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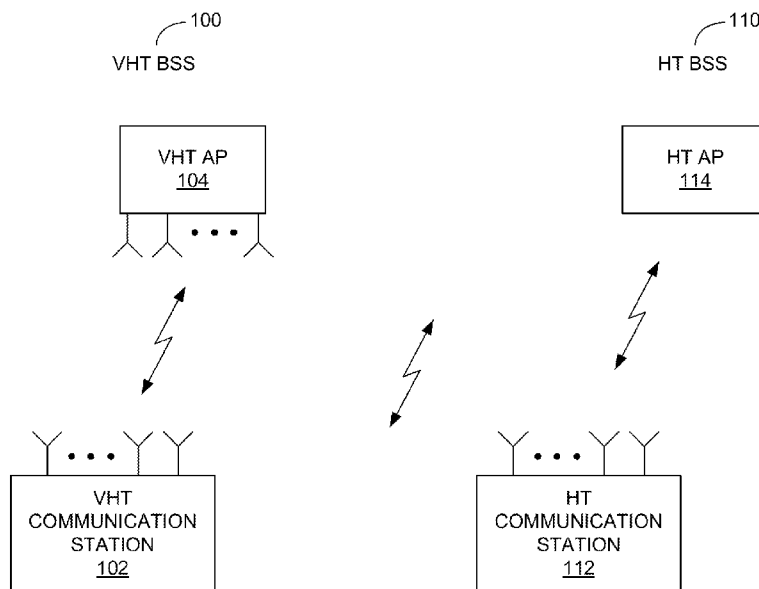
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(54) Title: METHOD AND APPARATUS FOR COLLISION DETECTION IN WIDER BANDWIDTH OPERATION



(57) Abstract: Embodiments of systems
and methods for providing collision de-
tection in a wider bandwidth are general-
ly described herein. Other embodiments
may be described and claimed.

FIG. 1

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METHOD AND APPARATUS FOR COLLISION DETECTION IN WIDER BANDWIDTH OPERATION

FIELD OF THE INVENTION

This application relates to wireless systems and, more particularly, to
5 systems and methods for co-existence of transmissions in one or more wireless
networks.

BACKGROUND

An increased throughput, e.g., above 1 Gigabit-per-second (Gbps) per
wireless communication client, may be required to satisfy a demand for
10 transferring increased amounts of data within wireless communication networks or
basic service sets (BSS), such as wireless local area networks (WLAN) and/or
wireless personal area networks (WPAN). The increased throughput may be
achieved by using a communication link having a wide bandwidth. For example, a
bandwidth of 40 Mega-Hertz (MHz) or more using a plurality of channels may be
15 required to provide high throughput in a network operating over one or more
frequency bands in accordance with the IEEE 802.11 standards.

The plurality of wireless communication channels can be used across a
number of BSSs, wherein one BSS overlaps one or more other BSSs. Collisions
can occur when one BSS occupies a channel of another BSS, wherein traffic over
20 a channel in a first BSS collides with traffic over the channel in a second BSS.
Stations (STA) within the first BSS may be hidden and not otherwise known or
detected within the second BSS. The presence of hidden nodes or STAs within
the range of a BSS can lead to collisions within the BSS.

BRIEF DESCRIPTION OF THE DRAWINGS

25 The present invention is illustrated by way of example and not as a
limitation in the figures of the accompanying drawings, in which:

Figure 1 is a schematic block diagram illustration of neighboring wireless
communication networks, in accordance with some demonstrative embodiments;

Figure 2 is a schematic block diagram illustration of a system, in
30 accordance with some demonstrative embodiments;

Figure 3 is a block diagram illustration of channel allocations, in
accordance with some demonstrative embodiments;

Figure 4 is a block diagram illustration of collision detection over a plurality of channels, in accordance with some demonstrative embodiments;

Figure 5 is a block diagram illustration of collision detection over a plurality of channels, in accordance with some demonstrative embodiments;

5 Figure 6 is a block diagram illustration of collision detection over a plurality of channels, in accordance with some demonstrative embodiments;

Figure 7 is a block diagram illustration of methods for collision detection in wideband transmission, in accordance with some demonstrative embodiments; and

10 Figure 8 is a block diagram illustration of methods for collision detection in wideband transmission, in accordance with some demonstrative embodiments.

DETAILED DESCRIPTION

In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of embodiments of the invention.

15 However it will be understood by those skilled in the art that embodiments of the invention may be practiced without these specific details. In other instances, well-known methods, procedures, components and circuits have not been described in detail so as not to obscure embodiments of the invention.

The following detailed description describes various embodiments for
20 communication using a device such as a platform, user equipment (UE), subscriber station (SS), station (STA), mobile station (MS), advanced mobile station (AMS), high throughput (HT) station (STA), or very HT STA (VHT STA). The various forms of devices described above such as the platform, UE, SS, MS, HT STA, and VHT STA may be interchanged and reference to a particular device
25 does not preclude other devices from being substituted in various embodiment(s). The device can communicate in a network with one or more other devices such as a base station (BS), access point (AP), node, node B, or enhanced node B (eNB). Further, these terms may be conceptually interchanged, depending on which wireless protocol is being used in a particular wireless network, so a reference to
30 BS herein may also be seen as a reference to either of ABS, eNB, HT AP, VHT AP or AP as one example. Similarly, a reference to MS herein may also be seen as a reference to either of HT STA, VHT STA, or SS as another example. Reference to a particular device does not preclude other devices from being substituted in various embodiment(s).

Some embodiments may be used in a wireless area network, a Wireless Video Area Network (WVAN), a Local Area Network (LAN), a Wireless LAN (WLAN), a Wireless Metropolitan Area Network (WMAN) communication system, a Personal Area Network (PAN), a Wireless PAN (WPAN), devices and/or networks operating in accordance with existing IEEE 802.11 (IEEE Standard for Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific requirements, Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications - June 2007), 802.11n, 802.11 task group ac (TGac), 802.11 task group ad (TGad). Further, networks operating in accordance with 802.16 (IEEE-Std 802.16, 2004 Edition, Air Interface for Fixed Broadband Wireless Access Systems), 802.16d, 802.16e (IEEE-Std 802.16e, 2005 Edition, Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands), 802.16f, 802.16m standards ("the 802.16 standards") and/or future versions and/or derivatives thereof, devices and/or networks operating in accordance with existing Wireless-Gigabit-Alliance (WGA) and/or WirelessHDTM specifications and/or future versions and/or derivatives thereof, devices and/or networks operating in accordance with existing cellular specifications and/or protocols, e.g., 3rd Generation Partnership Project (3GPP), 3GPP Long Term Evolution (LTE), and/or future versions and/or derivatives thereof.

In the field of communications, including wireless communications, it would be helpful to reduce interference or collisions for devices that operate using wideband transmissions in wireless environments that include multiple networks or BSSs. For example, devices associated with a first BSS in a wireless environment may be hidden or otherwise not associated with a second network, but can cause interference and/or collisions on the second network. Systems and methods for providing coexistence for wideband and narrower band transmissions in the wireless environment, while avoiding or reducing collisions, can provide improved throughput for the devices in the wireless environment.

