'357 Patent	Edens, the Handbook and Sonos APA under 35 U.S.C. 103(a)
	sample) frame time. The 'sub-frame' field of the Timestamp therefore is set to zero in this embodiment.") A person of ordinary skill would have understood that this disclosure from Edens was the claimed program instructions that, when executed by the one or more processors, further caused the first playback device to generate the device clock information of the first playback device, because the generation of the time of day, time sync and clock sync data could have been accomplished in a device such as multimedia PC 170 or other playback devices of Edens, such as when that playback device was the network clock device and also the device that was obtaining audio data from outside of the network and providing it to other playback devices of Edens.
11. The first playback device of claim 9, wherein the control information further comprises one or more instructions for the first playback device and the second playback device to playback audio information.	Edens discloses that the control information further comprises one or more instructions for the first playback device and the second playback device to playback audio information. No limitations are provided in regards to the format, substance or type of instructions, such that any instruction for the first playback device and the second playback device to playback audio information meets this limitation under the broadest reasonable interpretation. Edens discloses that network devices such as the playback devices can send commands to one another, pursuant to virtually any protocol, which would include simple playback protocols such as a "play" command. See Edens at 11:26-30 ("Network devices also can utilize channels of the data stream to send custom commands to one another, including control information, pursuant to virtually any protocol known to such devices.") Edens discloses that audio data can be played by surround sound amplifier/speaker devices 153-158, which can be controlled by control devices 190 and 195, which inherently requires instructions for the first playback device and the second playback device (e.g. two or more of surround sound amplifiers/speaker devices 153-158 (which can be CPU-based devices augmented with hardware and software as disclosed at 14:64-67) to playback audio information. See Edens at 14:11-23 ("The audio extracted by MPEG2 decoder 161 could be transmitted back onto logical ring network 120 and played by left 167 and right 168 amplifier/speakers. The audio extracted by MPEG2 decoder 151 could be transmitted back onto logical ring network 120, processed by DSP (e.g., AC-3 surround sound decoder) 152, and then transmitted back onto logical ring network 120 and played by surround sound amplifier/speakers 153, 154, 156, 157 and 158.

'357 Patent	Edens, the Handbook and Sonos APA under 35 U.S.C. 103(a)
	The systems in rooms 106 and 102 could be controlled by respective remote control/interface/monitor devices 190 and 195 (which could range from simple remote controls to complex controllers with large LCD screens capable of viewing computer graphics images, MPEG2 video, etc."). A controller of Edens can also send a START STREAMS command to networked audio devices to start playback. See Edens at 56:25-41 ("Finally, having assigned all reallocated network nibble streams to the relevant network devices, the controller could restart those streams simultaneously by sending the START STREAMS system command to such devices. The START STREAMS system command is identical to the STOP STREAMS system command discussed above, except that devices start (rather than stop) transmitting/receiving data at the time indicated by the Timestamp field. Thus, a controller can accommodate virtually any programming change a user makes (typically via some form of remote control device) with respect to the source (e.g., DSS satellite receiver, DVD player, CD player, etc.) or destination (e.g., particular speakers, televisions/monitors, etc.) of an audio or video program, or other form of data.") The start/stop streams commands applies to each device that is receiving the information and then further transmitting it on to another device. 10:4-7 ("Information can propagate around this logical ring, reaching every device on each revolution around the network. Network devices are full-duplex, transmitting and receiving information simultaneously.") A person of ordinary skill would have understood that this disclosure from Edens was the claimed control information further comprises one or more instructions for the first playback device and the second playback device to playback audio information, because the START STREAMS command was an instruction for playing back the audio content that could have been generated by a controlling multimedia PC, MDV 5100 or other control device of Edens, and would have been received and retransmitted by each playback device of Edens that was playing back the audio in synchrony .
12. The first playback device of claim 11, wherein the first and second playback devices are members of a synchrony group, and wherein the program	Edens discloses that the first and second playback devices are members of a synchrony group, which is any two devices that are synchronized in some manner under the broadest reasonable construction of the term "synchrony group." For example, Edens explicitly discloses synchronized playback between stereo speaker devices, and also between multiple sets of stereo speakers.

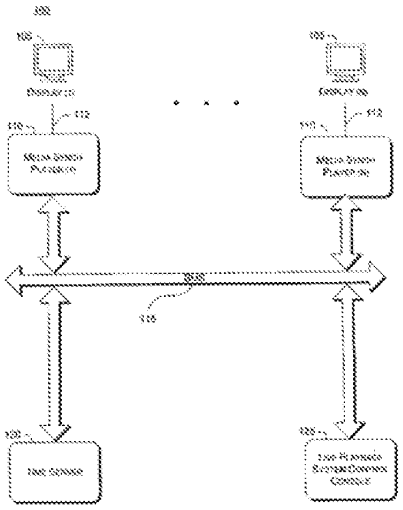
'357 Patent	Edens, the Handbook and Sonos APA under 35 U.S.C. 103(a)
instructions, when executed by the one or more processors, further cause the first playback device to:	52:66-53:10 ("As each frame propagates around the default network path (or alternate path) of the logic ring networks, the CD player would overwrite nibbles 10-15 and 74-79 with the respective (left and right channel) source digital audio streams. Other network devices would merely pass those nibbles of each frame along to the next network device on the logical ring network. **One or more "left" speaker network devices (e.g., in different rooms of a house) would extract nibbles 10-15 of each frame and play that left channel digital audio stream**. Similarly, **one or more "right" speaker network devices would extract nibbles 74-79 and play that right channel digital audio stream**.") A person of ordinary skill would have understood that this disclosure from Edens demonstrated that multiple playback devices of Edens could play back the audio in synchrony, which would make them members of a "synchrony group" under the BRI. See also Edens at 10:4-7; 11:13-18; 14:24-40; 27:1-5; 32:28-52; 56:9-14 and 104:7-15.
transmit, to the network device, status information that comprises a status of the synchrony group.	Edens discloses transmit status information to the network device that comprises a status of the synchrony group. The broadest reasonable interpretation of the term "status information" includes any kind of status information associated with the synchrony group, including any device that is capable of communicating with other devices, such as by responding to a MASTER RESET, CLOCK ID, SCAN RESET, SCAN REQUEST, SCAN REPLY and SCAN INITIATE system command, which are used to reset and initialize network devices, by communicating with other network devices and read/write one another's device-specific information via the MESSAGE, READ, WRITE, SET and GET system commands, or by responding to a data stream channel reallocation and control via the TALK ASSIGN, TALK QUERY, LISTEN ASSIGN, LISTEN QUERY, START STREAMS, STOP STREAMS, and QUERY STREAMS system commands. See Table V, 40:45 to 45:20. A person of ordinary skill would have understood that this disclosure from Edens was the claimed transmission of status information that comprises a status of the synchrony group to the network device, because device-specific information obtained via the MESSAGE, READ, WRITE, SET and GET system commands, or from a response to a data stream channel reallocation and control via the TALK ASSIGN, TALK QUERY, LISTEN ASSIGN, LISTEN QUERY, START STREAMS, STOP STREAMS, and QUERY STREAMS provided status information

