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(54) COORDINATION OF MULTIPLE PROTOCOLS USING A SHARED COMMUNICATION MEDIUM

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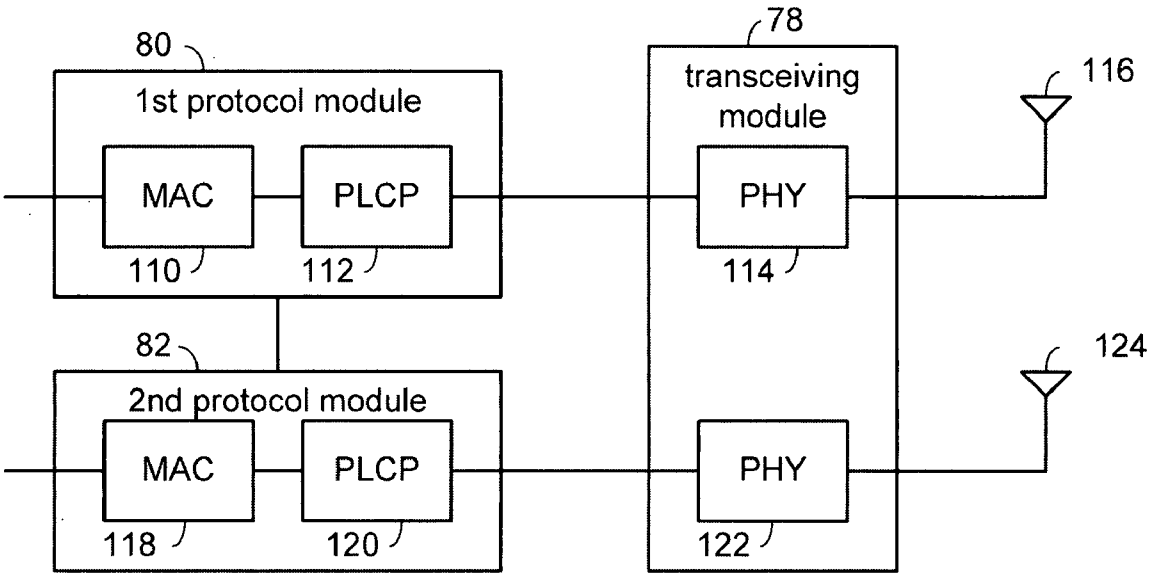
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H04J	***3/22***	(2006.01)
H04J	***3/16***	(2006.01)

(52) **U.S. Cl.** **370/461**; 370/443; 370/465

(57) **ABSTRACT**

The present invention provides a method and apparatus for coordinating multiple protocols using a shared communication medium. Such a method and apparatus includes processing that begins by determining, by a first protocol module, that a second protocol module desires access to the shared communication medium, wherein the second protocol module operates in accordance with a second protocol. The processing continues by transmitting, by the first protocol module, at least a segment of a frame, wherein the at least the segment of the frame includes an indication of a duration that the shared communication medium will be accessed, wherein the frame is in accordance with a first protocol. The processing continues by handing-off, by the first protocol module, access of the shared communication medium to the second protocol module for at least a portion of the duration that the shared communication medium will be accessed such that the second protocol module has access to the shared communication medium with negligible interference from devices of the first protocol.



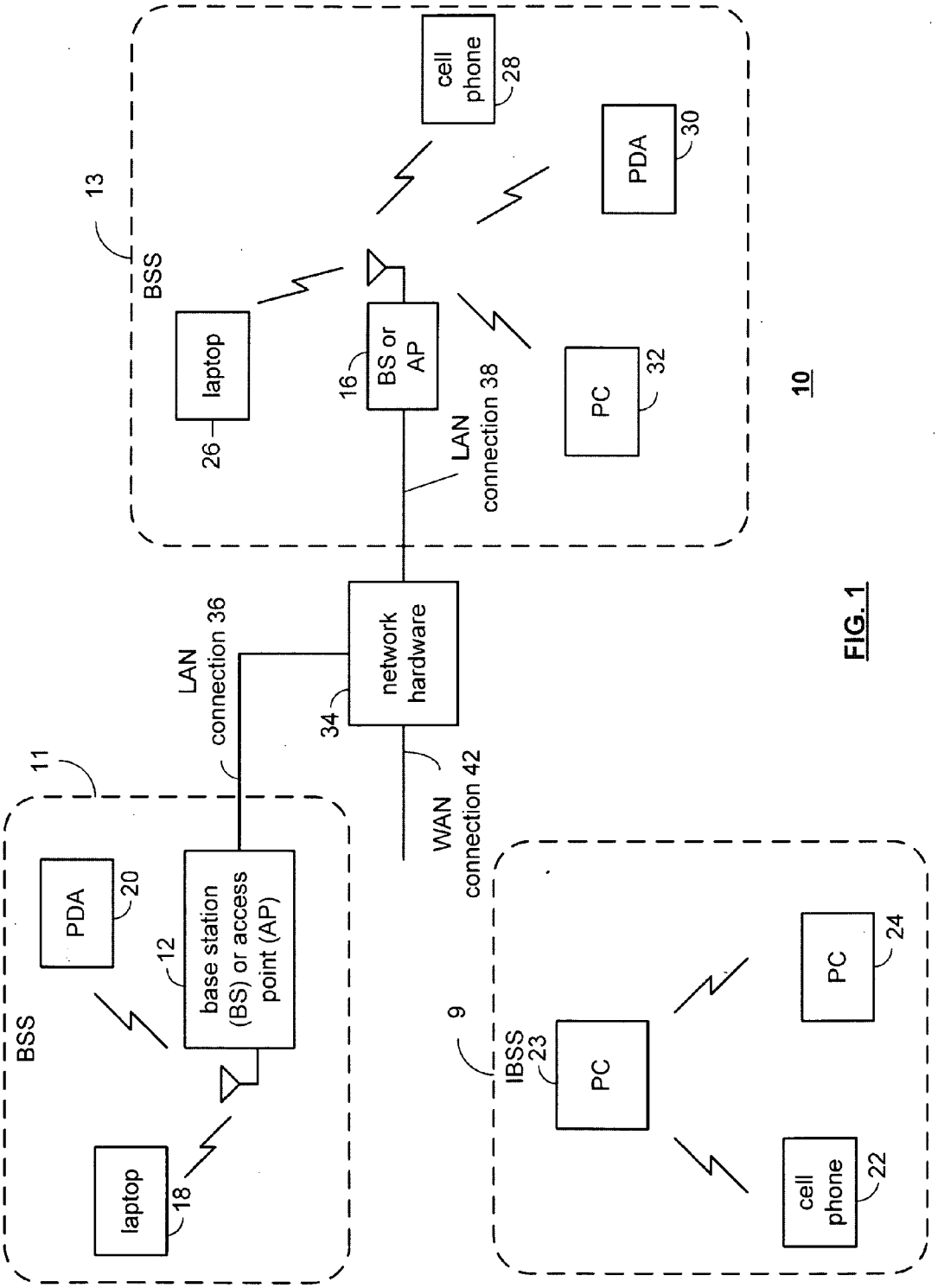

13
BSS
cell phone
28
PDA
30
laptop
26
BS or AP
16
LAN connection 38
PC
32
10
LAN connection 36
network hardware
34
11
PDA
20
base station (BS) or access point (AP)
12
BSS
WAN connection 42
9
IBSS
23
PC
PC
24
laptop
18
cell phone
22

