Exhibit 1003

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(54) **SYSTEMS AND METHODS FOR HIGH-THROUGHPUT WIDEBAND WIRELESS LOCAL AREA NETWORK COMMUNICATIONS**

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H04J 3/22 (2006.01)

(52) **U.S. Cl.** **370/471**

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See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,022,046 A * 6/1991 Morrow, Jr. 375/130
6,654,408 B1 11/2003 Kadous et al.
2002/0126650 A1* 9/2002 Hall et al. 370/349
2003/0058951 A1 3/2003 Thomson et al.
2003/0076777 A1 4/2003 Stuber et al.
2004/0085917 A1* 5/2004 Fitton et al. 370/292
2004/0163129 A1* 8/2004 Chapman et al. 725/126

(Continued)

FOREIGN PATENT DOCUMENTS

WO WO-01/99362 A2 12/2001

(Continued)

OTHER PUBLICATIONS

International Search Report for corresponding PCT Application No. PCT/US2004/031863 (Apr. 12, 2005), 4 pgs.

(Continued)

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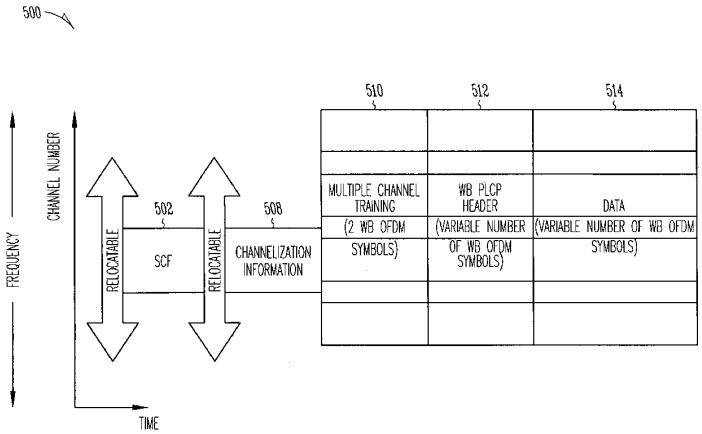
(57) **ABSTRACT**

A frame format provides for wideband wireless local area network communications and informs narrower-band communication units when the channels are occupied by wider-band communication units. In some embodiments, the frame format includes a channelization field identifying channels that are used for communicating subsequent wideband fields of a packet, and a wideband-header field communicated on the identified channels. The wideband-header field may identify sub-fields that may be present in the wideband-header field, and may identify the presence of a wideband-data field. A long-compatibility field may be present that provides protection at the MAC level. The long-compatibility field may transport MAC frames that may include medium-reservation information compatible with narrower-band communication units.

36 Claims, 6 Drawing Sheets



U.S. PATENT DOCUMENTS

2004/0202138	A1	10/2004	Song et al.	
2005/0002326	A1	1/2005	Ling et al.	
2005/0123060	A1	6/2005	Maltsev et al.	
2005/0152473	A1 *	7/2005	Maltsev et al.	375/299
2006/0274844	A1	12/2006	Walton et al.	

FOREIGN PATENT DOCUMENTS

WO	WO-03/061204	A1	7/2003
WO	WO-2005/004500	A2	1/2005
WO	WO-2005/034435	A2	4/2005
WO	WO-2005/062518	A1	7/2005

OTHER PUBLICATIONS

"802.11g[1m] IEEE Local and Metropolitan Area Networks; Part 11: Wireless LAN Medium Accesss Control (MAC) and Physical Layer (PHY) specifications; Amendment 4:Further Higher Data Rate extension in the 2.4 GHz Band", *IEEE STD 802.11G*, The Institute of Electrical and Electronics Engineers, Inc. NY,(Jun. 27, 2003), 78 pgs.

"Supplement to IEEE Standard for IT-Telecomm. & Info. Exchange Between Systems—Local and Metropolitan Area Networks—specific requirements. Part 11:Wireless LAN Medium Access Control(MAC)and Physical Layer(PHY)Specs:High-speed Physical Layer in 5GHZ Band", *IEEE Std 802.11a-1999*, (Dec. 30, 1999), 90 pgs.

Bangerter, B., et al., "High-Throughput Wireless LAN Air Interface", *Intel Technology Journal: Wireless Technologies*, 7(3), Available at http://developer.intel.com/technology/itj/index.htm,(Aug. 19, 2003), 47-57.

Khun-Jush, J., et al., "Structure and performance of the HIPERLAN/2 physical layer", *VTC 1999—Fall, IEEE VTS 50th Vehicular Technology Conference*, vol. 5, (Sep. 19-27,), 2667-2671.

Motegi, M., et al., "Optimum Modulation Assignment According to Subband Channel Status for BST-OFDM", *IEICE Transactions on Fundamentals of Electronics, Communications and Computer Sciences, Institute of Electronic Sciences, Institute of Electronics Information and Communications Eng.*, vol. E84-A (7), (Jul. 1, 2001), 1714-1722.

Zhen, L., et al., "A Modified Sub-Optimum Adaptive Bit and Power Allocation Algorithm in Wideband OFDM System", *CCECE 2003 Canadian Conf. on Electrical and Computer Engineering*. vol. 3 of 3, 2003 IEEE,(May 4, 2003), 1589-1592.