'357 Patent	Edens, the Handbook and Sonos APA under 35 U.S.C. 103(a)
	from a member of a synchrony group, which meets the claim limitation under the BRI. To the extent that it is considered that Edens does not disclose this limitation, the Sonos APA discloses the existence of discovery protocols that can be used to learn about other components on the network and to establish communication with them, such as the Universal Plug and Play (UPnP) architecture, which defines discovery as the first step in UPnP networking. This allows devices to discover other devices and to exchange information about themselves and/or their services. U.S. Provisional Application 60/490,768, filed July 28, 20013 (the '768 Provisional).
19. The first playback device of claim 9, wherein the audio information source outside of the LAN is an Internet-accessible audio information source, and wherein obtaining, from the audio information source outside of the LAN, the audio information, comprises obtaining the audio information from the Internet-accessible audio information source.	Edens discloses that the audio information source outside of the LAN can be an Internet-accessible audio information source, and wherein obtaining the audio information from the audio information source outside of the LAN comprises obtaining the audio information from the Internet-accessible audio information source. See, e.g., claim 3; 14:19-23 (playback devices "could be controlled by respective remote control/interface/monitor devices 190 and 195 (which could range from simple remote controls to complex controllers with large LCD screens capable of viewing computer graphics images, MPEG2 video, etc."); 14:42-44 ("[m]ultimedia PC 170 could be used to control devices on logical ring network 120, as well as to transmit and receive digital media to/from other network devices"); 14:64-67 ("by adding devices of greater complexity, particularly CPU-based devices controlled by software or firmware, the possibilities are virtually endless"); 46:56-60 ("Other interested devices can read this information for subsequent use in communicating directly with a particular device and/or obtaining additional information about a device from an external resource (e.g., the Internet via a URL 'pointer')."); and 47:47-54 ("As will be apparent to one reasonably skilled in the art, many different data structures (e.g., a linked list of objects) and combinations of RAM/ROM/registers can be employed to accommodate the various types of data contained within the configuration and code control block, as well as any other information stored in a network device's local memory and I/O address space, including 'pointers' to external information.") A person of ordinary skill would have understood that this disclosure from Edens was the claimed obtaining the audio information from the Internet-accessible audio information source, because the ability to obtain data from an external resource using a

'357 Patent	Edens, the Handbook and Sonos APA under 35 U.S.C. 103(a)
	URL or to browse the web could be used to obtain audio information from an Internet source. To the extent it is considered that Edens does not disclose a playback device that can receive, via the network interface from a network device configured to control the first playback device and communicatively coupled to the first playback device over a local area network (LAN), control information comprising an address identifying a network location of audio information available at an audio information source, wherein the audio information source is outside of the LAN, the Handbook discloses that PCs could be used as playback devices and included the ability to obtain audio information from a source outside the LAN. See the Handbook, pages see pages 17-18, 28-34, 66-84, 109-116, 123-154, 243-261.

G. Blank

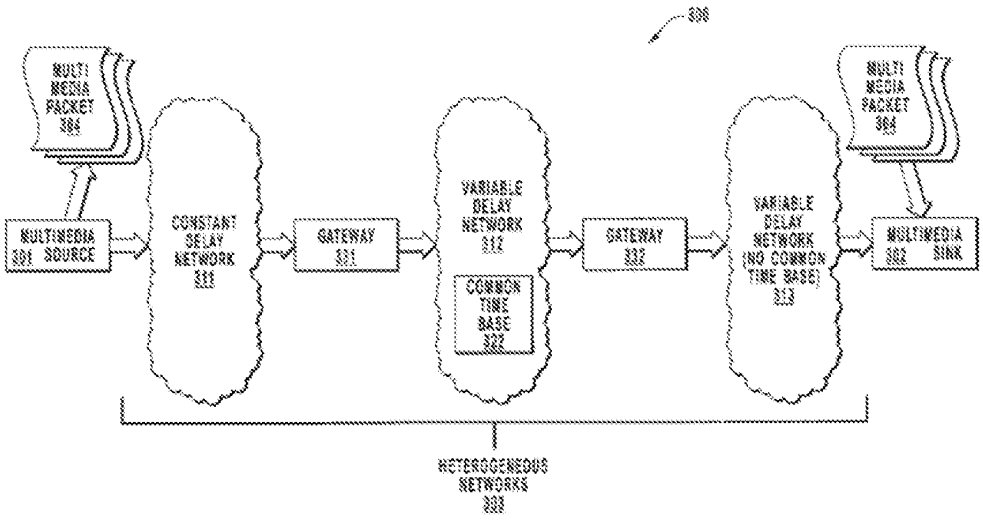
Blank discloses a system for synchronous playback between media synch players 110, which use a time server 120 to coordinate synchronous playback between the media synch players (1) through (N). See Blank at [0029] ("In operation, the media synch players 110 each generate a content stream such as video or audiovisual data in synchrony at the behest of the live playback system control console 125. Synchronism is derived from the time server 120, facilitating orchestration of the content provided by the media synch players 110. The system control console 125 and the media synch players 110 are slaved to the time server 120. As such, the system control console 125 can transmit a start time t+d for the media synch players 110 to start providing content from media files 210 (FIG. 2), and the media synch players 110 are synchronized with respect to this start time." An exemplary embodiment of the system of Blank is shown below from Figure 1 of Blank:



As such, the media synch players 110 of Blank form a synchrony group for the playback of audio information that is provided over a network. While Blank discloses a time server 120, a person having ordinary skill in the art would recognize that the time server 120 could be implemented on one or both of the media synch players of Blank.

