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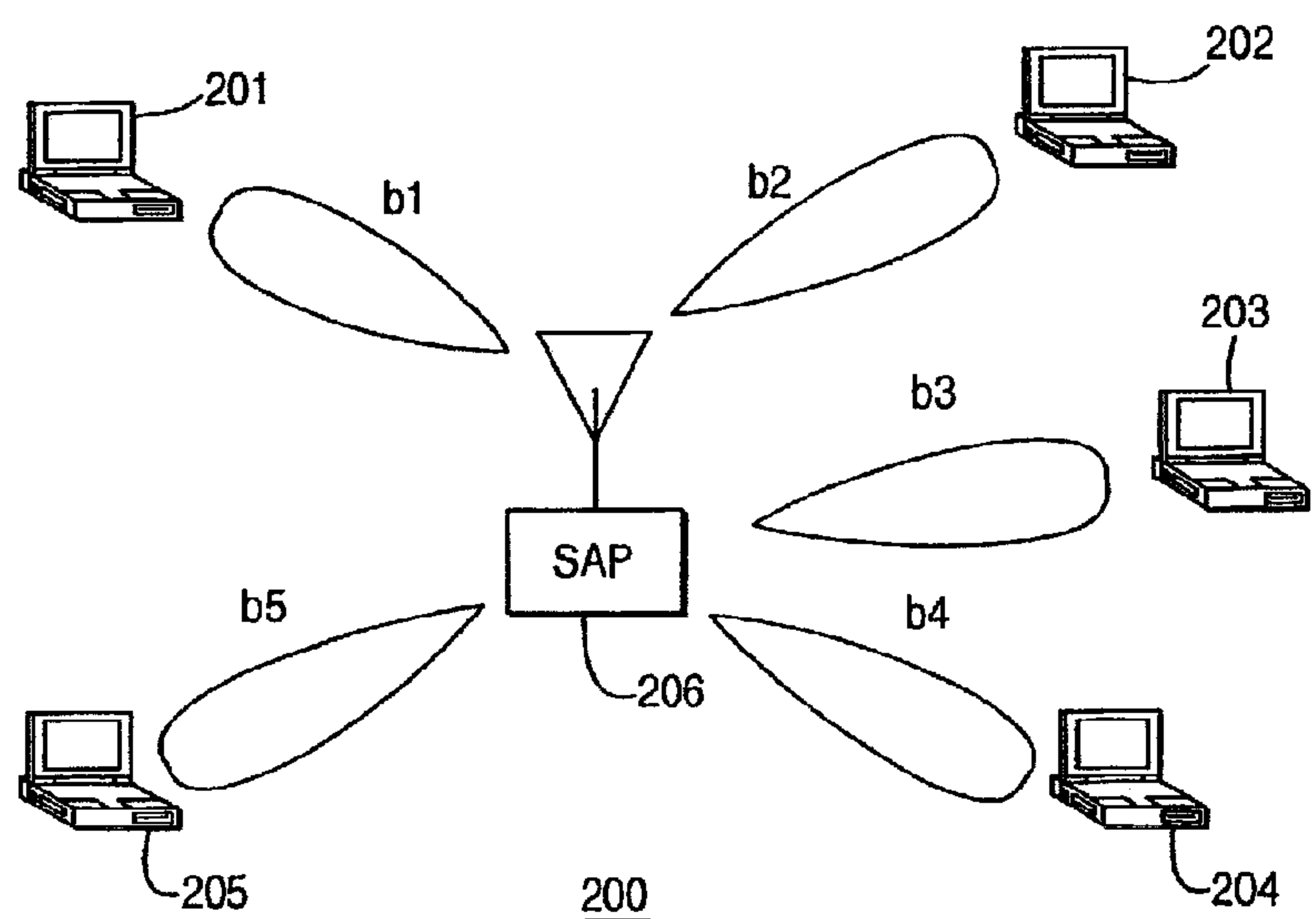

(57) Abrégé/Abstract:
A wireless LAN (WLAN) system for communications among a plurality of users within a basic service system or cell comprising a switching access point (SAP) for transmitting and receiving point-to-multipoint communications to and from the users. A plurality of ports are available 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.

