A DEDICATED DIGITAL-TO-ANALOG NETWORK AUDIO BRIDGING METHOD AND SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to the field of data networking. More specifically, the present invention relates to a dedicated digital-to-analog network audio bridging system.

2. Background Information

Rendering audio and even music on a personal computer (PC) is known in the art. In the past, computers contained a single internal speaker which was used to notify users of various system alerts through one or more audible beeps or tones. Early computer games would string together multiple beeps and tones in an attempt to simulate music through such a primitive speaker. As PC technology advanced, expansion cards dedicated to producing more robust audio sound effects and music within PCs became commonplace. Nowadays, audio expansion cards, or "sound cards" as they are known, are quite sophisticated and may even include various dedicated electronic components such as memory and audio processors to generate high-quality audio within a PC.

Most PC sound cards typically contain output ports through which audio from a PC may be directed by way of cables to one or more external pairs of speakers. Due to a variety of factors, external speakers are typically better equipped to produce high-quality sound than are standard issue internal PC speakers and are therefore more often desired as a source of audio output for PCs. In addition to

external speakers, the PC audio may also be connected to high-quality external amplification and/or digital signal processing components to produce a variety of desired effects. In fact, with the popularity of computer-based compact disc (CD) and digital video/versatile disc (DVD) players, as well as the popularity of realistic computer games and the ability to play digital music data files on PCs, the impetus for users to connect their PCs to home stereo systems is greater than ever.

Unfortunately, however, it is all together too common for a PC to be located in one area of a house (e.g. home office), and a stereo and/or high quality speaker system to be located in a second area of the house (e.g. family room) remote from the first area. Given such a configuration, a user typically has very few options regarding how to route the computer audio output through the home stereo.

Firstly, a user may opt to move the PC into the family room where the stereo/speaker system is located, or conversely, the user may opt to move the stereo/speaker system from the family room into the home office where the PC is located. This, however, may prove to be impractical given the designated uses of the two rooms. For example, the stereo/speaker system may have been part of a combined audio/visual entertainment system located in the family room. Similarly, the PC may have been used as a business computer serving multiple functions including for example, that of facsimile machine connected to a dedicated phone line located in the office.

Secondly, a user may resort to connecting very long cables between the PC and the stereo/speaker system. Not only might such a connection scheme be

awkward and unsightly, the audio quality may suffer due to attenuation of the analog audio signal caused by the length of the cables.

Lastly, a user may obtain a second PC for use near the stereo system within the family room. Not only is this an expensive proposition, it still does not solve the problem audio from the office PC being played through the stereo/speaker system.

SUMMARY OF THE INVENTION

A digital-to-analog audio bridge is disclosed. The digital-to-analog audio bridge includes a network interface to receive digital audio data transmitted over a network from a remote audio host, a processor coupled with the network interface to identify which one of a plurality of coding schemes the received digital audio data has been encoded with, and decode the encoded digital audio data based upon the identified coding scheme. The digital-to-analog audio bridge further includes a converter coupled to the processor to convert the received digital audio data to analog audio for use by a proximately located loudspeaker.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be more fully understood from the detailed description given below and from the accompanying drawings of various embodiments of the invention, which, however, should not be taken to limit the invention to the specific embodiments, but are for explanation and understanding only.

Figure 1 is a block diagram illustrating a network environment in which the present invention may be practiced.

Figure 2 is a block diagram illustrating one embodiment of a home-based network in which the present invention may be practiced.

Figure 3 illustrates one embodiment of a hardware system suitable for use as an audio host.

Figure 4 is a flow diagram illustrating the operation of an audio host according to one embodiment of the present invention.

Figure 5 illustrates a digital audio data packet formatted according to one embodiment of the present invention.

Figure 6 is a block diagram illustrating a dedicated digital-to-analog audio bridging device ("audio bridging device") according to one embodiment of the present invention.

Figure 7 is a flow diagram illustrating the operation of the audio bridging device according to one embodiment of the present invention.

DETAILED DESCRIPTION

In the following description, various aspects of the present invention will be described, and various details will be set forth in order to provide a thorough understanding of the present invention. However, it will be apparent to those skilled in the art that the present invention may be practiced with only some or all aspects of the present invention, and the present invention may be practiced without the specific details. In other instances, well known features are omitted or simplified in order not to obscure the present invention.