H. Gray

Blank incorporates U.S. patent application Ser. No. 09/836,834 (Published Application No. 2002/0150053 to Gray et a., hereinafter "Gray") by reference at [0042] and [0045]. Gray discloses communication of multimedia packets 304 from a multimedia source 301 to a multimedia sink 302 over heterogeneous networks 303, which inherently requires an address identifying a network location of audio information outside of a LAN for a multimedia sink 302 on a local area network 313. A person having skill in the art would recognize that all network communications between networked audio devices require the use of network addresses. Figure 3 of Gray is shown below and demonstrates that the multimedia source 301 is accessible through a network connection and is outside of the local area network of the multimedia sink 302:



The system of Gray uses transmitters at each gateway 331 and 332 that transmit "multimedia packets with time stamps that represent the time according to the reckoning of the transmitter application. When the transmitter link layer device receives the multimedia packet, it calculates a new time stamp that is in accordance with a network time base, the new time stamp being based on the time stamp provided by the transmitter application. The receiver link layer controller then uses the new time stamp to evaluate the rendering time of the corresponding information in the packet." [0015]. Gray also discloses that this time stamping procedure can be implemented at the application layer, and that "the application layer itself may maintain the common time reckoning across the devices, calculate the appropriate time stamp, and/or include the time stamp in the multimedia packet. Which of these tasks the application layer performs may depend on the capabilities of the link layer that the application layer uses to forward multimedia packets through the gateway." [0069]

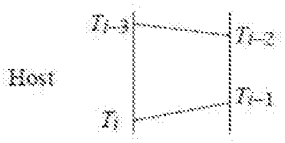
In combination, the time stamped packets of Gray allow synchronized playback at a plurality of media synch players 110 of the system of Blank, for content that is provided from a source outside of the LAN on which the media synch players 110 of Blank are operating. Furthermore, while Blank discloses that time server 120 can be separate from the media synch players 110, a person having ordinary skill in the art would recognize that it could also be included in one of media synch players 110, so as to reduce the number of devices required for synchronized playback.

I. SMPTE

Blank discloses that the Society of Motion Picture and Television Engineers (SMPTE) timecodes can be used at [0024], and thus incorporates that standard by reference. SMPTE time codes can be included in a frame format for multimedia data, such as an 80 bits format that includes hour, minute, second, frame number, ID and other suitable data. See "SMPTE Made Simple," TimeLine Vista, Inc., 1996 at pages 11-15. A person having ordinary skill in the art would understand that the disclosed use of SMPTE data in Blank includes frames of multimedia data that include such information for playback timing or as clock information of a playback device.

J. RFC 1305

Blank discloses that the Network Timing Protocol (NTP) timecodes can be used at [0024], and thus incorporates that standard by reference. NTP is disclosed in RFC 1305 and includes timing algorithms for use with networked devices at page 25, for calculating clock offset Θ and roundtrip delay δ for messages exchanged between a host device and a peer device:



$$\delta = (T_i - T_{i-3}) - (T_{i-1} - T_{i-2}),$$

$$\Theta = \frac{(T_{i-2} - T_{i-3}) + (T_{i-1} - T_i)}{2},$$

Thus, using RFC 1305, clock information is exchanged between host devices and peer devices to determine a common time base, which is then used to synchronize the processes of the host and peer. See RFC 1305, Abstract ("NTP provides the mechanisms to synchronize time and coordinate time distribution in a large, diverse internet operating at rates from mundane to lightwave." While RFC 1305 can be used "maintain accuracy and robustness, even when used over typical Internet paths involving multiple gateways, highly dispersive delays and unreliable nets," RFC 1305, page 1, this timing algorithm can be used with less robust implementations, such as for synchronizing a small number of devices on a local area network. See RFC 1769, Simple Network Time Protocol (SNTP), March 1995, at Abstract ("SNTP can be used when the ultimate performance of the full NTP implementation described in RFC-1305 is not needed or justified. It can operate in both unicast modes (point to point) and broadcast modes (point to multipoint).") A person having ordinary skill in the art as of the critical date of the '357 Patent would have been aware of these well-known synchronization and timing algorithms and associated applications, and would have understood that a reference to their use in Blank includes the transmission of clock

information from a time server, which could be located within a playback device in accordance with the Sonos APA.

K. pcAnywhere

The ability for a PC or other networked audio device to be remotely controlled by another device on the same LAN as the PC, or even from outside of the LAN, was well known prior to the Critical Date of the '357 Patent. For example, pcAnywhere discloses at page 12 that as of the Critical Date of the '357 Patent that it was possible to "remotely connect to another computer, open any file or program that you have permission to access, and work as though you are sitting at that computer." As further discussed at page 12, the "relationship between a host computer and a remote computer is similar to a television set and a remote control device. Using a remote control device, you can adjust the volume, change channels, or turn the television on or off without leaving your chair. Using pcAnywhere, a host computer waits for and accepts connections from remote computers and performs the functions that are requested, much like a television set accepts signals from a remote control device." As such, the ability to remotely control a networked audio device such as a PC over the network, such as to "receive, from a network device configured to control the first playback device and communicatively coupled to the first playback device over a local area network (LAN), control information comprising an address identifying a location of audio information available at an audio information source, wherein the audio information source is outside of the L3AN," was well known and would have been obvious to a person having skill in the art.

L. Microsoft File Sharing

Blank discloses that a Microsoft Windows Operating System can be used in conjunction with media synch players 110 at [0034]. A person having ordinary skill in the art would recognize that this is an incorporation by reference of the functionality that was commercially available in the Windows Operating System as of the Critical Date of the '357 Patent, such as the file sharing functionality disclosed in Microsoft File Sharing that allows other PCs on a network (such as other media synch players 110) to access files stored on a storage device of other PCs on the network.

M. Blank presents a Substantial New Question of Patentability, either alone under 35 U.S.C. 102(e)(1) (Table 4), or in combination with Gray, SMPTE, RFC 1305, Edens, the Handbook, Microsoft File Sharing, pcAnywhere and Sonos APA under 35 U.S.C. 103(a) (Table 5).

As shown in the claim chart below, Blank (with material from Gray, SMPTE and RFC 1305 incorporated by reference) discloses each element of the Challenged Claims of the '357 Patent in a manner that was not considered during the original prosecution of the '357 Patent. Although Blank was submitted to the Patent Office by Sonos during the original examination of the '357 Patent as one of hundreds of references in over 60 total pages of Information Disclosure Statements, it was not specifically considered by Examiner Survillo or applied against any of the claims of the '357 Patent. Blank discloses each element of the '357 Patent in a manner that was not considered during the original prosecution of the '357 Patent, at least because the prior art considered during the original prosecution did not include any explicit disclosure or teaching of networked audio devices that transmit playback timing data, clock data and audio data to other networked audio devices, for synchronous playback of the audio data, as disclosed in Blank. Therefore, the invalidity of the Challenged Claims in view of Blank presents a substantial new question of patentability

To the extent that it is considered that Blank does not incorporate Gray, SMPTE and RFC 1305 by reference so as to provide a single reference under 35 U.S.C. 102(e)(1), a person having ordinary skill in the art would have considered it obvious to combine Blank with Gray, SMPTE and RFC 1305, at least for the reasons that Blank specifically states that it can be used in conjunction with Gray, SMPTE and RFC 1305, and also because each of these references are directed to the field of synchronized network devices, and Blank and Gray are directed to field of synchronized networked devices that are used to provide synchronized multimedia playback. A person having ordinary skill in the art would have used SMPTE or NTP timing for synchronization, because these were well-known timing and synchronization standards that were specifically called out in Blank.