* cited by examiner

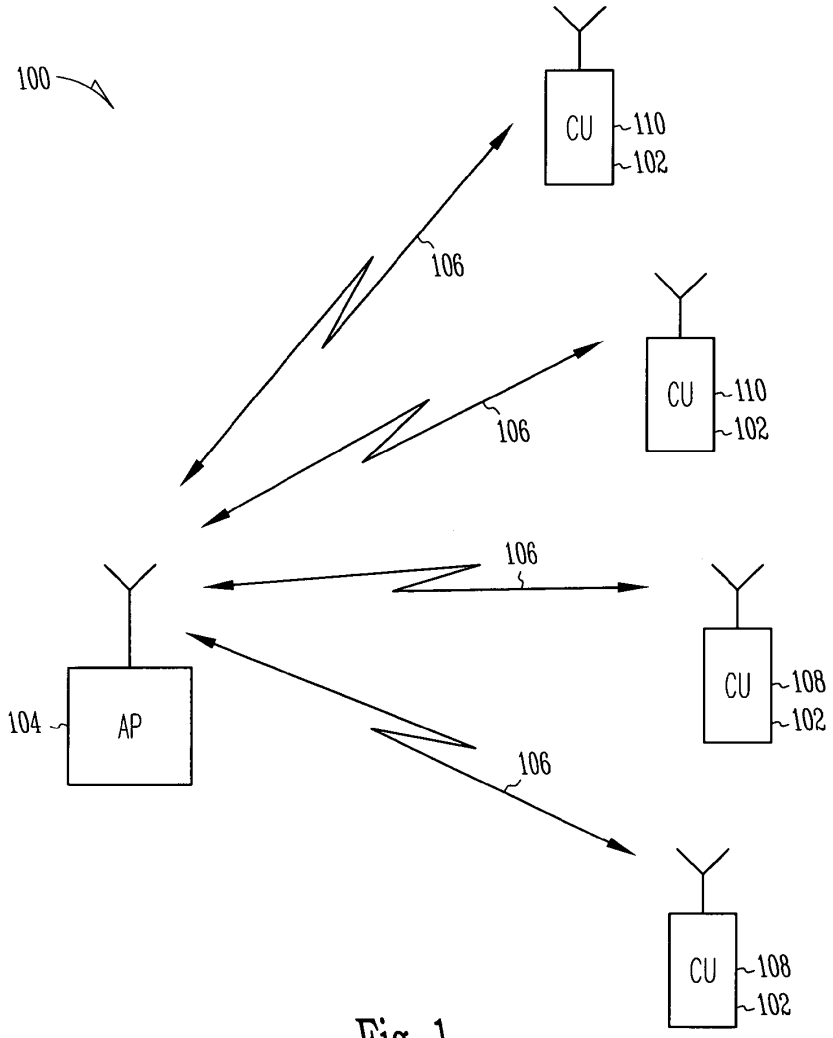

100
CU
110
102
106
CU
110
102
106
106
CU
108
102
104
AP
106
CU
108
102

Fig. 1

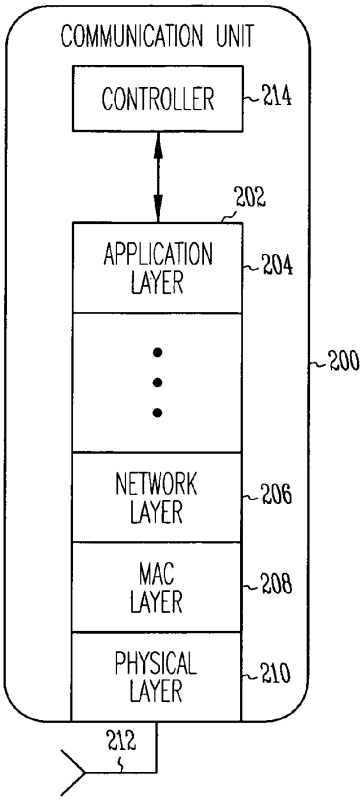

COMMUNICATION UNIT
CONTROLLER
214
202
APPLICATION LAYER
204
200
NETWORK LAYER
206
MAC LAYER
208
PHYSICAL LAYER
210
212

Fig. 2

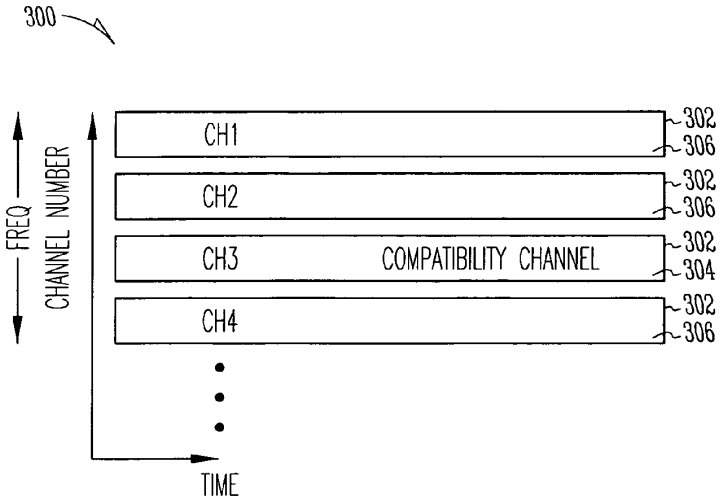

300
FREQ
CHANNEL NUMBER
CH1
CH2
CH3
COMPATIBILITY CHANNEL
CH4
302
306
304
TIME

Fig. 3

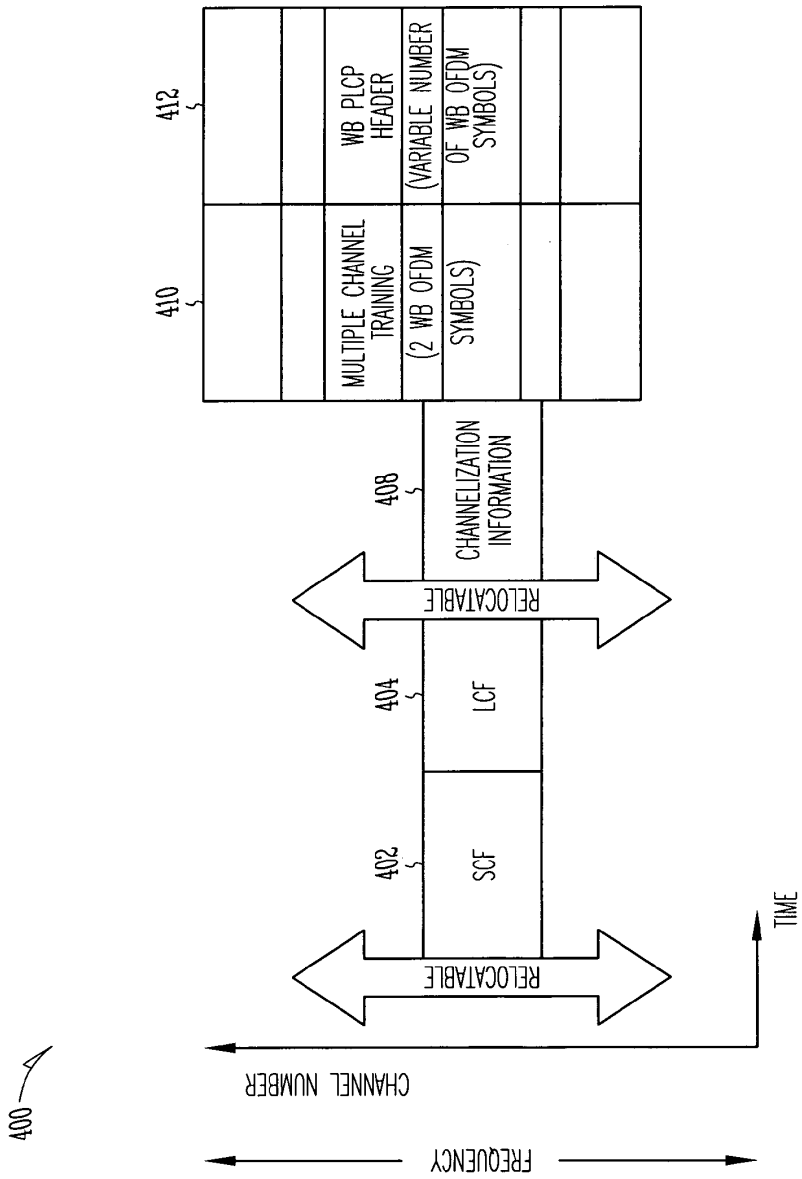

400
412
410
WB PLCP HEADER
(VARIABLE NUMBER OF WB OFDM SYMBOLS)
MULTIPLE CHANNEL TRAINING
(2 WB OFDM SYMBOLS)
408
CHANNELIZATION INFORMATION
RELOCATABLE
404
LCF
402
SCF
RELOCATABLE
TIME
CHANNEL NUMBER
FREQUENCY

Fig. 4

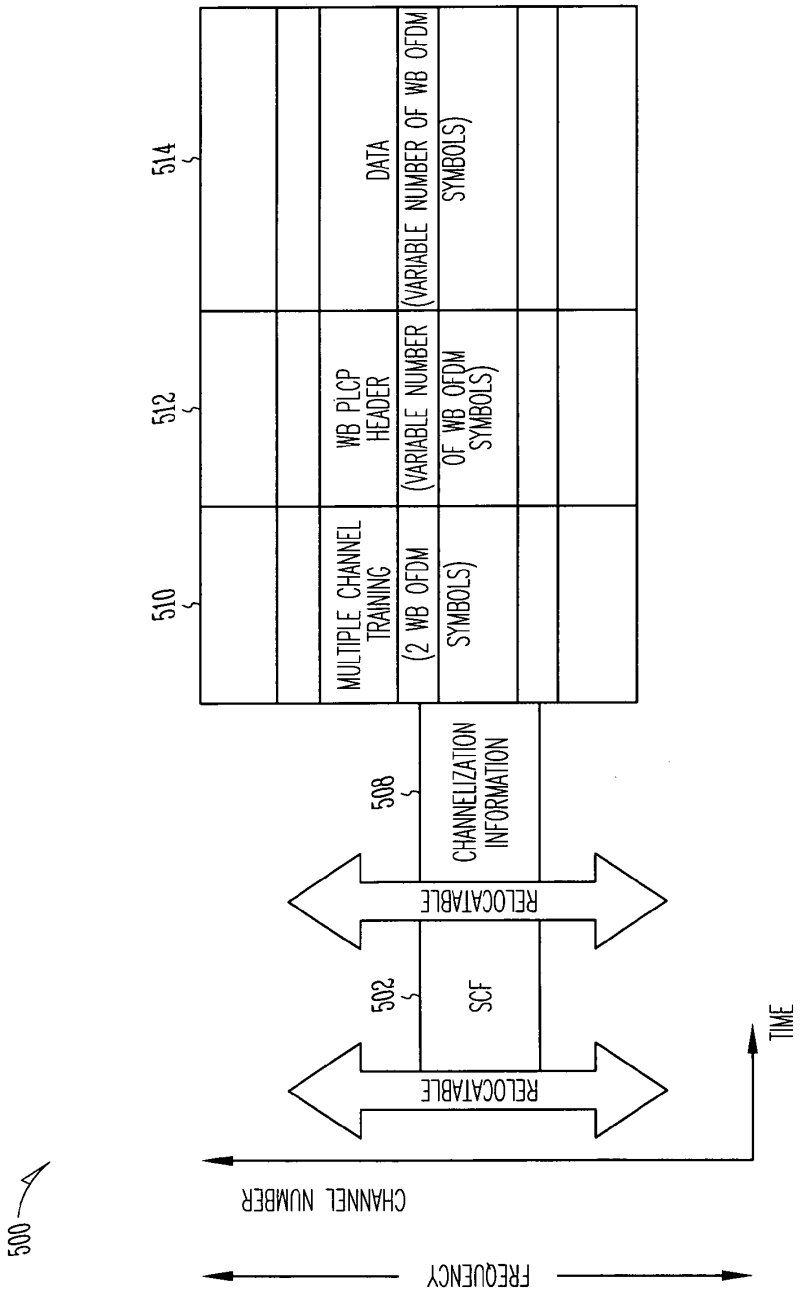

500
510
512
514
MULTIPLE CHANNEL TRAINING
(2 WB OFDM SYMBOLS)
WB PLCP HEADER
(VARIABLE NUMBER OF WB OFDM SYMBOLS)
DATA
(VARIABLE NUMBER OF WB OFDM SYMBOLS)
508
CHANNELIZATION INFORMATION
RELOCATABLE
502
SCF
RELOCATABLE
TIME
CHANNEL NUMBER
FREQUENCY

