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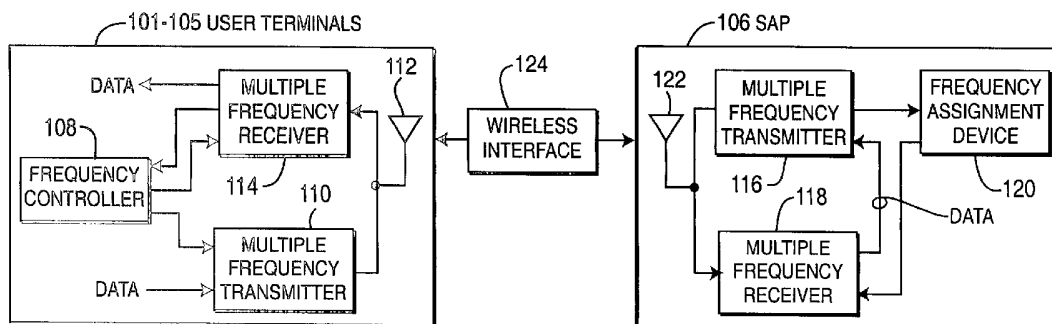
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For two-letter codes and other abbreviations, refer to the "Guid-
ance Notes on Codes and Abbreviations" appearing at the begin-
ning of each regular issue of the PCT Gazette.

(54) Title: METHOD FOR PERFORMING WIRELESS SWITCHING



(57) Abstract: A wireless LAN (WLAN) system for communications among a plurality of users (101-105) within a basic service system or cell comprising a switching access point (SAP) (106) for transmitting (116) and receiving (118) point-to-multipoint communications to and from the users. A plurality of ports are available at the SAP, each of which assigned to a unique carrier frequency for isolating communications among the users to prevent collisions, with the ability of frequency assignment to be non-permanent, and a capability of dynamic or pseudo-random carrier assignment. An alternative embodiment of the SAP uses beamforming to provide spatial ports for assignments to the plurality of users.

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METHOD FOR PERFORMING WIRELESS SWITCHING

FIELD OF INVENTION

[0001] The present invention relates to a Wireless LAN system (WLAN) with several users connected. More particularly, switching of WLAN systems for avoiding collisions.

BACKGROUND

[0002] WLAN systems make use of the unlicensed bands for wireless communication. Transmissions of a wireless LAN (WLAN) communication system may be from a particular terminal to a desired destination, either another terminal within the same Basic Service System (BSS) or the backbone network, but always within the same carrier. There are two modes of operation for WLAN systems: ad-hoc and infrastructure. In the ad-hoc mode, terminals can talk to each other in a multipoint-to-multipoint fashion. In the infrastructure mode, an access point (AP) acts as a base station to control the transmissions among users, thus providing a point-to-multipoint wireless network. Since all the users share the same medium in a WLAN, the infrastructure mode becomes more efficient for semi-heavy to heavy loaded networks.

[0003] In an infrastructure mode, the terminal first communicates with the AP when sending data to a desired destination terminal. The AP in turn bridges or routes the information to the desired destination. Thus, in this mode, an AP of a WLAN communication system controls the transmissions within a BSS or cell.

[0004] Medium Access Control (MAC) protocols are defined to coordinate the channel usage for WLAN users sharing the band. These MAC protocols are based upon avoiding collisions between users as several users access the channel at the same time. The efficiency of a protocol is gauged by successful avoidance of collisions.

[0005] Two protocols used by WLAN are CSMA/CA MAC and CSMA/CD Ethernet protocol. Both protocols can sense the carrier for other transmissions. An Ethernet can be connected in various manners, including Ethernet hubs and Ethernet switches. An Ethernet hub concentrates the connections in a central point as a point-to-multipoint connection, with no impact on performance. An

Ethernet switch operates every time that there is a packet arrival from a terminal. The switch reads the destination address, learns on which port it is connected and makes a direct connection between the two physical ports. The advantage of the Ethernet switch is that the MAC does not sense any other user in the medium, which improves performance through reduced probability of collisions and enhanced throughput as compared to an Ethernet hub. An Ethernet hub forwards a received packet to all users, even when there is only one intended receiver. The hub does not look at address information. The Ethernet switch only sends the packet directly to the intended destination, resulting in a more efficient usage of the available bandwidth.