FIG. 1

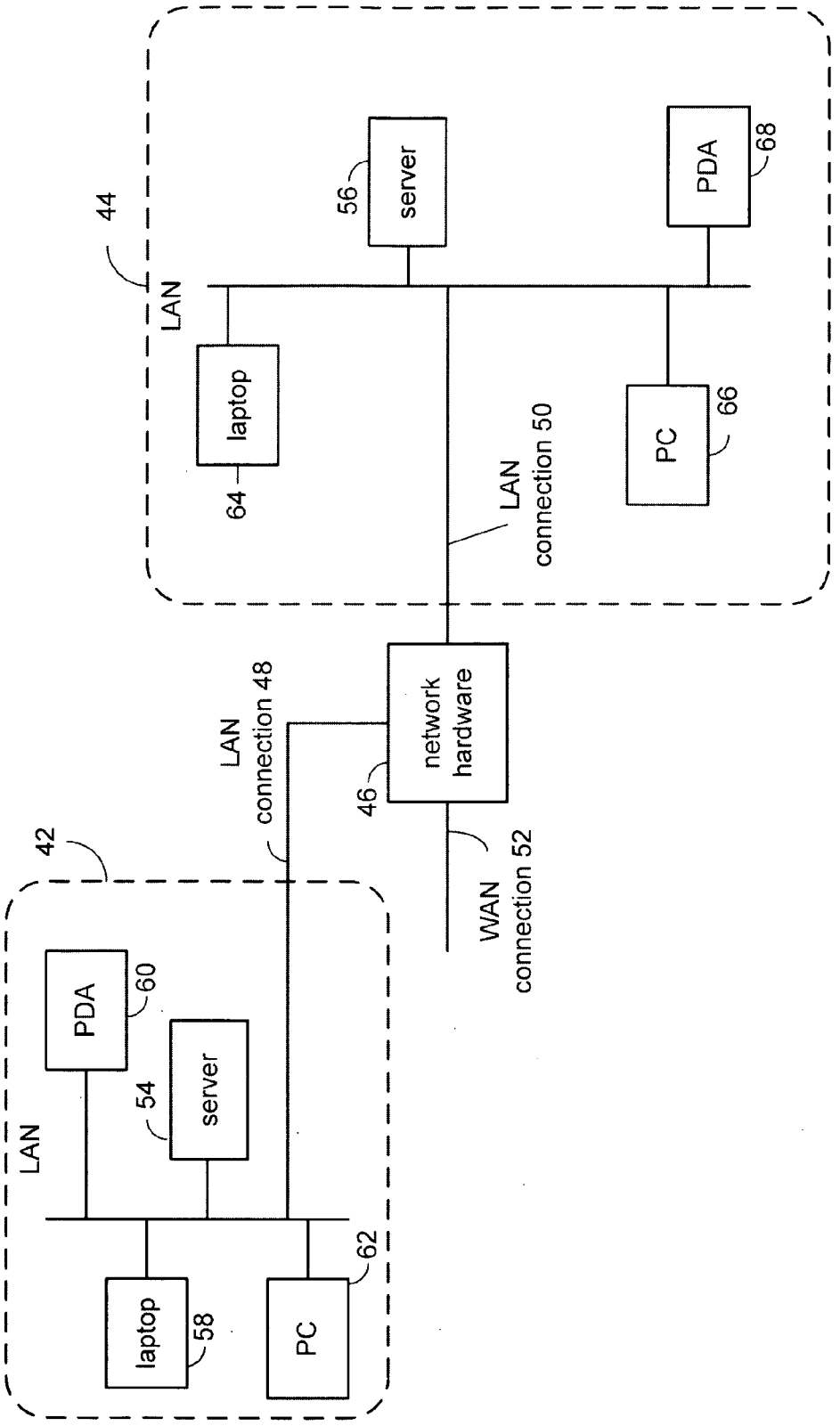

40
44
LAN
56
server
PDA
68
laptop
64
LAN
connection 50
PC
66
LAN
connection 48
network
hardware
46
42
WAN
connection 52
PDA
60
server
54
LAN
laptop
58
PC
62

FIG. 2

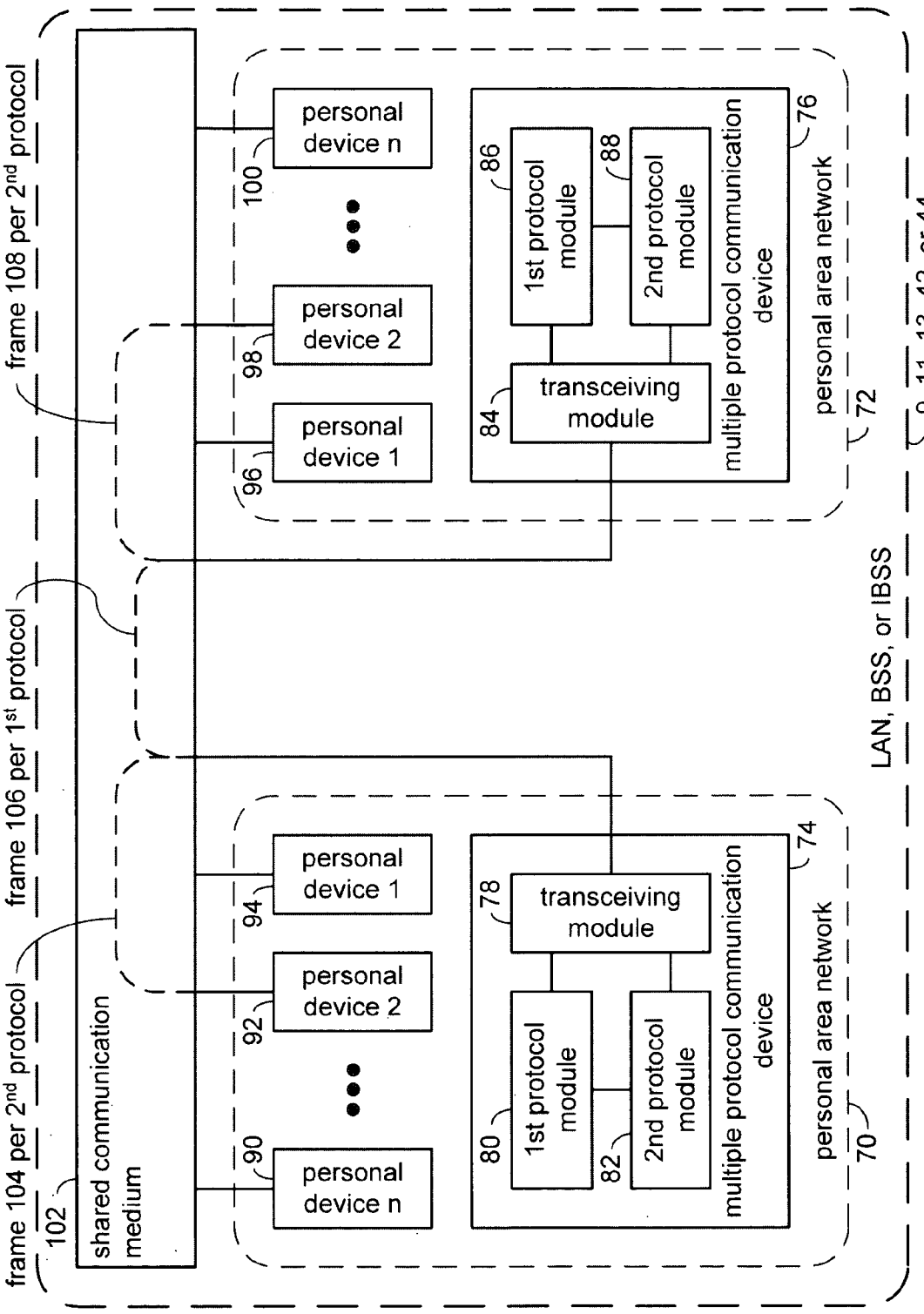

frame 104 per 2nd protocol
frame 106 per 1st protocol
frame 108 per 2nd protocol
shared communication medium
102
personal device n
personal device 2
personal device 1
90
92
94
98
100
96
multiple protocol communication device
1st protocol module
2nd protocol module
transceiving module
80
82
78
86
88
84
74
76
personal area network
70
72
LAN, BSS, or IBSS
9, 11, 13, 42, or 44

FIG. 3

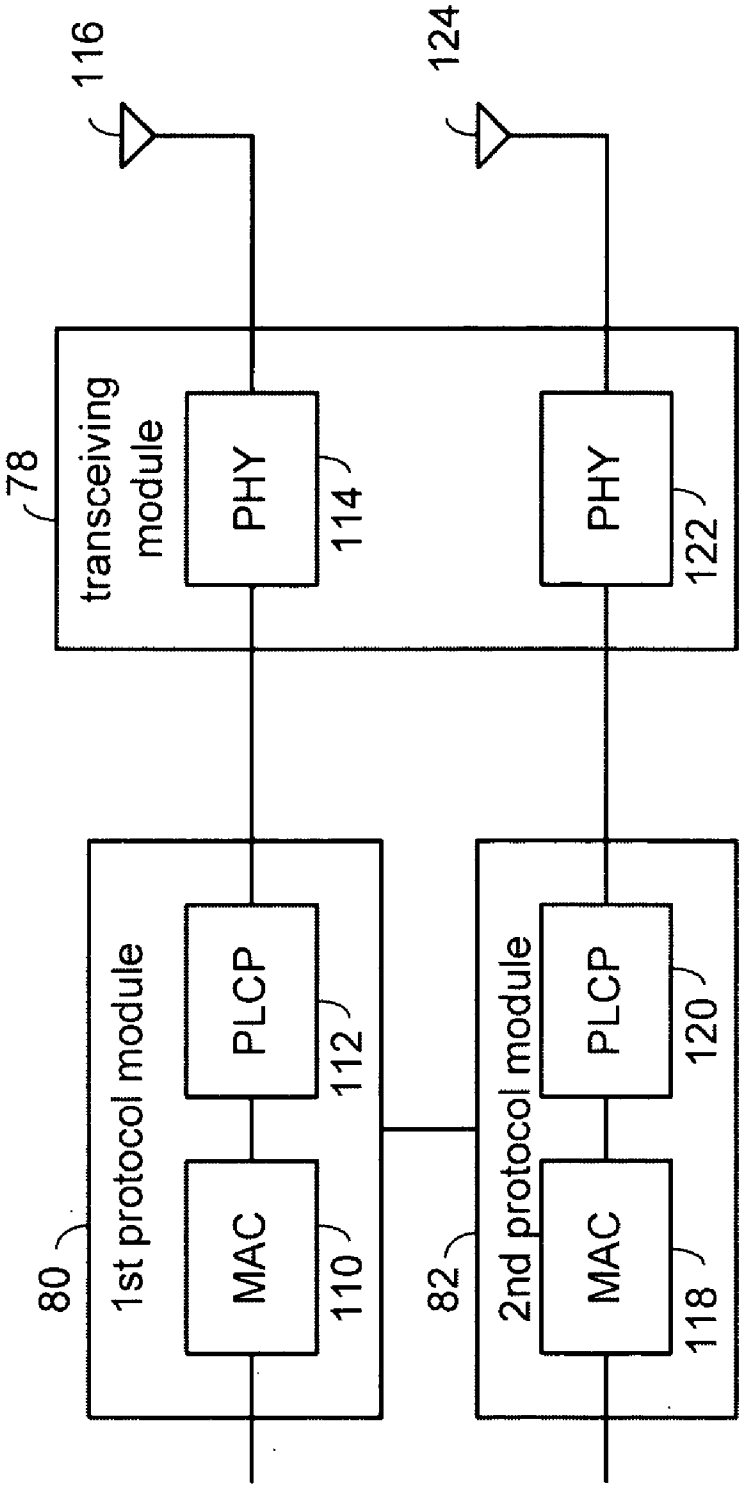

116
124
78
transceiving module
PHY
114
PHY
122
80
1st protocol module
PLCP
112
MAC
110
82
2nd protocol module
PLCP
120
MAC
118