Figure 1 illustrates neighboring wireless communication networks in accordance with some embodiments. The neighboring wireless communication networks include two or more basic service sets (BSS), such as very-high throughput (VHT) BSS 100 and high-throughput (HT) BSS 110, however the embodiment is not so limited. Alternate types wireless communication networks

may be substituted and/or added in alternate embodiments. The VHT BSS 100 comprises a VHT access point (AP) 104 and one or more VHT communication stations (STA) 102, and HT BSS 110 comprises neighboring HT AP 114 and one or more HT communication stations (STA) 112. In an embodiment, VHT BSS 100 is configured to operate in accordance with IEEE 802.11ac and the HT BSS 110 is configured to operate in accordance with IEEE 802.11n. Other wireless protocols may be used in the alternate embodiments.

VHT BSS 100 may utilize a primary channel and up to three or more non-primary or secondary channels. The HT BSS 110, on the other hand, may be limited to using a primary channel, or a primary channel and a secondary channel. The primary channel is a communications channel in the wireless communication network associated with a station. In embodiments, the station may perform carrier sensing functions and send data along the primary channel and optionally along a number of secondary channels. VHT communication station 102 and HT communication station 112 may utilize a contention-based collision-avoidance protocol such as the CSMA/CA protocol to contend for access on one or more channels.

In accordance with some embodiments, VHT communication station 102 is configured to communicate a data unit, such as a physical layer convergence procedure (PLCP) protocol data unit (PPDU), on a primary channel and up to three or more non-primary channels, and HT communication station 112 is configured to communicate a PPDU on a primary channel, or a primary channel and one secondary channel. In embodiments, the VHT communication station 102 is configured to reduce collisions that may occur with HT communication station 112 by detecting packets on the primary and/or non-primary channels used by the VHT BSS 100.

Reference is now made to Figure 2, which schematically illustrates a block diagram of a system 200 in accordance with some demonstrative embodiments. In some demonstrative embodiments, system 200 may include one or more wireless communication devices, e.g., wireless communication devices 202 and/or 206, capable of communicating content, data, information and/or signals over a wireless communication link 216. One or more elements of system 200 may optionally be capable of communicating over any suitable wired communication links.

In some demonstrative embodiments, wireless communication devices 202 and/or 206 may include the VHT STA 102, the VHT AP 104, the HT STA 112, the HT AP 114, or the like. In some demonstrative embodiments, device 202 includes a wireless communication unit 208 to transmit, via one or more antennae 212, a wireless transmission to device 206 over wireless communication link 216. Device 206 includes a wireless communication unit 240 to receive the wireless transmission via one or more antennae 214. Types of antennae that may be used for antennae 212 and/or 214 may include but are not limited to internal antenna, dipole antenna, omni-directional antenna, a monopole antenna, an end fed antenna, a circularly polarized antenna, a micro-strip antenna, a diversity antenna and the like.

In some demonstrative embodiments, wireless communication link 216 may have a wideband bandwidth of at least 160 Mega-Hertz (MHz). In other embodiments, wireless communication link 216 may have any other suitable wideband bandwidth, e.g. 80 MHz and 40 MHz. For example, wideband may be 80 MHz in bandwidth and sub-wideband may be 40 MHz or less in bandwidth, though the embodiments are not so limited.

In some demonstrative embodiments, wireless communication devices 202 and/or 206 may also include, for example, one or more of a processor 226, an input unit 218, an output unit 220, a memory unit 222, and a storage unit 224. Wireless communication devices 202 and/or 206 may optionally include other suitable hardware components and/or software components. The wireless communication devices 202 and/or 206 may further comprise transmission and reception capabilities in a single device wherein some or all of the components of each of wireless communication devices 202 and/or 206 may be enclosed in a common housing or packaging, and may be interconnected or operably associated using one or more wired or wireless links. In other embodiments, components of each of wireless communication devices 202 and/or 206 may be distributed among multiple or separate devices.

Processor 226 includes, for example, a Central Processing Unit (CPU), a Digital Signal Processor (DSP), one or more processor cores, a single-core processor, a dual-core processor, a multiple-core processor, a microprocessor, a host processor, a controller, a plurality of processors or controllers, a chip, a microchip, one or more circuits, circuitry, a logic unit, an Integrated Circuit (IC), an

Application-Specific IC (ASIC), or any other suitable multi-purpose or specific processor or controller. Processor 226 executes instructions, for example, of an Operating System (OS) of wireless communication devices 202 and/or 206 and/or of one or more suitable applications.

5 Memory unit 222 includes, for example, a Random Access Memory (RAM), a Read Only Memory (ROM), a Dynamic RAM (DRAM), a Synchronous DRAM (SD-RAM), a flash memory, a volatile memory, a non-volatile memory, a cache memory, a buffer, a short term memory unit, a long term memory unit, or other suitable memory units. Storage unit 224 includes, for example, a hard disk drive,
10 a floppy disk drive, a Compact Disk (CD) drive, a CD-ROM drive, a DVD drive, or other suitable removable or non-removable storage units. Memory unit 222 and/or storage unit 224, for example, may store data processed by wireless communication device 202 and/or 206.

 In some demonstrative embodiments, wireless communication link 216
15 includes a number of contiguous wireless communication channels. The phrase “contiguous channels”, as used herein, may refer to two or more wireless communication channels that are adjacent, neighboring, and/or bordering one another. In alternate embodiments, a number of channels may be dis-contiguous wherein two or more wireless communication channels in a channel block or
20 channel segment are non-adjacent or are separated by a frequency range.

 Some demonstrative embodiments are described below with reference to a wireless communication link, e.g., wireless communication link 216. In one example, the wireless communication link may include at least one channel having a bandwidth of 80MHz and at least one channel having a bandwidth
25 different from 80MHz, e.g., 20MHz, 40MHz, 160MHz and the like. For example, the 80Mhz channel includes four contiguous 20MHz channels, e.g., in accordance with the 802.11 standards and/or any other suitable standard and/or protocol.

 In some demonstrative embodiments, wireless communication unit 208 may include a plurality of transmit (Tx) chains 211 to transmit the wireless
30 transmission over the plurality of wireless communication channels. Wireless communication unit 240 may include a plurality of receive (Rx) chains 244 to receive the wireless transmission over the plurality of wireless communication channels. In some demonstrative embodiments, Tx chains 211 and/or Rx chains 244 may include any suitable Physical-layer (PHY) chains and/or components;

any suitable Radio-Frequency (RF) chains and/or components; and/or any other suitable elements.

In some demonstrative embodiments, wireless communication unit 208 may include a media-access-controller (MAC) 210, e.g., a single MAC, to commonly control the transmissions via Tx chains 211; and/or wireless communication unit 240 may include a MAC 242, e.g., a single MAC, to commonly control the reception via Rx chains 244, e.g., as described in detail below.

In some demonstrative embodiments, MAC 210 may control Tx chains 211 to simultaneously transmit symbols of a wireless communication packet over the plurality of wireless communication channels of wireless communication link 216. MAC 242 may control Rx chains 244 to simultaneously receive the symbols of the wireless communication packet over the plurality of wireless communication channels of wireless communication link 216.