[0006] A common WLAN AP is not capable of using more than one carrier frequency at the same time, which results in low protocol efficiency. Ethernet switches have proven to improve the efficiency of the Ethernet protocol considerably.

[0007] Therefore, what is needed is a method for improving the performance of a wireless point-to-multipoint network when the terminals share the same medium.

SUMMARY

[0008] A wireless LAN (WLAN) system for communications among a plurality of users within a basic service system or cell comprising a switching access point (SAP) for transmitting and receiving point-to-multipoint communications to and from the users. A plurality of ports are available at the SAP, each of which assigned to a unique carrier frequency for isolating communications among the users to prevent collisions, with the ability of frequency assignment to be non-permanent, and a capability of dynamic or pseudo-random carrier assignment. An alternative embodiment of the SAP uses beamforming to provide spatial ports for assignments to the plurality of users.

BRIEF DESCRIPTION OF THE DRAWING(S)

[0009] FIG. 1A shows a system diagram of a WLAN with frequency carrier Ethernet ports.

[0010] FIG. 1B shows a simplified diagram of a user terminal and a switching access point using frequency carrier Ethernet ports.

[0011] FIG. 2A shows a system diagram of a WLAN with spatial beam Ethernet ports.

[0012] FIG. 2B shows a simplified diagram of a user terminal and a switching access point using spatial beam Ethernet ports.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0013] FIG. 1A shows a system that applies the Ethernet switch principle to an access point (AP), allowing multi-frequency operation, so that the AP becomes a Switching Access Point (SAP) 106. Frequency carriers f1-f5 are treated as different ports in the SAP, from which user terminals 101-105 have centralized access to frequency carriers f1-f5 in a controlled manner.

[0014] As shown in FIG. 1A, each user terminal 101-105 is assigned to a frequency carrier f1-f5 and SAP 106 is capable of receiving and transmitting each carrier f1-f5. In order to avoid permanent assignment of carriers f1-f5 to each user terminal 101-105, two approaches may be used. In the preferred embodiment, it is desirable, although not essential, to not permanently assign carriers to user terminals 101-105. A non-permanent assignment avoids assigning a frequency to a terminal not sending data. When there are more terminals than available frequencies, a terminal that has data to send can be prevented from doing so if the terminal permanently assigned to a frequency is not using it.

[0015] A dynamic carrier assignment (DCA) scheme can be applied, in which user terminals 101-105 send a request-to-send (RTS) in a shared carrier and then the SAP replies with a clear-to-send (CTS) indicating the carrier that can be used for the transmission.

[0016] Alternatively, a frequency hopping scheme may be used, in which user terminals 101-105 have a pseudo-random sequence for changing carriers, known a priori by user terminals 101-105 and SAP 106, to minimize the probability of two user terminals simultaneously using the same carrier. For a preferred WLAN developed according to the current 802.11b standard, three

carriers are used for frequency hopping. For the 802.11a standard, eight carriers are used for frequency hopping. Wireless switching system 100 may employ DCA and frequency hopping either separately or combined.

[0017] FIG. 1B is an illustration of a preferred user terminal and SAP using multiple frequencies. The SAP 106 has a frequency assignment device 120 for assigning frequencies (frequency ports) to the user terminals 101-105. A multiple frequency receiver 118 receives data sent by the terminals 101-105 using the assigned frequency port. A multiple frequency transmitter 116 sends data from one terminal to another using the assigned frequency of the destination terminal. The multiple frequency transmitter 116 preferably also transmits the frequency assignment to the terminals 101-105. An antenna 122 or antenna array is used to send and receive data by the SAP 106 over the wireless interface 124.