Furthermore, while Blank (with the material from Gray either incorporated by reference or as combined under 35 U.S.C. 103(a)) explicitly discloses connecting to sources over the Internet for playback of audio data, to the extent that it is considered not to explicitly or inherently satisfy the limitation of receiving, via the network interface from a network device configured to control

the first playback device and communicatively coupled to the first playback device over a local area network (LAN), control information comprising an address identifying a network location of audio information available at an audio information source, wherein the audio information source is outside of the LAN, the Handbook discloses that it was well known as of the Critical Date of the '357 Patent to provide control information to a networked audio device such as a PC that comprises an address identifying a network location of audio information available at an audio information source, wherein the audio information source is outside of the LAN. A person of ordinary skill in the art would understand that the general information concerning the networked audio data processing functionality of PCs as disclosed in the Handbook was well known and in widespread commercial use.

Further, as discussed above, Sonos admits in the Background of the Invention at 1:47 to 2:28 that it was known in the art that there are a number of circumstances under which it is desirable to maintain synchrony of operations among a plurality of independently-clocked digital data processing devices in relation to, for example, information that is provided thereto by a common source, and that these include systems in which one audio information source can distribute audio information in digital form to a number of audio playback devices for playback. In such an arrangement, the audio information that is distributed to various audio playback devices may relate to the same audio program, and that the audio playback devices can contemporaneously play the same program (i.e. in a synchrony group). The audio playback devices have independent clocks, and if they are clocking at precisely the same rate, the audio playback provided by the various devices can occur in synchronization.

In addition, it would be obvious to combine Blank (in combination with Gray, SMPTE RFC 1305, the Handbook and the Sonos APA) with Edens, because Edens discloses how to use one of the networked audio devices of Blank as a network clock device for the purpose of synchronizing playback between networked audio devices as taught in Blank, such as the networked audio devices of Blank. A person having skill in the art would be motivated to combine the teachings of Blank and Edens in order to eliminate the need for a separate time server 120, because both references are directed to the problems of providing synchronized audio using networked audio devices, and the time server functionality of Edens could be included on any or all of the networked audio devices of Blank. Doing so would reduce the need for an additional dedicated device, and a person having skill in the art would recognize based on ordinary creativity

that if every networked audio device included that functionality as disclosed in Edens, it would provide the flexibility of allowing any networked audio device to function as the time server and thus provide redundancy and improved reliability without requiring additional equipment.

It would also be obvious to combine Blank with Microsoft File Sharing and pcAnywhere, because Microsoft File Sharing was part of the Microsoft Windows Operating System that is disclosed as being used with the PCs of Blank at [0034], and pcAnywhere was a commercially available software packages with well-known functionality that was in wide use. A person having skill in the art would be motivated to combine the teachings of Blank with Microsoft File Sharing and pcAnywhere, because Blank discloses the use of the Microsoft Windows Operating System and pcAnywhere was commonly used by users to control PCs over a network connection, and neither of those commonplace PC functions would have been considered novel or non-obvious, and the addition of those functional elements of the claims to devices such as PCs would not have been considered by a person having ordinary skill in the art as providing any additional novel or non-obvious functionality.

Therefore, the invalidity of the Challenged Claims over Blank in combination with Gray, Edens, SMPTE, RFC 1305, Microsoft File Sharing, pcAnywhere, the Handbook and Sonos APA presents a substantial new question of patentability.

TABLE 4

SUBSTANTIAL NEW QUESTION OF PATENTABILITY

BASED ON BLANK UNDER 35 U.S.C. 102(E)(1)

'357 Patent	Blank under 35 U.S.C. 102(e)(1)
9. A first playback device comprising:	Blank discloses a media synch player 110 that is a playback device. [0029] "In operation, the media synch players 110 each generate a content stream such as video or audiovisual data in synchrony at the behest of the live playback system control console 125. Synchronism is derived from the time server 120, facilitating orchestration of the content provided by the media synch players 110. The system control console 125 and the media synch players 110 are slaved to the time server 120. As such, the system control console 125 can transmit a start time t+d for the media synch players 110 to start providing content from media files 210 (FIG. 2), and the media synch players 110 are synchronized with respect to this start time. "

'357 Patent	Blank under 35 U.S.C. 102(e)(1)
	See also [0026], [0034], [0036]-[0041], [0044]-[0047], [0052]-[0059], [0065]-[0071], [0077]-[0093] Gray discloses a management system 212 at [0036]-[0037] that can receive audio data over the Internet for use with audio system 216, and that management system can be a playback device that is integral with audio system 216. A person of ordinary skill in the art would understand that management system 212 can be implemented as part of one or more media synch player 110. A person of ordinary skill in the art would consider the media synch players 110 of Blank or the management system 212 of Gray to be playback devices that could be implemented as PCs or in conjunction with PCs, and would understand that they could be implemented in conjunction with commonplace PC functionality disclosed in the Handbook.
one or more processors; a network interface; and	Blank discloses at least inherently that the media synch players 110 have processors (see claims 26 and 35-41) and network interfaces ([0023], [0028], [0043]), because it is well known that networked computers as disclosed at [0026] have processors and network interfaces. Gray discloses that the management system 212 includes one or more processors as processing unit 236 and a network interface as modem 266 or "any other available communication media." [0048] A person of ordinary skill in the art would consider the media synch players 110 of Blank or the management system 212 of Gray to be playback devices that could be implemented as PCs or in conjunction with PCs that have processors and network interfaces, and would understand that they could be implemented in conjunction with such commonplace PC hardware as disclosed in the Handbook.
tangible, non-transitory computer-readable memory comprising program instructions that, when executed by the one or more processors, cause the first playback device to:	Blank discloses that the media synch players 110 have computer readable media at [0026]-[0027] that includes "computer readable instructions, data structures, program logic or program modules." Gray discloses in regards to management system 212 that "[i]nstructions, data, and other program modules necessary for the operation of processing unit 236 and necessary for the operation of the ASIC 238 may be stored in mass storage device 250 and/or system memory 242, which includes read-only memory ("ROM") 246 and random-access memory ("RAM") 248.