Parts of the description will be presented using terminology commonly employed by those skilled in the art to convey the substance of their work to others skilled in the art, such as receivers, transmitters and so forth. Also, parts of the description will also be presented in terms of operations performed through the execution of programming instructions, using terms such as determining, and so on. As well understood by those skilled in the art, these operations are often accomplished through storing, transferring, combining, or otherwise manipulating electrical, magnetic, and/or optical signals.

Various operations will be described as multiple discrete steps performed in turn in a manner that is most helpful in understanding the present invention. However, the order of description should not be construed as to imply that these operations are necessarily performed in the order they are presented, or even order dependent. Lastly, repeated usage of the phrase "in one embodiment" does not necessarily refer to the same embodiment, although it may.

A dedicated digital-to-analog network audio bridging system is described herein. In the system, a personal computer equipped with a network card is utilized to transmit digital audio data over a home-based data network using, for example, home telephone lines as the communication medium. A special purpose receiving device receives the transmitted digital audio data, decodes the digital audio data if necessary, and converts the digital audio data to analog audio for output to a home stereo and/or high quality speaker system.

Figure 1 is a block diagram illustrating a network environment in which the present invention may be practiced. A dedicated, home network enabled, digital-to-analog audio bridging device (hereinafter "audio bridging device") **100** of the present invention is connected with audio host **120** through home-based network **130** by way of communication links **117**. Additionally, audio bridging device **100** is shown connected with stereo system **105** and/or active speakers **110** via audio cables **103** and **107** respectively.

Internet **115** represents a combination of multiple conventional hardware components, including computer systems, routers, repeaters, gateways, and communications links spread throughout the world. The various components of Internet **115** interact to route data, referred to as "packets" or "datagrams", from one networked device, appliance, or computer system to another. Typically, each packet includes the payload data, a source address identifying the system which

initiated the packet, and a target or destination address identifying the address to which the packet is to be sent. Additional control information, such as a checksum, may also be included within the packet.

Home-based network **130** represents a local area network (LAN) including for example, a phoneline network, a powerline network, or some other wireline or wireless network capable of transporting data locally throughout a home, office, or similar structure. As with Internet **115**, various components of home-based network **130** interact to route data packets or datagrams from one networked device, appliance, or computer system to another.

Communications links **117** may be any of a wide range of conventional communications mediums and may differ depending upon the capabilities of the networked devices and/or computer systems connected therewith. For example, communication links **117** may represent one or more coaxial or fiber optic cables, or communication links **117** may represent one or more nonphysical mediums that transmit signals in the electromagnetic spectrum, such as infrared or radio frequency signals. In one embodiment of the present invention, audio bridging device **100** and audio host **120** are connected with each other via home-based network **130** which, in one embodiment of the present invention, represents a phoneline network.

Audio host **120** represents a device equipped to transmit data, including digital audio data, over one or more data networks (e.g. Internet **115** and/or home-based network **130**) to one or more destination devices. In one embodiment of the

present invention, audio host **120** is a general purpose computer equipped to operate as an audio server or digital jukebox whereby audio data is streamed across a network in digital form to a receiving device so as to achieve near real-time output as analog audio. In another embodiment, rather than streaming the digital audio data, audio host **120** may simply transmit digital audio files residing locally on audio host **120** to a receiving device for subsequent output as analog audio.

Audio bridging device **100** of the present invention represents a special purpose, audio rendering, network enabled device, other than a general purpose computer system, and without the overhead of a large operating system, that is equipped to receive digital audio data transmitted over a network. Audio bridging device **100** is further equipped to convert the received digital audio data into analog audio suitable for use with one or more devices capable of receiving audio input. Examples of such devices include various audio and video devices, such as a home or portable stereo system, an active (e.g. amplified) or passive (e.g. non-amplified) speaker system, a video cassette recorder, a television, and so forth. In one embodiment of the present invention, audio bridging device **100** receives digital audio data transmitted from audio host **120** over home network **130**, and converts the received digital audio data to analog audio suitable for use as input into stereo **105** or active speakers **110**.