Fig. 5

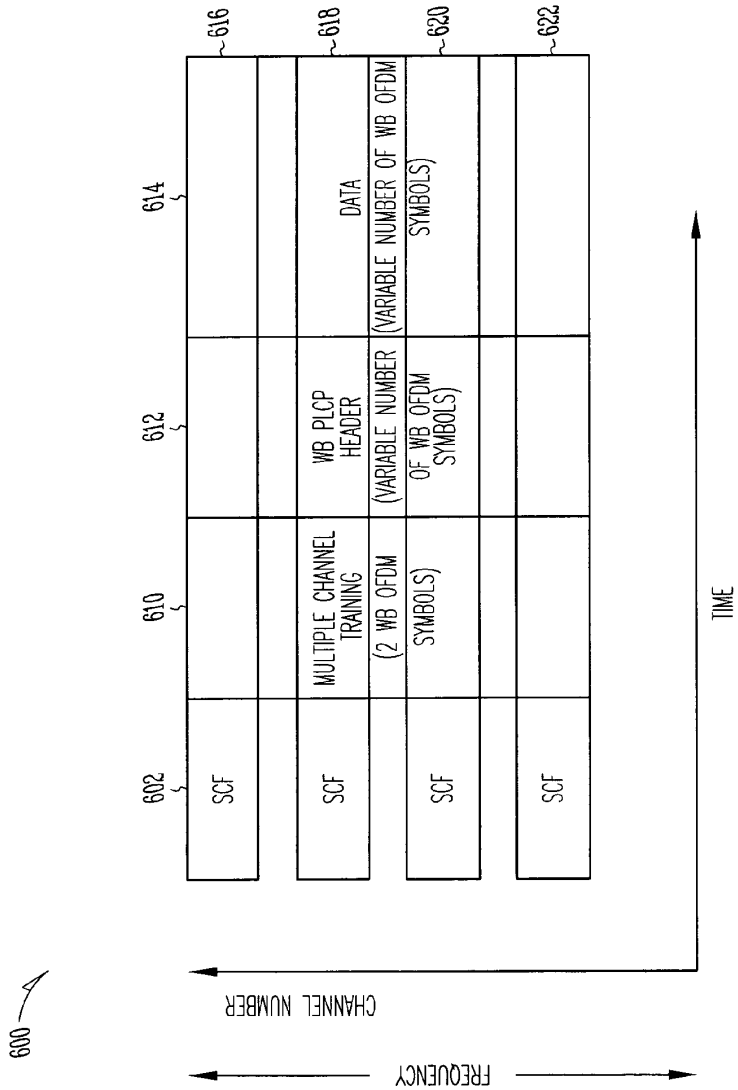

600
602
610
612
614
616
618
620
622
SCF
MULTIPLE CHANNEL TRAINING
(2 WB OFDM SYMBOLS)
WB PLCP HEADER
(VARIABLE NUMBER OF WB OFDM SYMBOLS)
DATA
(VARIABLE NUMBER OF WB OFDM SYMBOLS)
SCF
SCF
SCF
CHANNEL NUMBER
FREQUENCY
TIME

Fig. 6

700

702 BIT #	704 CORRESPONDING PARAMETER	
0	PRESENCE OF DATA FIELD	706
1	BIT LOADING PER SUBCARRIER	708
2	POWER LOADING PER SUBCARRIER	710
3	CODING RATE	712
4	LENGTH	714
5	TX POWER LEVEL	716
6	AVAILABLE TX POWER LEVEL	718
7	CHANNELIZATION REQUEST	720
8	BIT LOADING PER SUBCARRIER REQUEST	722
9	CODE RATE REQUEST	724
10	POWER LOADING PER SUBCARRIER REQUEST	726
11	POWER REQUEST	728
12	DURATION RECOMMENDATION	730
13	SERVICE	732
14	CHANNEL RESERVATION DURATION	734
15-17	RESERVED	738

PARAMETER MASK TABLE

Fig. 7

SYSTEMS AND METHODS FOR HIGH-THROUGHPUT WIDEBAND WIRELESS LOCAL AREA NETWORK COMMUNICATIONS

TECHNICAL FIELD

Embodiments of the present invention pertain to electronic systems, in particular to wireless communications, and in some embodiments, to high-throughput (HT) wideband (WB) communications with wireless local area networks (WLANs).

BACKGROUND

Orthogonal frequency division multiplexing (OFDM) is an example of a multi-carrier transmission technique that uses symbol-modulated orthogonal subcarriers to transmit information within an available spectrum. Many modern digital communication systems, including wireless local area networks (WLANS), are using symbol-modulated orthogonal subcarriers as a modulation scheme to help signals survive in environments having multipath reflections and/or strong interference. One problem with many conventional systems that use symbol-modulated subcarriers is that channel bandwidth is limited by the frame structure employed.

BRIEF DESCRIPTION OF THE DRAWINGS

The appended claims are directed to some of the various embodiments of the present invention. However, the detailed description presents a more complete understanding of embodiments of the present invention when considered in connection with the figures, wherein like reference numbers refer to similar items throughout the figures and:

FIG. **1** illustrates an operational environment in which some embodiments of the present invention may be practiced;

FIG. **2** is a block diagram of a communication unit in accordance with some embodiments of the present invention;

FIG. **3** illustrates frequency-spectrum allocation in accordance with some embodiments of the present invention;

FIG. **4** illustrates a structure of a long-compatibility frame in accordance with some embodiments of the present invention;

FIG. **5** illustrates a structure of a short-compatibility frame in accordance with some embodiments of the present invention;

FIG. **6** illustrates a structure of a multiple-channel frame in accordance with some embodiments of the present invention; and

FIG. **7** is a parameterization-mask table in accordance with some embodiments of the present invention.

DETAILED DESCRIPTION

The following description and the drawings illustrate specific embodiments of the invention sufficiently to enable those skilled in the art to practice them. Other embodiments may incorporate structural, logical, electrical, process, and other changes. Examples merely typify possible variations. Individual components and functions are optional unless explicitly required, and the sequence of operations may vary. Portions and features of some embodiments may be included in or substituted for those of others. The scope of embodiments of the invention encompasses the full ambit of the claims and all available equivalents of those claims.

FIG. **1** illustrates an operational environment in which some embodiments of the present invention may be practiced. Communication environment **100** may include one or more communication units (CUs) **102**, which may communicate with one or more access points (AP) **104** over wireless communication links **106**. CUs **102** may include, for example, mobile units such as personal digital assistants (PDAs), laptop and portable computers with wireless communication capability, web tablets, wireless telephones, wireless headsets, pagers, instant messaging devices, MP3 players, digital cameras, and other devices that may receive and/or transmit information wirelessly. In some embodiments, CUs **102** may also include access points (APs), although the scope of the invention is not limited in this respect.

In some embodiments, CUs **102** and AP **104** may communicate in accordance with one or more communication standards, such as one of the Institute of Electrical and Electronics Engineers (I.E.E.E.) 802.11 standards, although the scope of the invention is not limited in this respect. In these embodiments, CUs **102** may communicate among each other and/or with one or more of APs **104** using a multi-carrier transmission technique, such as an orthogonal frequency division multiplexing (OFDM) technique that uses orthogonal subcarriers to transmit information within an assigned spectrum. Other wireless local area network (WLAN) and wireless wide area network (WAN) communication techniques may also be suitable for communications between CUs **102** and AP **104**.

In addition to facilitating communications between CUs **102**, in some embodiments, APs **104** may be coupled with one or more networks, such as an intranet or the Internet, allowing CUs **102** to access such networks. Although FIG. **1** illustrates point-to-point communications (e.g., where an AP synchronizes with a network), embodiments of the present invention may also be suitable to point-to-multipoint communications, including peer-to-peer communications in which CUs may share the responsibility for synchronizing with a network.

Some embodiments of the present invention are applicable to communications between CUs **102** and APs **104** over links **106** in accordance with an infrastructure basic service set (IBSS) mode. Some embodiments of the present invention, however, are equally applicable to direct communications over links **106** between CUs **102** in an ad-hoc mode. In ad-hoc modes, CUs **102** may use channels of an IBSS. The IBSS channels may be a subset of the channels that are valid for a particular geographic region, although the scope of the invention is not limited in this respect.

In order to associate with a network through AP **104**, a CU may scan channels to determine which channels are active and to determine network identifiers (e.g., SSIDs) associated with the active channels. This scanning is generally performed each time a communication unit wishes to associate with (e.g., become part of or join) a wireless network, and each time the communication unit wishes to re-associate with a network. CUs **102** and AP **104** may be referred to herein as a transmitting unit, a receiving unit, or both. The terms "transmitting" and "receiving" are applied to communication units **102** and AP **104** for ease in understanding the embodiments of the present invention. It shall be understood that CUs and APs may include both transmitting and receiving capability to establish duplex communications therebetween.