'357 Patent	Blank under 35 U.S.C. 102(e)(1)
	A person of ordinary skill in the art would consider the media synch players 110 of Blank or the management system 212 of Gray to be playback devices that could be implemented as PCs or in conjunction with PCs that have tangible, non-transitory computer-readable memory comprising program instructions that, when executed by the one or more processors, cause the first playback device to perform the claimed functions, and would understand that they could be implemented in conjunction with such commonplace PC hardware as disclosed in the Handbook.
receive, via the network interface from a network device configured to control the first playback device and communicatively coupled to the first playback device over a local area network (LAN), control information comprising an address identifying a network location of audio information available at an audio information source, wherein the audio information source is outside of the LAN; and	Blank discloses that recorded media that are distributed over a wide geographic area can be used for a multimedia presentation that requires synchronization of multiple displays at [0008]. Blank discloses that live playback system control console 125 at [0054] that provides control signals to interface 220 of media synch players 110, and that these control signals can include commands to "play" and "get file." Thus, at least live playback system control console 125 is a "network device configured to control the first playback device and communicatively coupled to the first playback device over a local area network (LAN)." [0054] "In the block 405, control signals from the control console 125 are received by the interface 220. In one embodiment, the control signals may comprise, for example, one of: play, pause, stop, seek to time, get file and show images. Blank discloses that the disclosed system elements can be connected over a WAN or the Internet at [0023]. Blank incorporates U.S. patent application Ser. No. 09/836,834 (Published Application No. 2002/0150053 to Gray et a., hereinafter "Gray") by reference at [0042] and [0045]. Gray discloses communication of multimedia packets 304 from a multimedia source 301 to a multimedia sink 302 over heterogeneous networks 303, which inherently requires an address identifying a network location of audio information outside of a LAN for a multimedia sink 302 on a local area network 313. See, Gray at Fig. 1, [0053], [0059], [0061]. A person of ordinary skill in the art would recognize that streaming audio content from a source outside of the LAN could be accomplished using software programs such as the Windows Media Player, as disclosed at [0037] of Blank.

'357 Patent	Blank under 35 U.S.C. 102(e)(1)
	A person having ordinary skill in the art would thus understand that live playback system control console 125 can provide control information to a media synch player that comprises an address identifying a network location of audio information available at an audio information source, wherein the audio information source is outside of the LAN, as disclosed in Gray. To the extent it is considered that Blank does not disclose a playback device that can receive, via the network interface from a network device configured to control the first playback device and communicatively coupled to the first playback device over a local area network (LAN), control information comprising an address identifying a network location of audio information available at an audio information source, wherein the audio information source is outside of the LAN, the Handbook discloses that PCs could be used as playback devices and included the ability to obtain audio information from a source outside the LAN. See the Handbook, pages see pages 17-18, 28-34, 66-84, 109-116, 123-154, 243-261. In addition, to the extent that it is considered that Blank does not disclose remotely controlling a playback device over a LAN, it was also well known before the Critical Date of the '357 Patent to receive control information via the network interface of a first PC from a second PC that was configured to control the first PC and that was communicatively coupled to the first PC over a LAN. See pcAnywhere at page 12 ("pcAnywhere lets you connect to another computer and perform your work as though you were sitting in front of that computer. You can view and edit files, access network resources, and run programs that you have permission to access. You can also print files located on another computer to your default printer.") Such control information could comprise an address identifying a network location of audio information available at an audio information source that is outside of the LAN, as disclosed in the Handbook.
after receiving the control information, (i) obtain, via the network interface from the audio information source outside of the LAN, the audio information;	Blank discloses that media files 210 can be stored at a media storage location for each media synch player 110, or that is shared by two or more media synch players 110 at [0037]. Gray discloses at [0036]-[0037] that management system 212 can receive audio data over the Internet for use with audio system 216, and that management system can be a playback device that is integral with audio system 216. A person of ordinary skill in the art would understand that management system 212 can be implemented as part of one or more media synch player 110.

'357 Patent	Blank under 35 U.S.C. 102(e)(1)
	As such, a person having ordinary skill in the art would understand that audio data that is received over the Internet by the system of Gray can be stored as a media file 210 of a media synch player 110 of Blank. It was common as of the critical date of the '357 Patent (April 1, 2003) for users to obtain content over the Internet from sources outside of a user's LAN and to store that content on a personal computer or other playback device. See, e.g., the Handbook at Appendix A. A person of skill would also understand that the media synch players 110 of Blank or the management system 212 of Gray could also or alternatively be used as playback devices of Edens for synchronous playback, as members of the synchrony group of Edens, such as to allow the architecture of Edens to be used in a system other than the logical ring network of Edens. In addition, Edens discloses that one of the playback devices of Edens, such as multimedia PC 170 or MDV 5100, could be used to obtain audio data over the Internet and to provide that audio data to other playback devices, as discussed above for this limitation in regards to Eden. Also, see claim 3 of Eden.
(ii) transmit, via the network interface of the first playback device to a second playback device, the audio information, playback timing information associated with the audio information, and device clock information of the first playback device; and	Blank discloses clock module 212 of a media synch player 110 that can be slaved to another clocking system at [0038]. Blank also discloses the use of a time server 120 at [0029] and [0044]-[0051]. A person of ordinary skill in the art would recognize that the time server 120 could be located on a first media synch player 110, and could provide the master clock that is used to provide the playback timing information. The time server 120 would then transmit clock information to a second media synch players 110, to allow it to acquire lock with a clock contained in time server 120. See [0048] of Blank. As discussed below, the first media synch player 110 can obtain the audio information and provide it to the second media synch player 110 using Windows file sharing, and can then provide playback timing information by either 1) hosting live playback system control console 125 and transmitting a play command to the second media synch player 110, for "playback timing information" construction 1, or 2) add time stamps to the media data packets at the application layer that are used to control playback timing in accordance with the teachings of Gray, for "playback timing information" construction 2. Time information can also be transmitted from time server 120 to other media synch players 110 to cause them to "speed up or slow down rendering of clocks 212 in the individual media synch players 110." See [0045] of Blank. Time information that causes other media synch players 110 to speed up or slow down meets the