Stereo system **105** represents a standard home stereo system and includes audio amplification unit **102**, speaker cable **104**, and passive speakers **106**. Amplification unit **102** represents an audio component equipped to amplify analog

audio signals provided by internal and external audio sources, and forward the amplified audio signals to one or more passive speakers **106** via speaker cable **104**. In one embodiment, amplification unit **102** amplifies analog audio signals received from audio bridging device **100**. Amplification unit **102** may similarly amplify audio signals provided by an internal or external AM/FM radio tuner or other components, for example.

Stereo system **105** is shown connected with audio bridging device **100** through connector cable **103**, however, other wire-based or wireless connection mechanisms may be utilized. In one embodiment, connector cable **103** is a relatively short audio connector cable having a length in the neighborhood of 3 to 6 feet, for example. Furthermore, although stereo system **105** is depicted as including a single audio component (e.g. amplification device **102**), additional audio and even video components may be included without departing from the spirit and scope of the invention. Similarly, audio bridging device **100** may be connected to active speakers **110** through connector cable **107** rather than, or in addition to stereo system **105**. Various components or functions of stereo system **105** and/or active speakers **110** may be combined with that of audio bridging device **100** to form a multi-functional device contained within a single housing.

Figure 2 is a block diagram illustrating one embodiment of a home-based network in which the present invention may be practiced. In one embodiment of the present invention, network **230** is a phoneline network (according to HomePNA

Specification 2.0, published December 1999, available from the Home Phoneline Networking Alliance "HomePNA" Internet web site at http:\\www.homepna.org). In other embodiments, however, phoneline network **230** may be replaced by any of the various home-based and non home-based wireline, wireless, baseband, and broadband data communications mediums known in the art. Examples of such data communications mediums include for example, powerline networks, HomeRF networks, Ethernet networks, asynchronous transfer mode (ATM) networks, integrated services digital networks (ISDN & B-ISDN), Infrared networks, BLUETOOTH™ networks, IEEE 802.11 compliant networks (IEEE 802.11 standard - available from the IEEE Standards Department, Copyright Information, 445 Hoes Lane, P. O. Box 1331, Piscataway, NJ 08855-1331), and so forth.

Although various physical network communication mediums may be implemented with respect to the present invention, for purposes of clarity, only a home-based phoneline network implementation will be discussed. In accordance with the present invention, phoneline network **230** represents a data transport medium that utilizes standard home telephone wiring to route data between various network ports **225**. In one embodiment, network ports **225** represent standard RJ-11 modular telephone jacks. Phoneline networks provide the distinct advantage of enabling data communication between multiple devices over an arbitrary topology of unterminated wires, not originally intended to transmit data. In one embodiment, phoneline network **230** employs the IEEE 802.3 standard (IEEE 802.3 standard - published in 1996 and available from the IEEE Standards Department, Copyright

Information, 445 Hoes Lane, P. O. Box 1331, Piscataway, NJ 08855-1331) which specifies the carrier sense multiple access/collision detect (CSMA/CD) protocol for multiple access to a common communication medium.

Phoneline network **230** is connected with publicly switched telephone network (PSTN) **218** through line terminal **219**, and may optionally be connected with Internet **215** as well. Line terminal **219** provides a connection point through which the various legs of phoneline network **230** can be connected to a central office of PSTN **218**.

Various devices are shown connected to phoneline network **230** via network ports **225**, including computing device **260**, telephones **265** and **266**, audio host **120**, and audio bridging device **100** of the present invention. Computing device **260** represents a general purpose computer system and telephones **265** and **266** represent standard telephone devices, all of which are capable of communicating over phoneline network **230**. It should be appreciated, however, that computing device **260**, and telephones **265** and **266** are optional and may be omitted.

Audio host **120** of Figure 2 is substantially similar to audio host **120** of Figure 1. In Figure 2, audio host **120** is connected with phoneline network **230** and may optionally be connected with Internet **215** through a direct connection such as for example, a cable "MODEM", a satellite link, a digital subscriber line (DSL), and the like. In accordance with the teachings of the present invention, audio host **120** operates to transmit digital audio data from a first location (e.g. home office **235**) to second location (e.g. family room **237**) utilizing existing phoneline network **230**. In

one embodiment, audio host **120** is equipped to transmit digital audio data encoded according to a plurality of audio encoding schemes including, for example, moving picture experts group - audio level 3 (MP3) encoding, windows audio file (WAV) encoding, UNIX audio (AU) encoding, audio interchange file format (AIFF/IEF) encoding, etc. In one embodiment, audio host **120** is equipped to execute application **221** which represents any one of a variety of readily available audio "jukebox" applications, such as for example, RealJukebox™ available from RealNetworks, Inc., of Seattle, Washington.

