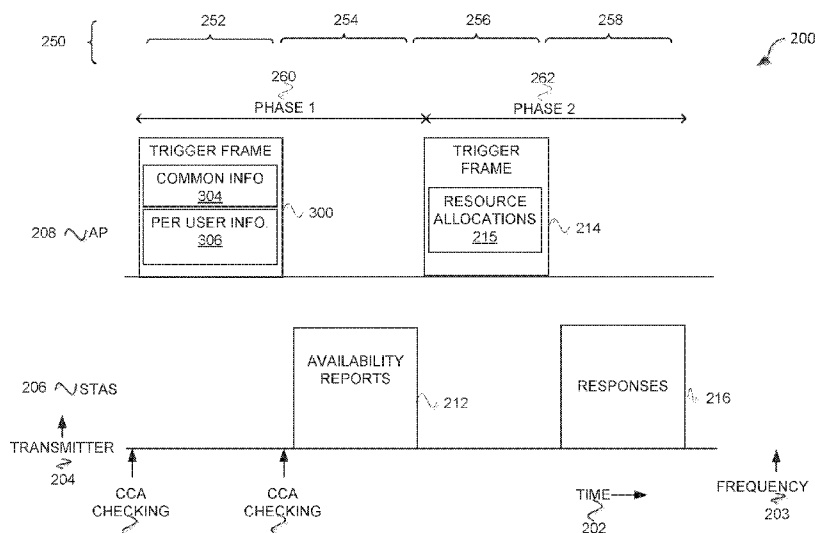


FIG. 2

(57) Abstract: Methods, computer readable media, and wireless apparatuses are disclosed for reporting channel availability. An apparatus of a wireless device is disclosed. The apparatus comprising processing circuitry configured to: encode a trigger frame for polling channel availability to a plurality of stations, configure the wireless device to transmit the trigger frame, and decode one or more responses of channel availability from one or more stations of the plurality of stations in accordance with the trigger frame for polling channel availability, where the one or more indications are received in accordance with orthogonal frequency division multiple-access (OFDMA).

CHANNEL AVAILABILITY REPORTS

5

PRIORITY CLAIM

[0001] This application claims the benefit of priority to U.S. Provisional Patent Application Serial No. 62/267,037, filed December 14, 2015, which is
10 incorporated herein by reference in its entirety.

TECHNICAL FIELD

15 [0002] Embodiments pertain to wireless networks and wireless communications. Some embodiments relate to wireless local area networks (WLANs) and Wi-Fi networks including networks operating in accordance with the IEEE 802.11 family of standards. Some embodiments relate to IEEE
20 802.11ax. Some embodiments relate to methods, computer readable media, and apparatus for trigger frames, channel availability reports, and transmitting and receiving trigger frames and channel availability reports.

BACKGROUND

25

[0003] Efficient use of the resources of a wireless local-area network (WLAN) is important to provide bandwidth and acceptable response times to the users of the WLAN. However, often there are many devices trying to share the same resources and some devices may be limited by the communication protocol
30 they use or by their hardware bandwidth. Moreover, wireless devices may need to operate with both newer protocols and with legacy device protocols.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] The present disclosure is illustrated by way of example and not limitation in the figures of the accompanying drawings, in which like references
5 indicate similar elements and in which:
[0005] FIG. 1 illustrates a WLAN in accordance with some embodiments;
[0006] FIG. 2 illustrates a method for channel availability reports in accordance with some embodiments;
10 [0007] FIG. 3 illustrates a trigger frame in accordance with some embodiments;
[0008] FIG. 4 illustrates channels in accordance with some embodiments;
[0009] FIGS. 5 and 6 illustrate type of availability reports in accordance
15 with some embodiments;
[0010] FIG. 7 illustrates an embodiment of the channel report in accordance with some embodiments;
[0011] FIG. 8 illustrates a method for reporting channel availability in accordance with some embodiments;
20 [0012] FIG. 9 illustrates a method for reporting channel availability in accordance with some embodiments; and
[0013] FIG. 10 illustrates a block diagram of an example machine upon which any one or more of the techniques (e.g., methodologies) discussed herein may perform.

25

DESCRIPTION

[0014] The following description and the drawings sufficiently illustrate
30 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.

[0015] FIG. 1 illustrates a WLAN 100 in accordance with some embodiments. The WLAN may comprise a basis service set (BSS) 100 that may include a master station 102, which may be an AP, a plurality of high-efficiency (HE) (e.g., IEEE 802.11ax) stations 104, and a plurality of legacy (e.g., IEEE 802.11n/ac) devices 106.

[0016] The master station 102 may be an AP using one of the IEEE 802.11 protocols to transmit and receive. The master station 102 may be a base station. The master station 102 may use other communications protocols as well as the IEEE 802.11 protocol. The IEEE 802.11 protocol may be IEEE 802.11ax. The IEEE 802.11 protocol may include using orthogonal frequency division multiple-access (OFDMA), time division multiple access (TDMA), and/or code division multiple access (CDMA). The IEEE 802.11 protocol may include a multiple access technique. For example, the IEEE 802.11 protocol may include space-division multiple access (SDMA) and/or multiple-user multiple-input multiple-output (MU-MIMO). The master station 102 and/or HE station 104 may use one or both of MU-MIMO and OFDMA. There may be more than one master station 102 that is part of an extended service set (ESS). A controller (not illustrated) may store information that is common to the more than one master station 102. The controller may have access to an external network such as the Internet.

[0017] The legacy devices 106 may operate in accordance with one or more of IEEE 802.11 a/b/g/n/ac/ad/af/ah/aj, or another legacy wireless communication standard. The legacy devices 106 may be STAs or IEEE 802.11 STAs. The HE stations 104 may be wireless transmit and receive devices such as cellular telephone, smart telephone, handheld wireless device, wireless glasses, wireless watch, wireless personal device, tablet, or another device that may be transmitting and receiving using the IEEE 802.11 protocol such as IEEE 802.11ax or another wireless protocol such as IEEE 802.11az. In some embodiments, the HE stations 104, master station 102, and/or legacy devices 106 may be termed wireless devices. In some embodiments the HE station 104 may

be a “group owner” (GO) for peer-to-peer modes of operation where the HE station 104 may perform some operations of a master station 102.

[0018] The master station 102 may communicate with legacy devices 106 in accordance with legacy IEEE 802.11 communication techniques. In example embodiments, the master station 102 may also be configured to communicate with HE stations 104 in accordance with legacy IEEE 802.11 communication techniques.

[0019] In some embodiments, a HE frame may be configurable to have the same bandwidth as a channel. The bandwidth of a channel may be 20MHz, 40MHz, or 80MHz, 160MHz, 320MHz contiguous bandwidths or an 80+80MHz (160MHz) non-contiguous bandwidth. In some embodiments, the bandwidth of a channel may be 1 MHz, 1.25MHz, 2.03MHz, 2.5MHz, 5MHz and 10MHz, or a combination thereof or another bandwidth that is less or equal to the available bandwidth may also be used. In some embodiments the bandwidth of the channels may be based on a number of active subcarriers. In some embodiments the bandwidth of the channels are multiples of 26 (e.g., 26, 52, 104, etc.) active subcarriers or tones that are spaced by 20 MHz. In some embodiments the bandwidth of the channels are 26, 52, 104, 242, etc. active data subcarriers or tones that are space 20 MHz apart. In some embodiments the bandwidth of the channels is 256 tones spaced by 20 MHz. In some embodiments a 20 MHz channel may comprise 256 tones for a 256 point Fast Fourier Transform (FFT). In some embodiments, a different number of tones is used.

[0020] A HE frame may be configured for transmitting a number of spatial streams, which may be in accordance with MU-MIMO. In some embodiments, a HE frame may be configured for transmitting in accordance with one or both of OFDMA and MU-MIMO. In other embodiments, the master station 102, HE station 104, and/or legacy device 106 may also implement different technologies such as code division multiple access (CDMA) 2000, CDMA 2000 1X, CDMA 2000 Evolution-Data Optimized (EV-DO), Interim Standard 2000 (IS-2000), Interim Standard 95 (IS-95), Interim Standard 856 (IS-856), Long Term Evolution (LTE), Global System for Mobile communications (GSM), Enhanced Data rates for GSM Evolution (EDGE), GSM EDGE

(GERAN), IEEE 802.16 (i.e., Worldwide Interoperability for Microwave Access (WiMAX)), BlueTooth®, WiMAX, WiGig, or other technologies.

[0021] Some embodiments relate to HE communications. In accordance with some IEEE 802.11ax embodiments, a master station 102 may operate as a
5 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 an HE control period. In some embodiments, the HE control period may be termed a transmission opportunity (TXOP). The master station 102 may transmit a HE master-sync transmission, which may be a trigger frame or HE control and
10 schedule transmission, at the beginning of the HE control period. The master station 102 may transmit a time duration of the TXOP and channel information. During the HE control period, HE stations 104 may communicate with the master station 102 in accordance with a non-contention based multiple access technique such as OFDMA and/or MU-MIMO. This is unlike conventional
15 WLAN communications in which devices communicate in accordance with a contention-based communication technique, rather than a multiple access technique. During the HE control period, the master station 102 may communicate with HE stations 104 using one or more HE frames. During the HE control period, the HE STAs 104 may operate on a channel smaller than the
20 operating range of the master station 102. During the HE control period, legacy stations refrain from communicating.

[0022] In accordance with some embodiments, during the master-sync transmission the HE STAs 104 may contend for the wireless medium with the legacy devices 106 being excluded from contending for the wireless medium
25 during the master-sync transmission or TXOP. In some embodiments the trigger frame may indicate an uplink (UL) UL-MU-MIMO and/or UL OFDMA control period. In some embodiments, the trigger frame may indicate a portions of the TXOP that are contention based for some HE station 104 and portions that are not contention based.

30 [0023] In some embodiments, the multiple-access technique used during the HE 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.

[0024] In example embodiments, the HE device 104 and/or the master station 102 are configured to perform the methods and operations herein described in conjunction with FIGS. 1-10.

[0025] FIG. 2 illustrates a method for channel availability reports in accordance with some embodiments. Illustrated in FIG. 2 is time 202 along a horizontal axis, frequency 204 along a vertical axis on the right hand side, transmitter 204, and operations 250 along the top. The AP 208 may be a master station 102 or HE station 104. The STAs 206 may be HE stations 104.

[0026] The method 200 is divided into two phases phase 1 260 and phase 2 262. In phase 1 260, the AP 208 determines channel availability for STAs 206 based on availability reports 213, and in phase 2 262 the AP 208 determines a resource allocations 215 based on the availability reports 213. FIG. 3-7 will be described in conjunction with FIG. 2.

[0027] The method 200 begins at operation 252 with the AP 208 transmitting trigger frame 300, which may be a trigger frame for channel availability reports 300. An example trigger frame 300 is illustrated in FIG. 3. The trigger frame 300 may be transmitted in a primary channel 20 MHz 402. In some embodiments, the trigger frame 300 may be broadcast in the second channel 160 MHz 410. In some embodiments, the trigger frame 300 may be repeated on one or more of the 20 MHz channels 412. The STAs 206 may be configured to determine which channels to CCA sense and report on (e.g., availability reports 212) based on the channels the trigger frame 300 is transmitted on.