ABSTRACT

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.

TITLE OF THE INVENTION

METHOD FOR PERFORMING WIRELESS SWITCHING

This application is a divisional of Canadian Patent Application Serial Number 2,689,852, which in turn is a divisional of Canadian Patent Application Serial No. 2,491,631 filed internationally on July 2, 2003 and which entered the Canadian national phase on January 4, 2005.

FIELD OF THE INVENTION

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

BACKGROUND OF THE INVENTION

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.

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.

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.

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.

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.

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 OF THE INVENTION

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.

In accordance with an aspect of the present disclosure, there is provided a wireless LAN (WLAN) user terminal comprising a transmitter configured to transmit a request-to-send message and data over an assigned unique combination of spatial port and transmit carrier; a receiver configured to receive a clear-to-send signal and data over an assigned unique combination of spatial beam and receive carrier; and a controller, operatively coupled to the receiver, for determining the assigned transmit carrier and the assigned receive carrier of the user terminal using the received clear-to-send signal.

In accordance with another aspect of the present disclosure, there is provided a method implemented by a wireless LAN (WLAN) user terminal, the method comprising transmitting a request-to-send message and data over an assigned unique combination of spatial port and transmit carrier; receiving a clear-to-send signal and data over an assigned unique combination of spatial beam and receive carrier; and determining the assigned transmit carrier and the assigned receive carrier of the user terminal using the received clear-to-send signal.

In accordance with yet another aspect of the present disclosure, there is provided a method for wireless communication by a switching access point (SAP), the method comprising: transmitting point-to-multipoint communications to a plurality of user terminals; receiving communications from the plurality of user terminals; assigning an SAP port to each user terminal; defining a unique combination of a carrier frequency and a spatial beam to each SAP port for isolating communications with the user terminals to prevent collisions; and using a dynamic or pseudo-random carrier assignment.

BRIEF DESCRIPTION OF THE DRAWINGS

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

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

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

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

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.

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.

A dynamic carrier assignation (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.

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.

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.

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.

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.

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.

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.

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.

WHAT IS CLAIMED IS:

1. A wireless user terminal comprising:

a receiver configured to receive a plurality of orthogonal frequency division multiplexing (OFDM) signals on at least one downlink carrier frequency, wherein each of the plurality of OFDM signals includes carrier frequency assignment information indicating an uplink carrier frequency and spatial pattern information indicating an uplink spatial pattern to transmit uplink data, wherein the uplink carrier frequency indicated in the carrier frequency assignment information and the uplink spatial pattern indicated in the spatial pattern information dynamically change over the plurality of OFDM signals;

a transmitter configured to transmit a plurality of uplink signals each responsive to a respective OFDM signal of the plurality of OFDM signals, wherein each uplink signal is transmitted on the uplink carrier frequency and using the uplink spatial pattern indicated, respectively, in the carrier frequency assignment information and the spatial pattern information of the respective OFDM signal of the plurality of OFDM signals to which the uplink signal is responsive; and

at least one processor cooperatively coupled to the receiver and the transmitter, the at least one processor is configured to dynamically change the uplink carrier frequency of the transmitter for transmitting the plurality of uplink signals according to the carrier frequency assignment information received over the plurality of OFDM signals, and

wherein the at least one processor is configured to dynamically change the uplink spatial pattern of the transmitter for transmitting the plurality of uplink signals according to the spatial pattern information received over the plurality of OFDM signals.

2. The wireless user terminal of claim 1, wherein the transmitter is further configured to transmit an indication that the wireless user terminal has data to transmit, and an OFDM signal of the plurality of OFDM signals is received in response to the indication.