In accordance with embodiments, links **106** may be bi-directional communication links comprising one or more channels. Each channel may be allocated a predetermined portion of spectrum, and in some embodiments, each channel may comprise approximately a 20 MHz portion of the spectrum. APs **104** that operate nearby other APs may be assigned non-interfering portions of spectrum. APs **104** and CUs **102** may use a frame structure for communicating therebetween, which may be time-division multiplexed to allow communications between many APs **104** and CUs **102** over one or more of the communication channels. In accordance with some embodiments, a channel may comprise a plurality of substantially orthogonal subcarriers that may be modulated with a data stream, such as with an OFDM channel.

In accordance with some embodiments, APs **104** and CUs **102** may use an observed or measured frequency selectivity and/or interference of a channel to select subcarrier modulation assignments for each subcarrier or groups of subcarriers. This may be referred to as adaptive bit loading (ABL). The subcarrier-modulation assignment decisions may affect the overall achieved data rate depending on the modulation orders selected. In accordance with some embodiments, APs **104** and CUs **102** may also select a transmit power level for the individual subcarriers, for groups of subcarriers, or for all the subcarriers of a channel. When combined with ABL, this may be referred to as adaptive bit and power loading (ABPL).

CUs **102** may comprise both wider-band CUs **108** and narrower-band CUs **110**. Narrower-band CUs **110** may communicate on a single channel while wider-band CUs **108** may communicate on one or more of the channels to provide wider-bandwidth communications. Wider-band CUs **108** may be referred to as high-throughput (HT) CUs, and in some embodiments, wider-band CUs **108** may communicate in accordance with an IEEE 802.11 standard for HT WLAN communications. Narrower-band CUs **110** may communicate in accordance with the IEEE 802.11(a/g) standard for WLAN communications, although the scope of the invention is not limited in this respect. The terms narrower-band and wider-band refer to a relative communication bandwidth that may be utilized by the communication units. For example, in some embodiments, narrower-band CUs **110** may communicate on narrower-band channels (e.g., a 20 MHz channel), while wider-band CUs **108** may communicate on wider-band channels (e.g., channels of up to 80 MHz or greater). In these embodiments, the wider-band channels may comprise one or more of the narrower-band channels. AP **104** may include capability for communicating with both wider-band CUs **108** and narrower-band CUs **110**.

To facility the sharing of channels among narrower-band CUs **110** and wider-band CUs **108**, communication packets may have a predetermined frame structure to provide for this flexible channel-width capability. Examples of suitable frame structures are described in more detail below.

FIG. **2** is a block diagram of a communication unit in accordance with some embodiments of the present invention. Communication unit **200** may be suitable for use as one or more of CUs **108** (FIG. **1**) and/or a HT AP such as AP **104** (FIG. **1**), although other devices may also be suitable. Among other things, CU **200** may comprise protocol stack **202**, which may include one or more layers, such as application layer **204**, network layer **206**, medium-access-control (MAC) layer **208**, and physical layer (PHY) **210**. Physical layer **210** may couple with antenna **212**. CU **200** may also comprise controller **214** to coordinate the activity of the various elements of CU **200** and protocol stack **202**. Antenna **212** may comprise a directional or omnidirectional antenna, including, for example, a dipole antenna, a monopole antenna, a loop antenna, a microstrip antenna or other type of antenna suitable for reception and/or transmission of RF signals which may be communicated by CU **200**.

Although CU **200** is illustrated as having several separate functional elements, one or more of the functional elements may be combined and may be implemented by combinations of software-configured elements, such as processing elements including digital signal processors (DSPs), and/or other hardware elements. For example, processing elements may comprise one or more microprocessors, DSPs, application specific integrated circuits (ASICs), and combinations of various hardware and logic circuitry for performing at least the functions described herein.

Physical layer **210** may generate a physical-layer packet format used to transport transmitted physical layer service data units (SDUs) to peers under the control of MAC layer **208**. MAC layer **208** may control access to the medium and may select operating modes of physical layer **210**. MAC layer **208** may be responsible for determining operating channels to select, and determining operating modes may be used within a wireless network. MAC layer **208** may also buffer network data to be transmitted, and in some embodiments, may choose modes of operation of physical layer **210** based on quality of service (QoS) requirements of specific streams of network data. MAC layer **208** may also scan or have other means of detecting the presence of narrower-band CUs **110** (FIG. **1**), which it may use to select operating channels as well as the type of physical layer packet format to be used.

FIG. **3** illustrates frequency-spectrum allocation in accordance with some embodiments of the present invention. Frequency spectrum **300** may be used for communications among CUs **102** (FIG. **1**), and for communications between CUs **102** (FIG. **1**) and AP **104** (FIG. **1**). Frequency spectrum **300** may comprise a plurality of channels **302**. In accordance with some embodiments, narrower-band CUs, such as CUs **110** (FIG. **1**) may communicate using a single channel, such as one of channels **302**, while wider-band CUs **108** may use one or more of channels **302** simultaneously. Although frequency spectrum **300** is illustrated as having four channels **302** (labeled as channels one through four), the scope of the invention is not limited in this respect. Embodiments of the present invention are equally suitable for use of more than four channels within an allocated portion of frequency spectrum **300**. In some embodiments, the channels may be 20 MHz channels and frequency spectrum **300** may comprise at least a contiguous 80 MHz portion of the spectrum, although non-contiguous portions of spectrum are also suitable. In some embodiments, frequency spectrum **300** may be utilized by an AP for communicating with CUs including both narrower-band CUs and wider-band CUs.

In some embodiments, one channel, such as channel **304** may be designated a compatibility channel, and the other channels, such as channels **306**, may be used for HT communications. In some embodiments, compatibility channel **304** may be used for communications for narrower-band CUs and may be used for association with an AP. In some embodiments, each AP may be assigned a particular compatibility channel **304** so as not to interfere with nearby APs. Compatibility channel **304** may also be used for carrier-sense multiple-access with collision avoidance (CSMA/CA).

Channels **306** may be suitable for HT communications depending on each individual channel's busy/idle state or channel quality. The decision about current channel state

may be dynamically made by a wider-band CU based on current measurements, information obtained from received packets and statistical information.

An AP with capability for communicating with wider-band CUs may be referred to as a HT AP and may be assigned a compatibility channel different from its neighbors. In some embodiments, the frequency spectrum may comprise at least a portion of an unlicensed national information infrastructure (U-NII) band, although the scope of the invention is not limited in this respect. In some embodiments, a nearest neighboring AP may be decoupled by compatibility channels in different U-NII 80 MHz bands or by more detailed spectrum division. For example, the spectrum may be divided into sets of six 40 MHz channels.

In other embodiments, a HT AP may select channels **302** so that compatibility channel **304** and other channels **306** match those of surrounding HT APs. Performing channel access on compatibility channel **302** is used by HT CUs to "reserve" those channels at the same time as the compatibility channel. Having two different compatibility channels may provide two independent reservation mechanisms for the same resource. To help prevent collisions on the other channels, the compatibility channel provides for the reservation for the other channels. Therefore, overlapping HT AP may use matching compatibility channels.

FIG. **4** illustrates a structure of a long-compatibility frame in accordance with some embodiments of the present invention. Long-compatibility frame format **400** is an example of an HT OFDM frame and may be used for communications between wider-band CUs **108** (FIG. **1**) and AP **104** (FIG. **1**), although other frame formats may also be suitable. Frame format **400** may include short-compatibility field **402**, long-compatibility field **404**, channelization field **408**, multiple-channel training field **410**, and wideband-header field **412**. In some embodiments, short-compatibility field **402**, long-compatibility field **404**, and channelization field **408** may be sent on a compatibility channel, such as compatibility channel **304** (FIG. **3**), which may be relocatable to any of the narrower-band channels. Multiple-channel training field **410** and wideband-header field **412** may be sent on one or more channels, such as channels **306** (FIG. **3**) including compatibility channel **304** (FIG. **3**).

Short-compatibility field **402** may include a preamble and a signal field. The preamble may be a physical layer convergence protocol (PLCP) preamble, and in some embodiments, short-compatibility field **402** may comprise a standard 802.11(a/g) preamble followed by a standard 802.11 (a/g) signal field, although the scope of the invention is not limited in this respect. Short-compatibility field **402** may be present in wideband (WB) OFDM frames regardless of their MAC type. Short-compatibility field **402** may provide physical layer protection for the transmitted WB OFDM frame from unwanted interferences from narrower-band CUs by reserving a channel (i.e., one of channels **302** (FIG. **3**)) at the PHY layer. For example, length and rate information in the signal field be used to determine the time for the WB OFDM data interchange.