[0028] FIG. 3 illustrates a trigger frame 300 in accordance with some embodiments. The trigger frame 300 includes fields before common information 302, common information 304, per user information 306.1 through per user information 306.N, and fields after per user information 308. The fields before common information 302 may include additional fields, e.g. frame control, duration, receiver address (RA), and transmitter address (TA). The fields after per user information 308 may include additional fields, e.g., padding and frame check sequence (FCS). The common information 304 may include zero or more

of response type 310, channel check type 312, channels to report on 314, and report type 316, and additional fields that are common to the users indicated in per user information 306, e.g., length, cascade indication, carrier sense (CS) required, HE signal A information, cyclic prefix (CP) and long training field (LTF) type, and trigger type (e.g., trigger frame for channel availability).

[0029] Response type 310 may be an indication whether the STA 206 should respond when the STA 206 is to transmit an availability report 213 on a particular RU. For example, if a STA 206 is to transmit an availability report 213 on a 2 MHz channel in the primary channel 302, then response type 310 may indicate that the STA 206 should transmit the availability report 213 based on zero or more of a NAV, an OBSS NAV, a regular NAV, and a CCA determination. For example, response type 310 may indicate that the STA 206 should transmit if an OBSS NAV is set and if a regular NAV is set, but not if a CCA determination indicates the channel is busy. In some embodiments, the response type 310 may be an indication that the STA 206 should respond if the NAV is set by a PPDU that is determined as Inter-BSS, or if the PPDU cannot be determined as Intra-BSS or Inter-BSS.

[0030] As another example, response type 310 may indicate that the STA 206 should respond even if a NAV is set and the CCA determination indicates the channel is busy. In another example, response type 310 may indicate that the STA 206 should transmit if a NAV is set, but CCA determination indicates the channel is not busy.

[0031] In some embodiments, the STA 206 may be configured to respond in accordance with one of the options above without response type 310 being signaled in the trigger frame 300. In some embodiments, the trigger frame 300 does not include response type 310. In some embodiments, the response type 310 may be indicated in an information element (IE) either with or before the trigger frame 300.

[0032] Channel check type 312 (e.g., to perform carrier sense, CS) may include an indication of a clear channel assessment (CCA) to use, e.g., energy detect (ED), mid packet detect for legacy signals with symbol duration 3.2 μ s, mid packet detect for HE physical (PHY) layer convergence procedure (PLCP) protocol data unit (PPDU) with 4 times symbol duration 12.8 μ s, etc. In some

embodiment channel check type 312 may not be indicated and may default to a particular way to check the channel, e.g. ED. Channel check type 312 may indicate whether a STA 206 should consider a channel busy based on a network availability vector (NAV) and/or a CCA. For example, the channel check type

5 312 may indicate to indicate that a channel is busy based only on the CCA or both on the NAV and the CCA. In some embodiments, channel check type 312 indicates whether the STA 206 should sense the channel before or after reception of the trigger frame 300.

[0033] In some embodiments, the STA 206 may be configured to

10 respond in accordance with one of the options above without channel check type 312 being signaled in the trigger frame 300. In some embodiments, the trigger frame 300 does not include channel check type 312. In some embodiments, the channel check type 312 may be indicated in an information element (IE) either with or before the trigger frame 300.

15 [0034] Channels to report 314 may indicate one or more channels for the STA 206 to report. FIG. 4 illustrates channels 400 in accordance with some embodiments. Illustrated in FIG. 4 is primary channel 20 MHz 402, secondary channel 20 MHz 404, secondary channel 40 MHz 406, second channel 80 MHz 408, secondary channel 160 MHz 410, and 20 MHz channels 412.1 through

20 412.8. Channels to report 314 may indicate one or more of the channels 400 illustrates in FIG. 4. In some embodiments, the channels 400 may occupy a different portion of the wireless spectrum. For example, there may be 16 20 MHz channels. In some embodiments, the channels 400 may be a different bandwidth. For example, some channels 400 may be less than 20 MHz in size or

25 greater than 20 MHz in size. In some embodiments, the channels may be defined by the number tones or sub-carriers for data which may be, in an example embodiment, 26, 52, 102, 242, and/or 996.

[0035] In some embodiments, the STA 206s may be configured to

30 respond in accordance with one of the options above without channels to report 314 being signaled in the trigger frame 300. In some embodiments, the trigger frame 300 does not include channels to report 314. In some embodiments, the channels to report 314 may be indicated in an information element (IE) either with or before the trigger frame 300. In some embodiments, the STAs 206 are

configured to determine that all 20 MHz channels occupied by the trigger frame 300 transmission should be CCA sensed and reported.

[0036] The report type 316 may indicate a type of report for the STA 206 to send. FIGS. 5 and 6 illustrate type of availability reports 500, 600 in accordance with some embodiments. Illustrated in FIG. 5 is primary 20 MHz 552, secondary 20 MHz 554, secondary 40 MHz 556 replicated twice. In each 20 MHz, STF 502, LTF 504, L-SIG 50, RL-SIG 508, and HE-SIG 510 are transmitted. The STAs 206 are allocated a portion of each channel, e.g., 26 tones, and transmit a HE-STF STA1 512.1, HE-LTF STA1 514.1, and code 1 515 in each channel that is determined to be clear (e.g., in accordance with channel check type 312). The AP 208 may allocate an RU for each of the STA 206 in the per user info 306. The AP 208 may indicate a code 515, 517 for groups of STAs 206. For example, as illustrated STA1 through STA9 use code 1 515 and STA-10 through STA use code 2. Each STA 206, STA1 through STA18 has 26 tones to transmit on a channel if they determine the channel is available or free. The AP 208 then distinguishes between the channels that are transmitted on by more than one STA 206 using the code 515, 517. For example, STA9 may transmit HE-STF STA9 516.9, HE-LTF STA1 518.9, and code 1 515 on secondary 20 MHz 554.1, and simultaneously or nearly simultaneously STA18 may transmit HE-STF STA18 540.9, HE-LTF STA18 542.9, and code 2 517 on secondary 40 MHz 556.2.

[0037] The same tones may be used by STA9 and STA18 on secondary 40 MHz to transmit. The AP 208 may distinguish between STA9 and STA18 based on whether the code is code 1 515 or code 2 517. The AP 208 may use spatial differentiation to assist in determining the different between STA9 and STA18. The STAs 206 may transmit different indications on the RU of the corresponding channel to indicate that the channel is available for the STA 206. In some embodiments, there may be more codes. For example, the AP 208 may assigned STA1 through STA9 code 1 515, STA10 through STA18 code 2 517, STA 19 through STA27 code 3, etc.

[0038] Illustrated in FIG. 6, is primary 20 MHz 662, secondary 20 MHz 664, secondary 40 MHz 666.1, and secondary 40MHz 666.2. On each 20 MHz channel may be transmitted STF 602, LTF 604, L-SIG 606, RL-SIG 608, and

HE-SIG 610. STAs 206 may be provided an RU in the per user info 306 portion of the trigger frame 300. The STAs 206 then transmit a report 616 (e.g., a channel availability report) in accordance with the RU. The STAs 206 may also transmit a HE-STF STA1 612.1, and HE-LTF STA1 614.1. In some

5 embodiments, the STAs 206 may transmit different information for the report.

[0039] FIG. 7 illustrates an embodiment of the channel report 702 in accordance with some embodiments. The STA 206 may not need to transmit the other portions of the frame because the AP 208 is expecting the channel reports 702 in accordance with the corresponding RU. The channel report 702 may be a
10 bit map with one bit per 20 MHz channel indicating whether the corresponding 20 MHz is available or not for the STA. The STA 206 may also transmit a FCS 704. The channel report 702 may be 1 octet, and the FCS 704 may be 4 octets. In some embodiments, the FCS 704 may not be included in the channel report 702. In some embodiments, the channel report 702 may be broadcast in one
15 symbol (e.g., tone or sub-carrier.)

[0040] In some embodiments, the STA 206 may be configured to respond in accordance with one of the options above without report type 316 being signaled in the trigger frame 300. In some embodiments, the trigger frame 300 does not include report type 316. In some embodiments, the report type 316
20 may be indicated in an information element (IE) either with or before the trigger frame 300.

[0041] The per user information 308 may include resource units (RUs) 318. In some embodiments, the per user information 308 may include one or more of response type 310, channel check type 312, channels to report 314,
25 and/or report type 316. The RU 318 may indicate a channel, or tones or sub-carriers for the STA 206 to use to transmit the availability report in accordance with OFDMA and/or MU-MIMO, e.g., one report, or a report on each available channel. Information regarding a modulation and coding scheme (MCS) and other transmission parameters may be included in the common information 304
30 and/or the per user information 306. In some embodiments, the RU 318 may be 26 tones or sub-carriers per channel. In some embodiments, the RU 318 may be fewer than 26 tones or sub-carriers, e.g. 1 tone.

[0042] Returning to method 200, the method 200 continues at operation 254 with the STAs 206 transmitting availability reports 212. The STAs 206 may perform CCA checking 220 in accordance with the common information 304 after receiving the trigger frame 300. In some embodiments, the STAs 206 may perform CCA checking 218 before reception of the trigger frame 300. The STAs 206 may determine whether to perform the CCA checking at 218 or 220 based on the channel check type 312 or another parameter signaled to the STAs 206. In some embodiments, the STAs 206 is configured to determine the CCA checking at 218 or 220 without being signaled where to perform the CCA checking.

[0043] The STAs 206 may determine whether to transmit the availability report 212 based on a response type 310. For example, response type 310 may indicate whether the STAs 206 should transmit the availability report 212 on the RU 318 based on one or more the CCA checking at 218 or 220, a regular NAV, and an OBSS NAV. In some embodiments, the STAs 206 may be configured to determine whether or not to transmit the availability report 212 on the RU based on the CCA checking at 218 or 220, a regular NAV, and an OBSS NAV without the response type 310 being signaled to the STAs 206.

[0044] The STAs 206 may determine how to perform the CCA checking at 218 or 220 based on the channel check type 312. In some embodiments, the STAs 206 may be configured to perform CCA checking at 218 or 220 without being signaled the channel check type 312.

[0045] The STAs 206 may determine which channels to check and report on based on the channel to report 314. In some embodiments, the STAs 206 may be configured to determine which channels to check and report on without being signaled the channel to report 314.

[0046] The STAs 206 may determine what type of report to transmit based on the report type 316, e.g., the report type of FIG. 5 or FIG. 6. In some embodiments, the STAs 206 may be configured to determine which report type to use without being signaled the report type 316. An example, availability report 212 may include an indication that the primary channel 20 MHz 402 is busy, the second channel 20 MHz 404 is busy, and that the secondary channel 40

MHz 406 is busy. Another example availability report 212 may indicate busy or idleness for each 20 MHz channel 412.

[0047] Phase I 260 may be completed once the STAs 206 transmit (or do not transmit if it is determined not to transmit based on the RU 318 being busy).

- 5 The method 200 continues at operation 256 with the AP 208 transmitting a trigger frame 214 to the STAs 206. For example, the AP 208 may determine resource allocations 215 for UL MU data TXOP based on the availability reports 212. For the report type 316 as illustrated in FIG. 5, the AP 208 may determine the channels that are free for each STA 206 if the AP 208 receives a transmission
10 on the corresponding RU for STA 206 on a channel. For the report type 316 as illustrated in FIG. 6, the AP 208 may determine the channels that are free for each STA 206 based on a received report 616, 619, 621, 627. If the AP 208 does not receive a report 616, 619, 621, 627, from a STA 206, then the AP 208 may assume that the RU assigned to the STA 206 for transmitting the report 616, 619,
15 621, 627 was busy for the STA 206 or that the STA 206 did not receive the trigger frame 300 (or that the AP 208 did not successfully receive the report 616, 619, 621, 627). The AP 208 may determine trigger frame 214 and not allocate resources for a STA 206 whose report 616, 619, 621, 627 was not received by the AP 208.