'357 Patent	Blank under 35 U.S.C. 102(e)(1)
	broadest reasonable interpretation of "playback timing information," because it is used to control playback timing. A person having skill in the art would recognize that live playback system control console 125 can also be implemented on a media synch player 110 with time server 120, and can be used to provide playback timing information to other media synch players 110 as disclosed at [0044] as a time stamp "t" and an indication of a delay "d" that is used to coordinate playback, which satisfies the broadest reasonable interpretation of "playback timing information," because it is used to control playback timing. Blank also discloses that the "exemplary media synch player 110 may be realized as a modified conventional personal computer, such as is available from a variety of commercial sources, employing a Windows ® operating system, available from many sources and from Microsoft Corporation of Redmond, Wash." [0034]. The Windows operating system permitted file sharing between personal computers, see, e.g., "File and Printer Sharing with Microsoft Windows," Microsoft Corporation, November 2003 at page 1 ("File and printer sharing is the ability of a computer running Windows to share a folder or attached printer with other computers on a network. File sharing allows you to make files and folders in a shared folder accessible to others on the network to view, copy, or modify. For example, with file sharing, you can store all of your documents on a central computer and share the folder that contains them. Then, from another computer attached to the same network as the computer that contains the files, you can connect to the shared folder and work with the documents as if they were locally stored. For example, you can access files that are stored on a central desktop computer from a wireless laptop computer that you can carry from room to room in your home.") As such, the system of Blank could allow a first media synch player 110 to obtain an audio file from a source outside of the LAN, store the audio file to a local media file 210 of the first media synch player 110, and then allow a second media synch player 110 to obtain that audio content over the LAN using the Windows operating system file sharing functionality, in response to a command from lice playback system control console 125. Gray discloses the use of time stamps in multimedia packets at [0062] that are used to control the time that a multimedia packet is to be rendered at, and further discloses at [0069] that the application layer can "maintain the common time reckoning across the devices,

'357 Patent	Blank under 35 U.S.C. 102(e)(1)
	calculate the appropriate time stamp, and/or include the time stamp in the multimedia packet." A person of ordinary skill in the art would recognize from this teaching that the application layer on the media synch player 110 that includes a time server 120 could include the time stamp into the multimedia packets of the audio data from media file 210 (that has been obtained from outside the LAN and stored in media file 210) and which is then provided to other media synch players 110 as "playback timing data" for synchronized playback, because that would allow the system of Blank to be implemented on as few as two different devices, and would eliminate the need for a separate time server 120. Blank discloses the playback timing information associated with the audio information under construction 1, such as when a start time t+d is generated by a first playback device that is also used to implement system control console 125. See [0029] Gray discloses the playback timing information associated with the audio information under construction 2, such as when the application layer of a media synch player 110 inserts timestamps into frames of audio data. . See [0016], [0087], [0089]. A person of ordinary skill in the art would consider the media synch players 110 of Blank or the management system 212 of Gray to be playback devices that could be implemented as PCs or in conjunction with PCs, and which can transmit audio information, playback timing information and clock information to another playback device for synchronous playback. A person of skill would also understand that the media synch players 110 of Blank or the management system 212 of Gray could also or alternatively be used as playback devices of Edens for synchronous playback, as members of the synchrony group of Edens, such as to allow the architecture of Edens to be used in a system other than the logical ring network of Edens, as discussed for the corresponding element in the Edens claim chart. To the extent that it is considered that Blank or Gray do not disclose this limitation, the Sonos APA discloses that it was known to transmit audio information and playback timing information associated with the audio information (for synchronous playback) and device clock information of the first playback device (using RFC 1305 or SNTP), via the network interface of the first playback device to a second playback device. See '357 Patent at 1:47 to 2:28 and the '768 Provisional at pages 1-2. It would be obvious to use the Sonos APA with the system of Blank, because both Blank and

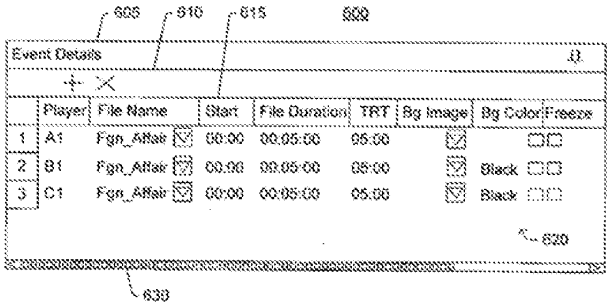
'357 Patent	Blank under 35 U.S.C. 102(e)(1)
	the Sonos APA are directed to networked audio devices that play back audio in synchrony, and the Sonos APA would eliminate the need for an additional device for time server 120, because it teaches that the timing functionality can be provided by a playback device.
(iii) play back the audio information in synchrony with the second playback device by using the playback timing information associated with the audio information and the device clock information of the first playback device to play back the audio information,	Blank discloses that media synch players 110 play back the audio information in synchrony with each other by using the playback timing information associated with the audio information that is generated by live playback system control consoled 125 and the device clock information of the first playback device (which is used to generate the NTP timing information) to play back the audio information. See [0009], [0010], [0022], [0024], [0025], [0029], [0041], [0043]-[0045]. Each media synch player 110 uses the audio information and its own clock information and the playback timing information (the start time of Blank t+d under construction 1, or frame-specific time stamps of Gray under construction 2), but even if the claims are amended to positively recite the second playback device and to require the second playback device to use the playback timing information associated with the audio information and the device clock information of the first playback device to play back the audio information, Blank or Blank and Gray disclose that also. The management systems 212 of Gray can play back the audio information in synchrony with a second management system 212 by using the playback timing information associated with each frame of the audio information and the device clock information of the first playback device to play back the audio information, such as using an application synchronization process in conjunction with the management systems 212. See [0016], [0087], [0089]. A person of ordinary skill in the art would consider the media synch players 110 of Blank or the management system 212 of Gray to be playback devices that could be implemented as PCs or in conjunction with PCs, and which can play back audio in synchrony with each other using the playback timing information and clock time information of the first playback device, as discussed above. A person of skill would also understand that the media synch players 110 of Blank or the management system 212 of Gray could also or alternatively be used as playback devices of Edens for synchronous playback, as members of the synchrony group of Edens, such as to allow the architecture of Edens to be used in a system other than the logical ring network of Edens, and to playback the audio data using the playback timing information and clock information of a first playback device as described for the corresponding limitation of Edens.