Depending on a frame type and interfering environment, short-compatibility field **402** may be transmitted over compatibility channel **304** (FIG. **3**), or alternatively, short-compatibility field **402** may be multiplied in frequency domain and transmitted over several or all channels **302** (FIG. **3**). The length and rate parameters of the signal field may be depend on the presence of long-compatibility field **404** in frame format **400**. When long-compatibility field **404** is present in the frame, the length and rate parameters of short-compatibility field **402** may describe the length in octets and bit rate of long-compatibility field **404**. When long-compatibility field **404** is not present in the frame, these parameters may be chosen to describe a virtual frame with duration corresponding to the duration of an entire HT data interchange, such as a series of control signals and/or data including, for example, request-to-send (RTS), clear-to-send (CTS), data, and acknowledgement (ACK) signals.

Long-compatibility field **404** may include a service sub-field and a physical-service data unit (PSDU) sub-field, and may be transmitted over the compatibility channel. In some embodiments, long-compatibility field **404** may be a standard 802.11(a/g) data field. Tail bits and pad bits may be added to long-compatibility field **404**. Long-compatibility frame format **400** may be used for frames of MAC type 'control'. Long-compatibility field **404** may carry an appropriate management protocol data unit (MPDU). Long-compatibility field **404** may also be used for frames of MAC type 'data' or for MAC management frames.

In accordance with some embodiments of the present invention, long-compatibility field **404** provides MAC layer protection of a transmitted WB OFDM frame from unwanted interferences from narrower-band CUs by reserving the medium (e.g., reserving time on one or more channels) using a MAC protocol, such as setting the narrower-band CUs network allocation vector (NAV) to cover the duration of the wider-band data interchange. When long-compatibility field **404** is present in a packet, length and rate values in the signal field of short-compatibility field **402** may be set to describe a modulation type and a data length actually used while transmitting long-compatibility field **404**.

In some embodiments, to reduce MAC changes, either long-compatibility field **404** or a wideband-data field may be used in a single frame. When long-compatibility field **404** is used, the MPDU may reside in it. When a wideband-data field is used, the MPDU(s) may reside in the wideband-data field, which is described in more detail below.

Channelization field **408** may include information about the frequency channelization structure of the subsequently transmitted wideband portions of a physical protocol data unit (PPDU) (e.g., packet **400**). When short-compatibility field **402** is initially transmitted over more than one channel to indicate busy (e.g., used) channels, channelization field **408** may be omitted because the channelization may be implicit by which channel short-compatibility field **402** is received on.

To determine whether channelization field **408**, wideband-training field **410** and wideband-header field **412** are incorporated into a packet, a wider-band CU may attempt to receive channelization field **408** and may then attempt to detect the wideband-training field **410** with the appropriate channelization. If the detection of wideband-training field **410** is successful, the wider-band CU may then receive wideband-header field **412**. Otherwise the CU may terminate the receiving.

Wideband-training field **410** may comprise multiple-channel training fields, and may be used for timing and fine-frequency-offset estimation, and channel estimation. These multiple-channel training fields may also be used for dynamic equalization and channel transfer-function variation rate-measurement purposes. In some embodiments, wideband-training field **410** may comprise a standard 802.11 (a/g) long training sequence multiplied in frequency domain and transmitted over one or more of the channels.

In some embodiments, the phases of long training sequence may be rotated among the channels to reduce peak-to-average power ratio. In some embodiments, mid-fix

training preambles may be incorporated into a wideband packet and positioned within the packet, and post-fix training preambles may be incorporated into the packet and positioned at the end of the packet.

Wideband-header field **412** may be a PLCP-header field and may contain parameters for demodulation and decoding the packet including parameters for adaptive modulation and coding techniques. Wideband-header field **412** may follow wideband-training field **410**. Wideband-header field **412** may be transmitted with the channelization indicated in channelization field **408**. When short-compatibility field **402** is transmitted over more than one channel, the channelization of wideband-header field **412** may be indicated by the frequency configuration of short-compatibility field **402**. Wideband-header field **412** may be encoded and modulated using uniform robust modulation and encoding schemes, such as BPSK or QPSK modulation and a convolutional code with a rate of ½. The size of wideband-header field **412** may be variable. Examples of particular parameters included into wideband-header field **412** are described below in more detail below. In some embodiments, wideband-header field **412** may include a parameter mask to indicate the presence of particular fields in wideband-header field **412**.

In some embodiments, frame format **400** may be viewed as a PLCP frame of long compatibility format, which may be used for transmission of frames of MAC type control signals such as RTS, CTS, ACK, as well as other control signals. For frames of format **400**, the MPDU may reside in long-compatibility field **404**, which may be a standard 802.11(a/g) data field.

Frames of format **400** may provide detection properties (e.g., maximum detection and PSDU decoding ranges) at least by narrower-band CUs. Frames of format **400** may also support NAV operation for narrower-band CUs and wider-band CUs (e.g., for all units in a given BSS). Frames of format **400** may also allow for the measurement of wide-band-channel transfer functions using the wideband-training fields. Frames of format **400** may also allow for parallel measurement of the noise environment in a wideband channel at the receiver side during the transmission of short-compatibility field **402** and/or long-compatibility field **404**. Frames of format **400** may also be used by a MAC layer of a CU to adapt dynamically to channel conditions by measuring the state of a channel and providing feedback on channel state. For example, a RTS/CTS exchange may be used with control frames in the wideband channel with channelization information. This may be done for almost any number of channels **302** (FIG. **3**) in addition to compatibility channel **304** (FIG. **3**).

Narrower-band CUs, such as CUs **110** (FIG. **1**), may also use a conventional frame format, such as a standard 802.11 (a/g) PLCP frame format, for transmission of frames of MAC type management information (e.g., beacon frames and others). This conventional frame format may include a PLCP preamble field and a signal field, which may be followed by a data field. In the case of a standard 802.11(a/g) PLCP frame, the preamble field may comprise twelve OFDM symbols, the signal field may comprise one OFDM symbol, and the data field may comprise a variable number of OFDM symbols. In accordance with embodiments of the present invention, a data unit, such as a PPDU, in a conventional frame format may be transmitted over compatibility channel **304** (FIG. **3**).

FIG. **5** illustrates a structure of a short-compatibility frame in accordance with some embodiments of the present invention. Short-compatibility frame format **500** is an example of a HT OFDM frame and may be used for communications between wider-band CUs **108** (FIG. **1**) and AP **104** (FIG. **1**), although other frame formats may also be suitable. Frame format **500** may include short-compatibility field **502**, channelization field **508**, multiple-channel training field **510**, wideband-header field **512** and wideband-data field **514**. In some embodiments, short-compatibility field **502**, and channelization field **508** may be sent on a compatibility channel, such as compatibility channel **304** (FIG. **3**), which may be relocatable to any of the narrower-band channels. Multiple-channel training field **510**, wideband-header field **512** and wideband-data field **514** may be sent on one or more channels, such as channels **306** (FIG. **3**) including the compatibility channel.

In some embodiments, short-compatibility field **502** may correspond to short-compatibility field **402** (FIG. **4**), channelization field **508** may correspond to channelization field **408** (FIG. **4**), multiple-channel training field **510** may correspond to multiple-channel training field **410** (FIG. **4**), and wideband-header field **512** may correspond to wideband-header field **412** (FIG. **4**).

Wideband-data field **514** may be used to carry meaningful data, such as one or more physical service data unit (PSDUs). Format **500** may be viewed as a PPDU of short compatibility format in which an MPDU may reside in wideband-data field **514**. Frames of format **500** may be used to transmit data-carrying MPDUs in an environment that includes narrower-band CUs and wider-band CUs. Frames of format **500** may allow high-speed data transmission for a dynamically changed channelization, which may be determined for a given moment from a prior training phase, such as an RTS/CTS signal exchange, which may be carried in frames of long-compatibility format **400** (FIG. **4**). Frames of format **500** may also provide for the detection and standard signal field decoding range properties of frames by both narrower-band CUs and wider-band CUs. Frames of format **500** may also allow for ABPL functionality. The use of short-compatibility field **502** transmitted in compatibility channel **304** (FIG. **3**) may help protect the frame from interferences from narrower-band CUs associated with a particular AP.

In some embodiments, a HT receiver may determine that the frame format comprises short-compatibility format **500** by using signaling within short-compatibility field **502**. For example, a subfield with no meaning for narrower-band CUs may be used in short-compatibility field **502**. Alternatively, a reserved value for a subfield used by narrower-band CUs may be used to indicate frame format **500**.