- 20 [0048] The method 200 may continue at operation 258 with the STAs 206 transmitting the responses 216. For example, the STAs 206 may transmit UL MU data to the AP 208 in accordance with the resource allocations 215.

- [0049] In some embodiments, the STAs 206 are configured to perform CCA on each 20 MHz channel simultaneously. In some embodiments, the STAs
25 206 are configured to respond to the trigger frame 300 after an interframe space (IFS), which may be a short interframe space (SIFS). The STAs 206 may be configured with different CCA capability in each channel they sense with bandwidth equal to 20 MHz or larger than 20 MHz.

- [0050] FIG. 8 illustrates a method 800 for reporting channel availability
30 in accordance with some embodiments. The method 800 begins at operation 802 with encoding a trigger frame for polling channel availability to a plurality of stations. For example, AP 208 may encode trigger frame 300 as described in conjunction with FIGS. 2-7. The method 800 continues at operation 804 with

configuring the wireless device to transmit the trigger frame. For example, an apparatus of AP 208 may configure the AP 208 to transmit the trigger frame 300. The method 800 continues at operation 806 with decoding one or more responses of channel availability from one or more stations of the plurality of stations in accordance with the trigger frame for polling channel availability, where the one or more indications are received in accordance with OFDMA. For example, the AP 206 may decode the availability reports 212 as described in conjunction with FIGS. 2-7.

[0051] FIG. 9 illustrates a method 900 for reporting channel availability in accordance with some embodiments. The method 900 begins at operation 902 with decoding a trigger frame for polling channel availability, where the trigger frame comprises a resource allocation for the station to transmit an availability report. For example, the STAs 206 may decode trigger frame 300 as described in conjunction with FIGS. 2-7. The method 900 may continue at operation 904 with performing a clear channel assessment (CCA) for one or more channels. For example, the STAs 206 may perform CCA for one or more channels as described in conjunction with FIGS. 2-7. The method 900 may continue at operation 906 with configuring the station to transmit the availability report in accordance with the resource allocation and in accordance with OFDMA. For example, an apparatus of the STAs 206 may configure the STAs 206 to transmit the availability report as described in conjunction with FIGS. 2-7.

[0052] In some embodiments, a MU-RTS/CTS exchange does not have the ability to determine channel availability, which in some embodiments may be due to overlapping CTS transmission. Some embodiments provide a channel availability report in response to a trigger frame. In some embodiments, stations may only be able to transmit an availability report on a resource unit allocated by a trigger frame, but the resource unit may be busy for the station. This couples the transmission and channel report and increases the complexity of design. Some embodiments provide that a station transmits on a RU on each channel if the channel is free for the station and not to transmit on a RU if the channel is busy for the station.

[0053] FIG. 10 illustrates a block diagram of an example machine 1000 upon which any one or more of the techniques (e.g., methodologies) discussed

herein may perform. In alternative embodiments, the machine 1000 may operate as a standalone device or may be connected (e.g., networked) to other machines. In a networked deployment, the machine 1000 may operate in the capacity of a server machine, a client machine, or both in server-client network environments.

- 5 In an example, the machine 1000 may act as a peer machine in peer-to-peer (P2P) (or other distributed) network environment. The machine 1000 may be a master station 102, HE station 104, personal computer (PC), a tablet PC, a set-top box (STB), a personal digital assistant (PDA), a mobile telephone, a smart phone, a web appliance, a network router, switch or bridge, or any machine
- 10 capable of executing instructions (sequential or otherwise) that specify actions to be taken by that machine. Further, while only a single machine is illustrated, the term “machine” shall also be taken to include any collection of machines that individually or jointly execute a set (or multiple sets) of instructions to perform any one or more of the methodologies discussed herein, such as cloud
- 15 computing, software as a service (SaaS), other computer cluster configurations.

- [0054] Examples, as described herein, may include, or may operate on, logic or a number of components, modules, or mechanisms. Modules are tangible entities (e.g., hardware) capable of performing specified operations and may be configured or arranged in a certain manner. In an example, circuits may
- 20 be arranged (e.g., internally or with respect to external entities such as other circuits) in a specified manner as a module. In an example, the whole or part of one or more computer systems (e.g., a standalone, client or server computer system) or one or more hardware processors may be configured by firmware or software (e.g., instructions, an application portion, or an application) as a module
- 25 that operates to perform specified operations. In an example, the software may reside on a machine readable medium. In an example, the software, when executed by the underlying hardware of the module, causes the hardware to perform the specified operations.

- [0055] Accordingly, the term “module” is understood to encompass a
- 30 tangible entity, be that an entity that is physically constructed, specifically configured (e.g., hardwired), or temporarily (e.g., transitorily) configured (e.g., programmed) to operate in a specified manner or to perform part or all of any operation described herein. Considering examples in which modules are

temporarily configured, each of the modules need not be instantiated at any one moment in time. For example, where the modules comprise a general-purpose hardware processor configured using software, the general-purpose hardware processor may be configured as respective different modules at different times.

- 5 Software may accordingly configure a hardware processor, for example, to constitute a particular module at one instance of time and to constitute a different module at a different instance of time.

[0056] Machine (e.g., computer system) 1000 may include a hardware processor 1002 (e.g., a central processing unit (CPU), a graphics processing unit
10 (GPU), a hardware processor core, or any combination thereof), a main memory 1004 and a static memory 1006, some or all of which may communicate with each other via an interlink (e.g., bus) 1008. The machine 1000 may further include a display device 1010, an input device 1012 (e.g., a keyboard), and a user interface (UI) navigation device 1014 (e.g., a mouse). In an example, the
15 display device 1010, input device 1012 and UI navigation device 1014 may be a touch screen display. The machine 1000 may additionally include a mass storage (e.g., drive unit) 1016, a signal generation device 1018 (e.g., a speaker), a network interface device 1020, and one or more sensors 1021, such as a global positioning system (GPS) sensor, compass, accelerometer, or other sensor. The
20 machine 1000 may include an output controller 1028, such as a serial (e.g., universal serial bus (USB), parallel, or other wired or wireless (e.g., infrared (IR), near field communication (NFC), etc.) connection to communicate or control one or more peripheral devices (e.g., a printer, card reader, etc.). In some embodiments the processor 1002 and/or instructions 1024 may comprise
25 processing circuitry and/or transceiver circuitry. The machine 1000 may further include NAV timers 1029. The NAV timers 1029 may be configured to operate as described herein in conjunction with FIGS. 7 and 8. In some embodiments, the NAV timers 1029 may be configured to generate an interrupt when NAV1
702 reaches zero.

30 [0057] The storage device 1016 may include a machine readable medium 1022 on which is stored one or more sets of data structures or instructions 1024 (e.g., software) embodying or utilized by any one or more of the techniques or functions described herein. The instructions 1024 may also reside, completely or

at least partially, within the main memory 1004, within static memory 1006, or within the hardware processor 1002 during execution thereof by the machine 1000. In an example, one or any combination of the hardware processor 1002, the main memory 1004, the static memory 1006, or the storage device 1016 may constitute machine readable media.

[0058] While the machine readable medium 1022 is illustrated as a single medium, the term "machine readable medium" may include a single medium or multiple media (e.g., a centralized or distributed database, and/or associated caches and servers) configured to store the one or more instructions 1024.

[0059] An apparatus of the machine 1000 may be one or more of a hardware processor 1002 (e.g., a central processing unit (CPU), a graphics processing unit (GPU), a hardware processor core, or any combination thereof), a main memory 1004, a static memory 1006, instructions 1024, display device 1010, input device 1012, UI navigation device 1014, mass storage 1016, signal generation 1018, output controller 1028, NAV timers 1029, sensors 1021, network interface device 1020, and antennas 1060 some or all of which may communicate with each other via an interlink (e.g., bus) 1008. One or more of the following of the apparatus of the machine 1000 may be separate from the machine 1000 and may be configured to work in conjunction with the machine 1000, be a portion or component of the machine 1000: a hardware processor (e.g., a central processing unit (CPU), a graphics processing unit (GPU), a hardware processor core, or any combination thereof), a main memory, a static memory, instructions, display device, input device, UI navigation device, mass storage, signal generation, output controller, NAV timers, sensors, network interface device, and antennas.

[0060] The term "machine readable medium" may include any medium that is capable of storing, encoding, or carrying instructions for execution by the machine 1000 and that cause the machine 1000 to perform any one or more of the techniques of the present disclosure, or that is capable of storing, encoding or carrying data structures used by or associated with such instructions. Non-limiting machine readable medium examples may include solid-state memories, and optical and magnetic media. Specific examples of machine readable media

may include: non-volatile memory, such as semiconductor memory devices (e.g., Electrically Programmable Read-Only Memory (EPROM), Electrically Erasable Programmable Read-Only Memory (EEPROM)) and flash memory devices; magnetic disks, such as internal hard disks and removable disks; magneto-optical disks; Random Access Memory (RAM); and CD-ROM and DVD-ROM disks. In some examples, machine readable media may include non-transitory machine readable media. In some examples, machine readable media may include machine readable media that is not a transitory propagating signal.

[0061] The instructions 1024 may further be transmitted or received over a communications network 1026 using a transmission medium via the network interface device 1020 utilizing any one of a number of transfer protocols (e.g., frame relay, internet protocol (IP), transmission control protocol (TCP), user datagram protocol (UDP), hypertext transfer protocol (HTTP), etc.). Example communication networks may include a local area network (LAN), a wide area network (WAN), a packet data network (e.g., the Internet), mobile telephone networks (e.g., cellular networks), Plain Old Telephone (POTS) networks, and wireless data networks (e.g., Institute of Electrical and Electronics Engineers (IEEE) 802.11 family of standards known as Wi-Fi®, IEEE 802.16 family of standards known as WiMax®, IEEE 802.15.4 family of standards, a Long Term Evolution (LTE) family of standards, a Universal Mobile Telecommunications System (UMTS) family of standards, peer-to-peer (P2P) networks, among others.

[0062] In an example, the network interface device 1020 may include one or more physical jacks (e.g., Ethernet, coaxial, or phone jacks) or one or more antennas to connect to the communications network 1026. In an example, the network interface device 1020 may include one or more antennas 1060 to wirelessly communicate using at least one of single-input multiple-output (SIMO), multiple-input multiple-output (MIMO), or multiple-input single-output (MISO) techniques. In some examples, the network interface device 1020 may wirelessly communicate using Multiple User MIMO techniques. The term “transmission medium” shall be taken to include any intangible medium that is capable of storing, encoding or carrying instructions for execution by the

machine 1000, and includes digital or analog communications signals or other intangible medium to facilitate communication of such software.

[0063] Various embodiments may be implemented fully or partially in software and/or firmware. This software and/or firmware may take the form of
5 instructions contained in or on a non-transitory computer-readable storage medium. Those instructions may then be read and executed by one or more processors to enable performance of the operations described herein. The instructions may be in any suitable form, such as but not limited to source code, compiled code, interpreted code, executable code, static code, dynamic code, and
10 the like. Such a computer-readable medium may include any tangible non-transitory medium for storing information in a form readable by one or more computers, such as but not limited to read only memory (ROM); random access memory (RAM); magnetic disk storage media; optical storage media; flash memory, etc.

15 [0064] The following examples pertain to further embodiments. Example 1 is an apparatus of a wireless device including: memory; and processing circuitry coupled to the memory, the processing circuitry configured to: encode a trigger frame for polling channel availability to a plurality of stations; configure the wireless device to transmit the trigger frame; and decode
20 one or more responses of channel availability from one or more stations of the plurality of stations in accordance with the trigger frame for polling channel availability, where the one or more responses are received in accordance with orthogonal frequency division multiple-access (OFDMA).