3. A method comprising:

receiving, by a wireless user terminal, a plurality of orthogonal frequency division multiplexing (OFDM) signals on at least one downlink carrier frequency, wherein

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each of the plurality of OFDM signals includes carrier frequency assignment information indicating an uplink carrier frequency and spatial pattern information indicating an uplink spatial pattern to transmit uplink data, wherein the uplink carrier frequency indicated in the carrier frequency assignment information and the uplink spatial pattern indicated in the spatial pattern information dynamically change over the plurality of OFDM signals; and

transmitting, by the wireless user terminal, a plurality of uplink signals each responsive to a respective OFDM signal of the plurality of OFDM signals, wherein each uplink signal is transmitted on the uplink carrier frequency and using the uplink spatial pattern indicated, respectively, by the carrier frequency assignment information and the spatial pattern information of the respective OFDM signal of the plurality of OFDM signals to which the uplink signal is responsive,

dynamically changing, by the wireless user terminal, the uplink carrier frequency for transmitting the plurality of uplink signals according to the carrier frequency assignment information received over the plurality of OFDM signals; and

dynamically changing, by the wireless user terminal, the uplink spatial pattern for transmitting the plurality of uplink signals according to the spatial pattern information received over the plurality of OFDM signals.

4. The method of claim 3, further comprising:

transmitting, by the wireless user terminal, an indication that the wireless user terminal has data to transmit; and

receiving, by the wireless user terminal, an OFDM signal of the plurality of OFDM signals in response to the indication.

5. An infrastructure device comprising:

a transmitter configured to transmit a plurality of orthogonal frequency division multiplexing (OFDM) signals on at least one downlink carrier frequency, wherein each of the plurality of OFDM signals includes carrier frequency assignment information indicating an uplink carrier frequency and spatial pattern information indicating an uplink spatial pattern to receive uplink data;

at least one processor configured to dynamically change the uplink carrier frequency indicated in the carrier frequency assignment information over the plurality of OFDM signals, and dynamically change the uplink spatial pattern indicated in the spatial pattern information over the plurality of OFDM signals; and

a receiver configured to receive a plurality of uplink signals each responsive to a respective OFDM signal of the plurality of OFDM signals, wherein each uplink signal is received on the uplink carrier frequency and having the uplink spatial pattern indicated, respectively, by the carrier frequency assignment information and the spatial pattern information of the respective OFDM signal of the plurality of OFDM signals to which the uplink signal is responsive.

6. The infrastructure device of claim 5, wherein the receiver is further configured to receive an indication that a wireless user terminal has data to transmit, and the transmitter is further configured to transmit an OFDM signal of the plurality of OFDM signals in response to the indication.

7. The wireless user terminal of claim 1, wherein the transmitter is further configured to assign a carrier frequency to receive an OFDM signal of the plurality of OFDM signals.

8. The method of claim 3, further comprising:

assigning, by the wireless user terminal, a carrier frequency to receive an OFDM signal of the plurality of OFDM signals.

9. The wireless user terminal of claim 1, wherein the receiver is further configured to receive the plurality of OFDM signals sequentially over time on a plurality of different downlink carrier frequencies.

10. The method of claim 3, further comprising:

receiving the plurality of OFDM signals sequentially over time on a plurality of different downlink carrier frequencies.

11. The infrastructure device of claim 5, wherein the transmitter is further configured to transmit the plurality of OFDM signals sequentially over time on a plurality of different downlink carrier frequencies.

