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BACKGROUND

Digital audio players, such as MP3 players and iPods, that store and play digital audio files, are very popular. Such devices typically comprise a data storage unit for storing and playing the digital audio, and a headphone set that connects to the data storage unit, usually with a ~~1A"~~1/4'' or a 3.5 mm jack and associated cord. Often the headphones are in-ear type headphones. The cord, however, between the headphones and the data storage unit can be cumbersome and annoying to users, and the length of the cord limits the physical distance between the data storage unit and the headphones. Accordingly, some cordless headphones have been proposed, such as the Monster iFreePlay cordless headphones from Apple Inc., which include a docking port on one of the earphones that can connect directly to an iPod Shuffle. Because they have the docking port, however, the Monster iFreePlay cordless headphones from Apple are quite large and are not in-ear type phones. Recently, cordless headphones that connect wirelessly via IEEE 802.11 to a WLAN-ready laptop or personal computer (PC) have been proposed, but such headphones are also quite large and not in-ear type phones.

SUMMARY

In one general aspect, the present invention is directed to a wireless earphone that comprises a transceiver circuit for receiving streaming audio from a data source, such as a digital audio player or a computer, over an ad hoc wireless network. When the data source and the earphone are out of range via the ad hoc wireless network, they may transition automatically to a common infrastructure wireless network (e.g., a wireless LAN). If there is no common infrastructure wireless network for both the data source and the earphone, the earphone may connect via an available infrastructure wireless network to a host server. The host server may, for example, broadcast streaming audio to the earphone and/or transmit to the earphone a network address (e.g., an Internet Protocol (IP) address) for a network-connected content server that streams digital audio. The earphone may then connect to the content server using the IP address. The content server may be an Internet radio server, including, for example, an Internet radio server that broadcasts streaming audio from the data source or some other content.

These and other advantageous, unique aspects of the wireless earphone are described below.

FIGURES

Various embodiments of the present invention are described herein by way of example in conjunction with the following figures, wherein:

~~Figures 1A-1E~~FIGS. 1A-1E are views of a wireless earphone according to various embodiments of the present invention;

~~Figures~~FIGS. 2A-2D illustrate various communication modes for a wireless earphone according to various embodiments of the present invention;

~~Figure~~FIG. 3 is a block diagram of a wireless earphone according to various embodiments of the present invention;~~ Figures~~

FIGS. 4A-4B show the wireless earphone connected to another device according to various embodiments of the present invention;

~~Figure~~FIG. 5 is a diagram of a process implemented by a host server according to various embodiments of the present invention;

~~Figure~~FIG. 6 is a diagram of a process implemented by the wireless earphone to transition automatically between wireless networks according to various embodiments of the present invention;

~~Figures~~FIGS. 7, 8 and 10 illustrate communication systems involving the wireless earphone according to various embodiments of the present invention;

~~Figure~~FIG. 9 is a diagram of a headset including a wireless earphone and a microphone according to various embodiments of the present invention; and

~~Figure~~FIG. 11 is a diagram of a pair of wireless earphones with a dongle according to various embodiments of the present invention.

DESCRIPTION

In one general aspect, the present invention is directed to a wireless earphone that receives streaming audio data via ad hoc wireless networks and infrastructure wireless networks, and that transitions seamlessly between wireless networks. The earphone may comprise one or more in-ear, on-ear, or over-ear speaker elements. Two exemplary in-ear earphone shapes for the wireless earphone 10 are

shown in ~~Figures 1A~~FIGS. 1A and ~~1B~~1B, respectively, although in other embodiments the earphone may take different shapes and the exemplary shapes shown in ~~Figures 1A~~FIGS. 1A and ~~1B~~1B are not intended to be limiting. In one embodiment, the earphone transitions automatically and seamlessly, without user intervention, between communication modes. That is, the earphone may transition automatically from an ad hoc wireless network to an infrastructure wireless network, without user intervention. As used herein, an "ad hoc wireless network" is a network where two (or more) wireless-capable devices, such as the earphone and a data source, communicate directly and wirelessly, without using an access point. An "infrastructure wireless network," on the other hand, is a wireless network that uses one or more access points to allow a wireless-capable device, such as the wireless earphone, to connect to a computer network, such as a LAN or WAN (including the Internet).