Figure 3 is a block diagram illustration of channel allocations, in accordance with some demonstrative embodiments. The block diagram illustrates part of a wireless spectrum in a 5 gigahertz (GHz) band wherein portions of the 5 GHz band are allocated as unlicensed bands and referred to as Unlicensed National Information Infrastructure (UNII) radio bands. Adjoining and/or separate frequency bands in the electromagnetic spectrum may be used in alternate embodiments.

The UNII radio bands are part of the radio frequency spectrum used by IEEE-802.11 devices and many wireless network service providers and is a is an Federal Communications Commission (FCC) regulatory domain for 5- GHz wireless devices in the United States. The UNII radio bands are categorized, for purposes of this application, as a UNII-1 band, a UNII-2 band, a UNII-2 extended band, and a UNII-3 band. The bands may be further categorized according to power limitations, frequency bandwidth, and number of channels allocated to each band wherein the channels may be grouped together.

Reference to particular bands within the 5 GHz band may differ depending on location. For example, the bands illustrated in Figure 3 reflect embodiments that may apply to the United States. Frequency ranges for each band can change depending on location and may differ in alternate embodiments. As shown in Figure 3, the UNII-1 band ranges between 5.15 to 5.25 GHz and the UNII-1 band comprises four even-numbered channel blocks ranging from 36 to 48 wherein

each channel block represents a 20 MHz channel 302. The 20 MHz channels 302 may be further combined to provide a wider bandwidth, represented as a 40 MHz channel 304, an 80 MHz channel 306, and a 160 MHz channel 308. Reference herein to a channel block may refer to a single channel or may refer to multiple
5 aggregated channels to provide a desired bandwidth for the channel block.

Similarly, the UNII-2 band contains four 20 MHz channels 302 between 5.25 to 5.35 GHz and ranges between even-numbered channel blocks 52 to 64. A UNII-2 extended band, which may also be referred to as a UNII Worldwide band, ranges between 5.47 and 5.725 GHz and contains twelve even-numbered
10 channel blocks from 100 to 144. In this embodiment, a gap 310 follows the UNII-2 extended band and precedes a UNII-3 band. The UNII-3 band extends to 5.825 GHz and contains five odd-numbered channel blocks from 149 to 165. Frequency labels in Figure 3 refer to established limits for corresponding UNII bands. In alternate embodiments, channel block numbers and the frequency bandwidth that
15 the channels occupy in each band may change depending on regulatory requirements or other limitations.

Transmission of a data stream in a number of channels may vary depending on a wireless protocol used for communications. For example, according to 802.11ac (TGac) draft specification, 80 MHz PHY transmission for
20 the VHT BSS 100 is supported using two adjacent 40 MHz channels. For the 80 MHz transmission, channel blocks 36 and 40 are two adjacent channel blocks, that when combined provide a total bandwidth of 40 MHz. Further, channel blocks 44 and 48 also provide a total bandwidth of 40 MHz. A combination of channel blocks 36, 40, 44, and 48 provide a total contiguous bandwidth of 80 MHz for
25 transmission. The combination of channel blocks 36-48 can provide a first frequency portion for 160 MHz transmission. A second frequency portion for 160 MHz transmission may include channel blocks 52, 56, 60, and 64, wherein the second frequency portion is 80 MHz in bandwidth. The contiguous first and second frequency portions allow for contiguous transmission in a first 160 MHz
30 channel 308. The first frequency portion and the second frequency portion may also be referred to as a lower and upper frequency portion in some embodiments.

Wideband channel communications may also be supported in the UNII-2 extended band and UNII-3 band using a plurality of channel blocks. A contiguous wideband channel in the 5 GHz band may be prevented due to frequency gap 310

as illustrated in Figure 3. The frequency gap 310 may be 5 MHz or larger in bandwidth (e.g. 10, 15, 20 or the like).

Figure 4 is a block diagram illustration of collision detection over a plurality of channels including a primary channel 420 and non-primary channels including secondary channel 430, tertiary channel 440, and quaternary channel 450, in accordance with some demonstrative embodiments. Fewer or additional channels may be used in alternate embodiments. Each of the channels 420, 430, 440, and 450 may be a 20 MHz channel 302, though the embodiment is not so limited. The channels of Figures 4, 5, and 6 may be wider or narrower than 20 MHz in alternate embodiments.

As illustrated in Figure 4, an initiating device or initiator such as the wireless communication device 202 attempts channel access using request to send (RTS) / clear to send (CTS) frames with a responding device or responder. The initiating device may scan, monitor or otherwise sense each of the channels 420, 430, 440, and 450, wherein the channels are monitored on a continuous or semi-continuous basis to determine if the channels are idle. If idle, the initiating device may dynamically select an available bandwidth based on a channel status and transmit RTS 404 frames comprising RTS preambles 402 to the responding device, such as the wireless communication device 206, using 80 MHz bandwidth over the primary channel 420, secondary channel 430, tertiary channel 440, and quaternary channel 450, for example in preparation to transmit a PPDU over 80Mhz bandwidth. Alternate bandwidths may be dynamically selected by the initiating device depending on a largest contiguous bandwidth available, e.g. 20MHz, 40MHz, or 160 Mhz. Further, a number of bits may be set in the RTS 404 frame and/or RTS preamble 402 to indicate whether the initiating device is using dynamic bandwidth operation.

The responding device can scan to determine a number of idle channels and may detect the RTS 404 frames. The RTS 404 frame can also carry bandwidth indication information that indicates a bandwidth occupied by the RTS 404 frame. Upon receiving a RTS frame, the responding device responds with CTS 410 frames comprising CTS preambles 408 at a widest contiguous bandwidth at which the responding device determines that the channel(s) are idle. In other embodiments, the receiving device senses or scans the channels prior to receiving the number of RTS 404 frames, such as at least a point coordination

function (PCF) interframe space (PIFS) prior to receiving the RTS 404 frames, to determine which channels are idle. The initiating and responding devices can operate dynamically, as opposed to a static bandwidth operation wherein if any of the non-primary channels 430, 440, and/or 450 are detected as busy when
5 scanned or sensed by either the initiating device or the responding device, transmission of frames over the primary channel 420 and non-primary channels 430, 440, and 450 is prevented and/or delayed such as by implementing a backoff procedure over the primary channel 420 and, in embodiments, without incrementing a retry counter.

10 The responding device may successfully detect the RTS 404 frames over the primary channel and may optionally detect the RTS 404 frames over the non-primary channels using one or more measurements parameters, such as a signal to noise ratio (SNR) or signal to interference noise ratio (SINR). The responding device may not detect one or more RTS 404 frames due to a collision over one or
15 more channels, indicating the one or more channels are busy. As an example, a corrupted preamble 412 results from a collision of a RTS preamble 402 over the tertiary channel 440. The corrupted preamble 412 may prevent the responding device from successfully receiving a RTS 404 frame over the tertiary channel 440.