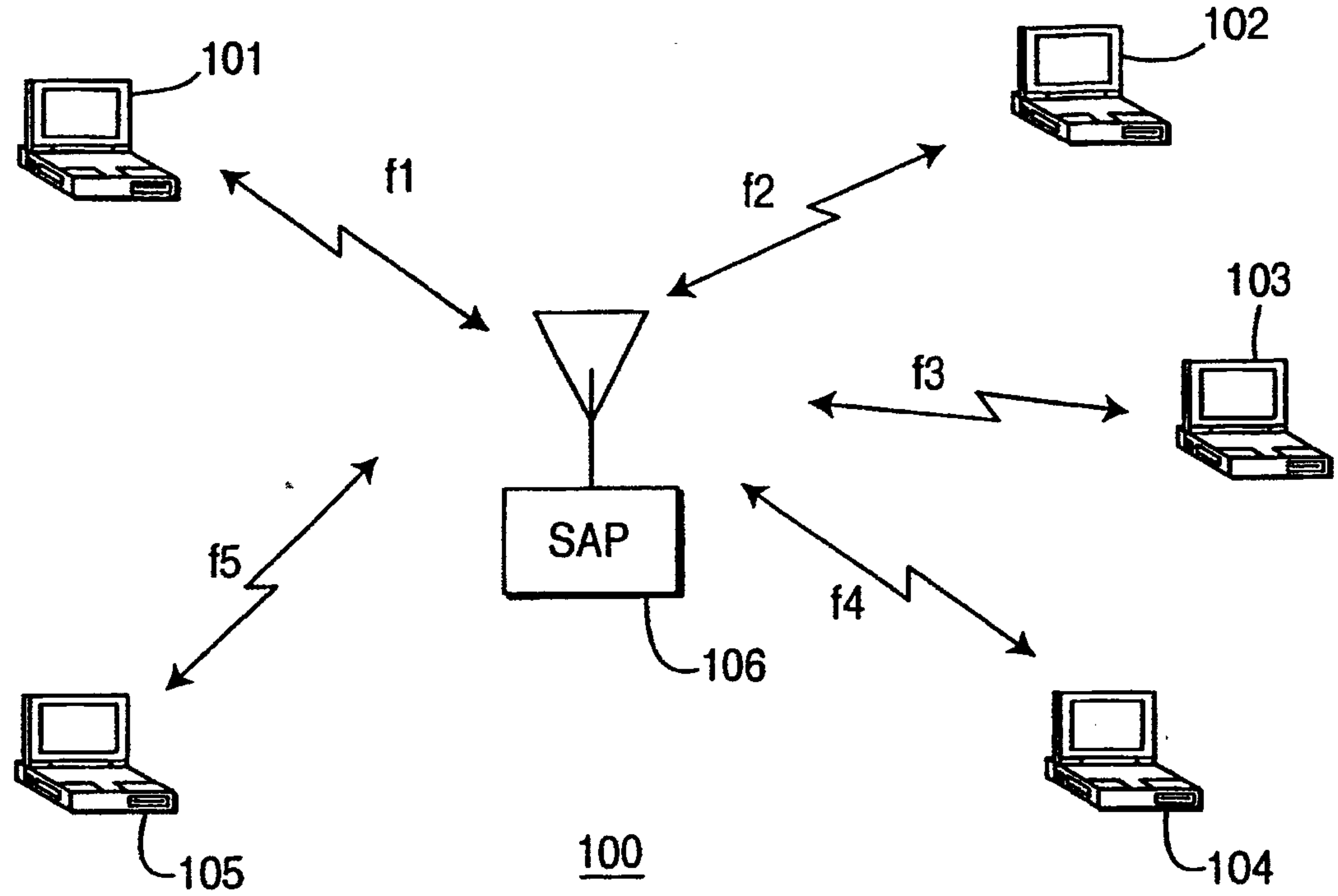

101
102
103
104
105
106
f1
f2
f3
f4
f5
SAP
100

FIG. 1A

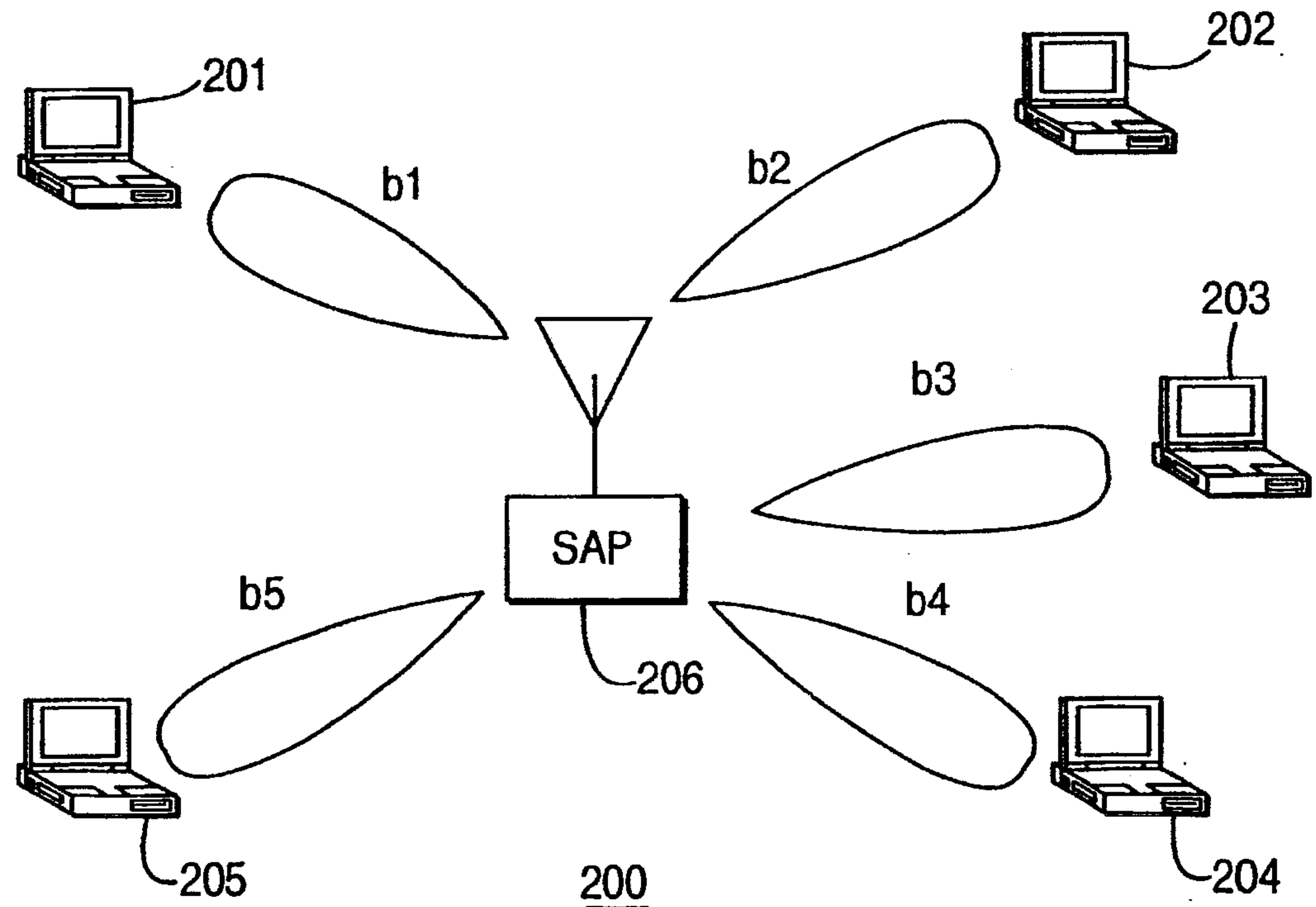

201
202
203
204
205
206
b1
b2