[0018] The terminals 101-105 have a multiple frequency receiver 114 for receiving the frequency assignment and recovers the transmitted data over the terminal's assigned frequency. A frequency controller 108 uses the received assigned frequencies to control the transmission and reception frequencies of the terminal 101-105. A multiple frequency transmitter 110 transmits the data over the assigned frequency.

[0019] FIG. 2A shows an alternative embodiment of wireless switching by assigning each user terminal 201-205 to a spatial port instead of a particular frequency. As shown in FIG. 2A, spatial beams b1-b5 are created by beamforming and can be used as ports to isolate user terminals 201-206 from each other. SAP 206 recognizes the destination address of each user terminal 201-205, and associates a beam to each address. SAP 206 is capable of receiving more than one beam at the same time.

[0020] FIG. 2B is an illustration of a preferred user terminal and SAP using spatial beams. The SAP 206 has a beam controller 220 for determining which beam (spatial port) is associated with a particular user. The controller 220 provides a beamforming transmitter 216 and a beamforming receiver 218 the beam information so that the appropriate spatial port is used for a given

terminal. An antenna array 214 is used to send and receive data over the wireless interface 222.

[0021] The terminals 201-205 have a beamforming receiver 210 for receiving transmitted data using an antenna array 212. A beamforming transmitter 208 is used to transmit data to the SAP 206 using the array 212.

[0022] Although the system configurations of FIGs. 1A, 1B, 2A and 2B show five user terminals, any number of user terminals may be used. The intent is to demonstrate and not to limit or restrict the scope of the system capabilities. The wireless switching systems of FIGs. 1A and 2A can be used separately or combined. To illustrate, user terminals 101-105 can be distinguished by a combination of spatial beam and frequency. The wireless switching systems of FIGs. 1A and 2A can be applied to systems including, but not limited to, direct sequence (DS) WLAN and orthogonal frequency division multiplexing (OFDM) WLAN systems.

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CLAIMS

What is claimed is:

1. A wireless LAN (WLAN) system for communications among a plurality of users within a basic service system or cell, comprising:

a switching access point (SAP) for transmitting and receiving point-to-multipoint communications to and from the users; and

a plurality of ports, each of which assigned to a unique carrier frequency for isolating communications among the users to prevent collisions;

wherein said assignment of frequencies is not permanent, and instead has capability of dynamic or pseudo-random carrier assignment.

2. The system of claim 1 wherein said not permanent assignment is the dynamic carrier assignment which is achieved by request-to-send signals from the users and clear-to-send signals from the SAP.

3. The system of claim 1 wherein said clear-to-send signals indicate a frequency assigned to the users.

4. The system of claim 1 wherein said clear-to-send signals indicate a pseudo-random carrier assignment to the users.

5. The system of claim 1 whereby said pseudo-random carrier assignment is achieved by frequency hopping of the users along a sequence of changing carriers, said sequence known a priori by the users and the SAP.

6. A wireless LAN (WLAN) system for communications among a plurality of users within a basic service system or cell, comprising:

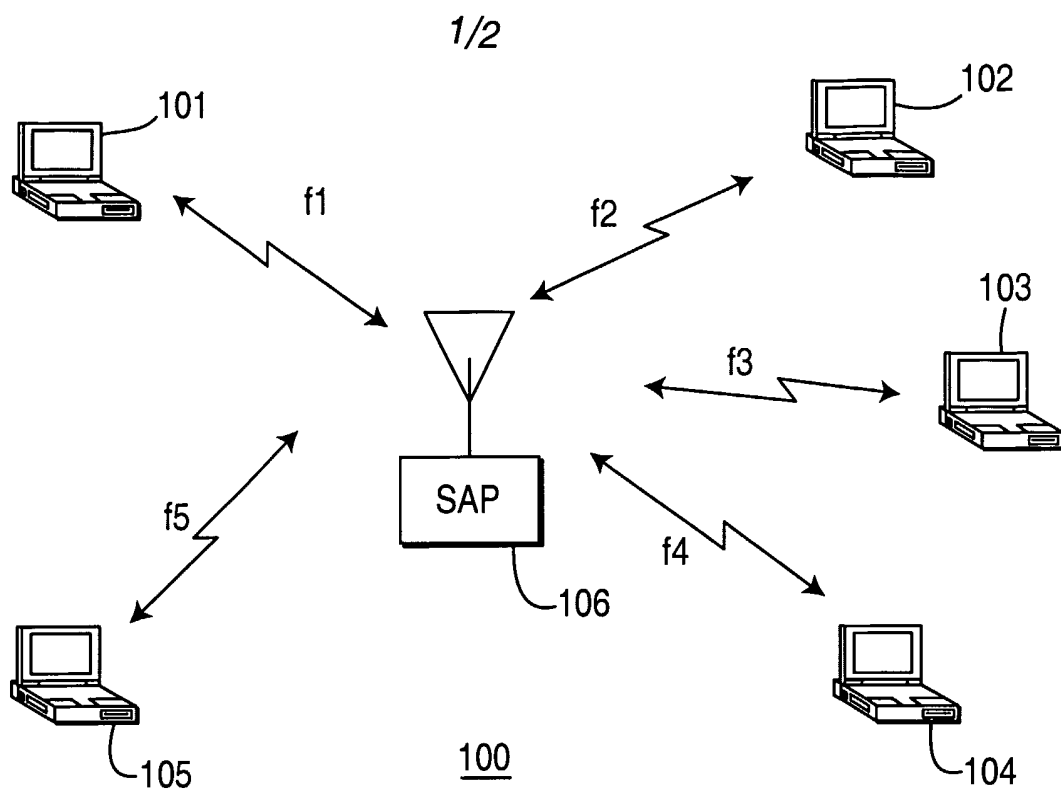
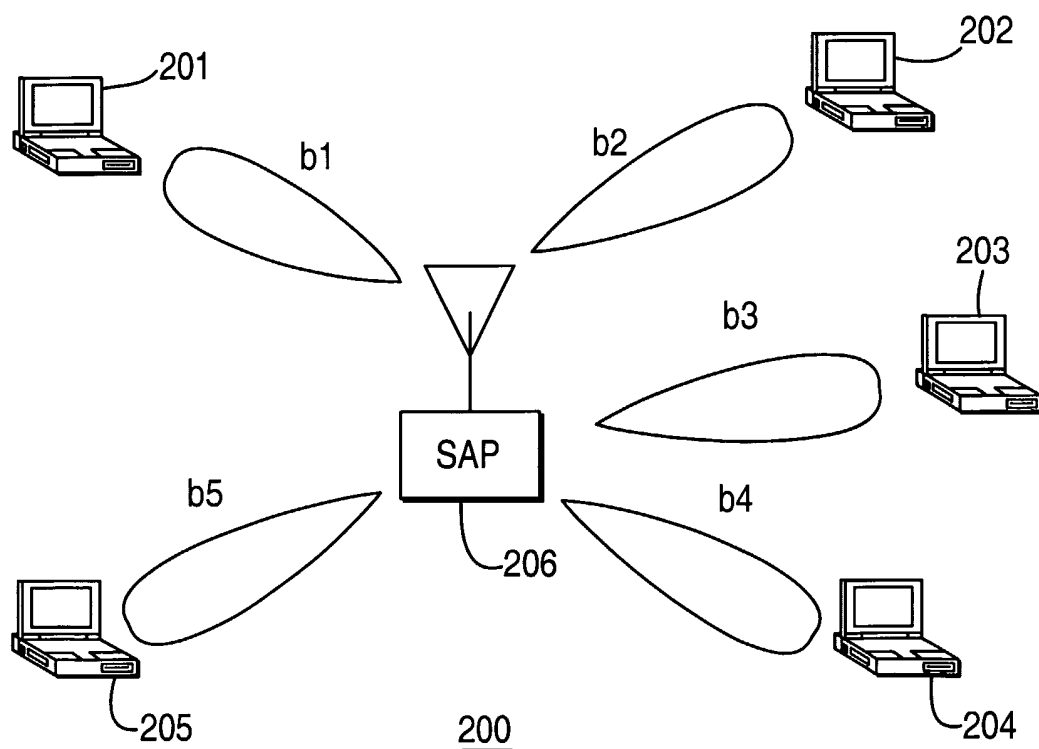
a switching access point (SAP) for transmitting and receiving point-to-multipoint communications to and from the users; and