FIG. **6** illustrates a structure of a multiple-channel frame in accordance with some embodiments of the present invention. Multiple-channel frame format **600** is an example of a HT OFDM frame and may be used for communications between wider-band CUs **108** (FIG. **1**) and a HT AP such as AP **104** (FIG. **1**), although other frame formats may also be suitable. Multiple-channel frame format **600** may include short-compatibility field **602**, multiple-channel training field **610**, wideband-header field **612** and wideband-data field **614**. In some embodiments, short-compatibility field **602** may be multiplied in frequency and transmitted on one or more channels, such as channels **616**, **618**, **620** and **622**. Multiple-channel training field **610**, wideband-header field **612** and wideband-data field **614** may be different for the different channels, such as channels **616**, **618**, **620** and **622** for communicating with different wider-band CUs. In other words, wideband fields, such as wideband-header field **612** and wideband-data field **614**, are spread across the used channels with different content on each channel. In some embodiments, a transmitting wider-band CU may use dif-

ferent channels depending on the receiving wider-band CU or the dynamics of the channel condition.

Frames of format **600** may be used in an environment that includes a combination of wider-band CUs and narrower-band CUs. Frames of format **600** may also be used when a HT AP overlaps (e.g., shares channels with) an AP that may communicate only with narrower-band CUs. Frames of format **600** allow narrower-band CUs, used in narrowband channels, to be provided with frame duration information at the physical layer through the signal field of short-compatibility field **602**. Frames of format **600** may also reduce overhead due to the absence of a long-compatibility field and a channelization field, such as in the case of formats **400** and **500**. Frames of format **600** may also provide an ability for CUs to distinguish frames of format **600** from conventional frames (e.g., standard 802.11(a/g) frames) at the very beginning of the frame during the energy detection phase. In embodiments, the receiver of an wider-band CU or HT AP may determine that the frame format comprises multiple-channel frame format **600** using a combination of energy detection in multiple narrow-band channels (e.g., individual channels **616**, **618**, **620** and **622**) and signaling within short compatibility field **602**. For example, a subfield within short compatibility field **602** may be used which may have no meaning for narrower-band CUs. Alternatively, a reserved value for a subfield used by narrower-band CUs may be used to indicate frame format **600**.

FIG. **7** is a parameterization-mask table in accordance with some embodiments of the present invention. Parameterization-mask table **700** illustrates parameter mask **702** comprising bits with corresponding parameters in column **704**. Parameter mask **702** is an example of a parameter mask that may be used in wideband-header field **412** (FIG. **4**) and/or wideband-header field **512** (FIG. **5**). The bits of parameter mask **702** may indicate the presence of particular fields in a wideband-header field and the presence of a wideband-data field, such as wideband-data field **514** (FIG. **5**). Other ways of indicating the presence of particular information in a wideband-header field and the presence of a wideband-data field are within the scope of the present invention.

In accordance with some embodiments, a "**1**" in parameter mask **702** may indicate that a corresponding field is present in a wideband-header field. However, a one bit (e.g., bit #**0**) in field **706** may indicate the presence of a wideband-data field, such as wideband-data field **514** (FIG. **5**), in the packet or PPDU. In alternative embodiments, "0s" may be used instead of "1s" provided that the CUs are aware of this. Furthermore, the precise values, order or size of the fields in parameter mask **702** is not critical.

In the case when there are no parameters to include into a wideband-header field, the wideband-header field may include a parameter mask field with all zero bits followed by a CRC field, tail bits and pad bits to occupy one wideband OFDM symbol. The parameter mask does not necessarily need to describe the presence of CRC field, tail bits and pad bits.

In accordance with some embodiments, a bit (e.g., bit #**1**) of parameter mask **702** may indicate the presence of field **708** which describes the bit loading per subcarrier. This parameter may describe the modulation type per subcarrier used to transmit the packet. The per-subcarrier modulations may be described for the narrowband channels as well as for the wideband channels.

In accordance with some embodiments, a bit (e.g., bit #**2**) may indicate the presence of field **710** which describes a power loading per subcarrier. This parameter may describe the power level per subcarrier applied during transmission of the packet through all the used channels.

In accordance with some embodiments, a bit (e.g., bit #**3**) may indicate the presence of field **712** which describes a coding rate. This parameter may indicate the coding rate(s) used in the packet.

In accordance with some embodiments, a bit (e.g., bit #**4**) may indicate the presence of field **714** which describes a length field which may indicate the number of octets in the PSDU that the MAC is currently requesting the physical layer to transmit.

In accordance with some embodiments, a bit (e.g., bit #**5**) may indicate the presence of field **716** which describes a transmit power level. The transmit power level parameter may indicate the power level at which the packet is transmitted.

In accordance with some embodiments, a bit (e.g., bit #**6**) may indicate the presence of field **718** which describes an available transmit power level. This parameter may indicate the maximum power level that the packet may be transmitted.

In accordance with some embodiments, a bit (e.g., bit #**7**) may indicate the presence of field **720** which indicates a channelization request. This parameter may contain a bit mask requesting narrowband channels to be used for transmission of a response packet. For example, each "1" in this mask may allow the corresponding channel to be used for response transmission.

In accordance with some embodiments, a bit (e.g., bit #**8**) may indicate the presence of field **722** which describes a bit-loading-per-subcarrier request. This parameter may request the modulation type per subcarrier to be applied during transmission of a response packet through the channels that are requested to be used by the channelization request parameter.

In accordance with some embodiments, a bit (e.g., bit #**9**) may indicate the presence of field **724** which describes a coding-rate request. This parameter may request coding rate(s) to be used in a response packet.

In accordance with some embodiments, a bit (e.g., bit #**10**) may indicate the presence of field **726** which describes a power-loading-per-subcarrier request. This parameter may request the modulation type per subcarrier to be applied during transmission of a response packet through the channels that are requested to be used by a channelization request parameter.

In accordance with some embodiments, a bit (e.g., bit #**11**) may indicate the presence of field **728** which describes a power request. This parameter may request an overall power level to be applied during a response transmission.

In accordance with some embodiments, a bit (e.g., bit #**12**) may indicate the presence of field **730** which requests a duration recommendation. This parameter may request the duration of the response packet. When granted, the fragmentation of the response packet should not exceed the value specified by this parameter.

In accordance with some embodiments, a bit (e.g., bit #**13**) may indicate the presence of field **732** which describes the presence of a service field which may be immediately before the PSDU payload. This field, for example, may be used to provide scrambler initialization. This field may be present when a self-synchronizing scrambler is used to reduce the impact of substantially non-white (i.e. many zeroes or ones) patterns in the PSDU data.

In accordance with some embodiments, a bit (e.g., bit #**14**) may indicate the presence of field **734** which describes channel reservation duration. The channel reservation dura-

tion parameter may have MAC layer NAV functionality by indicating the time which the channel is reserved for. The value of this field may be determined by the MAC layer based on frame type, channel quality and/or the amount of information to transmit.

In accordance with some embodiments, some bits of field **738** of parameter mask **702** (e.g., bits **15** through **17**) may be reserved. In some embodiments, wideband-header field **412** (FIG. **4**) and/or wideband-header field **512** (FIG. **5**) may also include a cyclic-redundancy check (CRC) which may be calculated over the preceding fields starting at the parameter mask. Wideband-header fields **412** (FIG. **4**) and **512** (FIG. **5**) may also have a PLCP header tail, which may be needed to drive the encoder into a zero state for proper decoding. Wideband-header fields **412** (FIG. **4**) and **512** (FIG. **5**) may also have pad bits, which may be needed to fill the last OFDM symbol of the wideband-header field.

The frame formats of embodiments of the present invention may be suitable for WB OFDM data communication systems and may be implemented in IEEE 802.11 standards for HT communication units. The frame formats may be suitable for duplex time division multiplexing (TDM) communication between two communication units, when, for example, they are acting over non-stationary frequency-selective channel and use ABPL techniques. In some embodiments, the frame formats allow for channel state information (CSI) feedback from the receiver side to the transmitter side to allow for more optimal bit and power loading techniques previously discussed.

The frame formats of some embodiments of the present invention may also allow a WB OFDM system to share a geographic area and a frequency band with existing systems, such as 802.11(a/g) systems with narrower-band CUs. The frame formats of some embodiments may allow flexible physical-layer carrier-sense information for conventional 802.11(a/g) systems working in the same band. The frame formats of some embodiments of the present invention may also allow flexible MAC layer carrier sense information for these conventional systems. The frame formats of some embodiments of the present invention may also provide for multiple channel-width support for HT systems, while providing increased and reliability by applying adaptive modulation and coding techniques. The frame formats of some embodiments of the present invention may also allow estimating the channel variation and applying channel prediction techniques and adaptive fragmentation capability for WB OFDM systems. The frame formats of some embodiments of the present invention may also allow precision channel estimation for more effective performance of ABPL algorithms and better use of available channel capacity. The frame formats of some embodiments of the present invention may also allow for the detecting the frequency configuration of an incoming packet on the fly. The frame formats of some embodiments may also provide additional confidentiality for point-to-point data transmission.

Unless specifically stated otherwise, terms such as processing, computing, calculating, determining, displaying, or the like, may refer to an action and/or process of one or more processing or computing systems or similar devices that may manipulate and transform data represented as physical (e.g., electronic) quantities within a processing system's registers and memory into other data similarly represented as physical quantities within the processing system's registers or memories, or other such information storage, transmission or display devices.