FIG. 4

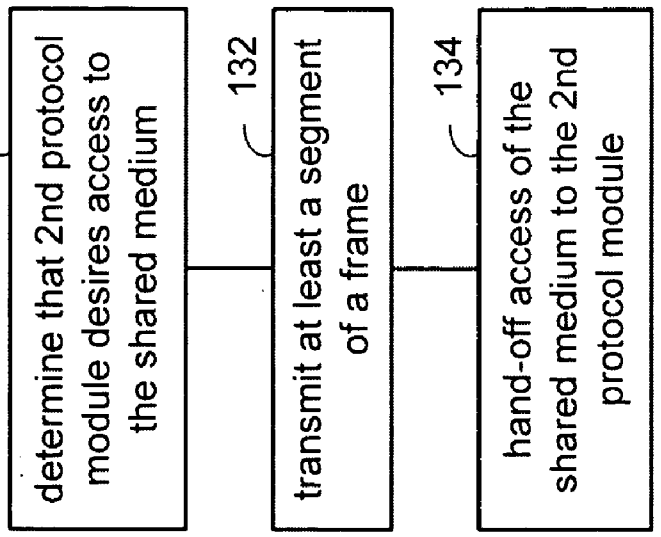

130
determine that 2nd protocol module desires access to the shared medium
132
transmit at least a segment of a frame
134
hand-off access of the shared medium to the 2nd protocol module

FIG. 5

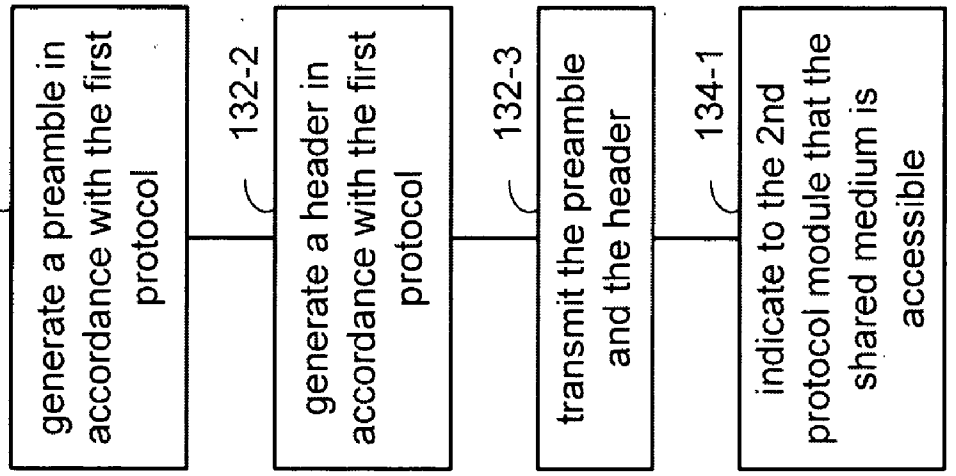

132-1
generate a preamble in accordance with the first protocol
132-2
generate a header in accordance with the first protocol
132-3
transmit the preamble and the header
134-1
indicate to the 2nd protocol module that the shared medium is accessible

FIG. 6

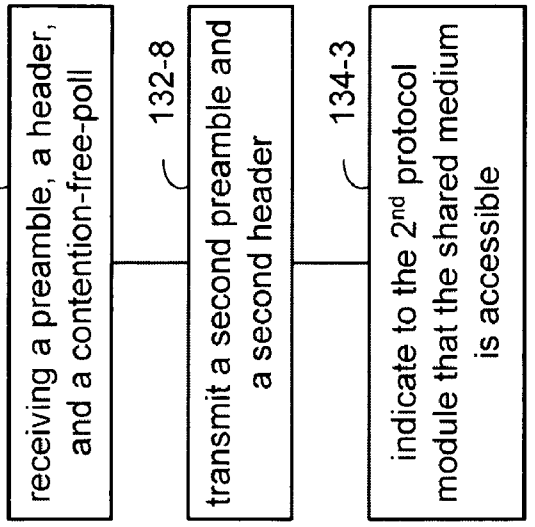

132-7
receiving a preamble, a header, and a contention-free-poll
132-8
transmit a second preamble and a second header
134-3
indicate to the 2nd protocol module that the shared medium is accessible

FIG. 8

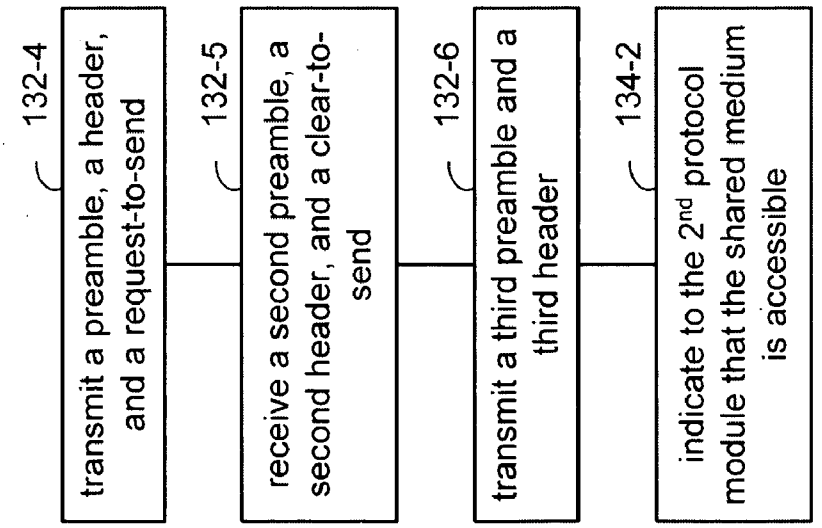

132-4
transmit a preamble, a header, and a request-to-send
132-5
receive a second preamble, a second header, and a clear-to-send
132-6
transmit a third preamble and a third header
134-2
indicate to the 2nd protocol module that the shared medium is accessible