b3
b4
b5
SAP
200

FIG. 2A

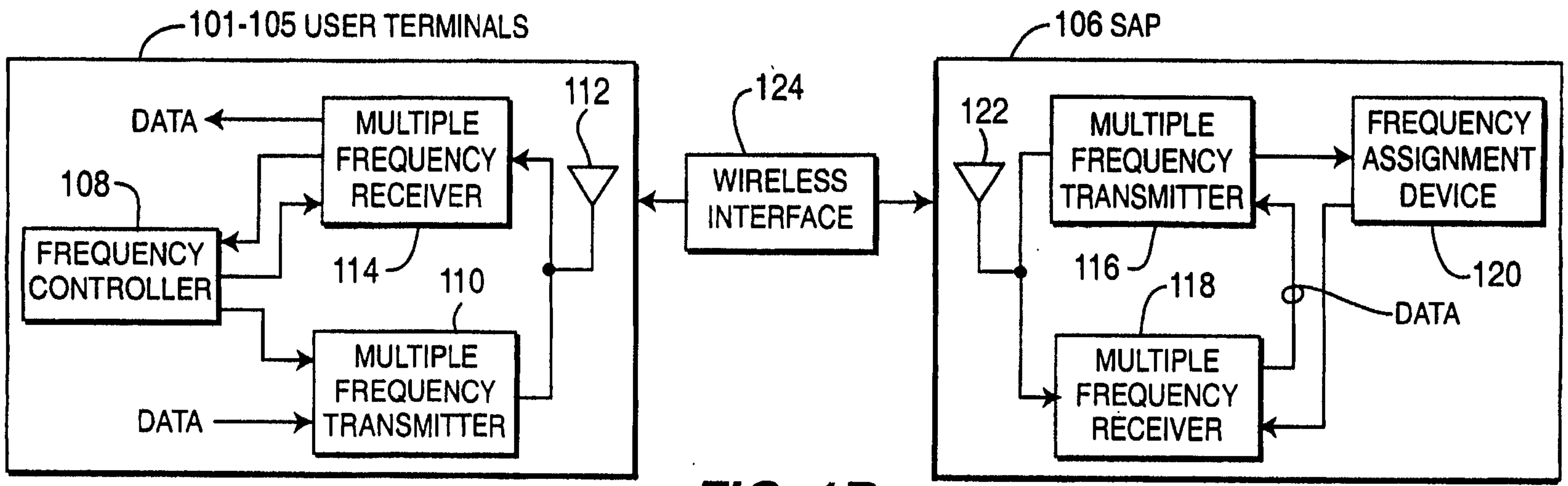

101-105 USER TERMINALS
DATA
MULTIPLE FREQUENCY RECEIVER
112
108
FREQUENCY CONTROLLER
114
110
MULTIPLE FREQUENCY TRANSMITTER
DATA
124
WIRELESS INTERFACE
106 SAP
122
MULTIPLE FREQUENCY TRANSMITTER
FREQUENCY ASSIGNMENT DEVICE
116
118
120
DATA
MULTIPLE FREQUENCY RECEIVER