Embodiments of the invention may b implemented in one or a combination of hardware, firmware and software. Embodiments of the invention may also be implemented as instructions stored on a machine-readable medium, which may be read and executed by at least one processor to perform the operations described herein. A machine-readable medium may include any mechanism for storing or transmitting information in a form readable by a machine (e.g., a computer). For example, a machine-readable medium may include read-only memory (ROM), random-access memory (RAM), magnetic disk storage media, optical storage media and flash-memory devices.

It is emphasized that 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.

In the foregoing detailed description, various features are occasionally grouped together in a single embodiment for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed embodiments of the subject matter require more features that are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed embodiment. Thus the following claims are hereby incorporated into the detailed description, with each claim standing on its own as a separate preferred embodiment.

What is claimed is:

1. A method for wirelessly communicating a packet over a wideband communication channel comprising a plurality of orthogonal frequency division multiplexed (OFDM) channels, the method comprising communicating:

a channelization field on a single OFDM channel identifying which of the OFDM channels that are used for communicating subsequent wideband fields of the packet; and

a wideband-header field on each of the identified OFDM channels to identify sub-fields present in the wideband-header field and the presence of a wideband-data field following the wideband-header field,

wherein the OFDM channels that comprise the wideband channel are separated in frequency from each other.

2. The method of claim **1** wherein the communicating comprises:

communicating the channelization field on a single compatibility channel of an allocated portion of spectrum comprising a plurality of channels; and

communicating the wideband-header field on the identified channels including the single compatibility channel,

wherein the single compatibility channel comprises a single OFDM channel.

3. The method of claim **1** wherein the communicating comprises communicating a wideband-training field as part of the packet following the channelization field, the wideband-training field comprising a training sequence on the channels identified by the channelization field.

4. The method of claim **3** wherein when the wideband-header field includes an indication of a presence of the wideband-data field, the communicating further comprises communicating the wideband-data field as part of the packet on the channels identified by the channelization field.

5. A method for communicating a packet comprising communicating:

a channelization field identifying channels that are used for communicating subsequent wideband fields of the packet; and

a wideband-header field on the identified channels to identify sub-fields present in the wideband-header field and the presence of a wideband-data field following the wideband-header field,

wherein the communicating comprises communicating a wideband-training field as part of the packet following the channelization field, the wideband-training field comprising a training sequence on the channels identified by the channelization field, and

wherein the method further comprises estimating at least one of a timing offset, fine-frequency offset, and channel response using at least the training sequence for processing subsequent wideband fields of the packet including the wideband-header field and the wideband-data field when included within the packet.

6. The method of claim **2** wherein the communicating comprises one of either sending the packet by a transmitting communication unit or receiving the packet by a receiving communication unit, and

wherein the identified channels, including the compatibility channel, comprise symbol-modulated subcarriers.

7. The method of claim **1** wherein the wideband-header field is encoded with a predetermined encoding scheme and modulated with a predetermined modulation scheme, wherein the predetermined modulation scheme comprises one of either BPSK or QPSK modulation, and wherein the predetermined encoding scheme comprises a ½ rate convolution code.

8. A method for communicating a packet comprising communicating:

a channelization field identifying channels that are used for communicating subsequent wideband fields of the packet; and

a wideband-header field on the identified channels to identify sub-fields present in the wideband-header field and the presence of a wideband-data field following the wideband-header field,

wherein the communicating comprises:

communicating the channelization field on a single compatibility channel of an allocated portion of spectrum comprising a plurality of channels;

communicating the wideband-header field on the identified channels including the compatibility channel; and

communicating a short-compatibility field as part of the packet on the compatibility channel, wherein the short-compatibility field includes length information defining a length of the packet, wherein communications units refrain from transmitting on the identified channels during transmission of the packet.

9. A method for communicating a packet comprising communicating:

a channelization field identifying channels that are used for communicating subsequent wideband fields of the packet; and a wideband-header field on the identified channels to identify sub-fields present in the wideband-header field and the presence of a wideband-data field following the wideband-header field,

wherein the communicating comprises:

communicating the channelization field on a single compatibility channel of an allocated portion of spectrum comprising a plurality of channels;

communicating the wideband-header field on the identified channels including the compatibility channel; and

communicating a long-compatibility field on the compatibility channel, the long-compatibility field comprising a variable number of symbols over a plurality of symbol-modulated subcarriers that comprise at least one of the channels,

wherein the long-compatibility field includes information to reserve at least one of the channels for a time period, wherein a narrower-band communication unit refrains from communicating during the time period in response to receipt of the long-compatibility field.

10. The method of claim **9** wherein the long-compatibility field and the channelization field of the packet are sent on the compatibility channel, and

wherein a wideband-training field, the wideband-header field and, when included, a wideband-data field are sent on the identified channels including the compatibility channel.

11. A method for communicating a packet comprising communicating:

a channelization field identifying channels that are used for communicating subsequent wideband fields of the packet; and

a wideband-header field on the identified channels to identify sub-fields present in the wideband-header field and the presence of a wideband-data field following the wideband-header field,

wherein the communicating comprises:

communicating the channelization field on a single compatibility channel of an allocated portion of spectrum comprising a plurality of channels; and

communicating the wideband-header field on the identified channels including the compatibility channel,

wherein the compatibility channel is relocatable to any one of a plurality of narrow-band channels within the allocated portion of spectrum, and

wherein the method further comprises:

scanning channels for the operation of narrower-band communication units, and

selecting one of the channels as the compatibility channel based on an overlapping use by at least some of the narrower-band communication units.

12. A method for communicating a packet comprising communicating:

a channelization field identifying channels that are used for communicating subsequent wideband fields of the packet; and

a wideband-header field on the identified channels to identify sub-fields present in the wideband-header field and the presence of a wideband-data field following the wideband-header field,

wherein the wideband-header field comprises:

a field to request bit-loading per subcarrier for subsequent transmission by a transmitting communication unit of a wideband-data field of a packet, the bit-loading per subcarrier indicating a modulation scheme for transmission of the individual symbol-modulated subcarriers of the identified channels;

a field to request a coding rate for the subsequent transmission of the wideband-data field; and

a field to request a power loading per subcarrier for the subsequent transmission of the wideband-data field.

13. The method of claim **12** wherein the wideband-header field comprises at least one of:

a field to indicate the presence of the wideband-data field;

a field to indicate a bit loading per subcarrier for the wideband-data field, the bit loading per subcarrier indicating a modulation scheme used for transmission of the individual symbol-modulated subcarriers of the identified channels;

a field to indicate a power loading per subcarrier for the wideband-data field, the power loading per subcarrier indicating a transmission power level used for transmission of the individual symbol-modulated subcarriers of the identified channels; and

a field to indicate coding rates for decoding the wideband-data field.

14. The method of claim **13** wherein the wideband-header field comprises a parameter mask to identify fields present in the wideband-header field and the presence of the wideband-data field.

15. The method of claim **14** further comprising:

receiving selected individual subcarrier modulation assignments in the wideband-header field, the subcarrier modulation assignments being selected based on channel characteristics measured during a receipt of the wideband-channel training field on the identified channels at a receiving communication unit; and

individually modulating subcarriers of the identified channels for transmission based on the selected individual subcarrier modulation assignments received in the wideband-header field.

16. The method of claim **1** wherein the communicating comprises:

communicating the channelization field on a single compatibility channel of an allocated portion of spectrum comprising a plurality of channels;

communicating the wideband-header field on the identified channels including the compatibility channel;

communicating a wideband-training field as part of the packet following the channelization field, the wideband-training field comprising a training sequence on the channels identified by the channelization field; and

communicating a long-compatibility field on the compatibility channel, the long-compatibility field comprising a variable number of symbols over a plurality of symbol-modulated subcarriers that comprise at least one of the channels,

wherein the long-compatibility field includes information to reserve at least one of the channels for a time period, wherein a narrower-band communication unit refrains from communicating during the time period in response to receipt of the long-compatibility field,

wherein the wideband-header field comprises:

a field to request bit-loading per subcarrier for subsequent transmission by a transmitting communication unit of a wideband-data field of a packet, the bit-loading per subcarrier indicating a modulation scheme for transmission of the individual symbol-modulated subcarriers of the identified channels;

a field to request a coding rate for the subsequent transmission of the wideband-data field; and

a field to request a power loading per subcarrier for the subsequent transmission of the wideband-data field.

17. The method of claim **16** wherein when the wideband-header field includes an indication of a presence of the wideband-data field,

the communicating further comprises communicating the wideband-data field as part of the packet on the channels identified by the channelization field,

wherein the method further comprising estimating at least one of a timing offset, fine-frequency offset, and channel response using at least the training sequence for processing subsequent wideband fields of the packet including the wideband-header field and the wideband-data field when included within the packet,

wherein the compatibility channel is relocatable to any one of a plurality of narrow-band channels within the allocated portion of spectrum, and

wherein the method further comprises:

scanning channels for the operation of narrower-band communication units;

selecting one of the channels as the compatibility channel based on an overlapping use by at least some of the narrower-band communication units;

receiving selected individual subcarrier modulation assignments in the wideband-header field, the subcarrier modulation assignments being selected based on channel characteristics measured during a receipt of the wideband-channel training field on the identified channels at a receiving communication unit; and

individually modulating subcarriers of the identified channels for transmission based on the selected individual subcarrier modulation assignments received in the wideband-header field.