FIG. 7

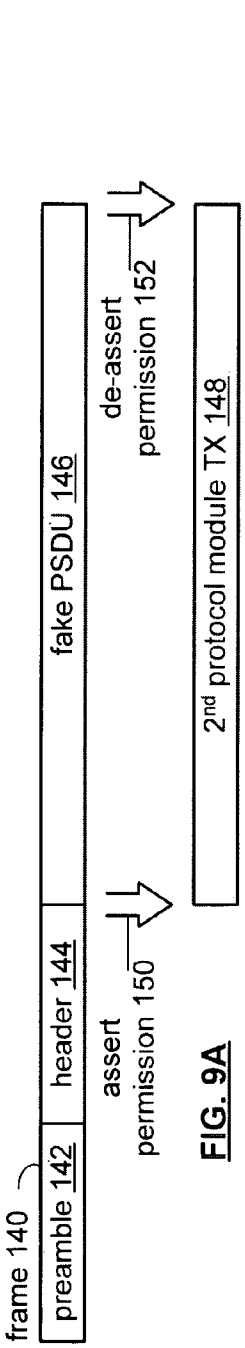


FIG. 9A

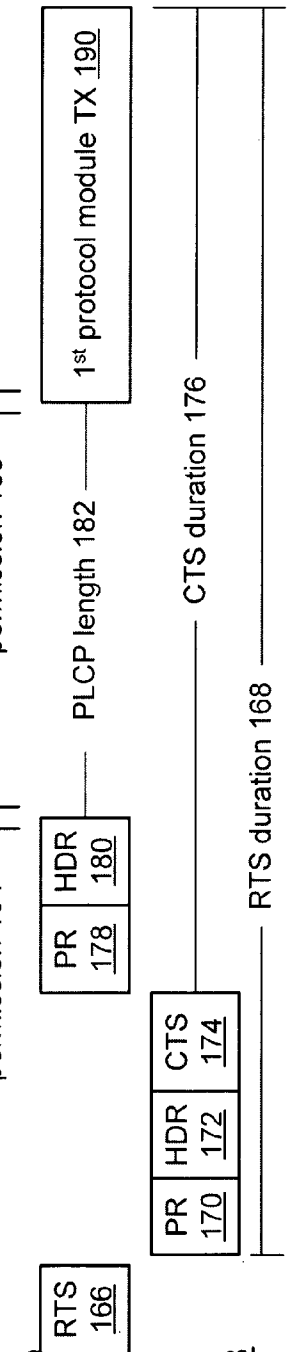


FIG. 9B

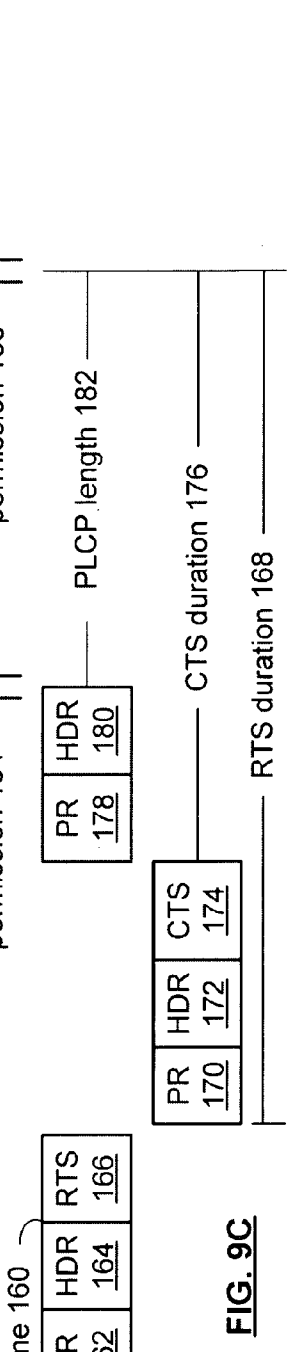


FIG. 9C

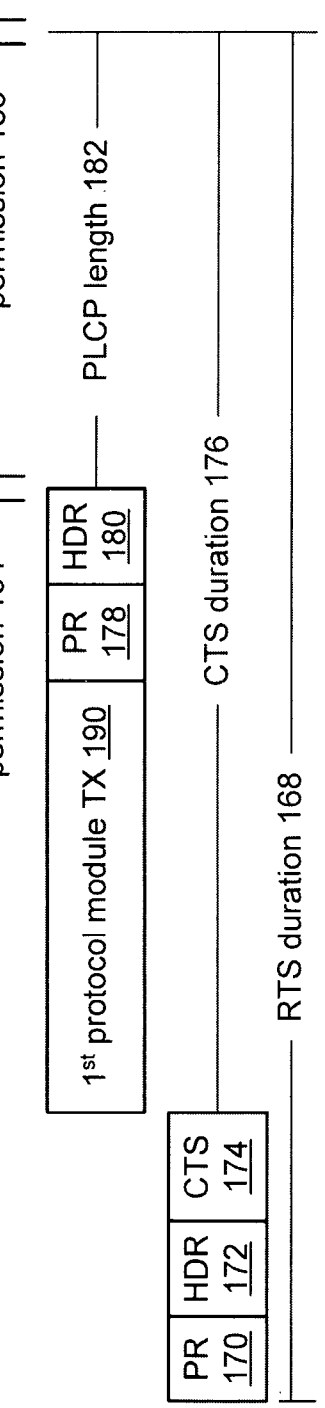

frame 160
PR 162
HDR 164
RTS 166
PR 170
HDR 172
CTS 174
1st protocol module TX 190
PR 178
HDR 180
2nd protocol module TX 188
assert permission 184
de-assert permission 186
PLCP length 182
CTS duration 176
RTS duration 168

FIG. 9D

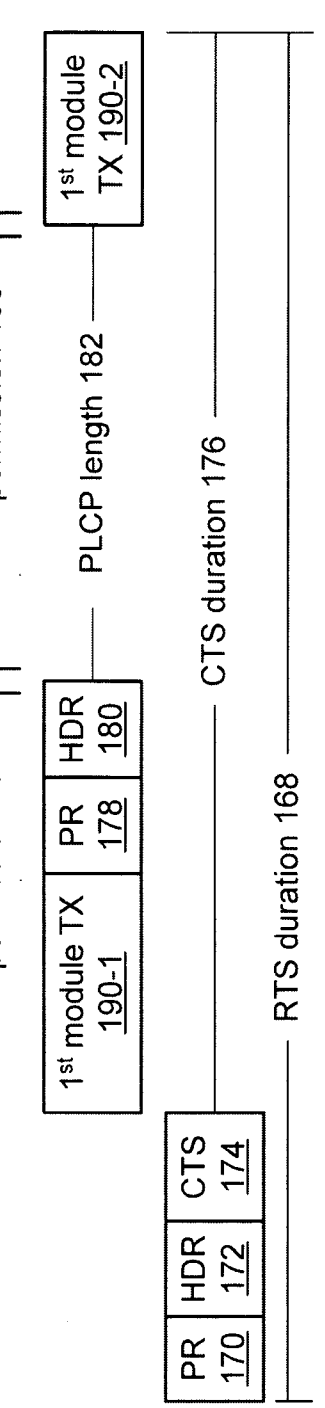

frame 160
PR 162
HDR 164
RTS 166
PR 170
HDR 172
CTS 174
1st module TX 190-1
PR 178
HDR 180
2nd protocol module TX 188
assert permission 184
de-assert permission 186
PLCP length 182
1st module TX 190-2
CTS duration 176
RTS duration 168

FIG. 9E

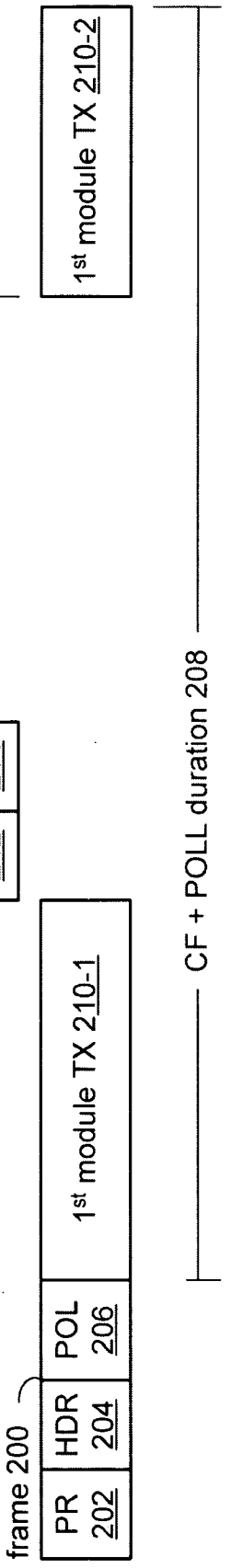

frame 200
PR 202
HDR 204
POL 206
1st module TX 210-1
PR 212
HDR 214
1st module TX 210-2
2nd protocol module TX 188
assert permission 184
de-assert permission 186
PLCP length 182
CF + POLL duration 208

FIG. 9E

COORDINATION OF MULTIPLE PROTOCOLS USING A SHARED COMMUNICATION MEDIUM

BACKGROUND OF THE INVENTION

[0001] 1. Technical Field of the Invention

[0002] This invention relates generally to communication systems and more particularly to coordinating access to a shared medium by multiple protocols of one or more communication systems.

[0003] 2. Description of Related Art

[0004] Communication systems are known to support wireless and wire lined communications between wireless and/or wire lined communication devices. Such communication systems range from national and/or international cellular telephone systems to the Internet to point-to-point in-home wireless networks. Each type of communication system is constructed, and hence operates, in accordance with one or more communication standards. For instance, wireless communication systems may operate in accordance with one or more standards including, but not limited to, IEEE 802.11, Bluetooth, advanced mobile phone services (AMPS), digital AMPS, global system for mobile communications (GSM), code division multiple access (CDMA), local multi-point distribution systems (LMDS), multi-channel-multi-point distribution systems (MMDS), and/or variations thereof.

[0005] Depending on the type of wireless communication system, a wireless communication device, such as a cellular telephone, two-way radio, personal digital assistant (PDA), personal computer (PC), laptop computer, home entertainment equipment, et cetera communicates directly or indirectly with other wireless communication devices. For direct communications (also known as point-to-point communications), the participating wireless communication devices tune their receivers and transmitters to the same channel or channels (e.g., one of the plurality of radio frequency (RF) carriers of the wireless communication system) and communicate over that channel(s). For indirect wireless communications, each wireless communication device communicates directly with an associated base station (e.g., for cellular services) and/or an associated access point (e.g., for an in-home or in-building wireless network) via an assigned channel. To complete a communication connection between the wireless communication devices, the associated base stations and/or associated access points communicate with each other directly, via a system controller, via the public switch telephone network, via the Internet, and/or via some other wide area network.

[0006] For each wireless communication device to participate in wireless communications, it includes a built-in radio transceiver (i.e., receiver and transmitter) or is coupled to an associated radio transceiver (e.g., a station for in-home and/or in-building wireless communication networks, RF modem, etc.). As is known, the receiver is coupled to the antenna and includes a low noise amplifier, one or more intermediate frequency stages, a filtering stage, and a data recovery stage. The low noise amplifier receives inbound RF signals via the antenna and amplifies then. The one or more intermediate frequency stages mix the amplified RF signals with one or more local oscillations to convert the amplified RF signal into baseband signals or intermediate frequency (IF) signals. The filtering stage filters the baseband signals or the IF signals to attenuate unwanted out of band signals to produce filtered signals. The data recovery stage recovers raw data from the filtered signals in accordance with the particular wireless communication standard.

[0007] As is also known, the transmitter includes a data modulation stage, one or more intermediate frequency stages, and a power amplifier. The data modulation stage converts raw data into baseband signals in accordance with a particular wireless communication standard. The one or more intermediate frequency stages mix the baseband signals with one or more local oscillations to produce RF signals. The power amplifier amplifies the RF signals prior to transmission via an antenna.

[0008] For both wireless and wireline communication systems, there are many standards that provide protocols as to how audio, text, video, data, and/or any other type information is to be conveyed within the system. Communication devices that are designed to be compliant with a particular standard (e.g., Ethernet 10Base-T, IEEE 802.11b, Bluetooth) are able to communication with any other communication device within the communication system that is compliant with the same standard. For example, wireless communication devices that are compliant with IEEE 802.11b can communicate with each other, provided they are properly registered to the same communication system.

[0009] As is known, differing standards sometimes use the same communication medium (e.g., allocated radio frequency spectrum, wired connections, etc.) due to a finite amount of communication medium. For example, both Bluetooth and IEEE 802.11b use the 2.4 GHz spectrum. As long as communication systems that are compliant with differing standards that share a communication medium do not physically overlap, the systems operate without interference from each other. However, if the communication systems do physically overlap, they will interfere with each other, degrading the performance of both systems. For example, if a Bluetooth pico net physically overlaps with an IEEE 802.11b local area network, simultaneous use of the 2.4 GHz spectrum will cause interference that will most likely cause both transmissions to fail.

[0010] To help reduce this problem, communication devices have been developed to be compliant with multiple standards that have different protocols for a share communication medium. For example, wireless communication devices have been developed that are compliant with both Bluetooth and IEEE 802.11(a), (b), and/or (g). In such devices, the Medium Access Control (MAC) layer of one protocol communications with the MAC layer of another protocol to avoid simultaneous use of the shared communication medium.