In an embodiment, the responding device implements an interference
20 estimation protocol on the non-primary channels including the secondary channel 430, the tertiary channel 440, and the quaternary channel 450 to estimate interference over a long training field (LTF) of the RTS preamble 402. The interference estimation protocol may include derivation of a SINR using a received signal strength indicator (RSSI) estimated or measured over the primary channel
25 420 and an interference level measured or estimated over one or more non-primary channels. For example, the responding device may determine the SINR for the tertiary channel 440 using the RSSI of the primary channel 420 and the interference level measured over the tertiary channel 440. In this embodiment, the responding device may determine that a collision occurred over the tertiary
30 channel 440 if the SINR is lower than a pre-determined threshold. The pre-determined threshold may be calculated or determined by the initiating device and/or responding device, or the pre-determined threshold may be provisioned within the initiating device and/or responding device. The responding device sends CTS 410 frames having CTS preambles 408 over the primary channel 420

and the secondary channel 430 after the SIFS 406 to provide a contiguous bandwidth for the initiator to send a subsequent data PPDU following a SIFS 418 using data 420 frames.

The responding device may determine a bandwidth to be used for transfer
5 of the data PPDU based on preamble detection over the non-primary channels
and timing-correlation between the primary channel 420 and the non-primary
channels 430, 440, and 450. If the responding device receives a RTS 404 with a
valid RTS preamble 402 over the primary channel 420 but either a valid RTS
preamble 402 is not received over one or more of the non-primary channels 430,
10 440, and 450, or a valid RTS preamble 402 is detected but very high interference
is estimated over one or more of the non-primary channels, the responding device
can reduce the transmit bandwidth and transmit CTS 410 frames over a subset of
channels for which valid preambles have been received and have been time-
correlated with a correctly received RTS 404 frame over the primary channel 420.
15 Collisions may occur during the CTS 410 frames also and the initiating device
may detect the collisions and adjust an operating bandwidth in response to the
collisions by selecting channels that were collision-free during the RTS 404
frames and the CTS 410 frames.

Dynamic allocation or selection of bandwidth may be provided in
20 embodiments by using a number of bits in the RTS 404 and/or CTS 410 frames.
As an example, 2 out of 9 reserved bits in a service field of the RTS 404 frame
and/or CTS 410 frame may be used to indicate bandwidth mode. The bits
indicating bandwidth mode may be reserved service bits that follow scrambler
initialization fields in the RTS 404 and/or the CTS 410 frames. In other
25 embodiments, the RTS 404 may be wrapped in a control wrapper and/or the CTS
410 frames may be wrapped in a control wrapper. The control wrapper may
comprise one or more of a frame control field, a duration identifier field, an
address field, a carried frame control field, a high throughput control field, a
carried frame field, and a frame check sequence field. A number of reserved bits
30 may be set to indicate bandwidth for the RTS 404 frame or the CTS 410 frame in
a field of the control wrapper. As an example, two reserved bits in the HT control
field may be used to indicate bandwidth. Alternate fields may be used to indicate
bandwidth through use of a number of bits.

In alternate embodiments for Figure 4, the frames may be referred to as multichannel frames such as a multichannel RTS (MRTS) 404 frame and a multichannel CTS (MCTS) 410 frame. An MRTS is an RTS 404 that comprises an embedded list of channels the MRTS is transmitted on. The MRTS 404 frame and the MCTS 410 frame may be configured to identify available bandwidth wherein interference estimation is used to determine whether a collision has been detected, instead of preamble detection as described earlier in reference to Figure 4. A responding device may receive the MRTS 404 frame and determine collision-free channels and indicate bandwidth in the MCTS 410 frame. The bandwidth intended to be used by a device may be indicated in a bandwidth field of the MRTS 404 frame and the MCTS 410 frame using a number of bits. For example, two bits may be used in the bandwidth field of the MRTS 404 frame and/or the MCTS 410 frame to indicate that a selected bandwidth will be used for a subsequent transmission. The initiating device and the responding device may monitor all channels in the embodiment of Figure 4, though the embodiment is not so limited.

Figure 5 is a block diagram illustration of collision detection over a plurality of channels, in accordance with some demonstrative embodiments. An initiating device such as the VHT communication STA 102 or the VHT AP 104 uses a RTS frame 504 including a RTS preamble 502 over a plurality of channels comprising the primary channel 420 and a number of non-primary channels including the secondary channel 430, the tertiary channel 440, and the quaternary channel 450. Fewer or additional channels may be used in alternate embodiments.

To improve energy efficiency and to reduce hardware complexity, a responding device such as the VHT communication STA 102 or the VHT AP 104 may monitor only a subset of available channels on a continuous or semi-continuous basis to determine if the subset of available channels are idle and to sense RTS frames 404. For example, the responding device may select some but not all of the channels 420, 430, 440, and 450 for packet reception to detect collisions on the selected channels. If a collision is detected on one of the selected channels, the initiating device can reduce a transmission bandwidth of subsequent packets or frames. A corrupted preamble 512 sent by the initiating device as part of the RTS 504 frame along the secondary channel 430 may not be detected if the responding device selectively monitors a subset of channels that

excludes the secondary channel 430. As a result, a CTS 510 frame is sent despite the collision on the secondary channel 430 and a bandwidth used for transmission is not disturbed or modified because the collision was not detected on a channel monitored by the responding device.

5 Figure 6 is a block diagram illustration of collision detection over a plurality of channels, in accordance with some demonstrative embodiments. An initiating device such as the VHT communication STA 102 or the VHT AP 104 uses a RTS frame 504 including a RTS preamble 502 over a plurality of channels comprising the primary channel 420 and a number of non-primary channels including the
10 secondary channel 430, the tertiary channel 440, and the quaternary channel 450. In embodiments, the primary channel 420 is monitored on a continuous or semi-continuous basis. However, the remaining channels 430, 440, and 450 are not monitored, for example to save energy or to reduce hardware complexity.

Prior to establishing a transmission opportunity (TXOP), the initiating
15 device transmits a RTS 604 frame over all of the available channels 420, 430, 440, and 450. Fewer or additional channels may be used in alternate embodiments. A RTS preamble 602, as part of the RTS 604 frame, indicates the available bandwidth and, in particular embodiments, an association identifier (AID) of the responding device. The bandwidth may be indicated in the RTS preamble
20 602 using a number of bits. For example, for four available channels, two bits may be used to indicate the available bandwidth, or the bandwidth detected as idle by the initiating device.

Upon receiving the RTS preamble 602 and detecting a match of the AID, the responding device switches from a first bandwidth mode to a second
25 bandwidth mode. In embodiments, the responding device may also determine if the channels are idle prior to receiving the RTS frame 604. The responding device may switch from a 20 MHz mode to an 80 MHz mode based on the bandwidth indicated in the RTS preamble 602. After switching modes, the responding device monitors channels corresponding to the bandwidth indicated in
30 the RTS preamble 602. Following the short interframe space (SIFS) 606, the initiating device transmits a RTS 610 over all the channels corresponding to the available bandwidth. The responding device may detect a collision over the tertiary channel 440, resulting in a corrupted preamble 628 which is detected by the responding device. After receiving the RTS 610 frames over all the available

channels, the responding device responds with CTS 616 frames over collision free channels which may be a subset of the available channels including the primary channel 420 and the secondary channel 430. In response to detecting the collision on the tertiary channel, the responding device may switch off an upper
5 band circuit corresponding to the tertiary channel 440 and the quaternary channel 450. In an alternate embodiment, a collision may be detected along the quaternary channel 450, resulting in the initiating device transmitting along the primary channel 420 and the secondary channel 430 as illustrated in Figure 6.