FIG. 1B

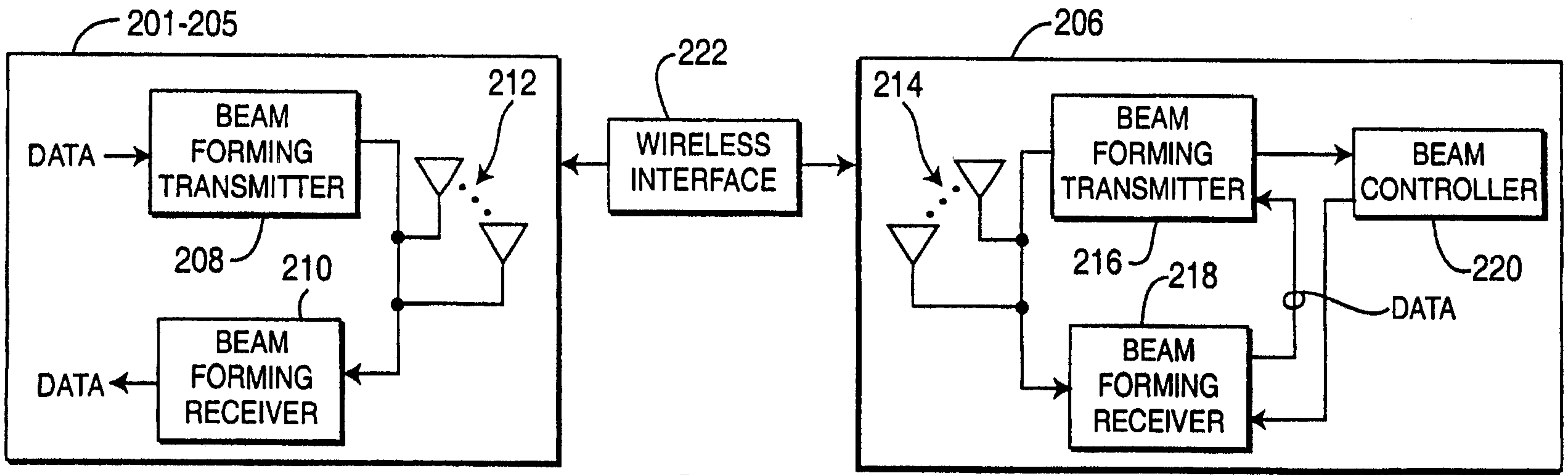
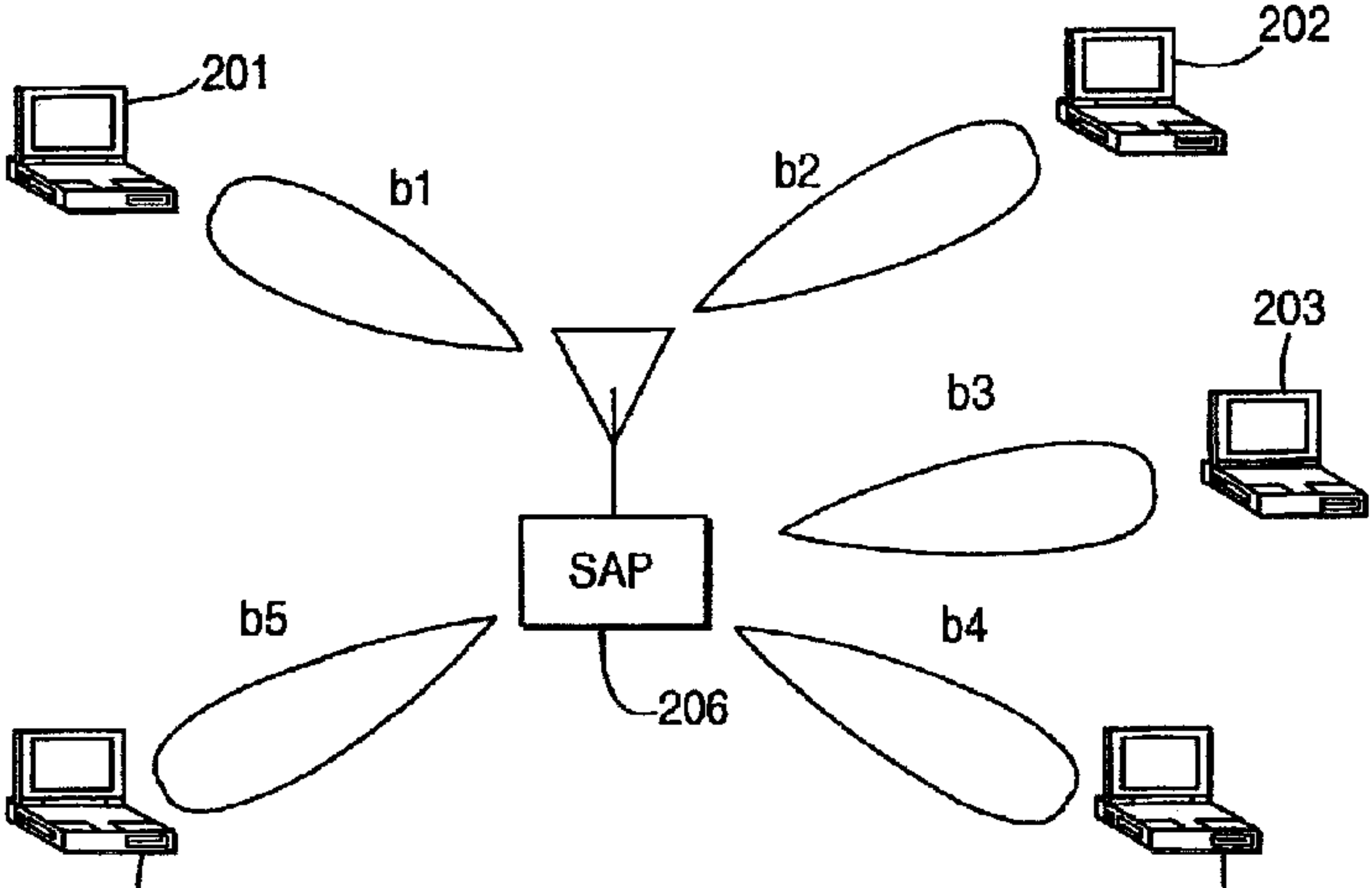

201-205
212
DATA
BEAM FORMING TRANSMITTER
208
210
DATA
BEAM FORMING RECEIVER
222
WIRELESS INTERFACE
206
214
BEAM FORMING TRANSMITTER
BEAM CONTROLLER
216
218
220
DATA
BEAM FORMING RECEIVER

FIG. 2B



200