In one embodiment, audio host **120** transmits digital audio data stored within an internal storage device **222**, whereas in other embodiments audio host **120** may transmit digital audio data received from an external data storage device or external network such as Internet **215**. Audio host **120** may encapsulate digital audio data for network transmission according to one of a plurality of network transmission protocols including, but not limited to the Transmission Control Protocol/Internet Protocol (TCP/IP) and the User Datagram Protocol/Internet Protocol (UDP/IP), both known in the art. In one embodiment, audio host **120** utilizes UDP/IP in conjunction with a streaming protocol such as the real-time transport protocol ("RTP" as defined in Request for Comments 1889, published January 1996, and available at http://www.rfc-editor.org) to enable dynamic audio streaming across phoneline network **230**. In one embodiment of the present invention, audio host **120** operates to transmit and/or stream digital audio data to a single receiving device, such as for example audio bridging device **100**, whereas in other embodiments, audio host **120**

may utilize IP multicast to transmit and/or stream digital audio data to multiple recipients.

By transmitting such digital audio data over a network to a destination device such as audio bridging device **100**, it is possible to render digital audio, including music and sound effects, in a remote location with minimal human intervention and without the need for additional network wiring other than, for example, preexisting telephone cables. Likewise, because such audio data is transmitted in digital form to the remote location prior to being converted to analog audio, audio signal loss due to attenuation is also minimized.

Figure 3 illustrates one embodiment of a hardware system suitable for use as audio host **120** described herein. In the illustrated embodiment, hardware system **300** includes processor **302** and cache memory **304** coupled to each other as shown. Additionally, hardware system **300** includes high performance input/output (I/O) bus **306** and standard I/O bus **308**. Host bridge **310** couples processor **302** to high performance I/O bus **306**, whereas I/O bus bridge **312** couples the two buses **306** and **308** to each other. Coupled to bus **306** are system memory **314**, and video memory **316**. In turn, display device **318** is coupled to video memory **316**. Coupled to bus **308** is mass storage device **320**, keyboard and pointing device **322**, I/O ports **326**, and network interface **324**. Collectively, these elements are intended to represent a broad category of hardware systems, including but not limited to general purpose computer systems based on the

PENTIUM® processor, PENTIUM® II processor, or PENTIUM® III processor manufactured by Intel Corporation of Santa Clara, California.

Network interface **324** is used to provide communication between system **300** and any of a wide range of conventional networks, including phoneline network **230**. It is to be appreciated that the circuitry of interface **324** may vary depending upon the type of network the system **300** is being coupled to. In one embodiment, network interface **324** is a 21145 phoneline/Ethernet LAN controller available from Intel Corporation of Santa Clara, California.

Mass storage **320** is used to provide permanent or extended storage for data and programming instructions to perform the functions described herein, whereas system memory **314** is used to provide temporary storage for the data and programming instructions when executed by processor **302**.

I/O ports **326** represent one or more serial and/or parallel communication ports used to provide communication between additional peripheral devices which may be coupled to hardware system **300**.

It is to be appreciated that various components of hardware system **300** may be re-arranged. For example, cache **304** may be on-chip with processor **302**. Alternatively, cache **304** and processor **302** may be packed together as a "processor module", with processor **302** being referred to as the "processor core". Furthermore, certain implementations of the present invention may not require nor include all of the above components. For example, mass storage **320**, keyboard and pointing device **322**, and/or display device **318** and video memory **316** may not

be included in system **300**. Additionally, the peripheral devices shown coupled to standard I/O bus **308** may be coupled to high performance I/O bus **306**. In addition, in some implementations only a single bus may exist with the components of hardware system **300** being coupled to the single bus. Furthermore, additional components may be included in system **300**, such as additional processors, storage devices, or memories.

In one embodiment, the elements of the present invention are implemented as a series of software routines run by hardware system **300** of Figure 3. These software routines comprise a plurality or series of instructions to be executed by a processor in a hardware system, such as processor **302** of Figure 3. Initially, the series of instructions are stored on a storage device, such as mass storage **320**. It is to be appreciated that the series of instructions can be stored on any conventional storage medium, such as a diskette, CD-ROM, magnetic tape, DVD, ROM, etc. It is also to be appreciated that the series of instructions need not be stored locally, and could be received from a remote storage device, such as a server on a network, via network interface **324**.