a plurality of ports, each of which assigned to a unique spatial beam for isolating communications among the users to prevent collisions;
wherein the SAP receives more than one spatial beam at once.

7. The system of claim 4 wherein beamforming is used to create said spatial ports.

8. A wireless LAN (WLAN) user terminal comprising:
a multiple frequency transmitter for transmitting a request-to-send message and for transmitting data over an assigned transmit carrier;
a multiple frequency receiver for receiving a clear-to-send signal over a first frequency and for receiving data over an assigned receive carrier; and
a frequency controller, operatively coupled to the multiple frequency receiver, for determining the assigned transmit and the assigned receive carrier of the user terminal using the received clear-to-send signal.

9. The WLAN user terminal of claim 8 wherein the clear-to-send signal indicating a pseudo-random transmit and receive carrier assignment.

**FIG. 1A****FIG. 2A**

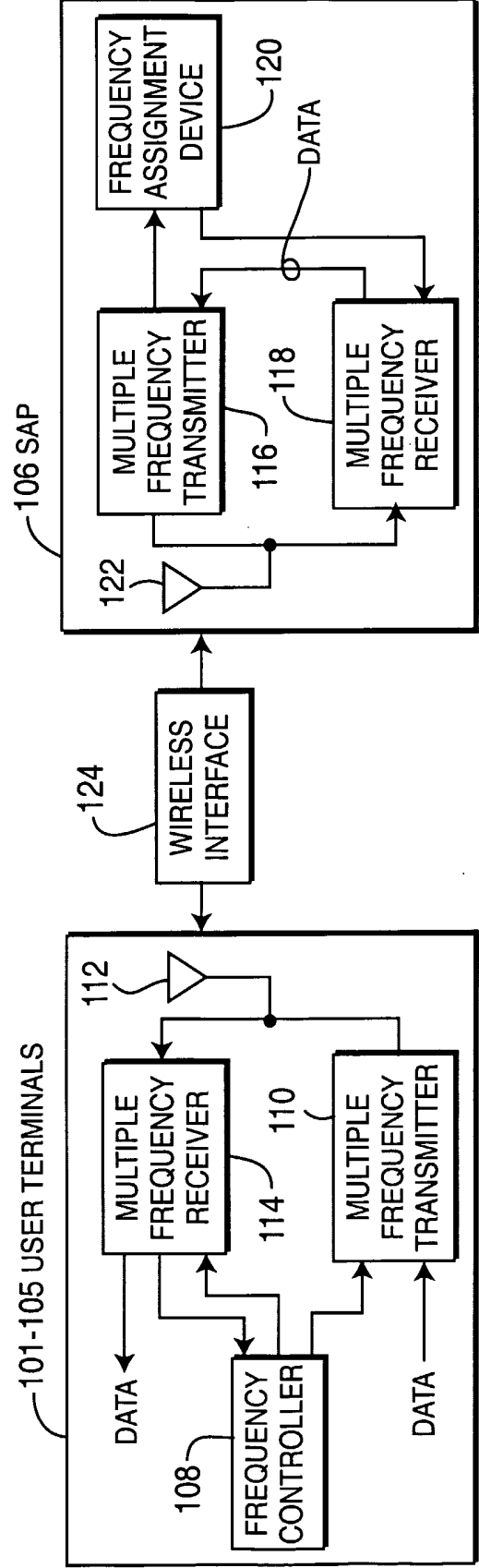


FIG. 1B