Figure 7 is a block diagram illustration of devices and methods for collision
10 detection in wideband transmission as described earlier in reference to Figure 2 through Figure 6. In element 702, a device such as the wireless communication device of Figure 2, i.e. 202 or 206, configured for wideband communication monitors for traffic over a plurality of channels, e.g. primary channel 420, secondary channel 430, tertiary channel 440, and quaternary channel 450. In
15 element 704, the device determines that one or more channels of the plurality of channels are idle. In element 706, the device transmits a RTS frame over the one or more idle channels, wherein the one or more idle channels includes a primary channel 420, and each RTS frame indicates available bandwidth at the transmitter and comprises a preamble. A CTS frame is received in element 708 over the
20 primary channel 420, wherein the CTS frame indicates a number of available channels and available bandwidth at a responder. Data is transmitted by the device over the number of available channels indicated by the CTS frame in element 710.

Figure 8 is a block diagram illustration of methods for collision detection in
25 wideband transmission as described earlier in reference to Figure 2 through Figure 6. In element 802, a device such as the wireless communication device of Figure 2, i.e. 202 or 206, configured for wideband communication determines if a primary channel 420 and a number of non-primary channels (e.g. 430 – 450) are idle. In element 804, the device receives a RTS frame over the primary channel
30 420, wherein the RTS frame indicates an available bandwidth at the device. The device transmits a CTS frame over a number of the primary channel 420 and one or more non-primary channels in element 806 based at least in-part on whether the primary channel 420 and the non-primary channels are idle, wherein the CTS frame indicates an available bandwidth at a responder. In element 808, the

device receives data over at least a subset of the number of the one or more primary channel 420 and non-primary channels.

The operations discussed herein may be generally facilitated via execution of appropriate firmware or software embodied as code instructions on tangible media as applicable. Thus, embodiments of the invention may include sets of instructions executed on some form of processing core or otherwise implemented or realized upon or within a machine-readable medium. A machine-readable medium includes any mechanism for storing or transmitting information in a form readable by a machine (e.g., a computer). For example, a machine-readable medium can include an article of manufacture such as a read only memory (ROM); a random access memory (RAM); a magnetic disk storage media; an optical storage media; and a flash memory device, *etc.* In addition, a machine-readable medium may include propagated signals such as electrical, optical, acoustical or other form of propagated signals (e.g., carrier waves, infrared signals, digital signals, *etc.*).

Unless specifically stated otherwise, as apparent from the following discussions, it is appreciated that throughout the specification discussions utilizing terms such as "processing," "computing," "calculating," "determining," "selecting," "decoding," or the like, may refer to the action and/or processes of a computer or computing system, or similar electronic computing device, that manipulate and/or transform data represented as physical, such as electronic, quantities within the computing system's registers and/or memories into other data similarly represented as physical quantities within the computing system's memories, registers or other such information storage, transmission or display devices. In addition, the term "plurality" as used throughout the specification describes two or more components, devices, elements, parameters and the like.

The term "device" as used herein includes, for example, a device capable of wireless communication, a communication device capable of wireless communication, a communication station capable of wireless communication, a portable or non-portable device capable of wireless communication, or the like. In some demonstrative embodiments, a wireless device may be or may include a peripheral that is integrated with a computer, or a peripheral that is attached to a computer. In some demonstrative embodiments, the term "device" may optionally include a wired service.

While certain features of the invention have been illustrated and described herein, many modifications, substitutions, changes, and equivalents will now occur to those skilled in the art. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within
5 embodiments of the invention.

CLAIMS

What is claimed is:

1. A method to communicate using wideband transmissions, comprising:
monitoring for traffic over a plurality of channels using a station (STA)
5 configured for wideband transmission over a number of channels in the
plurality of channels;
determining that one or more channels of the plurality of channels is idle;
transmitting a request to send (RTS) frame over the one or more idle
channels, wherein the one or more idle channels includes a primary channel,
10 and each RTS frame indicates available bandwidth at the transmitter and
comprises a preamble;
receiving a clear to send (CTS) frame over the primary channel, wherein
the CTS frame indicates a number of available channels and available
bandwidth at a responder; and
15 transmitting data by the STA over the number of available channels
indicated by the CTS frame.
2. The method of claim 1, wherein the plurality of channels comprise a
primary channel and one or more non-primary channels.
3. The method of claim 1, further comprising determining if a collision
20 occurred over one or more of the plurality of channels based on a number of idle
channels and number of CTS frames received.
4. The method of claim 1, wherein the number of available channels are
contiguous channels.
5. The method of claim 2, wherein the STA monitors the primary channel
25 and at least a subset of the one or more non-primary channels.
6. The method of claim 2, wherein the STA monitors the primary channel
and does not monitor the one or more non-primary channels.
7. The method of claim 6, wherein the preamble comprises an association
identifier of the responder.
- 30 8. The method of claim 1, wherein the CTS frame and the RTS frame
comprise bandwidth mode bits.
9. A method to communicate using wideband transmissions, comprising:
sensing to determine if a primary channel and a number of non-primary
channels are idle;

receiving a request to send (RTS) frame over the primary channel from a station (STA) configured for wideband communication, wherein the RTS frame indicates an available bandwidth at the STA;

5 transmitting a clear to send (CTS) frame over a number of the primary channel and one or more non-primary channels based at least in-part on whether the primary channel and the non-primary channels are idle, wherein the CTS frame indicates an available bandwidth at a responder; and

receiving data over at least a subset of the number of the one or more primary channel and non-primary channels.

10 10. The method of claim 9, further comprising:

estimating interference for each non-primary channel using a long training field (LTF) in the preamble;

estimating a received signal strength indicator for the primary channel;

15 determining a signal to interference noise ratio (SINR) for each non-primary channel;

determining a threshold value; and

evaluating if a collision occurred over each non-primary channel based on the SINR and the threshold value.

20 11. The method of claim 9, further comprising performing timing-correlation between the primary and non-primary channels.

12. The method of claim 11, further comprising estimating an operating bandwidth based on preamble detection over the one or more non-primary channels and the timing-correlation between the primary and non-primary channels.

25 13. The method of claim 10, wherein the CTS frame is transmitted over a widest subchannel block based on the RTS frame received over the primary channel and one or more non-primary channels.

14. The method of claim 9, wherein the CTS frame and the RTS frame comprise bandwidth mode bits.

30 15. The method of claim 9, further comprising detecting whether a preamble was received over the one or more non-primary channels while the RTS frame was received over the primary channel.

16. A method to communicate using wideband transmissions, comprising:

receiving a request to send (RTS) frame, for a plurality of channels wherein the RTS frame comprises a RTS preamble, by a station (STA) over a primary channel, wherein the RTS frame also indicates an available bandwidth;

estimating an interference level for a number of non-primary channels;

5 determining if a collision occurred over one or more of the non-primary channels based at least on the interference level;

transmitting a clear to send (CTS) frame over one or more of the primary channel and non-primary channels, wherein the CTS indicates a collision-free bandwidth; and

10 receiving data over at least a subset of the one or more primary channel and non-primary channels, wherein the subset of the one or more primary channel and non-primary channels are contiguous channels.