18. The method of claim **17** wherein the communicating comprises one of either sending the packet by a transmitting communication unit or receiving the packet by a receiving communication unit,

wherein the identified channels, including the compatibility channel, are comprised symbol-modulated subcarriers, and

wherein the wideband-header field is encoded with a predetermined encoding scheme and modulated with a predetermined modulation scheme, wherein the predetermined modulation scheme comprises one of either BPSK or QPSK modulation, and wherein the predetermined encoding scheme comprises a ½ rate convolution code.

19. A wireless communication unit for communicating over a wideband communication channel comprising a plurality of orthogonal frequency division multiplexed (OFDM) channels, the wireless communication unit comprising:

a physical layer to communicate a packet comprising at least a channelization field on a single OFDM channel to identify which of the OFDM channels that are used for communicating subsequent wideband fields of the packet, and to communicate a wideband-header field on each of the identified OFDM channels, the wideband-header field to identify sub-fields present in the wideband-header field and the presence of a wideband-data field following the wideband-header field; and

a medium access control layer to select channels for communication by the physical layer and obtain access to the selected channels,

wherein the OFDM channels that comprise the wideband channel are separated in frequency from each other.

20. The communication unit of claim **19** wherein the physical layer is to communicate the channelization field on a compatibility channel of an allocated portion of spectrum comprising a plurality of channels, and is to communicate the wideband-header field on the identified channels including the compatibility channel,

wherein the compatibility channel comprises a single one of the OFDM channels.

21. The communication unit of claim **19** wherein the physical layer is to further communicate a wideband-training field as part of the packet following the channelization field, the wideband-training field comprising a training sequence on the channels identified by the channelization field.

22. The communication unit of claim 21 wherein when the wideband-header field includes an indication of a presence of the wideband-data field, the physical layer is to further communicate the wideband-data field as part of the packet on the channels identified by the channelization field.

23. A system for wirelessly communicating over a wideband communication channel comprising a plurality of orthogonal frequency division multiplexed (OFDM) channels, the system comprising:

an omnidirectional antenna;

a physical layer to communicate a packet with the omnidirectional antenna, the packet comprising at least a channelization field communicated on a single OFDM channel to identify which of the OFDM channels that are used for communicating subsequent wideband fields of the packet, and to communicate a wideband-header field on the identified OFDM channels, the wideband-header field to identify sub-fields present in the wideband-header field and the presence of a wideband-data field following the wideband-header field; and

a medium access control layer to select channels for communication by the physical layer and obtain access to the selected channels,

wherein the OFDM channels that comprise the wideband channel are separated in frequency from each other.

24. The system of claim 23 wherein the physical layer is to communicate the channelization field on a compatibility channel of an allocated portion of spectrum comprising a plurality of channels, and is to communicate the wideband-header field on the identified channels including the compatibility channel,

wherein the comparability channel comprises a single one of the OFDM channels.

25. The system of claim 23 wherein the physical layer is to further communicate a wideband-training field as part of the packet following the channelization field, the wideband-training field comprising a training sequence on the channels identified by the channelization field,

wherein when the wideband-header field includes an indication of a presence of the wideband-data field, the physical layer is to further communicate the wideband-data field as part of the packet on the channels identified by the channelization field.

26. A computer-readable medium that stores instructions for execution by one or more processors, cause said processors to perform operations for wirelessly communicating a packet over a wideband communication channel comprising a plurality of orthogonal frequency division multiplexed (OFDM) channels including communicating a channelization field on a single OFDM channel identifying which of the OFDM channels that are used for communicating subsequent wideband fields of the packet, and further comprising a wideband-header field on each of the identified OFDM channels to identify sub-fields present in the wideband-header field and the presence of a wideband-data field following the wideband-header field,

wherein the OFDM channels that comprise the wideband channel are separated in frequency from each other.

27. The computer-readable medium of claim 26 wherein the instructions, when further executed by one or more of said processors cause said processors to perform operations further comprising:

communicating the channelization field on a single compatibility channel of an allocated portion of spectrum comprising a plurality of channels; and

communicating the wideband-header field on the identified channels including the compatibility channel,

wherein the single compatibility channel comprises one of the single OFDM channels.

28. The computer-readable medium of claim 26 wherein the instructions, when further executed by one or more of said processors cause said processors to perform operations further comprising communicating a wideband-training field as part of the packet following the channelization field, the wideband-training field comprising a training sequence on the channels identified by the channelization field.

29. The computer-readable medium of claim 28 wherein the instructions, when further executed by one or more of said processors cause said processors to perform operations wherein when the wideband-header field includes an indication of the presence of the wideband-data field, the communicating further comprises communicating the wideband-data field as part of the packet on the channels identified by the channelization field.

30. A wireless communication packet for communication over a wideband communication channel comprising a plurality of orthogonal frequency division multiplexed (OFDM) channels, the packet comprising:

a channelization field communicated on a single OFDM channel identifying which of the OFDM channels that are used for communicating subsequent wideband fields of the packet; and

a wideband-header field for communication on each the identified OFDM channels to identify sub-fields present in the wideband-header field and the presence of a wideband-data field following the wideband-header field,

wherein the channels comprise a plurality of substantially orthogonal symbol-modulated subcarriers,

wherein the OFDM channels that comprise the wideband channel are separated in frequency from each other.

31. The packet of claim 30 wherein the channelization field is for communication on a single compatibility channel assigned an allocated portion of spectrum comprising the plurality of channels, and

wherein the wideband-header field is for communication on the identified channels including the compatibility channel,

wherein the compatibility channel comprises one of the single OFDM channels.

32. The packet of claim 30 further comprising:

a wideband-training field to follow the channelization field, the wideband-training field comprising a training sequence for communication on the channels identified by the channelization field,

wherein when the wideband-header field includes an indication of the presence of the wideband-data field, the packet includes the wideband-data field for communication on the channels identified by the channelization field.

33. A communication packet comprising:

a channelization field identifying channels that are used for communicating subsequent wideband fields of the packet;

a wideband-header field for communication on the identified channels to identify sub-fields present in the wideband-header field and the presence of a wideband-data field following the wideband-header field, wherein the channels comprise a plurality of substantially orthogonal symbol-modulated subcarriers; and

a long-compatibility field for communication on the compatibility channel, the long-compatibility field compris-

ing a variable number of symbols transmitted over a plurality of symbol-modulated subcarriers that comprise the compatibility channel,

wherein the long-compatibility field includes information to reserve at least one of the channels for a time period, wherein a narrower-band communication unit refrains from communicating during the time period in response to receipt of the long-compatibility field.

34. A method comprising:

communicating a wideband-training field as part of a packet, the wideband-training field comprising a training sequence modulated on a plurality of symbol-modulated subcarriers on a plurality of channels;

communicating a wideband-header field on the channels, the wideband-header field to identify sub-fields present in the wideband-header field and to identify a presence of a wideband-data field;

communicating the wideband-data field as part of the packet on the channels when indicated in the wideband-header field; and

communicating a short-compatibility field as part of the packet on the plurality of channels, wherein the short-compatibility field includes packet-length information defining a length of the packet, wherein narrower-band communication units refrain from communicating on the plurality of channels during the packet in response to the packet-length information.

35. A method comprising:

communicating a wideband-training field as part of a packet, the wideband-training field comprising a training sequence modulated on a plurality of symbol-modulated subcarriers on a plurality of channels;

communicating a wideband-header field on the channels, the wideband-header field to identify sub-fields present in the wideband-header field and to identify a presence of a wideband-data field;

communicating the wideband-data field as part of the packet on the channels when indicated in the wideband-header field; and

estimating at least one of a timing offset, fine-frequency offset, and channel response using at least the training sequence for processing subsequent wideband fields of the packet including the wideband-header field and the wideband-data field when included within the packet.

36. The method of claim **34** wherein the wideband-header field is encoded with a predetermined encoding scheme and modulated with a predetermined modulation scheme, wherein the predetermined modulation scheme comprises one of either BPSK or QPSK modulation, and wherein the predetermined encoding scheme comprises a ½ rate convolution code.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 7,349,436 B2
APPLICATION NO. : 10/676372
DATED : March 25, 2008
INVENTOR(S) : Maltsev et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In column 18, line 28, in Claim 30, delete "on each the" and insert -- on each of the --, therefor.

Signed and Sealed this

Fifteenth Day of July, 2008

JON W. DUDAS
Director of the United States Patent and Trademark Office