The instructions are copied from the storage device, such as mass storage **320**, into memory **314** and then accessed and executed by processor **302**. In one implementation, these software routines are written in the C++ programming language. It is to be appreciated, however, that these routines may be implemented in any of a wide variety of programming languages. In alternative embodiments, the present invention may be implemented in discrete hardware or firmware. For

example, an application specific integrated circuit (ASIC) could be programmed with the above described functions of the present invention.

Figure 4 is a flow diagram illustrating the operation of audio host **120** according to one embodiment of the present invention. Applications **410** represent multiple software applications that may be executed by audio host **120**. Applications **410** include any of a variety of audio and video applications known in the art to cause digital audio data to be played within a computer system. Such digital audio data may be processed by an on-board audio processor in conjunction with one or more dynamically linked libraries and/or device drivers. In one embodiment, applications **410** include an audio jukebox application capable of causing multiple digital data files of various formats including for example, MP3 audio data, to be played on audio host **120** through a sound card.

In Figure 4, digital audio output from applications **410** may be passed to processing interface **415**, and/or interceptor **420** by way of an application program interface (API) or a media control interface (MCI). In one embodiment, by selecting an option within a graphical user interface, a user may choose whether the digital audio output from applications **410** is to be played on local speaker **460**, transmitted across network **430**, or played locally *and* transmitted across network **430**. If a user selects for the digital audio output to be played on local speaker **460**, data path A may be followed. If, however, a user chooses to transmit the digital audio data output across network **430**, data path **B** may be followed to the exclusion of data

path A. Data paths A and B need not, however, be mutually exclusive and may both be followed depending upon specific implementations.

Processing interface **415** represents a system level interface, such as a dynamically linked library (DLL), used by applications **410** to process and/or decode the digital audio output by way of one or more function calls or CODECs, for example. In one embodiment, after being handled by processing interface **415**, decoded digital audio follows data path **C** as it is passed from processing interface **415** to device driver **417**. Device driver **417** communicates directly with sound card **419** and indirectly with local speaker **460**. It should be appreciated that the functionality of processing interface **415** and device driver **417** may be combined into a single interface. In an alternative embodiment, after being handled by processing interface **415**, digital audio output may follow data path **D** passing from processing interface **415** to interceptor **420**. It may be desirable for the digital audio output to follow data path **D** rather than data path **B**, such that the digital audio data gets decoded through processing interface **415** prior to being transmitted across network **430**. This may be desirable in the case where the receiving device is not equipped to decode the audio data. It should be noted that digital audio output may also be passed to processing interface **415** or device driver **417** after passing through interceptor **420**.

Interceptor **420** represents an interface that operates to effectively intercept the digital audio output from applications **410** and pass the data to network interface **425** where it may be encapsulated and transmitted across network **430**. Interceptor

420 may operate to temporarily or permanently re-route static or dynamic links that may point to processing interface 415, such that they point to interceptor 420. Similarly, interceptor 420 may establish a static or dynamic link back to processing interface 415.

Interceptor 420 further operates to identify whether the digital audio output is encoded according to one of a plurality of audio coding schemes. If the digital audio output is encoded, interceptor 420 operates to classify the particular encoding type and pass both the digital audio output along with the coding information to network interface 425. Network interface 425 operates to encapsulate and transmit the digital audio data across network 430. Depending upon the size of the data, network interface 425 may segment the data into multiple packets or datagrams prior to transmission. In one embodiment, the data is encapsulated according to the IEEE 802.3 and Internet protocols containing a variety of data sections and fields. In one embodiment, network interface 425 formulates data packets for transmission to a receiving device based upon previous communication with the receiving device.

Figure 5 illustrates a digital audio data packet formatted according to one embodiment of the present invention. Referring to Figure 5, digital audio packet 500 is divided into various network transmission sections including: Media Access Control (MAC) header section 505, Internet Protocol (IP) header section 510, UDP header section 515, and various audio sections including: digital audio data header section 520, and digital audio data payload section 530. MAC header 505 contains

the various data fields necessary to operate according to the IEEE 802.3 specification including, a network destination address, a network source address, and a data length field. IP header **510** contains the various data fields specified under RFC 1042, published February 1988, which addresses using IP over IEEE 802 networks. UDP header **515** contains various fields including a source port field, a destination port field, a data length field, and a checksum field.