17. The method of claim 16, wherein the RTS preamble further comprises an association identifier (AID) of the STA.

15 18. The method of claim 16, further comprising switching bandwidth operation based at least on the RTS preamble to monitor channels within the available bandwidth.

19. The method of claim 16, wherein the CTS frame and the RTS frame comprise bandwidth mode bits.

20

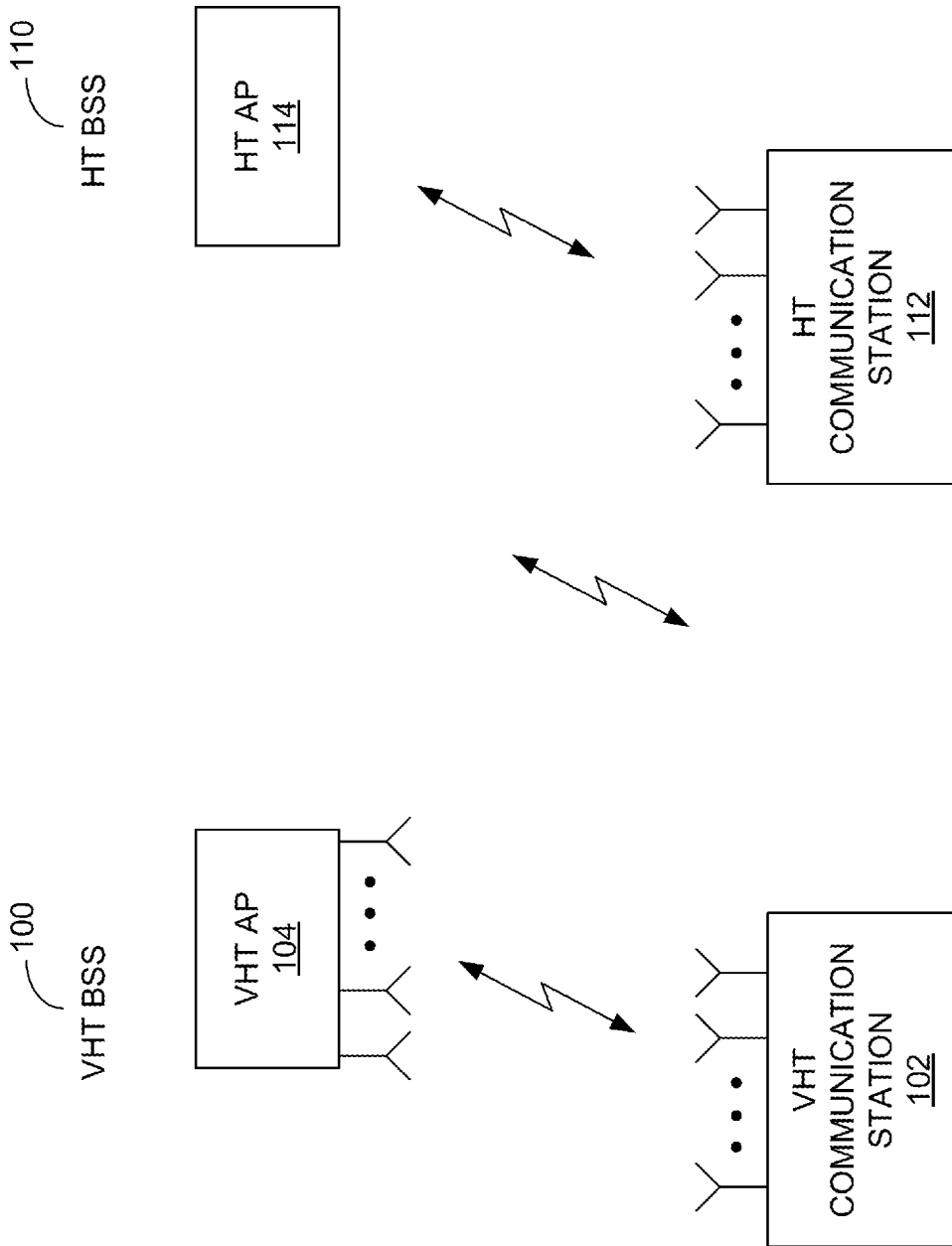


FIG. 1

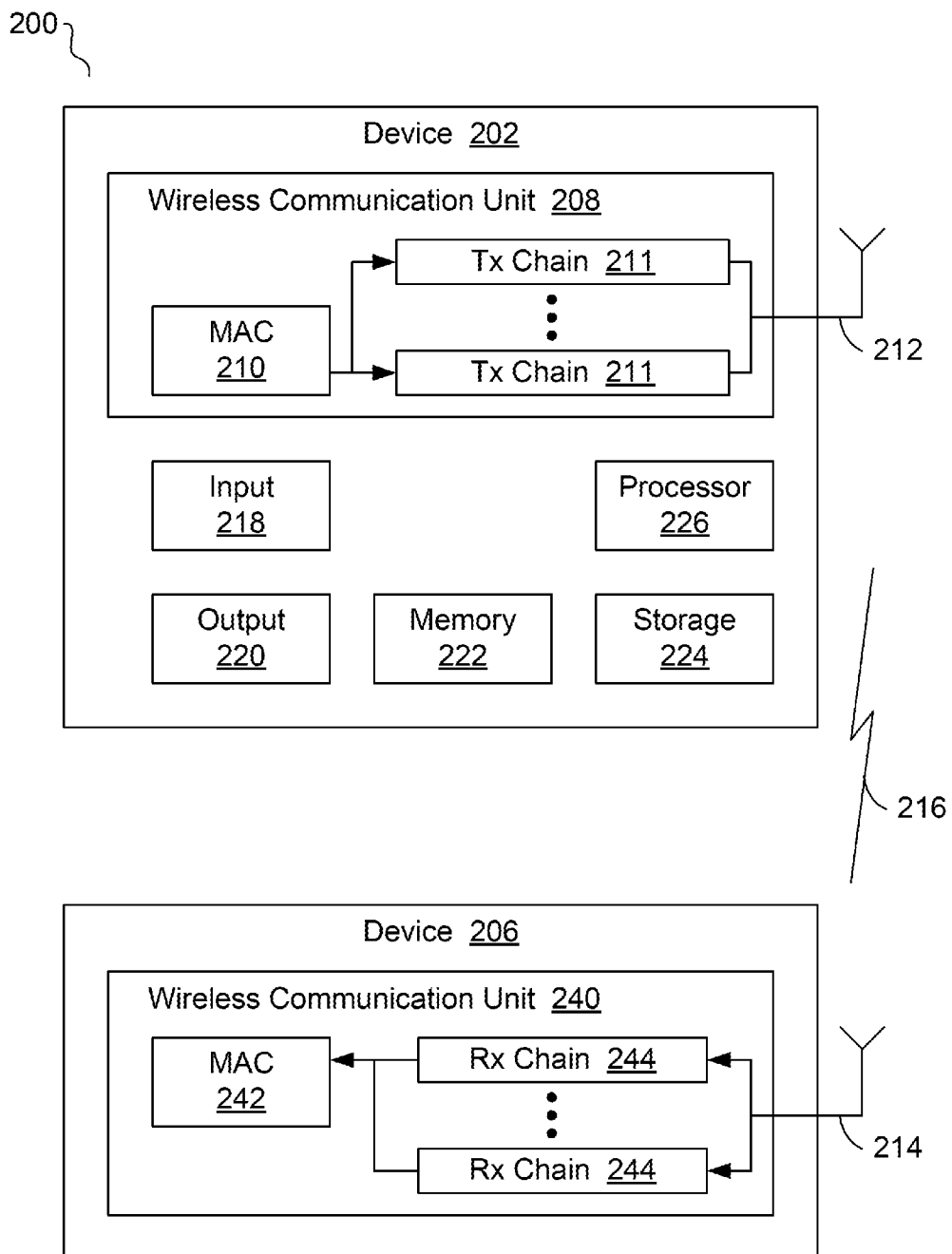


FIG. 2

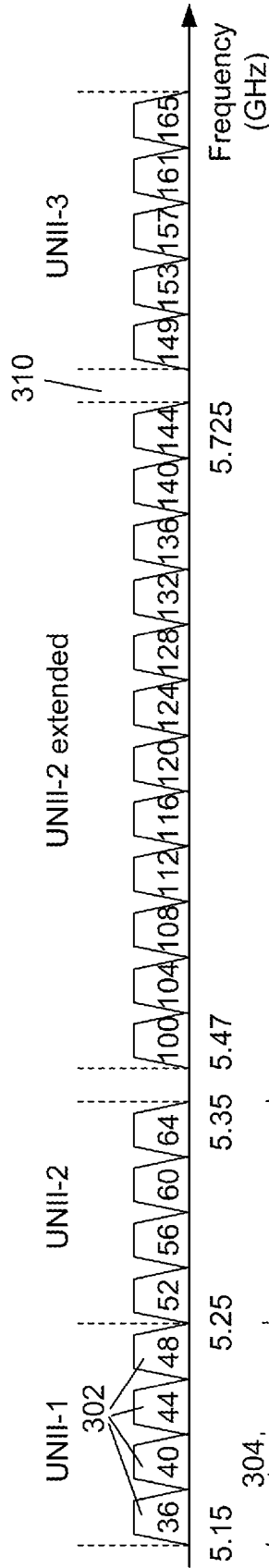


FIG. 3

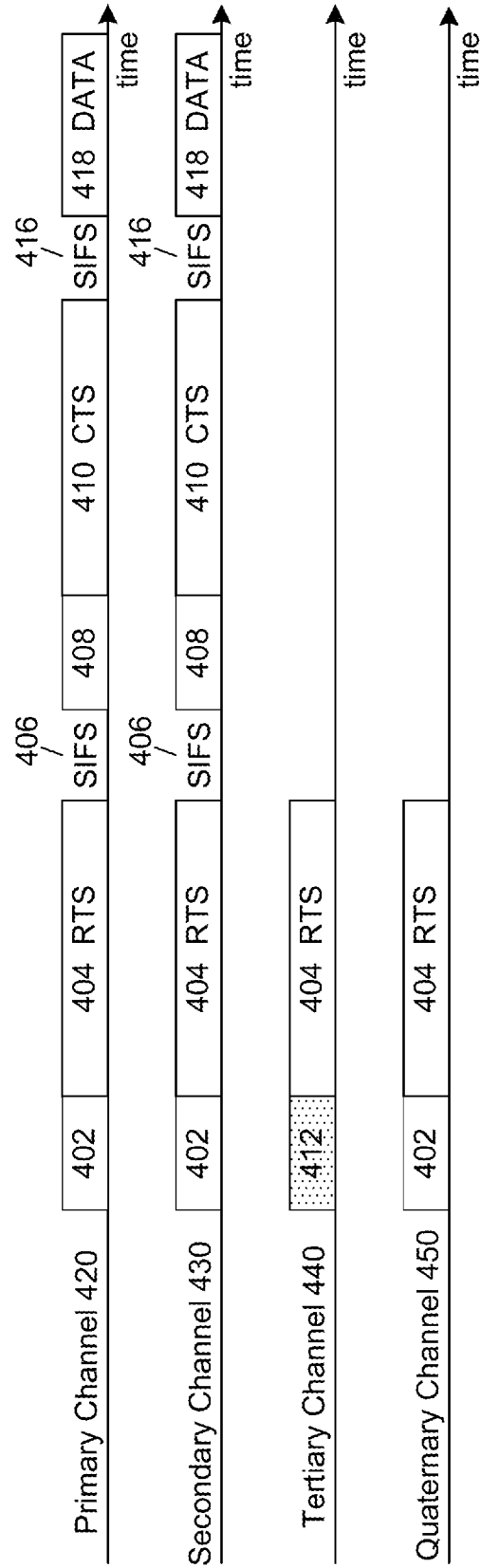


FIG. 4

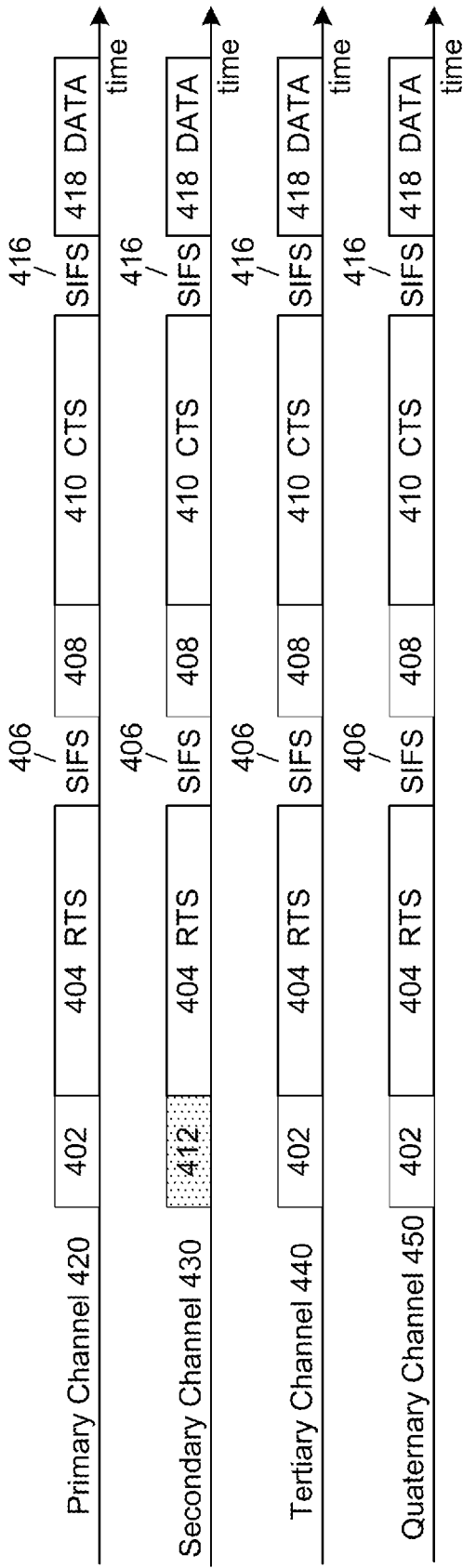


FIG. 5

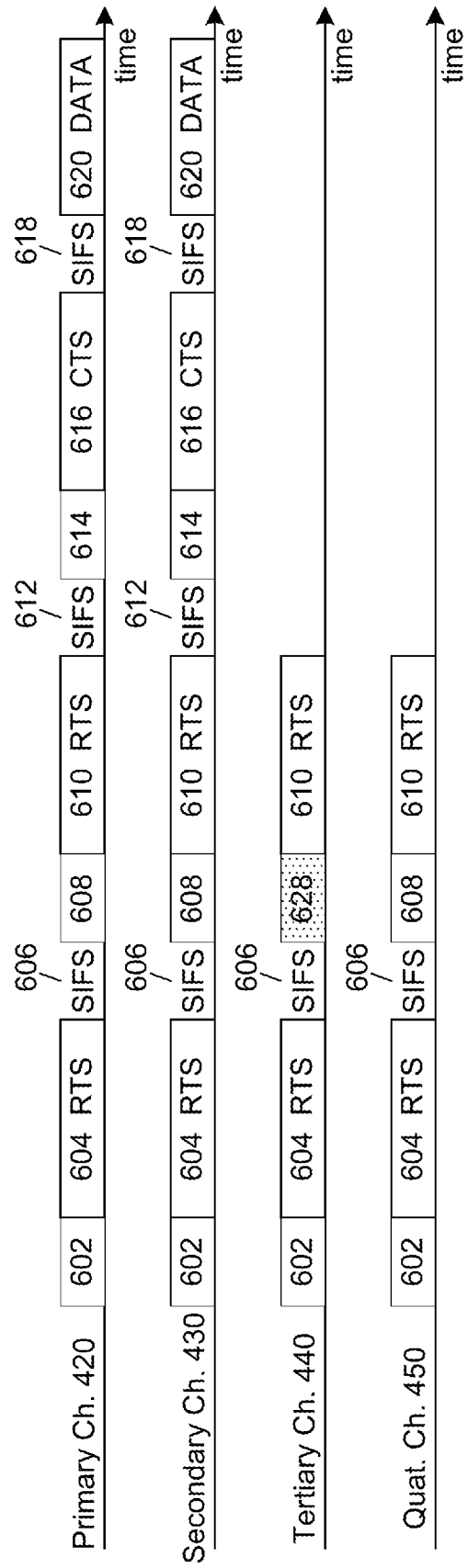


FIG. 6

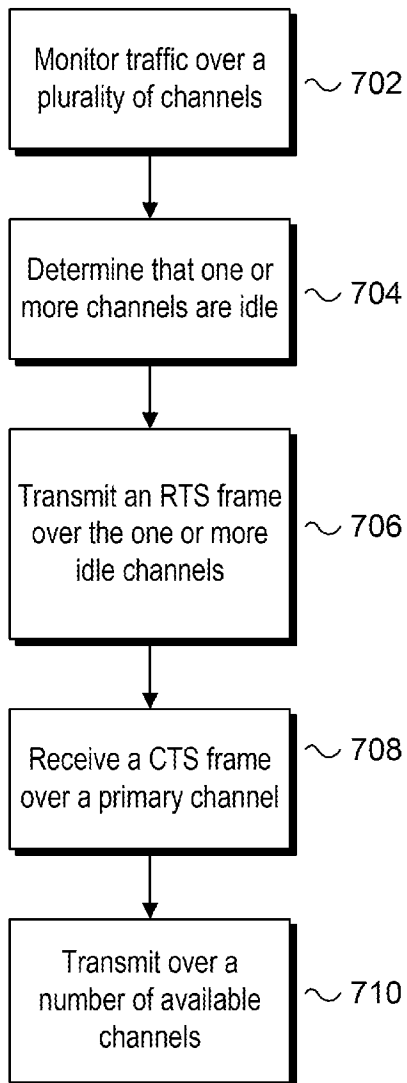


FIG. 7

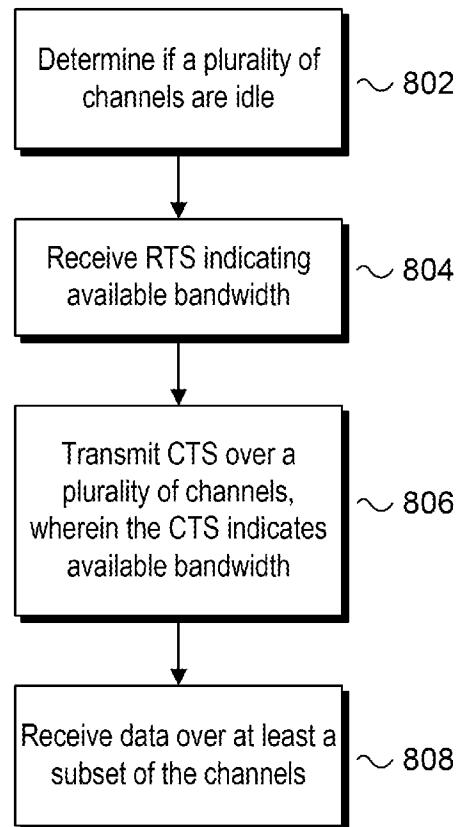




FIG. 8