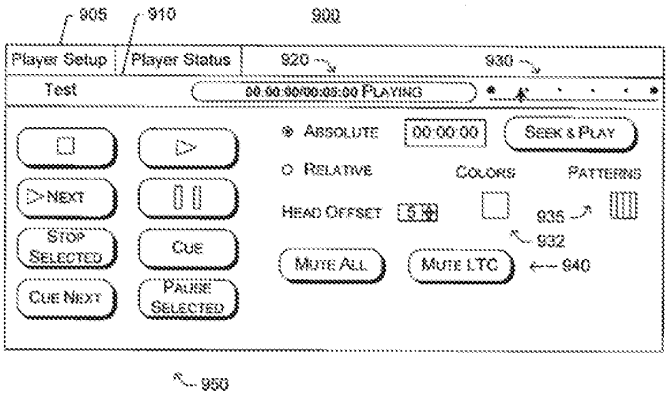
'357 Patent	Blank under 35 U.S.C. 102(e)(1)
	It is noted that this limitation does not require the second playback device to playback the audio information by using the playback timing information associated with the audio information and the device clock information of the first playback device to play back the audio information. That limitation only applies to the first playback device, and as long as the second playback device is playing back the audio information in synchrony with the first playback device while the first playback device uses the playback timing information associated with the audio information and the device clock information of the first playback device to play back the audio information, then the claim limitation is satisfied. To the extent that it is considered that Blank or Gray do not disclose this limitation, the Sonos APA discloses that it was known to transmit audio information and playback timing information associated with the audio information (for synchronous playback) and device clock information of the first playback device (using RFC 1305 or SNTP), via the network interface of the first playback device to a second playback device. See '357 Patent at 1:47 to 2:28 and the '768 Provisional at pages 1-2. It would be obvious to use the Sonos APA with the system of Blank, because both Blank and the Sonos APA are directed to networked audio devices that play back audio in synchrony, and the Sonos APA would allow Blank to provide the timing functionality on one of the media synch players 110 instead of a dedicated time server 120, thus reducing the need for an additional device.
wherein the first and second playback devices remain independently clocked during synchronous playback of the audio information.	Each media synch player 110 of Blank includes a clock module or clocking system 212 that is an independent clock, where the media synch players 110 operating in accordance with their own respective clocks during synchronous playback. A person of ordinary skill in the art would consider the media synch players 110 of Blank or the management system 212 of Gray to be playback devices that could be implemented as PCs or in conjunction with PCs, and which can remain independently clocked during synchronous playback, at least because PCs contain multiple clocks that can be independent. A person of skill would also understand that the media synch players 110 of Blank or the management system 212 of Gray could also or alternatively be used as playback devices of Edens for synchronous playback, as members of the synchrony group of Edens, such as to allow the architecture of Edens to be used in a system other than the logical ring network of Edens.

'357 Patent	Blank under 35 U.S.C. 102(e)(1)
	To the extent that it is considered that Blank or Gray do not disclose this limitation, the Sonos APA discloses that playback devices can remain independently clocked during synchronous playback of audio information, see '357 Patent at 2:21-27 ("When an audio playback device converts the digital audio information from digital to analog form, it does so using a clock that provides timing information. Generally, the audio playback devices that are being developed have independent clocks, and, if they are not clocking at precisely the same rate, the audio playback provided by the various devices can get out of synchronization."). Thus, if the independent clocks of the audio playback devices are clocking at precisely the same rate by design, or if they are synchronized, then the audio playback provided by the various devices remains in synchronization. The claims do not address how to address the situation where the independent clocks of the audio playback devices are not clocking at precisely the same rate or are not synchronized, and how to accommodate/correct/address that condition.
10. The first playback device of claim 9, wherein the program instructions, when executed by the one or more processors, further cause the first playback device to: generate the playback timing information associated with the audio information; and	Blank discloses that the software generates the playback timing information associated with the audio information under construction 1, such as when a start time t+d is generated by a first playback device that is also used to implement system control console 125. See [0029] Gray discloses that the software generates the playback timing information associated with the audio information under construction 2, such as when the application layer of a media synch player 110 inserts timestamps into frames of audio data. See [0016], [0087], [0089]. A person of ordinary skill in the art would consider the media synch players 110 of Blank or the management system 212 of Gray to be playback devices that could be implemented as PCs or in conjunction with PCs that use SMPTE or RFC 1305 to generate playback timing information associated with the audio information, under either construction 1 in the form of a "play" command or under construction 2 in the form of frame-specific playback timing information. A person of skill would also understand that the media synch players 110 of Blank or the management system 212 of Gray could also or alternatively be used as playback devices of Edens for synchronous playback, as members of the synchrony group of Edens, such as to allow the architecture of Edens to be used in a system other than the logical ring network of Edens and by using the timing information architecture of Edens (i.e. designation of one of the playback devices as a network clock device, and serial

'357 Patent	Blank under 35 U.S.C. 102(e)(1)
	streaming of audio data between devices in the synchrony group as taught by Edens.
generate the device clock information of the first playback device.	Blank discloses that the media synch player 110 software causes the media synch player 110 to generate device clock information of the first playback device, such as by activating the Network Time Protocol module 15. See [0038], [0046]-[0048]. A person of ordinary skill in the art would consider the media synch players 110 of Blank or the management system 212 of Gray to be playback devices that could be implemented as PCs or in conjunction with PCs that have tangible, non-transitory computer-readable memory comprising program instructions that, when executed by the one or more processors, cause the first playback device to generate the device clock information of the first playback device, such as for any device clock of the PC that can be actuated in response to such instructions (e.g. a sound card, a network card and so forth). A person of skill would also understand that the media synch players 110 of Blank or the management system 212 of Gray could also or alternatively be used as playback devices of Edens for synchronous playback, as members of the synchrony group of Edens, such as to allow the architecture of Edens to be used in a system other than the logical ring network of Edens.
11. The first playback device of claim 9, wherein the control information further comprises one or more instructions for the first playback device and the second playback device to playback audio information.	Blank discloses at [0029] that the "media synch players 110 each generate a content stream such as video or audiovisual data in synchrony at the behest of the live playback system control console 125. Synchronism is derived from the time server 120, facilitating orchestration of the content provided by the media synch players 110. The system control console 125 and the media synch players 110 are slaved to the time server 120. As such, the system control console 125 can transmit a start time t+d for the media synch players 110 to start providing content from media files 210 (FIG. 2), and the media synch players 110 are synchronized with respect to this start time." The start time is control information that includes one or more instructions for the first playback device and the second playback device to playback audio information. Claim 5 of Blank includes the "process of claim 1, wherein providing content comprises providing content from each of the multiple media players in response to commands from a control console at a time specified by the control console." See also Blank at [0044] ("In operation, a time stamp "t" is obtained by each device from the controller 125, which is synchronized with the time server 120. Also included with the time stamp t is a delay indication "d". In combination, these time related components