[0011] While this substantially reduced simultaneous use of a shared communication medium on a device-by-device basis, it does little to reduce simultaneous use on a communication system level. For example, if a first communication device desires to use the shared communication medium in accordance with a first protocol, it will block its use of a second protocol for the duration of the use per the first protocol, however, a second communication device may concurrently desire to use the shared communication medium in accordance with the second protocol. Since the protocols are different, the first device will obtain access of

the share communication medium in accordance with the first protocol and the second device will obtain access of the shared communication medium in accordance with the second protocol. With both devices concurrently accessing the shared communication medium, their transmissions will interfere with each other, causing at least one of the transmissions to fail.

[0012] Therefore, a need exists for a method and apparatus for coordinating multiple protocols using a shared communication medium.

BRIEF SUMMARY OF THE INVENTION

[0013] The present invention is directed to apparatus and methods of operation that are further described in the following Brief Description of the Drawings, the Detailed Description of the Invention, and the claims. Other features and advantages of the present invention will become apparent from the following detailed description of the invention made with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0014] **FIG. 1** is a schematic block diagram of a wireless communication system in accordance with the present invention;

[0015] **FIG. 2** is a schematic block diagram of a wireline communication system in accordance with the present invention;

[0016] **FIG. 3** is a schematic block diagram of a LAN, BSS, and/or IBSS in accordance with the present invention;

[0017] **FIG. 4** is a schematic block diagram of a wireless communication device in accordance with the present invention;

[0018] **FIG. 5** is a logic diagram of a method for coordinating multiple protocols using a shared communication medium in accordance with the present invention;

[0019] **FIGS. 6-8** are logic diagrams of various embodiments of transmitting a frame, or portion thereof, and handing-off access of the shared communication medium of the method of **FIG. 5**; and

[0020] **FIGS. 9A-9E** are diagrams of various examples of coordinating multiple wireless protocols using a shared communication medium in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0021] **FIG. 1** is a schematic block diagram of an example of a wireless communication system **10** that includes a plurality of base stations and/or access points **12**, **16**, a plurality of wireless communication devices **18-32** and a network hardware component **34**. Note that the network hardware **34**, which may be a router, switch, bridge, modem, system controller, et cetera provides a wide area network connection **42** for the communication system **10**. Further note that the wireless communication devices **18-32** may be laptop host computers **18** and **26**, personal digital assistant hosts **20** and **30**, personal computer hosts **24** and **32** and/or cellular telephone hosts **22** and **28**. The details of the wireless communication devices will be described in greater detail with reference to **FIGS. 3 and 4**.

[0022] Wireless communication devices **22**, **23**, and **24** are located within an independent basic service set (IBSS) area and communicate directly (i.e., point to point). In this configuration, these devices **22**, **23**, and **24** may only communicate with each other. To communicate with other wireless communication devices within the system **10** or to communicate outside of the system **10**, the devices **22**, **23**, and/or **24** need to affiliate with one of the base stations or access points **12** or **16**.

[0023] The base stations or access points **12**, **16** are located within basic service set (BSS) areas **11** and **13**, respectively, and are operably coupled to the network hardware **34** via local area network connections **36**, **38**. Such a connection provides the base station or access point **1216** with connectivity to other devices within the system **10** and provides connectivity to other networks via the WAN connection **42**. To communicate with the wireless communication devices within its BSS **11** or **13**, each of the base stations or access points **12-16** has an associated antenna or antenna array. For instance, base station or access point **12** wirelessly communicates with wireless communication devices **18** and **20** while base station or access point **16** wirelessly communicates with wireless communication devices **26-32**. Typically, the wireless communication devices register with a particular base station or access point **12**, **16** to receive services from the communication system **10**.

[0024] Typically, base stations are used for cellular telephone systems and like-type systems, while access points are used for in-home or in-building wireless networks (e.g., IEEE 802.11 and versions thereof, Bluetooth, and/or any other type of radio frequency based network protocol). Regardless of the particular type of communication system, each wireless communication device includes a built-in radio and/or is coupled to a radio.

[0025] **FIG. 2** is a schematic block diagram of an example of a wireline communication system **40** that includes two local area networks (LAN) **42** and **44** and network hardware **46**. Each of the LANs **42** and **44** includes a server **54**, **56** and a plurality of communication devices **58-62** and **64-68**, which are connected to the network hardware **46** via LAN connections **48** and **50**. Note that the network hardware **46**, which may be a router, switch, bridge, modem, system controller, et cetera provides a wide area network connection **52** for the communication system **40**. Further note that the communication devices **58-62** and **64-68** each include a network card to communicate with the network hardware **46** and may be a laptop computer **58**, **64**, a personal digital assistant **60**, **68**, or a personal computer **62**, **66**. The details of the communication devices will be described in greater detail with reference to **FIG. 3**.

[0026] **FIG. 3** is a schematic block diagram of an example of a LAN, BSS, and/or IBSS **9**, **11**, **13**, **42**, or **44** that includes personal area networks **70** and **72** and a shared communication medium **102**. Each of the personal area networks **70** and **72** includes a multiple protocol communication device **74**, **76** (which may be any one of the wireless communication devices **18-32** of **FIG. 1** or the wireline communication devices **58-68** of **FIG. 2**) and a plurality of personal devices **90-94** and **96-100**. The personal devices **90-100** may be any peripheral device affiliated with the communication device

72, **74** including, but not limited to, a headset, a keyboard, a mouse, a printer, a monitor, a fax machine, a scanner, a digital camera, a digital camcorder, a digital audio playback device, or a video playback device. The shared communication medium **102** may be a shared twisted pair connection, a shared optical connection, a shared coaxial connection, or a shared frequency spectrum.

[**0027**] Each of the multiple protocol communication devices **74** and **76** includes a first protocol module **80**, **84**, a second protocol module **82**, **88**, and a transceiving module **78**, **84**. In one embodiment, the first protocol module **80**, **84** is configured to support a first protocol that enables the communication device **74**, **76** to communicate at a local area network level and/or wide area network level using the shared communication medium **102**, while the second protocol module is configured to support a second protocol that enables the communication device **72**, **74** to communicate with the personal devices **90-94**, **96-100** within its personal area network **70**, **72** using the shared communication medium **102**. For instance, the first and second protocols may be one or more of a past, current, or future version of Ethernet, SONET, asynchronous transfer mode (ATM), frame relay, TCP/IP, advanced mobile phone services (AMPS), digital AMPS, global system for mobile communications (GSM), code division multiple access (CDMA), local multi-point distribution systems (LMDS), multi-channel-multi-point distribution systems (MMDS), Bluetooth, IEEE 802.11(a), (b), (g), (n), any other wireline standard or any other wireless standard.

[**0028**] The first and second protocol modules **80**, **82**, **84**, **86** may be implemented using a processing module and associated memory. The processing module may be a single processing device or a plurality of processing devices. Such a processing device may be a microprocessor, micro-controller, digital signal processor, microcomputer, central processing unit, field programmable gate array, programmable logic device, state machine, logic circuitry, analog circuitry, digital circuitry, and/or any device that manipulates signals (analog and/or digital) based on operational instructions. The associated memory may be a single memory device or a plurality of memory devices. Such a memory device may be a read-only memory, random access memory, volatile memory, non-volatile memory, static memory, dynamic memory, flash memory, cache memory, and/or any device that stores digital information. Note that when the processing module implements one or more of its functions via a state machine, analog circuitry, digital circuitry, and/or logic circuitry, the memory storing the corresponding operational instructions may be embedded within, or external to, the circuitry comprising the state machine, analog circuitry, digital circuitry, and/or logic circuitry. In general, the memory stores, and the processing module executes, operational instructions corresponding to at least some of the steps and/or functions illustrated in **FIGS. 3-9E**. In addition, the memory may store data produced by the processing module.

[**0029**] The transceiving modules **78**, **84** may be a wireless transceiver and/or a wireline transceiver. In one embodiment, a wireline transceiver is a network card or multiple network cards that enable the communication device **74**, **76** to communicate within the LAN and outside of the LAN and also to communicate with the personal devices **90-94**, **96-100**. In another embodiment, a wireless transceiver enables the communication device **74**, **76** to wirelessly communicate within the LAN and outside of the LAN and also to communicate with the personal devices **90-94**, **96-100**.

[**0030**] In operation, when a multiple protocol communication device **74**, **76** desires to communicate with one of the personal devices **90-94** or **96-100**, the first protocol module **80**, **86** generates a frame, or segment thereof, **106** in accordance with the first protocol and includes an indication of the duration for which the device **74**, **76** desires to use the shared communication medium **102**. The device **74**, **76** transmits the frame **106** to other devices in the system, to an access point, to a base station, to a server, etc. The other devices will process the frame **106** in accordance with the first protocol and, upon proper interpretation, will not use the shared communication medium **102** for the time period indicated in the frame **106**.

[**0031**] After transmitting the frame **106**, the first protocol module **80**, **86** hands-off access of the shared communication medium **102** to the second protocol module **82**, **88**. For the duration of access to the shared communication medium **102**, or a portion thereof, the second protocol module **82**, **88** conveys data, audio, video, and/or text information with one or more personal devices **90-94**, **96-100** in frames **104**, **108** via the shared communication medium **102** and in accordance with the second protocol. Since the other communication devices in the system know that the shared communication medium **102** is being accessed, they will not attempt to access the shared communication medium **102** until it becomes available, again, according to the time period indicated in the frame **106**, thus avoiding collisions from other devices while a different protocol is accessing the shared communication medium **102**.

[**0032**] **FIG. 4** is a schematic block diagram of a wireless communication device **74** that includes the first protocol module **80**, the second protocol module **82**, the transceiving module **78**, and antenna structures **116** and **124**. Each of the antenna structures **116** and **124** may be a single antenna or an array of antennas. The first protocol module **80** includes a Medium Access Control (MAC) module **110** in accordance with a first protocol (e.g., a version of IEEE 802.11) and a Physical Layer Convergence Procedure (PLCP) module **112** in accordance with the first protocol. The second protocol module **82** includes a MAC module **118** in accordance with the second protocol (e.g., a version of Bluetooth) and a PLCP module **120**.