~~Figures 1A~~FIGS. 1A and ~~1B~~1B show example configurations for a wireless earphone 10 according to various embodiments of the present invention. The examples shown in ~~Figures 1A~~FIGS. 1A and ~~1B~~1B are not limiting and other configurations are within the scope of the present invention. As shown in ~~Figures 1A~~FIGS. 1A and ~~1B~~1B, the earphone 10 may comprise a body 12. The body 12 may comprise an ear canal portion 14 that is inserted in the ear canal of the user of the earphone 10. ~~In~~In various embodiments, the body 12 also may comprise an exterior portion 15 that is not inserted into user's ear canal. The exterior portion 15 may comprise a knob 16 or some other user control (such as a dial, a pressure-activated switch, lever, etc.) for adjusting the shape of the ear canal portion 14. That is, in various embodiments, activation (e.g. rotation) of the knob 16 may cause the ear canal portion 14 to change shape so as to, for example, radially expand to fit snugly against all sides of the user's ear canal. Further details regarding such a shape-changing earbud earphone are described in application PCT/US08/88656, filed 31 ~~December~~Dec. 2008, entitled "Adjustable Shape Earphone," which is incorporated herein by reference in its entirety. The earphone 10 also may comprise a transceiver circuit housed within the body 12. The transceiver circuit, described further below, may transmit and receive the wireless signals, including receive streaming audio for playing by the earphone 10. The transceiver circuit may be housed in the exterior portion 15 of the earphone 10 and/or in the ear canal portion 14.

Although the example earphones 10 shown in ~~Figures 1A~~FIGS. 1A and ~~1B~~1B include a knob 16 for adjusting the shape of the ear canal portion 14, the present invention is not so limited, and in other embodiments, different means besides a knob 16 may be used to adjust the ear canal portion 14. In addition, in other embodiments, the earphone 10 may not comprise a shape-changing ear canal portion 14.

In various embodiments, the user may wear two discrete wireless earphones 10: one in each ear. In such embodiments, each earphone 10 may comprise a transceiver circuit. In such embodiments, the earphones 10 may be connected by a string or some other cord-type connector to keep the earphones 10 from being separated.

In other embodiments, as shown in ~~Figure~~FIG. 1C, a headband 19 may connect the two (left and right) earphones 10. The headband 19 may be an over-the-head band, as shown in the example of ~~Figure~~FIG. 1C, or the headband may be a behind-the-head band. In embodiments comprising a headband 19, each earphone 10 may comprise a transceiver circuit; hence, each earphone 10 may receive and transmit separately the wireless communication signals. In other embodiments comprising a headband 19, only one earphone 10 may comprise the transceiver circuit, and a wire may run along the headband 19 to the other earphone 10 to connect thereby the transceiver circuit to the acoustic transducer in the earphone that does not comprise the transceiver circuit. The embodiment shown in ~~Figure~~FIG. 1C comprises on-ear earphones 10; in other embodiments, in-ear or over-ear earphones may be used.

In other embodiments, the earphone 10 may comprise a hanger bar 17 that allows the earphone 10 to clip to, or hang on, the user's ear, as shown in the illustrated embodiment of ~~Figures 1D-1E. Figure 1D~~FIGS. 1D-1E. FIG. 1D is a perspective view of the earphone and ~~Figure 1E~~FIG. 1E is a side view according to one embodiment. As shown in the illustrated embodiment, the earphone 10 may comprise dual speaker elements 106-A, 106-B. One of the speaker elements (the smaller one) 106-A is sized to fit into the cavum concha of the listener's ear and the other element (the larger one) 106-B is not. The listener may use the hanger bar to position the earphone on the listener's ear. In that connection, the hanger bar may comprise a horizontal section that rests upon the upper external curvature of the listener's ear behind the upper portion of the auricula (or pinna). The earphone may comprise a knurled knob that allows the user to adjust finely the distance between the horizontal section of the hanger bar and the speaker elements, thereby providing, in such embodiments, another measure of adjustability for the user. More details regarding such a dual element, adjustable earphone may be found in ~~United States~~U.S. provisional patent application ~~Serial~~Ser. No. 61/054,238, which is incorporated herein by reference in its entirety.

~~Figures~~FIGS. 2A-2D illustrate various communication modes for a wireless data communication system involving the earphone 10 according to embodiments of the present invention. As shown in ~~Figure 2A~~FIG. 2A, the system comprises a data source 20 in communication with the earphone 10 via an ad hoc wireless network 24. The earphone 10, via its transceiver circuit (described in more detail below), may communicate wirelessly with a data source 20, which may comprise a wireless network adapter 22 for transmitting the digital audio wirelessly. For example, the data source 20 may be a digital audio player (DAP), such as an mp3 player or an iPod, or any other suitable digital audio playing device, such as a laptop or personal computer, that stores and/or plays digital audio files. In other embodiments, the data source 20 may generate analog audio, and the wireless network adapter 22 may encode the analog audio into digital format for transmission to the earphone 10.

The wireless network adapter 22 may be an integral part of the data source 20, or it may be a separate device that is connected to the data source 20 to provide wireless connectivity for the data source 20. For example, the wireless network adapter 22 may comprise a wireless network interface card (WNIC) or other suitable transceiver that plugs into a USB port or other port or jack of the data source 20 (such as a TRS connector) to stream data, e.g., digital audio files, via a wireless network (e.g., the ad hoc

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