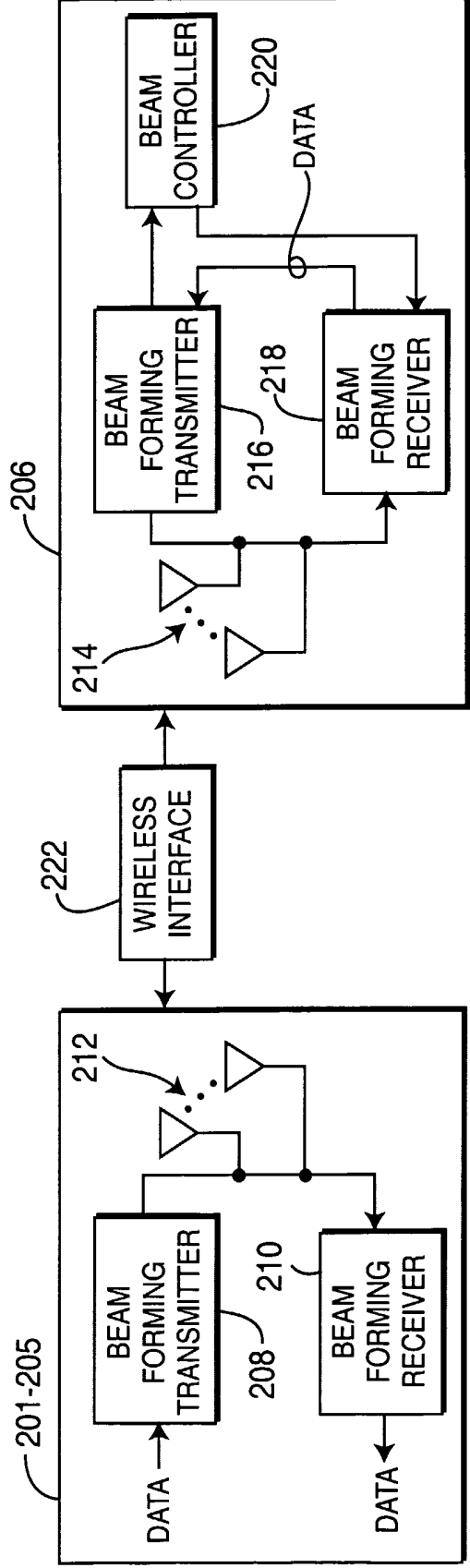


FIG. 2B

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US03/20823

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : G06F 15/177, 15/173; H04B 1/713 ; H04Q 7/00, 7/20; H04J 1/00

US CL : 709/221,238,244; 375/132; 370/330,343,480; 455/447,63.3

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 709/221,238,244; 375/132; 370/330,343,480; 455/447,63.3

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2001/0022805 A1 (DABAK et al) 20 September 2001 (20.09.2001), paragraphs 5, 15, 17.	1-9
Y	US 2001/0030988 A1 (FRY) 18 October 2001 (18.10.2001), paragraphs 9, 28-29, 42-45.	1-9
Y	US 5,933,420 A (JASZEWSKI et al) 03 August 1999 (03.08.1999), column 7, lines 8-35; column 3 line 43 - column 4 line 48.	1-5, 8-9
Y	US 5,781,536 A (AHMADI et al) 14 July 1998 (14.07.1998), column 7, lines 17-47; column 8 line 34 - column 9 line 46; column 5 line 65 - column 6 line 52; column 2, lines 7-11.	1-9

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

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