[**0033**] The transceiving module **78** includes a first physical layer (PHY) module **114** coupled to the first protocol module **80** and a second PHY module **122** coupled to the second protocol module **82**. Each of the PHY modules **114** and **122** includes a transmit section and a receive section coupled to the corresponding antenna structure **116**, **124** such that each PHY module **114**, **122** converts outbound baseband data into outbound RF signals and converts inbound RF signals into inbound baseband signals. As one of ordinary skill in the art will appreciate, the PHY modules **114** and **122** may share at least a portion of the antenna structures **116** or **124** and may share common components such as the low noise amplifier, power amplifier, RF bandpass filters, direct conversion mixers, etc.

[**0034**] In operation, when a multiple protocol communication device **74** desires to communicate with one of its personal devices **90-94**, the MAC module **110** generates a

frame, or segment thereof, **106** in accordance with the first protocol (e.g., a version of the IEEE 802.11 standard) and includes an indication of the duration for which the device **74** desires to use the shared communication medium **102**. The MAC module **110** provides the frame **106** to the PLCP module **112**, which in turn provides the frame **106** to the PHY module **114** for RF transmission to other devices in the system, to an access point, to a base station, to a server, etc. The other devices will process the frame **106** in accordance with the first protocol and, upon proper interpretation, will not use the shared communication medium **102** for the time period indicated in the frame **106**.

[**0035**] In addition, the MAC module **110** communicates with the MAC module **118** to indicate the duration for which the MAC module **118** will have access to the shared network. The MAC module **110** also hands-off control of the shared communication medium to the MAC module **118** for transmitting and/or receiving communications in accordance with the second protocol.

[**0036**] **FIG. 5** is a logic diagram of a method for coordinating multiple protocols using a shared communication medium that begins at step **130** where the first protocol module determines that the second protocol module desires access to the shared communication medium, wherein the second protocol module operates in accordance with a second protocol. The determination may be made in a plurality of ways including, but not limited to, receiving a communication from the second protocol module indicating the desire to access the shared communication medium; determining, on a periodic basis, that the second protocol module desires access based on an application supported by the second protocol module (e.g. the second protocol module is supporting a headset function polling); receiving from another protocol module that the second protocol module desires access to the shared communication medium (e.g., from a higher layer which knows that a particular program (e.g., a voice program) is active and access is needed); and determining, on a random basis, that the second protocol module desires access to the shared communication medium (e.g., polling).

[**0037**] The process then proceeds to step **132** where the first protocol module transmits at least a segment of a frame to other devices in the system. The frame, or portion thereof, which is in accordance with a first protocol, includes an indication of a duration that the shared communication medium will be accessed. This will be described in greater detail with reference to **FIGS. 6-9E**.

[**0038**] The process then proceeds to step **134** where the first protocol module hands-off access of the shared communication medium to the second protocol module for at least a portion of the duration that the shared communication medium will be accessed such that the second protocol module has access to the shared communication medium with negligible interference from devices of the first protocol. This will be described in greater detail with reference to **FIGS. 6-9E**.

[**0039**] **FIGS. 6-8** are logic diagrams of various embodiments of transmitting a frame, or portion thereof, and handing-off access of the shared communication medium of the method of **FIG. 5**. In **FIG. 6**, the processing begins at step **132-1** where the first protocol module generates generating a preamble in accordance with the first protocol. For example, if the first protocol corresponds to IEEE 802.11(b), the first protocol module generates the preamble to include a short training sequence and a long training sequence. The process then proceeds to step **132-2** where the first protocol module generates a header in accordance with the first protocol to include a frame length indication, wherein the frame length indication includes length of a data section of the frame. Continuing with the IEEE 802.11(b) example, the header includes a signal field and a service field, either of which may contain a frame length indication.

[**0040**] The process then proceeds to step **132-3** where the first protocol module transmits the preamble and the header as the at least the segment of the frame to the transceiving module, which, in turn, converts the frame into an RF signal that is sent to other communication devices in the system. With the other devices in the system knowing that the shared communication medium will be accessed for the duration corresponding to the frame length they will not attempt to access it. Thereby avoiding inter-protocol interference (i.e., the devices operable in accordance with first protocol will not access the shared communication medium while a device operable in accordance with the second protocol is accessing the share communication medium.)

[**0041**] The process then proceeds to step **134-1** where the first protocol module indicates to the second protocol module that the shared communication medium is accessible for the duration corresponding to the length of the data section of the frame. This may be accomplished by providing a message, or a signal, from the first protocol module to the second protocol module directly or through a baseband processing module.

[**0042**] **FIG. 7** includes processing that begins at step **132-4** where the first protocol module transmits a preamble, a header, and a request-to-send as the at least the segment of the frame to an access point in accordance with the first protocol, which is done via the transceiving module. The processing then proceeds to step **132-5** where the first protocol module receives a second preamble, a second header, and a clear-to-send from the access point in accordance with the first protocol. The request-to-send and/or the clear-to-send include a network allocation vector that identifies the duration that the shared communication medium will be accessed following the successful exchange of the request-to-send and/or clear-to-send frames and hence, an indication of the duration of the opportunity for medium sharing between the first protocol module and the second protocol module.

[**0043**] The process then proceeds to step **132-6** where the first protocol module transmits a third preamble and a third header, wherein the third header includes length of a data section of the frame that corresponds to the available opportunity for medium sharing of the duration allocated to the second protocol module, which is conveyed to the system via the transceiving module. The process then proceeds to step **134-2** where the first protocol module indicates to the second protocol module that the shared communication medium is accessible for the duration corresponding to the length of the data section of the third frame, or a portion thereof.

[**0044**] **FIG. 8** includes processing that begins at step **132-7** where the first protocol module receives a preamble, a header, and a contention-free-poll from an access point in

accordance with the first protocol. The contention-free-poll includes a network allocation vector that identifies the maximum duration that the shared communication medium is allowed to be accessed by the receiving node which is addressed in the contention-free-poll frame and hence, an indication of the duration of the opportunity for medium sharing between the first protocol module and the second protocol module. The processing then continues at step **132-8** where the first protocol module transmits a second preamble and a second header, wherein the second header includes length of a data section of the frame that corresponds to the available opportunity for medium sharing of the duration allocated to the second protocol module, which is relayed to the access point via the transceiving module. The processing then proceeds to step **134-3** where the first protocol module indicates to the second protocol module that the shared communication medium is accessible for the duration corresponding to the length of the data section of the frame, or a portion thereof.

[**0045**] **FIGS. 9A-9E** are diagrams of various examples of coordinating multiple wireless protocols using a shared communication medium via a fake PSDU and/or NAV-based indication. In general, the fake PSDU approach operates in a communication device that contains both an 802.11 LAN function and a Bluetooth master node function, or an 802.11 LAN function and the timing master of some other communication protocol function which is dissimilar to the 802.11 LAN function. The mechanism may also be applied to a case wherein the other protocol is also an 802.11 LAN function, such as when a more distant 802.11 LAN device desires access to the shared medium, but is generally unable to communicate with the other devices in the LAN because of, for example, distance limitations, but is able to communicate with the device containing the first 802.11 LAN function. To facilitate this approach, a communication channel exists between the 802.11 LAN function and the Bluetooth Master function within the common device. Such a communication channel may consist of a single signal which acts as a transmit/receive permission signal to the Bluetooth Master function. In one embodiment, the assertion of the signal indicates that the Bluetooth Master function is free to engage in transmit and receive activity according to the Bluetooth protocol. This is the Bluetooth permission channel.

[**0046**] In such an embodiment, the Bluetooth master node obeys the communication channel signaling strictly in order to create the desired coordination. In another embodiment, the 802.11 LAN function instructs the Bluetooth Master function to remain idle (i.e. refrain from transmit and receive activity) while the 802.11 LAN function is active. Accordingly, the 802.11 LAN function acts as the master of the Bluetooth function and will dictate the times when the Bluetooth function may become active.

[**0047**] When the 802.11 LAN function determines that a Bluetooth activity period should begin, the 802.11 LAN function gains control of the 802.11 LAN network (and therefore, the shared medium) and then secures uncontested access to the medium by sending an 802.11 preamble plus physical layer PLCP header which indicates that it is about to transmit a physical layer service data unit (PSDU). However, the PLCP indication is an intentional misdirection to the other 802.11 devices operating in the vicinity. Instead of sending a PSDU, the 802.11 LAN function immediately after sending the PLCP header information, passes control of the shared medium to the Bluetooth Master function through the Bluetooth permission channel. The Bluetooth Master function, through a prior frequency and duration requirements agreement, uses the medium for transmissions and receptions, directing other Bluetooth devices to transmit and receive according to the previously described frequency and duration agreements. (The PLCP header information contains encoded length information which signals to the other 802.11 LAN devices that a PSDU is to be received, and those devices then remain in a receive mode for the duration of time indicated by that length information, regardless of whether an actual PSDU is sent or not.) The length information transmitted in the "fake PSDU" corresponds to the desired Bluetooth activity duration.

[**0048**] At the end of the agreed upon duration of time which was granted to the Bluetooth Master function for the purpose of transmission and reception activity, the 802.11 LAN function de-asserts the Bluetooth permission signal, thereby disallowing any further Bluetooth function activity. As per the outstanding agreement, the Bluetooth Master function should have completed its current activity on the shared medium. Shortly after the removal of the Bluetooth permission signal, the end of the length of time as was indicated in the PLCP header should occur, allowing the normal 802.11 LAN medium access process to resume.