[0065] In Example 2, the subject matter of Example 1 optionally includes
25 where the processing circuitry is further configured to: encode a second trigger frame including resource allocations for the one or more stations for uplink multi-user data based on the one or more responses of channel availability from the one or more stations of the plurality of stations; configure the wireless device to transmit the second trigger frame; and decode one or more packets in
30 accordance with the resource allocations.

[0066] In Example 3, the subject matter of any one or more of Examples 1–2 optionally include where the trigger frame indicates the plurality of stations

are to perform a clear channel assessment (CCA) after decoding the trigger frame to generate the one or more responses of channel availability.

[0067] In Example 4, the subject matter of any one or more of Examples 1–3 optionally include where the trigger frame comprises an indication of one or more channels the plurality of stations are to report availability for.

[0068] In Example 5, the subject matter of any one or more of Examples 1–4 optionally include where the trigger frame comprises for each channel of one or more channels a resource allocation and code for each station of the plurality of stations, where the plurality of stations are to transmit on each channel that is available (or in some embodiments not available) on the corresponding resource allocation with the corresponding code.

[0069] In Example 6, the subject matter of Example 5 optionally includes where the resource allocation comprises exactly 6 is missing parent: 26 sub-carriers.

[0070] In Example 7, the subject matter of any one or more of Examples 1–6 optionally include where the trigger frame comprises a resource allocation for each station to transmit a channel availability report on.

[0071] In Example 8, the subject matter of Example 7 optionally includes where the trigger frame further comprises an indication that each station of the plurality of stations is to transmit the channel availability report even if a clear channel assessment indicates a channel of the resource allocation is busy.

[0072] In Example 9, the subject matter of Example 8 optionally includes where the trigger frame further comprises a second indication that each station of the plurality of stations is to transmit the channel availability report even if a network allocation vector (NAV) indicates a channel of the resource allocation is busy, where the NAV indicates the channel of the resource is busy if a physical layer convergence protocol (PLCP) protocol data unit (PPDU) is determined as an inter-basic service set (inter-BSS) or if the PPDU cannot be determined as an intra-BSS or an inter-BSS PPDU.

[0073] In Example 10, the subject matter of any one or more of Examples 1–9 optionally include where the trigger frame further comprises an indication that the plurality of stations are to perform carrier sense based on one of the following group: energy detect (ED), mid packet detect for legacy signals

with a symbol duration 10 is missing parent: 3.2 μ s, and mid packet detect for high energy (HE) physical (PHY) layer convergence procedure (PLCP) protocol data unit (PPDU) with 4 times symbol duration 10 is missing parent: 12.8 μ s.

[0074] In Example 11, the subject matter of any one or more of

- 5 Examples 1–10 optionally include where the wireless device and each of the plurality of stations is one from the following group: an Institute of Electrical and Electronic Engineers (IEEE) 11 is missing parent: 11 is missing parent: 802.11ax access point, an IEEE 802.11ax station, an IEEE 11 is missing parent: 11 is missing parent: 802.11 station, and an IEEE 802.11 access point.

- 10 [0075] In Example 12, the subject matter of any one or more of Examples 1–11 optionally include transceiver circuitry coupled to the processing circuitry.

- [0076] Example 13 is a non-transitory computer-readable storage medium that stores instructions for execution by one or more processors, the
15 instructions to configure the one or more processors to cause a wireless device to: encode a trigger frame for polling channel availability to a plurality of stations; configure the wireless device to transmit the trigger frame; and decode one or more responses of channel availability from one or more stations of the plurality of stations in accordance with the trigger frame for polling channel
20 availability, where the one or more responses are received in accordance with orthogonal frequency division multiple-access (OFDMA).

- [0077] In Example 14, the subject matter of Example 13 optionally includes where the trigger frame comprises for each channel of one or more channels a resource allocation and code for each station of the plurality of
25 stations, where the plurality of stations are to transmit on each channel that is on the corresponding resource allocation with the corresponding code.

[0078] In Example 15, the subject matter of any one or more of Examples 13–14 optionally include where the trigger frame comprises a resource allocation for each station to transmit a channel availability report on.

- 30 [0079] Example 16 is a method performed by a wireless device, the method including: encoding a trigger frame for polling channel availability to a plurality of stations; configuring the wireless device to transmit the trigger frame; and decoding one or more responses of channel availability from one or

more stations of the plurality of stations in accordance with the trigger frame for polling channel availability, where the one or more responses are received in accordance with orthogonal frequency division multiple-access (OFDMA).

[0080] In Example 17, the subject matter of Example 16 optionally includes where the trigger frame comprises for each channel of one or more channels a resource allocation and code for each station of the plurality of stations, and where the trigger frame indicates that the plurality of stations are to transmit on each channel that is available in accordance with the corresponding resource allocation with the corresponding code.

10 [0081] In Example 18, the subject matter of any one or more of Examples 16–17 optionally include where the trigger frame comprises a resource allocation for each station to transmit a channel availability report on.

[0082] Example 19 is an apparatus of a station including: memory; and processing circuitry coupled to the memory, the processing circuitry configured to: decode a trigger frame for polling channel availability, where the trigger frame comprises a resource allocation for the station to transmit an availability report; perform a clear channel assessment (CCA) for one or more channels; and configure the station to transmit the availability report in accordance with the resource allocation and in accordance with orthogonal frequency division multiple-access (OFDMA).

20 [0083] In Example 20, the subject matter of Example 19 optionally includes where the trigger frame further comprises a code, and where the processing circuitry is further configured to: configure the station to transmit the availability report and the code on each channel that the CCA indicates is free and in accordance with the resource allocation and OFDMA.

[0084] In Example 21, the subject matter of any one or more of Examples 19–20 optionally include where the trigger frame further comprises a code, and where the processing circuitry is further configured to: configure the station to transmit the availability report and the code on each channel that the CCA indicates is free and that a network allocation vector (NAV) indicates is free and in accordance with the resource allocation and OFDMA.

[0085] In Example 22, the subject matter of any one or more of Examples 19–21 optionally include where the availability report comprises one bit for each channel to indicate whether the channel is free or busy.

[0086] In Example 23, the subject matter of any one or more of
5 Examples 19–22 optionally include where the trigger frame further comprises an indication of the one or more channels to perform CCA on.

[0087] Example 24 is an apparatus of a wireless device, the apparatus including: means for encoding a trigger frame for polling channel availability to a plurality of stations; means for configuring the wireless device to transmit the
10 trigger frame; and means for decoding one or more responses of channel availability from one or more stations of the plurality of stations in accordance with the trigger frame for polling channel availability, where the one or more responses are received in accordance with orthogonal frequency division multiple-access (OFDMA).

[0088] In Example 25, the subject matter of Example 24 optionally includes means for encoding a second trigger frame including resource allocations for the one or more stations for uplink multi-user data based on the one or more responses of channel availability from the one or more stations of the plurality of stations; means for configuring the wireless device to transmit
20 the second trigger frame; and means for decoding one or more packets in accordance with the resource allocations.

[0089] In Example 26, the subject matter of any one or more of Examples 24–25 optionally include where the trigger frame indicates the plurality of stations are to perform a clear channel assessment (CCA) after
25 decoding the trigger frame to generate the one or more responses of channel availability.

[0090] In Example 27, the subject matter of any one or more of Examples 24–26 optionally include where the trigger frame comprises an indication of one or more channels the plurality of stations are to report
30 availability for.

[0091] In Example 28, the subject matter of any one or more of Examples 24–27 optionally include where the trigger frame comprises for each channel of one or more channels a resource allocation and code for each station

of the plurality of stations, where the plurality of stations are to transmit on each channel that is on the corresponding resource allocation with the corresponding code.

[0092] In Example 29, the subject matter of Example 28 optionally

5 includes where the resource allocation comprises exactly 26 sub-carriers.

[0093] In Example 30, the subject matter of any one or more of Examples 24–29 optionally include where the trigger frame comprises a resource allocation for each station to transmit a channel availability report on.

[0094] In Example 31, the subject matter of Example 30 optionally

10 includes where the trigger frame further comprises an indication that each station of the plurality of stations is to transmit the channel availability report even if a clear channel assessment indicates a channel of the resource allocation is busy.

[0095] In Example 32, the subject matter of Example 31 optionally

15 includes where the trigger frame further comprises a second indication that each station of the plurality of stations is to transmit the channel availability report even if a network allocation vector (NAV) indicates a channel of the resource allocation is busy, where the NAV indicates the channel of the resource is busy if a physical layer convergence protocol (PLCP) protocol data unit (PPDU) is determined as an inter-basic service set (inter-BSS) or if the PPDU cannot be
20 determined as an intra-BSS or an inter-BSS PPDU.

[0096] In Example 33, the subject matter of any one or more of

Examples 24–32 optionally include where the trigger frame further comprises an indication that the plurality of stations are to perform carrier sense based on one of the following group: energy detect (ED), mid packet detect for legacy signals
25 with a symbol duration 33 is missing parent: 3.2 μ s, and mid packet detect for high energy (HE) physical (PHY) layer convergence procedure (PLCP) protocol data unit (PPDU) with 4 times symbol duration 33 is missing parent: 12.8 μ s.

[0097] In Example 34, the subject matter of any one or more of

30 Examples 24–33 optionally include where the wireless device and each of the plurality of stations is one from the following group: an Institute of Electrical and Electronic Engineers (IEEE) 34 is missing parent: 34 is missing parent: 802.11ax access point, an IEEE 802.11ax station, an IEEE 34 is missing parent: 34 is missing parent: 802.11 station, and an IEEE 802.11 access point.

[0098] In Example 35, the subject matter of any one or more of Examples 1–34 optionally include means for transmitting and receiving radio waves.

[0099] Example 36 is a non-transitory computer-readable storage medium that stores instructions for execution by one or more processors, the instructions to configure the one or more processors to cause a wireless device to: decode a trigger frame for polling channel availability, where the trigger frame comprises a resource allocation for the station to transmit an availability report; perform a clear channel assessment (CCA) for one or more channels; and
5 configure the station to transmit the availability report in accordance with the resource allocation and in accordance with orthogonal frequency division multiple-access (OFDMA).
10

[00100] In Example 37, the subject matter of Example 36 optionally includes where the trigger frame further comprises a code, and where the instructions further configure the one or more processors to cause the wireless device to: configure the station to transmit the availability report and the code on each channel that the CCA indicates is free and in accordance with the resource allocation and OFDMA.
15

[00101] In Example 38, the subject matter of any one or more of Examples 36–37 optionally include where the trigger frame further comprises a code, and where the instructions further configure the one or more processors to cause the wireless device to: configure the station to transmit the availability report and the code on each channel that the CCA indicates is free and that a network allocation vector (NAV) indicates is free and in accordance with the resource allocation and OFDMA.
20
25

[00102] In Example 39, the subject matter of any one or more of Examples 36–38 optionally include where the availability report comprises one bit for each channel to indicate whether the channel is free or busy.

[00103] In Example 40, the subject matter of any one or more of Examples 36–39 optionally include where the trigger frame further comprises an indication of the one or more channels to perform CCA on.
30

[00104] Example 41 is a method performed by an apparatus of a wireless device, the method including: decoding a trigger frame for polling channel

availability, where the trigger frame comprises a resource allocation for the station to transmit an availability report; performing a clear channel assessment (CCA) for one or more channels; and configuring the station to transmit the availability report in accordance with the resource allocation and in accordance with orthogonal frequency division multiple-access (OFDMA).