In addition to the MAC, IP, and UDP header sections, the digital audio packet **500** also contains digital audio data header section **520**, and digital audio data payload section **530**. In one embodiment, digital audio data header section **520** contains version field **522** and sequence field **524**, whereas digital audio data payload section **530** contains encoded audio data. In one embodiment, the version field is used by a digital audio data transmitting source, such as audio host **120**, to indicate to a receiving device, such as audio bridging device **100**, which one of multiple audio encoding schemes was used to encode the associated digital audio data payload. In one embodiment, each supported audio encoding scheme is represented by an indicator code that may be referenced via a lookup table, for example. In one embodiment, sequence field **524** is used by audio host **120** to indicate an order according to which the digital audio data was segmented, and therefore an order according to which the data should be reconstructed once received by audio bridging device **100**.

Although various data field and header sections have been described with respect to the digital audio data packet of the present invention, it should be

apparent that a variety of other implementations are equally acceptable. For example, instead of digital audio packet **500** including a separate header section **520**, and data payload section **530**, the sections may be combined into a single section. Similarly, if TCP/IP is used as a transfer protocol, UDP header **515** may be replaced by an appropriate TCP header (not shown), and/or sequence field **524** may be omitted.

Figure 6 is a block diagram illustrating an audio bridging device according to one embodiment of the present invention. Audio bridging device **100** includes home-based network interface **610**, FIFO buffers **615** and **625**, embedded processor **620**, audio converter **630**, and memory device **640** coupled together as shown. Additionally, audio bridging device **100** is coupled with data input port **605**, and with audio output ports **632** and **633** as shown.

Home-based network interface **610** represents a communications interface through which network data is transmitted and received. Home-based network interface **610** represents a device further equipped to provide data communications across harsh networking environments such as home-based phoneline networks, powerline networks and/or HomeRF networks. In such home-based networks, as well as other less controlled harsh networking environments, it is sometimes difficult to distinguish noise or echo phenomenon caused by various environmental factors from another transmission source. For this reason, alternative networking approaches have been developed to address these harsh networking concerns.

One such approach can be found in U.S. Patent application no. <42390.P7044>, entitled "A Networking Method And Apparatus Using Silent Slots To Facilitate Transmission Collision Detection", filed _, and assigned to the corporate assignee of the present application. In one embodiment, the teachings of <42390.P7044> are implemented within home-based network interface **610**. In one embodiment, home-based network interface **610** is an IEEE 802.3 compliant interface supporting the CSMA/CD protocol. In one embodiment, home-based network interface **610** is an Intel 21145 phoneline/Ethernet LAN controller that supports communication over both Ethernet and phoneline networks.

FIFO buffers **615** and **625** are used to coordinate data exchange between the various devices shown in Figure 6. For example, after receiving network data, home-based network interface **610** writes the data to FIFO buffer **615** which subsequently asserts a not_empty signal indicating the presence of the data to embedded processor **620**. Once the not_empty signal is detected, embedded processor **620** reads the data from FIFO buffer **615** for processing. FIFO buffer **625** is connected between embedded processor **620** and is operationally similar to FIFO buffer **615**. It will be apparent to one skilled in the art, however, that one or both of FIFO buffers **615** and **625** may be included within any of the various devices shown in Figure 6, or may be omitted completely.

Embedded processor **620** represents one of various processing devices known in the art to process data, including for example a general or special purpose microprocessor or microcontroller that operates according to one of multiple

computing paradigms including, reduced instruction set computing (RISC), and complex instruction set computing (CISC). In one embodiment, embedded processor **620** is an ARM7 series embedded processor available from ARM Inc., of Los Gatos California. In one embodiment, embedded processor **620** is configured to perform a variety of operations on digital audio data received from home-based network interface **610**. As those skilled in the art will appreciate, by virtue of the dedicated nature of the audio bridging device, the embedded processor may be a relatively low cost, low processing power "microcontroller", and yet because it is not asked to undertake a variety of non-audio related tasks, it is nevertheless capable of bridging very high quality audio notwithstanding its limited processing capability.