[**0049**] Because of the possible existence of hidden nodes, and as a measure to deal with the generally uncontrolled nature of the RF medium (especially when operating in unlicensed bands) and the resulting possible loss of the "fake PSDU"'s PLCP header information, the proxy TXOP mechanism supports additional optional transmissions which serve to offer redundant protection against 802.11 LAN use of the medium. Specifically, protective NAV values can be established around the "fake PSDU" transmission through additional, normal 802.11 LAN protocol mechanisms such as RTS/CTS.

[**0050**] The transmission of the "fake PSDU" does not require a preceding transmission or reception or succeeding transmission or reception, although such is not precluded. In general, the use of the "fake PSDU" allows a secondary LAN function to operate in a coordinated fashion with the primary, controlling LAN function.

[**0051**] In the NAV-based indication approach, function, or an 802.11 LAN function, the timing master of some other communication protocol function is dissimilar to the 802.11 LAN function. In this embodiment, a communication channel exists between the 802.11 LAN function and the Bluetooth Master function within the common device.

[**0052**] When the 802.11 LAN function determines that a Bluetooth activity period should begin, the 802.11 LAN function gains control of the 802.11 LAN network (and therefore, the shared medium) and then secures uncontested access to the medium by sending frames that are intended to cause a Network Allocation Vector (NAV) to become set in the other participating LAN devices. However, the NAV indication is an intentional misdirection to the other 802.11 devices operating in the vicinity. Instead of using the allocated time for additional 802.11 LAN frame exchanges, as would naturally be assumed by the other 802.11 LAN devices which received the NAV-setting frames, the 802.11

LAN function instead passes control of the shared medium to the Bluetooth Master function through the Bluetooth permission channel.

[0053] The Bluetooth Master function, through a prior frequency and duration requirements agreement, uses the medium for transmissions and receptions, directing other Bluetooth devices to transmit and receive according to the previously described frequency and duration agreements. The NAV duration information transmitted in the earlier 802.11 LAN messages corresponds to the desired Bluetooth activity duration. At the end of the agreed upon duration of time which was granted to the Bluetooth Master function for the purpose of transmission and reception activity, the 802.11 LAN function de-asserts the Bluetooth permission signal, thereby disallowing any further Bluetooth function activity. As per the outstanding agreement, the Bluetooth function should have completed its current activity on the shared medium.

[0054] Shortly after the removal of the Bluetooth permission signal, the end of the length of time as was indicated in the NAV duration information should occur, allowing the normal 802.11 LAN medium access process to resume. It is possible that the NAV duration information exceeds the allotment of time required by the Bluetooth Master function—this may be intentionally done in order to allow the device's 802.11 LAN function to perform 802.11 activity within the same shared medium access period. It is also possible that the original NAV setting operation was preceded by other of this device's 802.11 activity, and that following the original NAV setting operation, but preceding any Bluetooth activity, this device's 802.11 LAN function engaged in 802.11 activity.

[0055] The transmission of the NAV information does not require a preceding transmission or reception or succeeding transmission or reception, although it may include such transmission or reception. In general, the use of some of the time which has been secured by the 802.11 LAN function through the NAV mechanism is to be used by the secondary LAN function to operate in a coordinated fashion with the primary, controlling LAN function. Best practices suggest the use of preceding transmissions and/or receptions in order to provide further/redundant guarantees that the other devices of the same type as the controlling LAN function have temporarily ceased their attempts to use the shared medium.

[0056] **FIG. 9A** is a diagram of a frame **140** generated by the first protocol module, which in this example, is compliant with a version of IEEE 802.11. The frame **140** includes a preamble **142**, a header **144**, and a fake PDSU **146**. The preamble **142** and header **144** are implemented in accordance with a version of IEEE 802.11 and the header **144** includes a frame length indication. The fake PDSU **148** corresponds to the data field of a normal IEEE 802.11 compliant frame. However, in this instance, the data field is empty, meaning that the transmitter sends no energy during this period of time, and access permission to the shared communication resource is asserted **150** such that the second protocol module may transmit and/or receive communications **148** via the shared resource. When the frame **140** ends, the first protocol module de-asserts **152** the second protocol module's permission to access the shared medium.

[0057] **FIG. 9B** is a diagram of a frame **160** generated by the first protocol module, which in this example, is compliant with a version of IEEE 802.11. The frame **160** includes a preamble **162**, a header **164**, and a request to send (RTS) field **166**. In the RTS field portion of frame **160**, a RTS duration **168** is provided to other devices within the communication system. In response to frame **160**, the first protocol module **160** receives a preamble **170**, a header **172**, and a clear to send (CTS) field **174**. The header **172** and/or within the CTS field **174** include a CTS duration **178**.

[0058] In response to the CTS field **174**, the first protocol module generates another preamble **178** and another header field **180**. In this embodiment, the header field **180** includes a PLP length **182**, which is allocated to the second protocol module for second protocol transmissions **188** via assertion of permission **184** and a subsequent de-assertion of permission **186**. In this example, the shared communication medium is still allocated to the first protocol module after de-assertion of access to the second protocol module such that the first protocol module may transmit **190** because the time allocated to the second protocol module and indicated in the PLCP length **182** was less than the time indicated in the CTS field **174**.

[0059] **FIG. 9C** is similar to **FIG. 9B**, with the exception that the entire duration of access to the shared communication medium as indicated in the CTS field **174** is granted to the second protocol module.

[0060] **FIG. 9D** illustrates a variation to the allocation of access to the shared communication medium. In **FIG. 9D**, the first protocol module has access to the shared communication medium prior to access being passed to the second protocol module.

[0061] **FIG. 9E** illustrates another frame **200** that includes a preamble **202**, a header **204**, and a poll field **206**. This field may be constructed in accordance with a version of IEEE 802.11 and include an indication of a CF (contention free)+ Poll duration **208**, which provides an indication of a maximum allowed opportunity for shared medium use on the part of the recipient. In this embodiment, the first protocol module of another transmitter which may or may not contain a second protocol function may transmit **210-1** followed by the transmission of another preamble **212** and a header **214** by the device which contains the first and second protocol functions. The header **214** indicates a PLCP length **182**, during which access to the shared communication medium is provided to the second protocol module for transmissions **188**. After the PLCP length **182** has ended, the first protocol module of the first transmitter may transmit **210-2** which may occur before the completion of the CF+POLL duration **208** time, provided that the recipient of the **210-1** has not employed all of the possible time allotted for transmissions by either the first or second protocol.

[0062] As one of ordinary skill in the art will appreciate, the term "substantially" or "approximately", as may be used herein, provides an industry-accepted tolerance to its corresponding term and/or relativity between items. Such an industry-accepted tolerance ranges from less than one percent to twenty percent and corresponds to, but is not limited to, component values, integrated circuit process variations, temperature variations, rise and fall times, and/or thermal noise. Such relativity between items ranges from a difference of a few percent to magnitude differences. As one of ordinary skill in the art will further appreciate, the term "operably coupled", as may be used herein, includes direct

coupling and indirect coupling via another component, element, circuit, or module where, for indirect coupling, the intervening component, element, circuit, or module does not modify the information of a signal but may adjust its current level, voltage level, and/or power level. As one of ordinary skill in the art will also appreciate, inferred coupling (i.e., where one element is coupled to another element by inference) includes direct and indirect coupling between two elements in the same manner as "operably coupled". As one of ordinary skill in the art will further appreciate, the term "compares favorably", as may be used herein, indicates that a comparison between two or more elements, items, signals, etc., provides a desired relationship. For example, when the desired relationship is that signal **1** has a greater magnitude than signal **2**, a favorable comparison may be achieved when the magnitude of signal **1** is greater than that of signal **2** or when the magnitude of signal **2** is less than that of signal **1**.

[**0063**] The preceding discussion has presented a method and apparatus for coordinating multiple protocols using a shared communication medium. As one of ordinary skill in the art will appreciate, other embodiments may be derived from the teachings of the present invention without deviating from the scope of the claims.

What is claimed is:

1. A method for coordinating multiple protocols using a shared communication medium, the method comprises:

determining, by a first protocol module, that a second protocol module desires access to the shared communication medium, wherein the second protocol module operates in accordance with a second protocol;

transmitting, by the first protocol module, at least a segment of a frame, wherein the at least the segment of the frame includes an indication of a duration that the shared communication medium will be accessed, wherein the frame is in accordance with a first protocol; and

handing-off, by the first protocol module, access of the shared communication medium to the second protocol module for at least a portion of the duration that the shared communication medium will be accessed such that the second protocol module has access to the shared communication medium with negligible interference from devices of the first protocol.

2. The method of claim 1, wherein the determining that the second module desires access to the shared communication medium comprises at least one of:

receiving a communication from the second protocol module indicating the desire to access the shared communication medium;

determining, on a periodic basis, that the second protocol module desires access based on an application supported by the second protocol module;

receiving from another protocol module that the second protocol module desires access to the shared communication medium; and

determining, on a random basis, that the second protocol module desires access to the shared communication medium.

3. The method of claim 1 comprises:

the transmitting the at least the segment of the frame including:

generating a preamble in accordance with the first protocol;

generating a header in accordance with the first protocol to include a frame length indication, wherein the frame length indication includes length of a data section of the frame; and

transmitting the preamble and the header as the at least the segment of the frame; and

the handing-off access to the shared communication medium including:

indicating, by the first protocol module, to the second protocol module that the shared communication medium is accessible for the duration corresponding to the length of the data section of the frame.