[00105] In Example 42, the subject matter of Example 41 optionally includes where the trigger frame further comprises a code, and where the instructions further configure the one or more processors to cause the wireless device to: configure the station to transmit the availability report and the code on each channel that the CCA indicates is free and in accordance with the resource allocation and OFDMA.

[00106] In Example 43, the subject matter of any one or more of Examples 41–42 optionally include where the trigger frame further comprises a code, and the method further including: configuring the station to transmit the availability report and the code on each channel that the CCA indicates is free and that a network allocation vector (NAV) indicates is free and in accordance with the resource allocation and OFDMA.

[00107] In Example 44, the subject matter of any one or more of Examples 41–43 optionally include where the availability report comprises one bit for each channel to indicate whether the channel is free or busy.

[00108] In Example 45, the subject matter of any one or more of Examples 41–44 optionally include where the trigger frame further comprises an indication of the one or more channels to perform CCA on.

[00109] Example 46 is an apparatus of a wireless device, the apparatus including: means for decoding a trigger frame for polling channel availability, where the trigger frame comprises a resource allocation for the station to transmit an availability report; means for performing a clear channel assessment (CCA) for one or more channels; and means for configuring the station to transmit the availability report in accordance with the resource allocation and in accordance with orthogonal frequency division multiple-access (OFDMA).

[00110] In Example 47, the subject matter of Example 46 optionally includes where the trigger frame further comprises a code, and further including: means for configuring the station to transmit the availability report and the code

on each channel that the CCA indicates is free and in accordance with the resource allocation and OFDMA.

5 [00111] In Example 48, the subject matter of any one or more of Examples 46–47 optionally include where the trigger frame further comprises a code, and where the instructions further configure the one or more processors to cause the wireless device to: configure the station to transmit the availability report and the code on each channel that the CCA indicates is free and that a network allocation vector (NAV) indicates is free and in accordance with the resource allocation and OFDMA.

10 [00112] In Example 49, the subject matter of any one or more of Examples 46–48 optionally include where the availability report comprises one bit for each channel to indicate whether the channel is free or busy.

[00113] In Example 50, the subject matter of any one or more of Examples 46–49 optionally include where the trigger frame further comprises an indication of the one or more channels to perform CCA on.

15 [00114] 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.

20

CLAIMS

What is claimed is:

1. An apparatus of a wireless device comprising: memory; and
5 processing circuitry coupled to the memory, the processing circuitry configured to:
 encode a trigger frame for polling channel availability to a plurality of stations;
 configure the wireless device to transmit the trigger frame; and
10 decode one or more responses of channel availability from one or more stations of the plurality of stations in accordance with the trigger frame for polling channel availability, wherein the one or more responses are received in accordance with orthogonal frequency division multiple-access (OFDMA).
- 15 2. The apparatus of claim 1, wherein the processing circuitry is further configured to:
 encode a second trigger frame comprising resource allocations for the one or more stations for uplink multi-user data based on the one or more responses of channel availability from the one or more stations of the plurality of
20 stations;
 configure the wireless device to transmit the second trigger frame;
 and
 decode one or more packets from the one or more stations in accordance with the resource allocations.
- 25 3. The apparatus of claim 1, wherein the trigger frame indicates the plurality of stations are to perform a clear channel assessment (CCA) after decoding the trigger frame to generate the one or more responses of channel availability.
- 30 4. The apparatus of claim 1, wherein the trigger frame comprises an indication of one or more channels the plurality of stations are to report availability for.

5. The apparatus of claim 1, wherein the trigger frame comprises, for each channel of one or more channels, a resource allocation and code for each station of the plurality of stations, and wherein the trigger frame indicates
5 that the plurality of stations are to transmit on each channel that is available to the corresponding station of the plurality of stations on the corresponding resource allocation with the corresponding code.

6. The apparatus of claim 5, wherein the resource allocation
10 comprises exactly 26 sub-carriers.

7. The apparatus of claim 1, wherein the trigger frame comprises a resource allocation for each station of the plurality of stations to transmit a channel availability report on.
15

8. The apparatus of claim 7, wherein the trigger frame further comprises an indication that each station of the plurality of stations is to transmit the channel availability report even if a clear channel assessment indicates a channel of the resource allocation is busy.
20

9. The apparatus of claim 8, wherein the trigger frame further comprises a second indication that each station of the plurality of stations is to transmit the channel availability report even if a network allocation vector (NAV) indicates a channel is busy, wherein the NAV indicates the channel of
25 the resource is busy if a physical layer convergence protocol (PLCP) protocol data unit (PPDU) is determined as an inter-basic service set (inter-BSS) or if the PPDU cannot be determined as an intra-BSS or an inter-BSS PPDU.

10. The apparatus of claim 1, wherein the trigger frame further
30 comprises an indication that the plurality of stations are to perform carrier sense based on one of the following group: energy detect (ED), mid packet detect for legacy signals with a symbol duration 3.2 μ s, and mid packet detect for high

energy (HE) physical (PHY) layer convergence procedure (PLCP) protocol data unit (PPDU) with 4 times symbol duration 12.8 μ s.

11. The apparatus of claim 1, wherein the wireless device and each of
5 the plurality of stations is one from the following group: an Institute of Electrical and Electronic Engineers (IEEE) 802.11ax access point, an IEEE 802.11ax station, an IEEE 802.11 station, and an IEEE 802.11 access point.

12. The apparatus of claim 1, further comprising transceiver circuitry
10 coupled to the processing circuitry.

13. A non-transitory computer-readable storage medium that stores instructions for execution by one or more processors, the instructions to configure the one or more processors to cause a wireless device to:
15 encode a trigger frame for polling channel availability to a plurality of stations;
configure the wireless device to transmit the trigger frame; and
decode one or more responses of channel availability from one or more stations of the plurality of stations in accordance with the trigger frame for
20 polling channel availability, wherein the one or more responses are received in accordance with orthogonal frequency division multiple-access (OFDMA).

14. The non-transitory computer-readable storage medium of claim 13, wherein the trigger frame comprises for each channel of one or more
25 channels a resource allocation and code for each station of the plurality of stations, wherein the trigger frame indicates that the plurality of stations are to transmit on each channel that is available on the corresponding resource allocation with the corresponding code.

15. The non-transitory computer-readable storage medium of claim
30 13, wherein the trigger frame comprises a resource allocation for each station to transmit a channel availability report on.

16. A method performed by a wireless device, the method comprising:

encoding a trigger frame for polling channel availability to a plurality of stations;

5 configuring the wireless device to transmit the trigger frame; and
decoding one or more responses of channel availability from one or more stations of the plurality of stations in accordance with the trigger frame for polling channel availability, wherein the one or more responses are received in accordance with orthogonal frequency division multiple-access (OFDMA).

10

17. The method of claim 16, wherein the trigger frame comprises for each channel of one or more channels a resource allocation and code for each station of the plurality of stations, and wherein the trigger frame indicates that each station of the plurality of stations are to transmit on each channel of the
15 plurality of stations that is available in accordance with the corresponding resource allocation and with the corresponding code.

18. The method of claim 16, wherein the trigger frame comprises a resource allocation for each station to transmit a channel availability report on.

20

19. An apparatus of a station comprising: memory; and processing circuitry coupled to the memory, the processing circuitry configured to:

decode a trigger frame for polling channel availability, wherein the trigger frame comprises a resource allocation for the station to transmit an
25 availability report;

perform a clear channel assessment (CCA) for one or more channels; and

configure the station to transmit the availability report in accordance with the resource allocation and in accordance with orthogonal
30 frequency division multiple-access (OFDMA).

20. The apparatus of claim 19, wherein the trigger frame further comprises a code, and wherein the processing circuitry is further configured to:

configure the station to transmit the availability report and the code on each channel that the CCA indicates is free and in accordance with the resource allocation and OFDMA.

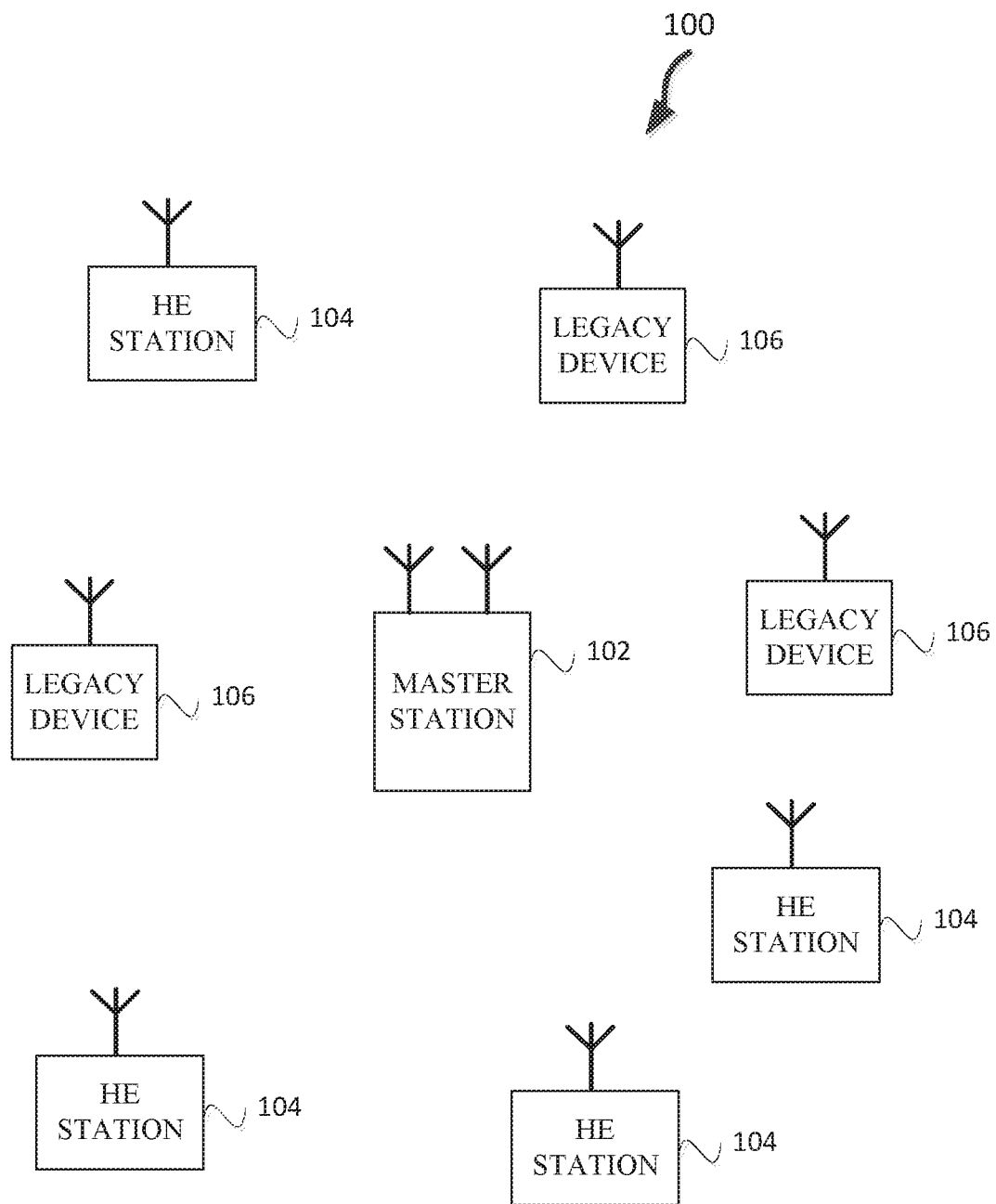
5 21. The apparatus of claim 19, wherein the trigger frame further comprises a code, and wherein the processing circuitry is further configured to:

 configure the station to transmit the availability report and the code on each channel that the CCA indicates is free and that a network allocation vector (NAV) indicates is free and in accordance with the resource allocation
10 and OFDMA.