Audio converter **630** represents a digital to analog (D-to-A) data converter to receive digital audio data processed by embedded processor **620**, and convert the digital audio data to analog audio for output through audio output ports **632** and **633**. In one embodiment, audio converter **630** is a TMS320VC5416 16-bit digital signal processor available from Texas Instruments Inc., of Dallas, Texas. As those skilled in the art will recognize, the functionality of audio converter **630** and embedded processor **620** may be combined within a single device.

Memory device **640** represents a non-volatile data storage device to hold instructions to be executed by embedded processor **620**. Memory device **640** may include any of the various read only memory (ROM) devices known in the art such as a programmable read-only memory (PROM), an electronically erasable programmable read-only memory (EEPROM), flash memory, and so forth. In one

embodiment of the present invention, audio bridging device **100** is equipped to receive additional instructions, data, and/or CODECs to replace or supplement information previously stored in memory device **640**. In one embodiment, audio bridging device **100** receives such data through home-based network interface **610**, whereas in another embodiment, audio bridging device **100** can receive such data by way of an additional input port (not shown) coupled to memory device **640**. In such a manner, audio bridging device **100** may be updated with new or improved audio CODECs or other data as necessary. Audio bridging device **100** can also include a volatile data storage device (not shown) such as random access memory (RAM), dynamic random access memory (DRAM), synchronous dynamic random access memory (SDRAM), and the like.

Figure 7 is a flow diagram illustrating the operation of audio bridging device **100** according to one embodiment of the present invention. Referring to Figure 7, with reference to Figure 6, home-based network interface **610** receives digital audio data transmitted across phoneline network **203** through data input port **605 (705)**. Upon receiving the digital audio data, home-based network interface **610** operates in a conventional manner to separate the various network transmission data (e.g. MAC, IP, and TCP or UDP headers) from the digital audio data (e.g. digital audio data header and digital audio data payload sections). Once the network data and digital audio data are separated, the digital audio data is passed to memory **640** which causes embedded processor **620** to be interrupted via data bus **615**. Once

the digital audio data has been passed to memory **640**, embedded processor **620** operates to identify whether the digital audio data has been encoded according to one of multiple audio or video coding schemes **(710)**. If embedded processor **620** identifies that the received digital audio data has been encoded, embedded processor **620** subsequently classifies which particular coding scheme was used **(715)**. In one embodiment, embedded processor **620** utilizes the earlier described indicator code **522** provided within the digital audio data packet to identify and classify the presence and type of data encoding. According to one embodiment of the present invention, once embedded processor **620** identifies that a particular encoding scheme was used, embedded processor **620** accesses memory device **640** or similar equipped memory device to retrieve an appropriate CODEC **(720)** with which the digital audio data is decoded **(725)**. In the case that the digital audio data is compressed, embedded processor **620** further operates to decompress the digital audio data. Once the digital data has been decoded and/or decompressed, or if the data was not encoded or compressed to begin with **(710)**, the digital audio data is passed to audio converter **630** where the digital audio data is then converted to analog audio **(730)**. Once the digital audio data has been converted to analog audio, the analog audio is passed through audio output ports **632** and **633 (735)**.

Thus a dedicated digital-to-analog audio bridging system has been described. Whereas many alterations and modifications of the present invention will no doubt become apparent to a person of ordinary skill in the art after having read

the foregoing description, it is to be understood that any particular embodiment shown and described by way of illustration is no way intended to be considered limiting. Therefore, references to details of various embodiments are not intended to limit the scope of the claims which in themselves recite only those features regarded as essential to the invention.

Claims

1. A method comprising:

receiving at an audio-rendering device, data comprising digital audio data transmitted across a network from a host;

determining whether the received digital audio data is encoded;

selecting a decoding scheme based on one of at least two coding schemes by which the received digital audio data is encoded, if the determining determines that the received digital audio data is encoded;

decoding the encoded digital audio data in accordance with the selected decoding scheme, if the determining determines that the received digital audio data is encoded; and

preparing the received digital audio data for output.

2. The method according to claim 1, wherein preparing the received digital audio data for output comprises converting the received digital audio data to analog audio for output.

3. The method according to claim 1, wherein determining whether the received digital audio data is encoded according to one of the at least two coding schemes comprises determining whether the received digital audio data is encoded according to coding schemes including mp3, way, au, and aiff.