A. CLASSIFICATION OF SUBJECT MATTER		
<i>H04W 74/08(2009.01)i, H04B 7/26(2006.01)i</i>		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) H04W 74/08; H04W 84/18; H04W 72/04; H04L 12/28		
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: RTS, CTS, available bandwidth, collision		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2007-0133490 A1 (KWON, CHANG-YEUL) 14 June 2007 See abstract; paragraphs [0013]-[0017], [0047]-[0049], [0052], [0055]-[0057]; claims 1,8,9 and figures 8-10.	1-19
A	KR 10-0772535 B1 (ELECTRONICS AND TELECOMMUNICATIONS RESEARCH INSTITUTE) 01 November 2007 See abstract; paragraphs [0017], [0018], [0021]-[0026]; claims 1-4 and figures 2,3,5.	1-19
A	KR 10-2010-0067894 A (LG ELECTRONICS INC.) 22 June 2010 See abstract; paragraphs [0010], [0011], [0027], [0033], [0048]; claims 1-3, 10, 11 and figures 3,4,9,10.	1-19
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> 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 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 26 FEBRUARY 2012 (26.02.2012)		Date of mailing of the international search report 27 FEBRUARY 2012 (27.02.2012)
Name and mailing address of the ISA/KR  Korean Intellectual Property Office Government Complex-Daejeon, 189 Cheongsu-ro, Seo-gu, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140		Authorized officer Hwang, Wooncheol Telephone No. 82-42-481-5985 

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2011/053758

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KR 10-2010-0067894 A	22.06.2010	EP 2362580 A2 US 2011-0243025 A1 WO 2010-068065 A2 WO 2010-068065 A3	31.08.2011 06.10.2011 17.06.2010 10.09.2010