 22. The apparatus of claim 19, wherein the availability report comprises one bit for each channel to indicate whether the channel is free or
15 busy.

 23. The apparatus of claim 19, wherein the trigger frame further comprises an indication of the one or more channels to perform CCA on.

1/10



BSS

FIG. 1

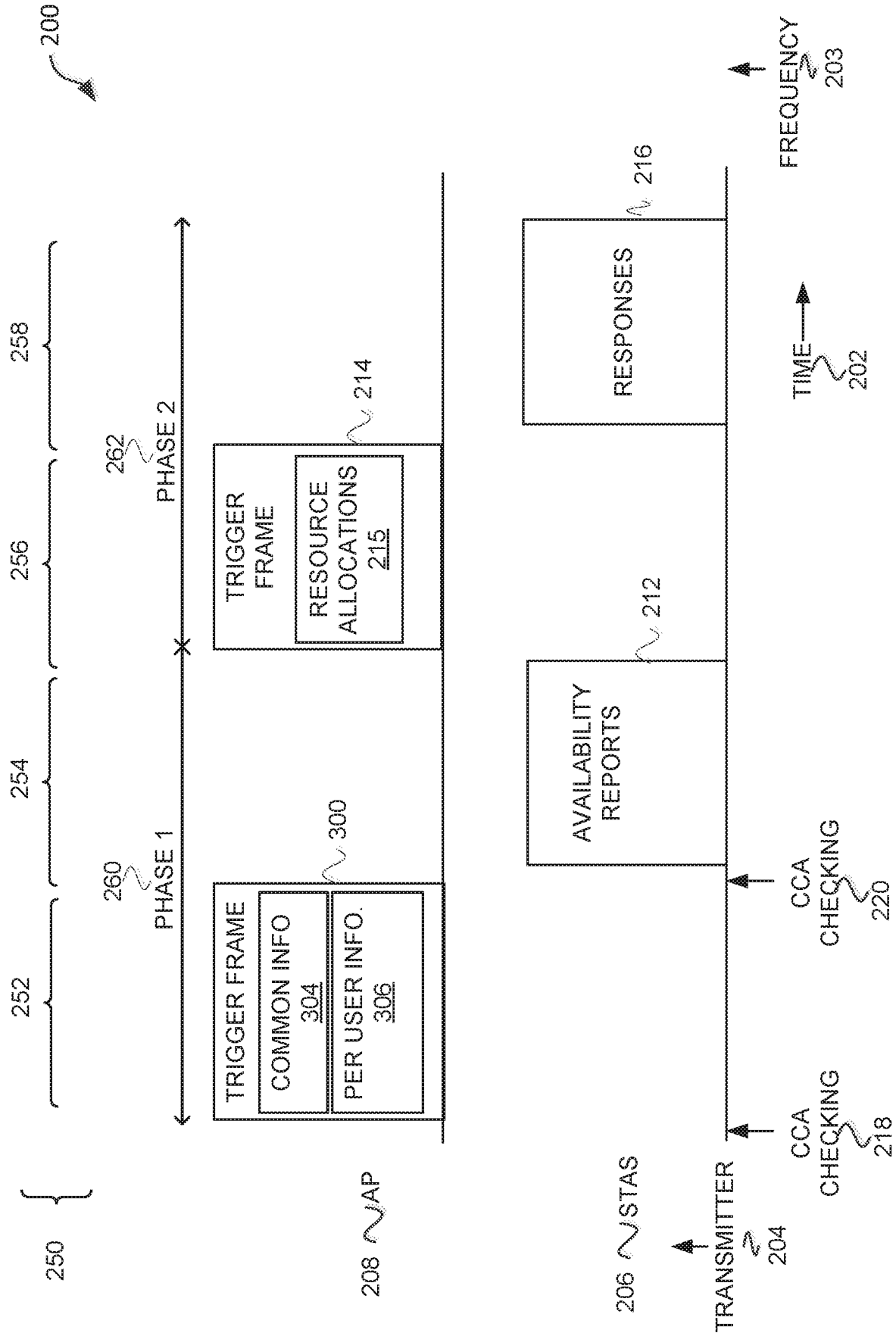


FIG. 2

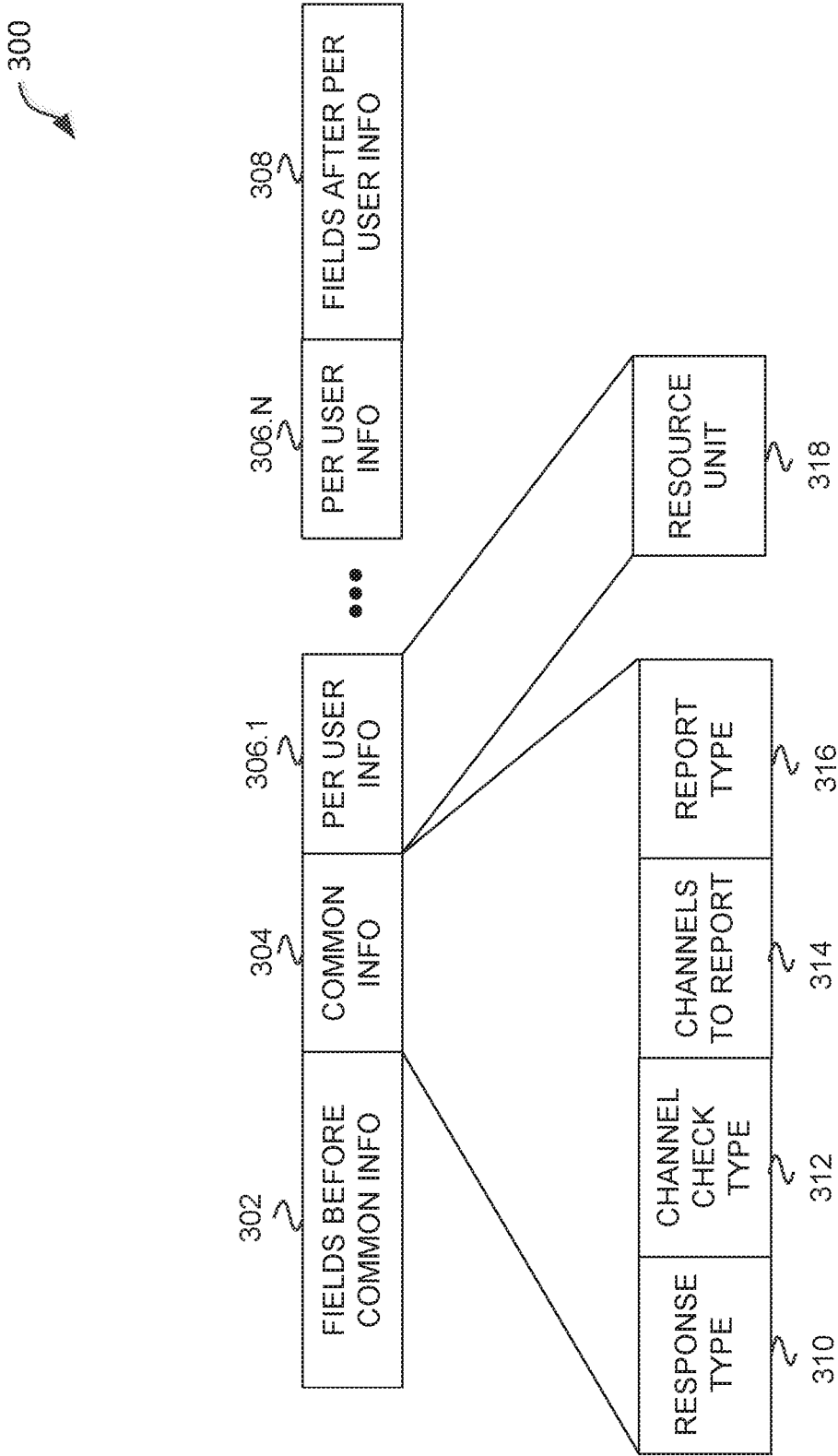


FIG. 3

4/10

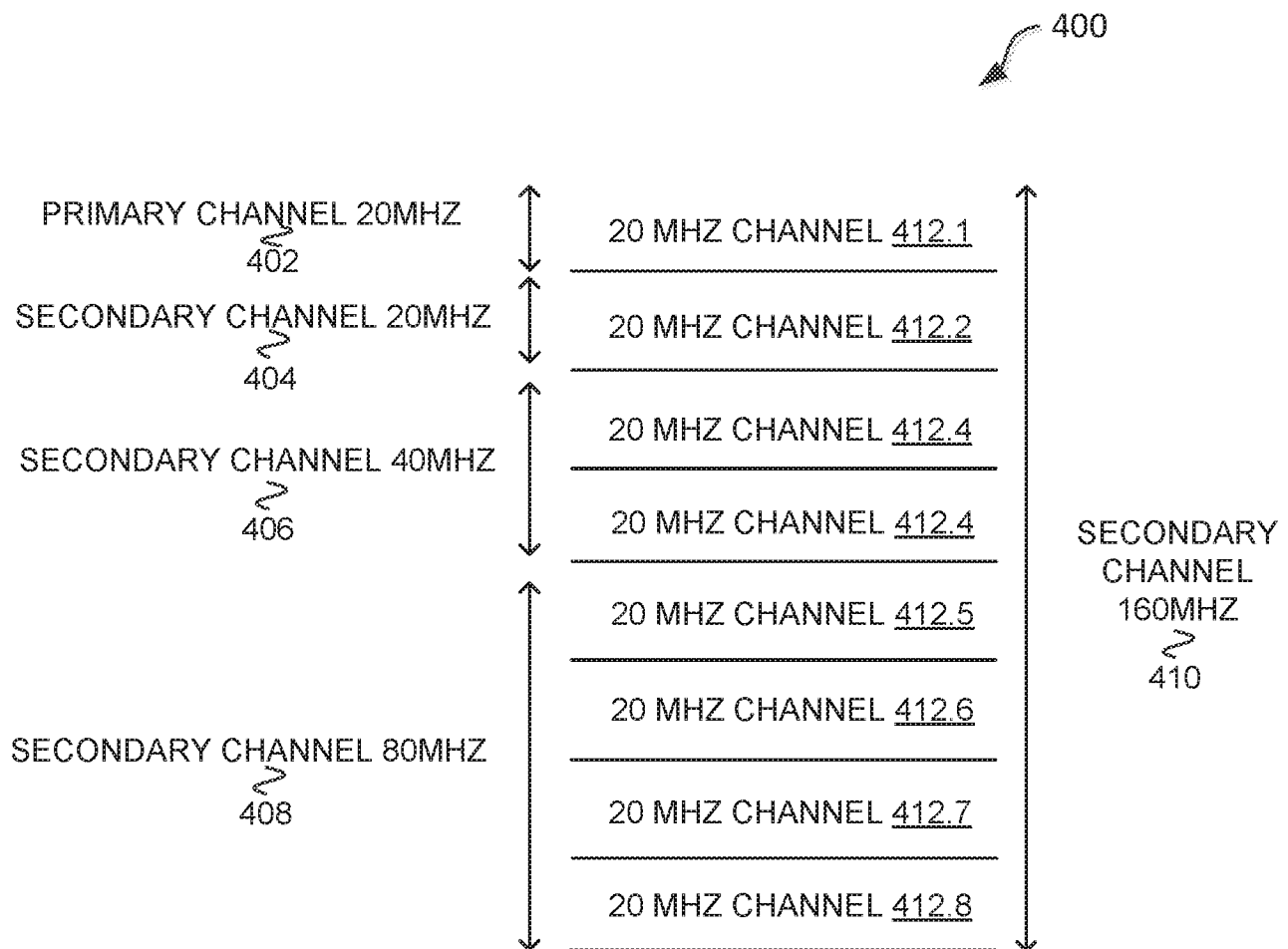
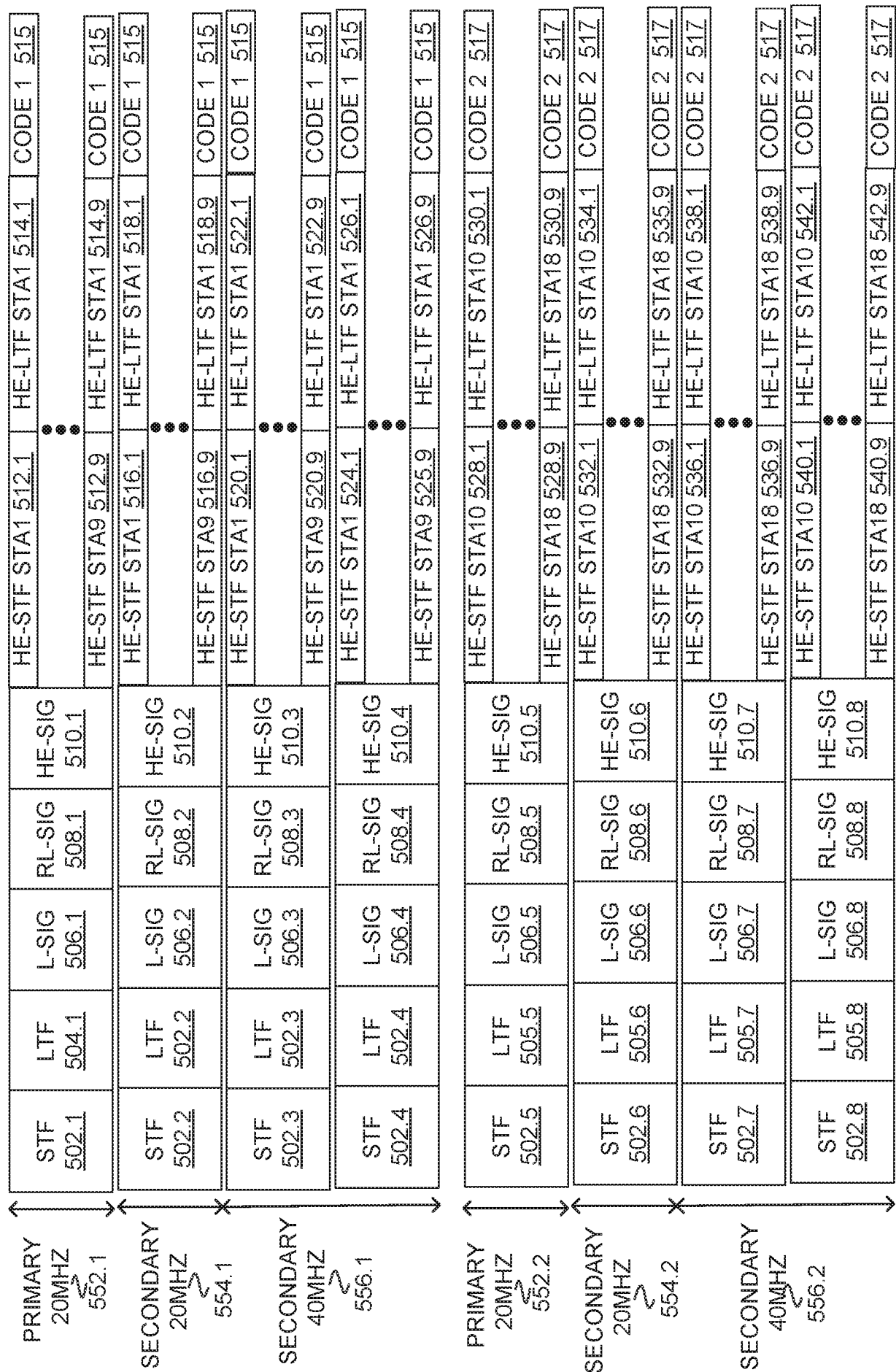