4. The method according to claim 1, wherein receiving digital audio data comprises receiving a plurality of digital audio data segments and reconstructing the digital audio data from the received plurality of digital audio data segments.

5. The method according to claim 4, wherein determining whether the received digital audio data is encoded according to one of at least two coding schemes comprises identifying an indicator code included within at least one of the plurality of digital audio data segments.

6. The method according to claim 2, further comprising:

determining whether the received digital audio data is compressed; and

if the received digital audio data is determined to be compressed, then decompressing the compressed digital audio data based upon the selected decoding scheme.

7. The method according to claim 6, further comprising providing as output the analog audio to an amplification device.

8. The method of claim 1, wherein the digital audio data is received across at least one of a plurality of networks including a phoneline network, a powerline network, and a HomeRF network.

9. A special purpose audio-rendering device comprising:

a network interface to receive digital audio data transmitted over a network from an audio host;

a processor coupled with the network interface to:

determine whether the received digital audio data is compressed;

select a decoding scheme based on one of at least two coding schemes by which the received digital audio data is encoded, if the received digital audio data is determined to be compressed; and

decode the encoded digital audio data in accordance with the selected decoding scheme, if the received digital audio data is determined to be compressed; and

a converter coupled to the processor to convert the received digital audio data to analog audio for output.

10. The special purpose audio-rendering device according to claim 9, further comprising a read only memory coupled to the processor to store at least one CODEC.

11. A residential network audio system comprising:

a host device disposed in a first location to transmit digital audio data over a network;

an audio bridging device disposed in a second location, the audio bridging device communicatively coupled to the host device via the network to receive the digital audio data transmitted from the host device, to determine whether received digital audio data is encoded, to select a decoding scheme based on one of at least two coding

schemes by which the received digital audio data is encoded, to decode the received digital audio data in accordance with the selected decoding scheme, and to convert the received digital audio data to analog audio for output; and

stereo equipment communicatively coupled to the audio bridging device, the stereo equipment to amplify the analog audio.

12. The residential network audio system according to claim 11, wherein the network comprises a network including at least one of a phoneline network, a powerline network, and a HomeRF network.

13. The residential network audio system according to claim 11, wherein the audio bridging device is further disposed to:

determine whether the received digital audio data is compressed; and

decompress the compressed digital audio data in accordance with the selected decoding scheme.

14. The residential network audio system according to claim 11, wherein the digital audio data is transmitted according to the real-time transport protocol (RTP).

15. An article comprising a machine readable medium having a plurality of machine readable instructions stored thereon, that when executed by the machine, cause the machine to:

receive digital audio data;

determine whether the received digital audio data is encoded;

select a decoding scheme based on one of at least two coding schemes by which the received digital audio data is encoded, if the received digital audio data is, determined to be encoded;

decode the encoded digital audio data in accordance with the selected decoding scheme, if the received digital audio data is determined to be encoded; and

prepare the received digital audio data for output.

16. The article of claim 15, wherein receiving the digital audio data further comprises receiving the digital audio data transmitted across a local area network from a host device.

17. A method comprising:

providing an indication, within at least one of a plurality of data segments, whether digital audio data is encoded according to one of at least two audio coding schemes; and

transmitting the plurality of data segments across at least one of a plurality of networks including a home phoneline network, a powerline network, and a HomeRF network to an audio-rendering device.

18. The method according to claim 17, wherein providing the indication, within the at least one of the plurality of data segments, whether the digital audio data is encoded according to the one of the at least two audio coding schemes comprises providing an indicator code within the at least one of the plurality of data segments.

19. A method of claim 18, further comprising:

selecting the one of the two coding schemes based on the identified indicator code.

20. The method of claim 19, wherein selecting the one of the two coding schemes based on the identified indicator code comprises:

accessing a lookup table that includes entries for the at least two coding schemes;

comparing the identified indicator code to the entries in the lookup table; and

identifying an entry in the lookup table that corresponds to the indicator code,

wherein the entry is the coding scheme by which the received digital audio data is encoded.

21. The method of claim 15, wherein preparing the received digital audio data for output comprises converting the received digital audio data to analog audio for output.

22. The method of claim 2, wherein converting the received digital audio data to analog audio for output comprises converting the received digital audio data to analog audio for output to a speaker proximate the audio-rendering device.