4. The method of claim 1 comprises:

the transmitting the at least the segment of the frame including:

transmitting a preamble, a header, and a request-to-send as the at least the segment of the frame to an access point in accordance with the first protocol;

receiving a second preamble, a second header, and a clear-to-send from the access point in accordance with the first protocol, wherein at least one of the request-to-send and the clear-to-send includes a network allocation vector that identifies the duration that the shared communication medium will be accessed and an indication of time sharing of the duration between the first protocol module and the second protocol module;

transmitting a third preamble and a third header, wherein the third header includes length of a data section of the frame that corresponds to the time sharing of the duration allocated to the second protocol module;

the handing-off the access to the shared communication medium including:

indicating, by the first protocol module, to the second protocol module that the shared communication medium is accessible for the duration corresponding to the length of the data section of the frame.

5. The method of claim 1 comprises:

the transmitting the at least the segment of the frame including:

receiving a preamble, a header, and a contention-free-poll from an access point in accordance with the first protocol, wherein the contention-free-poll includes a network allocation vector that identifies the duration that the shared communication medium will be accessed and an indication of time sharing of the duration between the first protocol module and the second protocol module;

transmitting a second preamble and a second header, wherein the second header includes length of a data section of the frame that corresponds to the time sharing of the duration allocated to the second protocol module;

the handing-off the access to the shared communication medium including:

indicating, by the first protocol module, to the second protocol module that the shared communication medium is accessible for the duration corresponding to the length of the data section of the frame.

6. The method of claim 1 comprises:

the shared communication medium including at least one of: a wired network connection and a wireless network connection; and

each of the first and second protocols including a version of at least one of: Ethernet, SONET, asynchronous transfer mode (ATM), frame relay, TCP/IP, advanced mobile phone services (AMPS), digital AMPS, global system for mobile communications (GSM), code division multiple access (CDMA), local multi-point distribution systems (LMDS), multi-channel-multi-point distribution systems (MMDS), Bluetooth, IEEE 802.11 (b), IEEE 802.11 (g), and IEEE 802.11 (n).

7. A multiple protocol communication device comprises:

transceiving module operably coupled to convert outbound signals into transmit signals and to convert receive signals into inbound signals in accordance with at least one of a first protocol and a second protocol, wherein the transmit signals and the receive signals are conveyed via a shared communication medium;

a first protocol module operably coupled to the transceiving module; and

a second protocol module operably coupled to the first protocol module and to the transceiving module, wherein the first protocol module functions to:

determine that the second protocol module desires access to the shared communication medium, wherein the second protocol module operates in accordance with a second protocol;

generate the outbound signals to include at least a segment of a frame, wherein the at least the segment of the frame includes an indication of a duration that the shared communication medium will be accessed, wherein the frame is in accordance with a first protocol; and

hand-off access of the shared communication medium to the second protocol module for at least a portion of the duration that the shared communication medium will be accessed such that the second protocol module has access to the shared communication medium with negligible interference from devices of the first protocol.

8. The multiple protocol communication device of claim 7, wherein the first protocol module determines that the second module desires access to the shared communication medium comprises at least one of:

receiving a communication from the second protocol module indicating the desire to access the shared communication medium;

determining, on a periodic basis, that the second protocol module desires access based on an application supported by the second protocol module;

receiving from another protocol module that the second protocol module desires access to the shared communication medium; and

determining, on a random basis, that the second protocol module desires access to the shared communication medium.

9. The multiple protocol communication device of claim 7, wherein the first protocol module further functions to:

generate the outbound signals by:

generating a preamble in accordance with the first protocol;

generating a header in accordance with the first protocol to include a frame length indication, wherein the frame length indication includes length of a data section of the frame; and

transmitting the preamble and the header as the at least the segment of the frame; and

hand-off access to the shared communication medium by:

indicating, by the first protocol module, to the second protocol module that the shared communication medium is accessible for the duration corresponding to the length of the data section of the frame.

10. The multiple protocol communication device of claim 7, wherein the first protocol module further functions to:

generate the outbound signals by:

generating a preamble, a header, and a request-to-send as the at least the segment of the frame to an access point in accordance with the first protocol;

receiving a second preamble, a second header, and a clear-to-send from the access point in accordance with the first protocol, wherein at least one of the request-to-send and the clear-to-send includes a network allocation vector that identifies the duration that the shared communication medium will be accessed and an indication of time sharing of the duration between the first protocol module and the second protocol module;

generating a third preamble and a third header, wherein the third header includes length of a data section of the frame that corresponds to the time sharing of the duration allocated to the second protocol module;

hand-off the access to the shared communication medium by:

indicating, by the first protocol module, to the second protocol module that the shared communication medium is accessible for the duration corresponding to the length of the data section of the frame.

11. The multiple protocol communication device of claim 7, wherein the first protocol module further functions to:

generate the outbound signals by:

receiving a preamble, a header, and a contention-free-poll from an access point in accordance with the first protocol, wherein the contention-free-poll includes a network allocation vector that identifies the duration that the shared communication medium will be accessed and an indication of time sharing of the duration between the first protocol module and the second protocol module;

generating a second preamble and a second header, wherein the second header includes length of a data

section of the frame that corresponds to the time sharing of the duration allocated to the second protocol module;

hand-off the access to the shared communication medium by:

indicating, by the first protocol module, to the second protocol module that the shared communication medium is accessible for the duration corresponding to the length of the data section of the frame.

12. The multiple protocol communication device of claim 7 comprises:

the shared communication medium including at least one of: a wired network connection and a wireless network connection; and

each of the first and second protocols including a version of at least one of: Ethernet, SONET, asynchronous transfer mode (ATM), frame relay, TCP/IP, advanced mobile phone services (AMPS), digital AMPS, global system for mobile communications (GSM), code division multiple access (CDMA), local multi-point distribution systems (LMDS), multi-channel-multi-point distribution systems (MMDS), Bluetooth, IEEE 802.11 (b), IEEE 802.11 (g), and IEEE 802.11 (n).

13. The multiple protocol communication device of claim 7, wherein the transceiving module comprises:

a first transceiving module operably coupled to the first protocol module; and

a second transceiving module operably coupled to the second protocol module.

14. An integrated circuit comprises:

transceiving module operably coupled to convert outbound signals into transmit signals and to convert receive signals into inbound signals in accordance with a first protocol, wherein the transmit signals and the receive signals are conveyed via a shared communication medium; and

a first protocol module operably coupled to the transceiving module, wherein the first protocol module includes an interface to a second protocol module and wherein the first protocol module functions to:

determine that the second protocol module desires access to the shared communication medium, wherein the second protocol module operates in accordance with a second protocol;

generate the outbound signals to include at least a segment of a frame, wherein the at least the segment of the frame includes an indication of a duration that the shared communication medium will be accessed, wherein the frame is in accordance with a first protocol; and

hand-off access of the shared communication medium to the second protocol module for at least a portion of the duration that the shared communication medium will be accessed such that the second protocol module has access to the shared communication medium with negligible interference from devices of the first protocol.

15. The integrated circuit of claim 14, wherein the first protocol module determines that the second module desires access to the shared communication medium comprises at least one of:

receiving a communication from the second protocol module indicating the desire to access the shared communication medium;

determining, on a periodic basis, that the second protocol module desires access based on an application supported by the second protocol module;

receiving from another protocol module that the second protocol module desires access to the shared communication medium; and

determining, on a random basis, that the second protocol module desires access to the shared communication medium.

16. The integrated circuit of claim 14, wherein the first protocol module further functions to:

generate the outbound signals by:

generating a preamble in accordance with the first protocol;

generating a header in accordance with the first protocol to include a frame length indication, wherein the frame length indication includes length of a data section of the frame; and

transmitting the preamble and the header as the at least the segment of the frame; and

hand-off access to the shared communication medium by:

indicating, by the first protocol module, to the second protocol module that the shared communication medium is accessible for the duration corresponding to the length of the data section of the frame.

17. The integrated circuit of claim 14, wherein the first protocol module further functions to:

generate the outbound signals by:

generating a preamble, a header, and a request-to-send as the at least the segment of the frame to an access point in accordance with the first protocol;

receiving a second preamble, a second header, and a clear-to-send from the access point in accordance with the first protocol, wherein at least one of the request-to-send and the clear-to-send includes a network allocation vector that identifies the duration that the shared communication medium will be accessed and an indication of time sharing of the duration between the first protocol module and the second protocol module;

generating a third preamble and a third header, wherein the third header includes length of a data section of the frame that corresponds to the time sharing of the duration allocated to the second protocol module;

hand-off the access to the shared communication medium by:

indicating, by the first protocol module, to the second protocol module that the shared communication

medium is accessible for the duration corresponding to the length of the data section of the frame.

18. The integrated circuit of claim 14, wherein the first protocol module further functions to:

generate the outbound signals by:

receiving a preamble, a header, and a contention-free-poll from an access point in accordance with the first protocol, wherein the contention-free-poll includes a network allocation vector that identifies the duration that the shared communication medium will be accessed and an indication of time sharing of the duration between the first protocol module and the second protocol module;

generating a second preamble and a second header, wherein the second header includes length of a data section of the frame that corresponds to the time sharing of the duration allocated to the second protocol module;

hand-off the access to the shared communication medium by:

indicating, by the first protocol module, to the second protocol module that the shared communication medium is accessible for the duration corresponding to the length of the data section of the frame.

19. The integrated of claim 14 comprises:

the shared communication medium including at least one of: a wired network connection and a wireless network connection; and

each of the first and second protocols including a version of at least one of: Ethernet, SONET, asynchronous transfer mode (ATM), frame relay, TCP/IP, advanced mobile phone services (AMPS), digital AMPS, global system for mobile communications (GSM), code division multiple access (CDMA), local multi-point distribution systems (LMDS), multi-channel-multi-point distribution systems (MMDS), Bluetooth, IEEE 802.11 (b), IEEE 802.11 (g), and IEEE 802.11 (n).

20. The integrated circuit of claim 14 comprises:

the second protocol module; and

the transceiving module including:

a first transceiving module operably coupled to the first protocol module; and

a second transceiving module operably coupled to the second protocol module.

* * * * *