FIG. 4



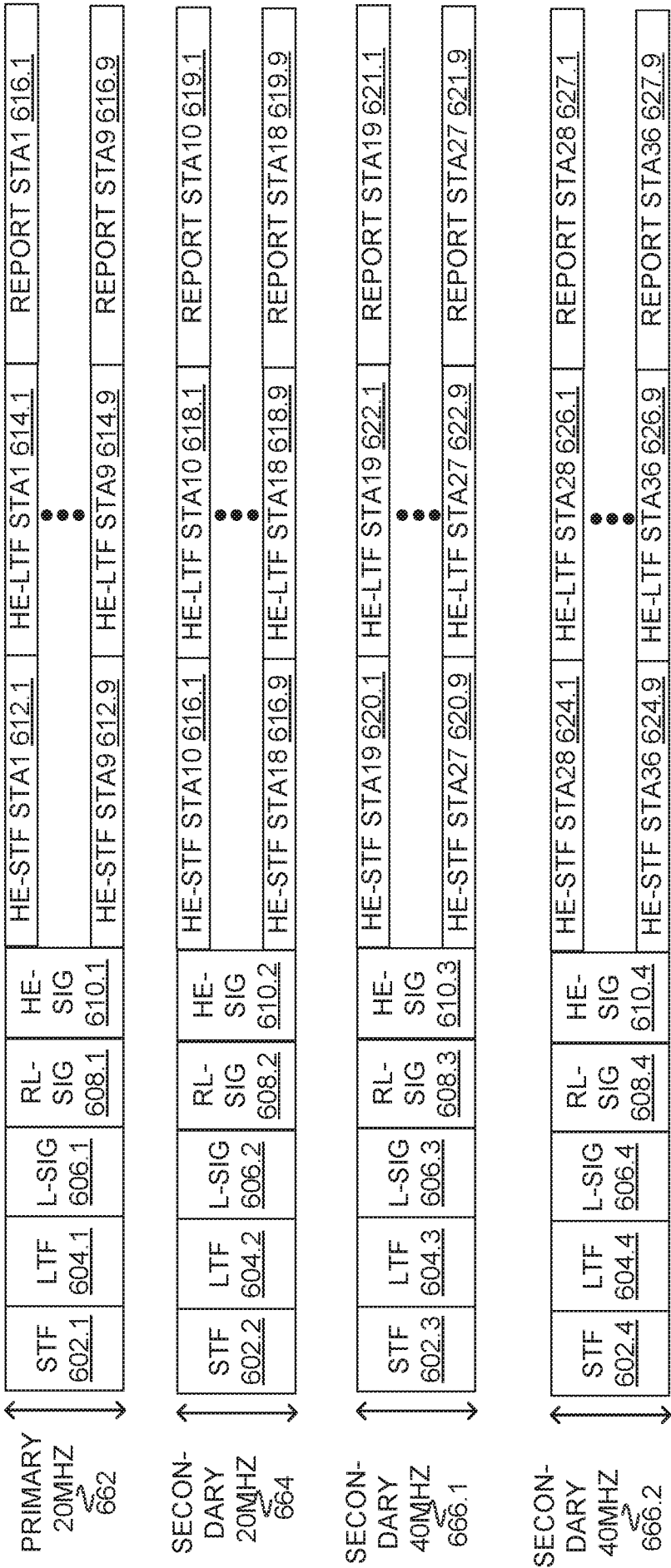


FIG. 6

700 ↗

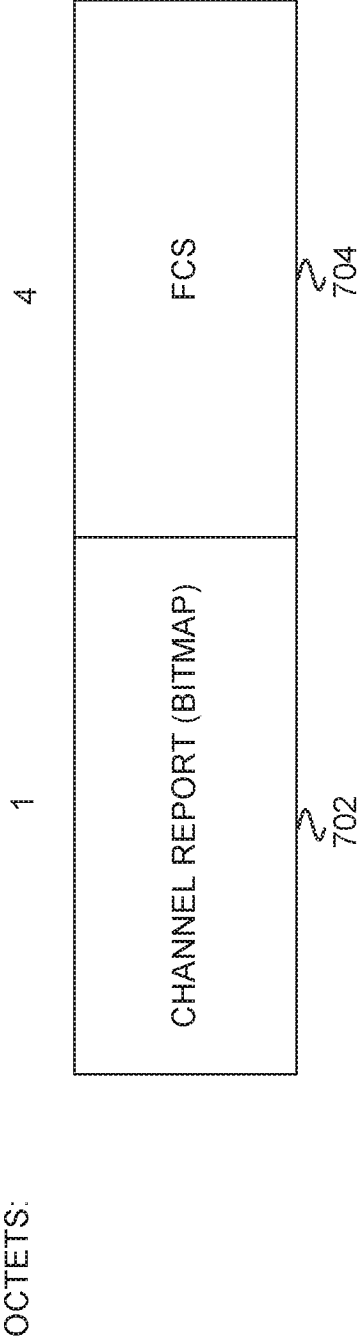


FIG. 7

8/10

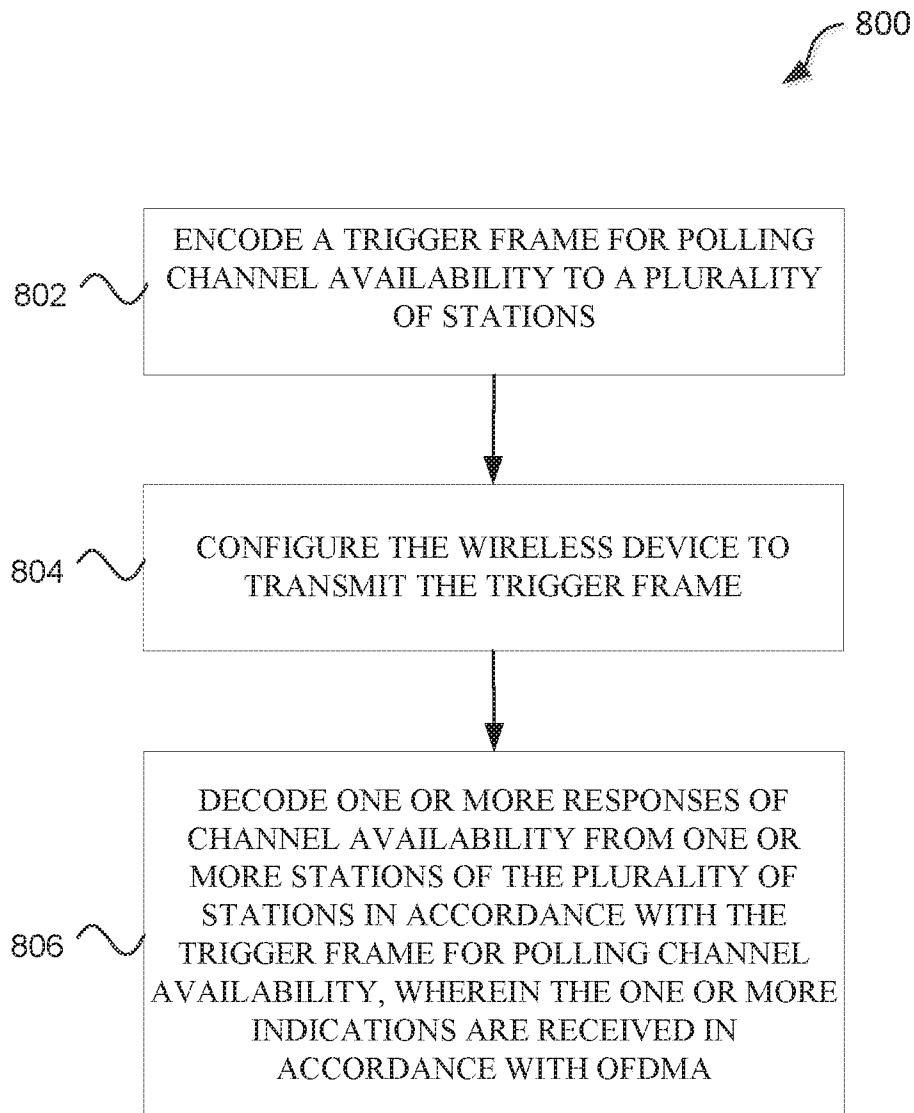


FIG. 8

9/10

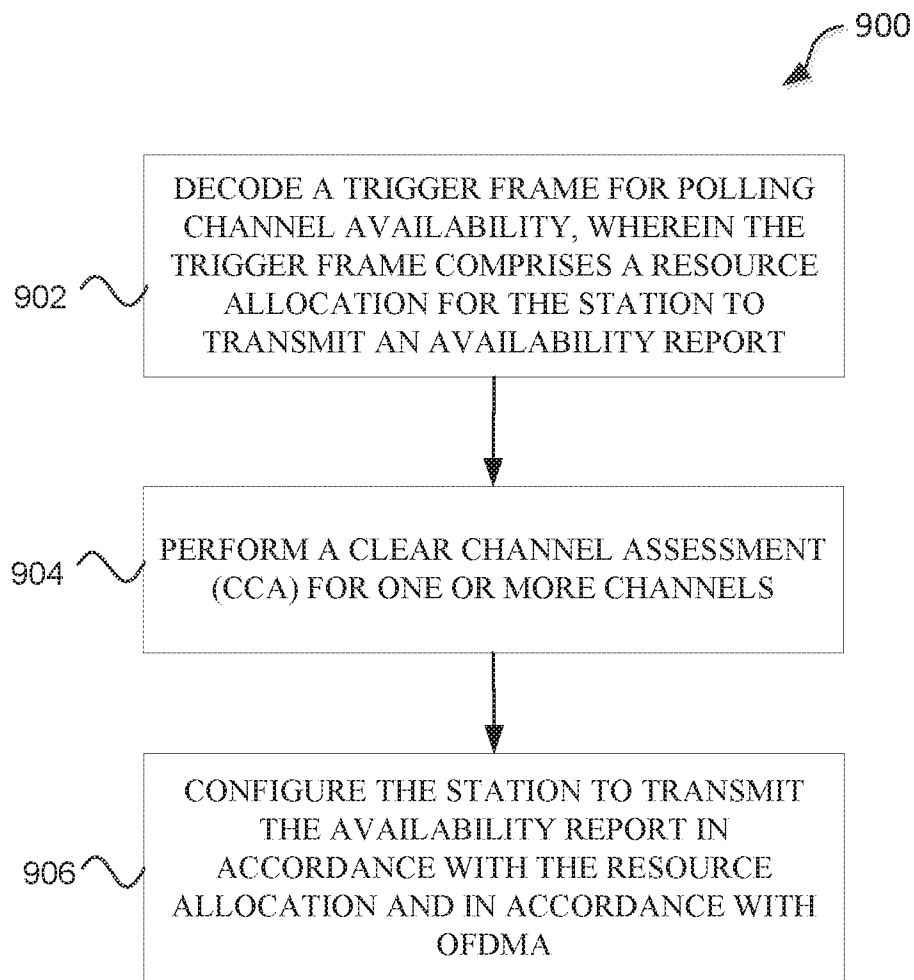


FIG. 9

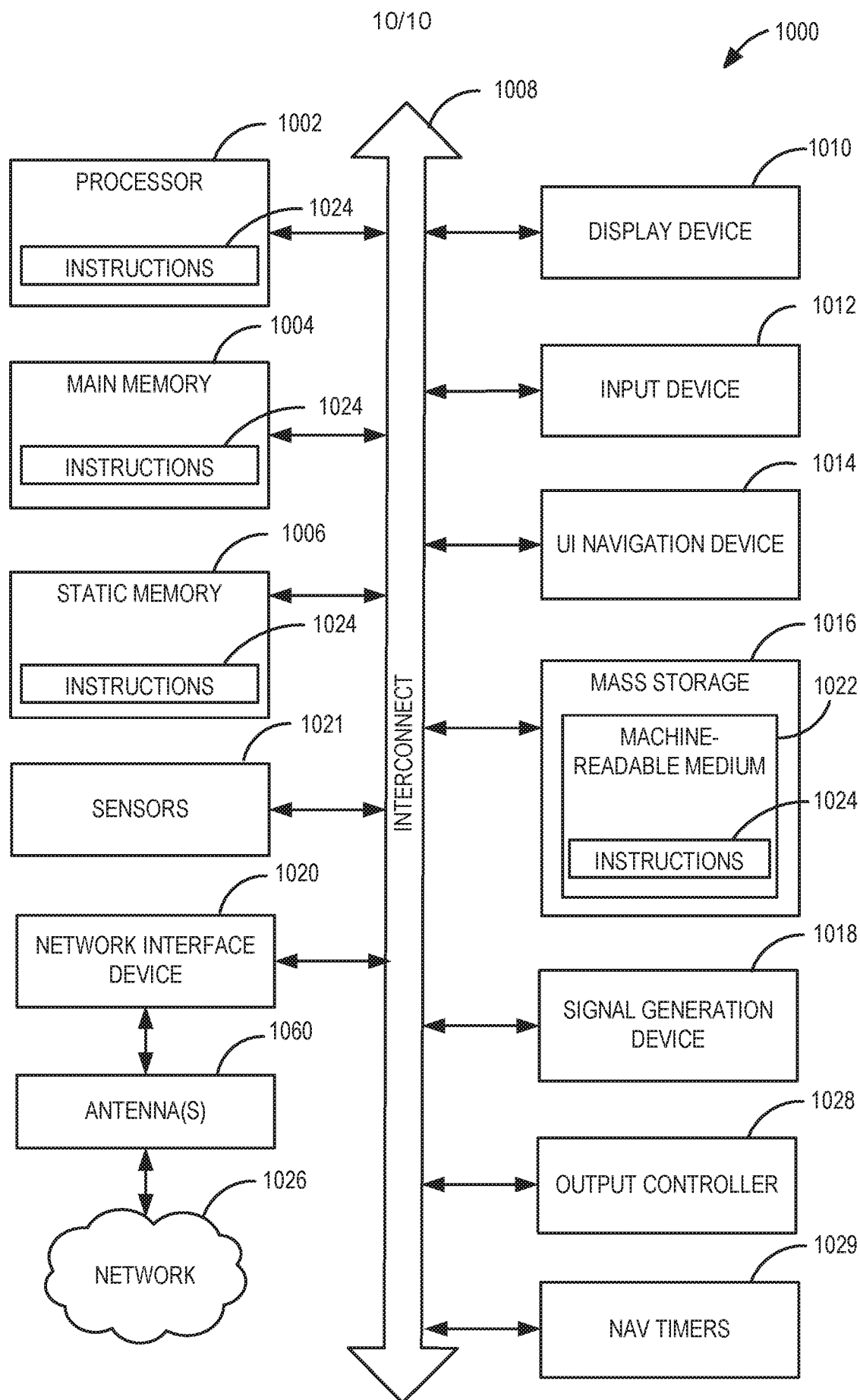


FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/039774**A. CLASSIFICATION OF SUBJECT MATTER****H04W 74/00(2009.01)i, H04W 74/08(2009.01)i, H04W 84/12(2009.01)i, H04L 27/26(2006.01)i**

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W 74/00; H04W 74/08; H04L 5/00; H04W 52/14; H04W 24/10; H04W 72/04; H04W 84/12; H04L 27/26

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: channel availability report, trigger frame, polling channel, OFDMA, CCA

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2015-076532 A1 (LG ELECTRONICS INC.) 28 May 2015 See paragraphs [0028], [0036], [0045], [0077], [0093], [0118], [0124]; claims 1-2; and figure 7.	1-7, 11-19, 22
Y		10, 20, 23
A		8-9, 21
Y	US 2015-0049730 A1 (QUALCOM INCORPORATED) 19 February 2015 See paragraph [0033]; and figure 10.	10
Y	US 2015-0057008 A1 (LG ELECTRONICS INC.) 26 February 2015 See paragraphs [0087]-[0089]; and figure 2.	20, 23
A	US 2015-0229457 A1 (NOKIA SOLUTIONS AND NETWORKS OY) 13 August 2015 See paragraphs [0092]-[0147]; and figure 2.	1-23
A	US 2014-0044112 A1 (ADRIAN P. STEPHENS et al.) 13 February 2014 See paragraphs [0075]-[0078]; and figures 4A-4B.	1-23

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

06 October 2016 (06.10.2016)

Date of mailing of the international search report

07 October 2016 (07.10.2016)

Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

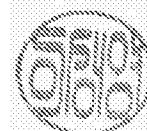
189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea

Facsimile No. +82-42-481-8578

Authorized officer

LEE, Seoung Young

Telephone No. +82-42-481-3535



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2016/039774

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2015-076532 A1	28/05/2015	AU 2014-353789 A1 CA 2930899 A1 CN 105766031 A	09/06/2016 28/05/2015 13/07/2016
US 2015-0049730 A1	19/02/2015	CA 2849479 A1 CN 103843443 A EP 2761965 A1 JP 05781699 B2 JP 2014-528665 A KR 10-1604732 B1 KR 10-2014-0069328 A RU 2014117176 A RU 2573641 C2 US 2013-0195081 A1 US 8917705 B2 WO 2013-049826 A1	04/04/2013 04/06/2014 06/08/2014 24/09/2015 27/10/2014 18/03/2016 09/06/2014 10/11/2015 27/01/2016 01/08/2013 23/12/2014 04/04/2013
US 2015-0057008 A1	26/02/2015	AU 2013-217790 A1 AU 2013-217790 B2 AU 2013-217792 A1 AU 2013-217792 B2 CA 2864234 A1 CA 2864372 A1 CN 104221443 A CN 104335662 A EP 2814288 A1 EP 2814296 A1 EP 2814296 A4 JP 2015-510350 A JP 2015-510351 A KR 10-2014-0130118 A KR 10-2014-0130119 A US 2015-0341880 A1 WO 2013-119095 A1 WO 2013-119097 A1	15/08/2013 13/08/2015 11/09/2014 25/02/2016 15/08/2013 15/08/2013 17/12/2014 04/02/2015 17/12/2014 17/12/2014 04/11/2015 02/04/2015 02/04/2015 07/11/2014 07/11/2014 26/11/2015 15/08/2013 15/08/2013
US 2015-0229457 A1	13/08/2015	CA 2823749 A1 CN 103392371 A EP 2661938 A1 JP 05763782 B2 JP 2014-503145 A KR 10-1523030 B1 KR 10-2013-0108450 A SG 191876 A1 TW 201236397 A US 2012-0176924 A1 US 9007933 B2 WO 2012-093156 A1	12/07/2012 13/11/2013 13/11/2013 12/08/2015 06/02/2014 26/05/2015 02/10/2013 30/08/2013 01/09/2012 12/07/2012 14/04/2015 12/07/2012

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2016/039774Patent document
cited in search reportPublication
datePatent family
member(s)Publication
date

US 2014-0044112 A1

13/02/2014

WO 2014-025476 A1

13/02/2014