'357 Patent	Blank under 35 U.S.C. 102(e)(1)
	instruct the media synch players 110 on when to render content available from the media files 210. Essentially, each media synch player 110 will wait to render content until a particular time t+d, derived from the time stamp from the controller 125. As such, content from all of the media synch players 110 will be synchronized to the same moment in time—t+d —regardless of when the time synchronization was initiated."); [0056] ("In a block 410, the media synch players 110 respond to the control signals and provide appropriate output signals via the signal paths 112 to the displays 105. Such may comprise start of synchronized operation of the media synch players 110 and associated displays 105, switching from one media file 210 to another (e.g., get file followed by start), cease operation (e.g., stop), which may include initiation of a predetermined state such as a blank or black display 105, and the like."). A person of ordinary skill in the art would consider the media synch players 110 of Blank or the management system 212 of Gray to be playback devices that could be implemented as PCs or in conjunction with PCs, and which can play back audio in synchrony with each other in response to a suitable playback command. A person of skill would also understand that the media synch players 110 of Blank or the management system 212 of Gray could also or alternatively be used as playback devices of Edens for synchronous playback, as members of the synchrony group of Edens, such as to allow the architecture of Edens to be used in a system other than the logical ring network of Edens.
12. The first playback device of claim 11, wherein the first and second playback devices are members of a synchrony group, and wherein the program instructions, when executed by the one or more processors, further cause the first playback device to:	Blank discloses that media synch players 110 are members of a synchrony group that play back the audio information in synchrony with each other by using the playback timing information associated with the audio information that is generated by live playback system control consoled 125 and the device clock information of the first playback device (which is used to generate the NTP timing information) to play back the audio information. See [0009], [0010], [0022], [0024], [0025], [0029], [0041], [0043]-[0045], The management systems 212 of Gray can play back the audio information in synchrony with a second management system 212 in a synchrony group by using the playback timing information associated with each frame of the audio information and the device clock information of the first playback device to play back the audio information, such as using an application synchronization process in conjunction with the management systems 212. See [0016], [0087], [0089].

'357 Patent	Blank under 35 U.S.C. 102(e)(1)
	A person of ordinary skill in the art would consider the media synch players 110 of Blank or the management system 212 of Gray to be playback devices that could be implemented as PCs or in conjunction with PCs, and which can play back audio in synchrony with each other, which would make then members of a synchrony group. A person of skill would also understand that the media synch players 110 of Blank or the management system 212 of Gray could also or alternatively be used as playback devices of Edens for synchronous playback, as members of the synchrony group of Edens, such as to allow the architecture of Edens to be used in a system other than the logical ring network of Edens.
transmit, to the network device, status information that comprises a status of the synchrony group.	Blank discloses that status information that comprises a status of the synchrony group can be displayed in Figure 6, which shows the status of players A1, B1 and C1, which are each playing the same audio source ("Fgn_Affair"). See [0064]-[0065]  Fig. 6 Blank discloses that status information can be displayed using a player status mode [0070], and that the status information can include a status such as "playing" [0071]. See Fig. 9, "player status," which is a "status of the synchrony group" because it is a status of a member of the synchrony group under the broadest reasonable construction of the term:

'357 Patent	Blank under 35 U.S.C. 102(e)(1)
	 Fig. 9 See also Figures 7 and 8, [0066]-[0069]. A person of ordinary skill in the art would consider the media synch players 110 of Blank or the management system 212 of Gray to be playback devices that could be implemented as PCs or in conjunction with PCs that can transmit status information to a controller, such as a remote control interface in conjunction with pcAnywhere or the group status functionality as discussed for Edens for the corresponding element. To the extent that it is considered that Blank does not disclose this limitation, the Sonos APA discloses the existence of discovery protocols that can be used to learn about other components on the network and to establish communication with them, such as the Universal Plug and Play (UPnP) architecture, which defines discovery as the first step in UPnP networking. This allows devices to discover other devices and to exchange information about themselves and/or their services. See U.S. Provisional Application 60/490,768, filed July 28, 2003 (the '768 Provisional). A person of ordinary skill in the art would understand that such discovery protocols would result in the transmission of status information for each device in the synchrony group to a controller device, which could be implemented in conjunction with live playback system control console 125 or other suitable control devices.
19. The first playback device of claim 9, wherein the audio information source outside of the LAN is an Internet-accessible	Blank discloses that the system elements can be connected by LANs, WANs or the Internet. See [0023]. Gray discloses that audio content can be obtained from a remote source over the Internet. See [0035]-[0037], [0041], [0046]-[0048].

'357 Patent	Blank under 35 U.S.C. 102(e)(1)
audio information source, and wherein obtaining, from the audio information source outside of the LAN, the audio information, comprises obtaining the audio information from the Internet-accessible audio information source.	A person of ordinary skill in the art would consider the media synch players 110 of Blank or the management system 212 of Gray to be playback devices that could be implemented as PCs or in conjunction with PCs that can obtain audio information from an Internet-accessible source, as disclosed in Edens for multimedia PC 170 or MDV 5100, or the Handbook.

TABLE 5

SUBSTANTIAL NEW QUESTION OF PATENTABILITY FOR CLAIMS 9, 10, 12 AND 19 BASED ON BLANK, GRAY, SMPTE, RFC 1305, MICROSOFT FILE SHARING, PCANYWHERE, THE HANDBOOK AND SONOS APA UNDER 35 U.S.C. 103(A)

'357 Patent	Blank in combination with Gray, SMPTE, RFC 1305, Microsoft File Sharing, pcAnywhere, the Handbook and Sonos APA under 35 U.S.C. 103(a)
9. A first playback device comprising:	Blank discloses a media synch player 110 that is a playback device. [0029] "In operation, the media synch players 110 each generate a content stream such as video or audiovisual data in synchrony at the behest of the live playback system control console 125. Synchronism is derived from the time server 120, facilitating orchestration of the content provided by the media synch players 110. The system control console 125 and the media synch players 110 are slaved to the time server 120. As such, the system control console 125 can transmit a start time t+d for the media synch players 110 to start providing content from media files 210 (FIG. 2), and the media synch players 110 are synchronized with respect to this start time. " See also [0026], [0034], [0036]-[0041], [0044]-[0047], [0052]-[0059], [0065]-[0071], [0077]-[0093] Gray discloses a management system 212 at [0036]-[0037] that can receive audio data over the Internet for use with audio system 216, and that management system can be a playback device that is integral with audio system 216. A person of ordinary skill in the art would understand that management system 212 can be implemented as part of one or more media synch player 110. A person of ordinary skill in the art would consider the media synch players 110 of Blank or the management system 212 of Gray to be playback devices that could be implemented as PCs or in conjunction with PCs, and would understand that they could be implemented in conjunction with commonplace PC functionality disclosed in the Handbook.
one or more processors; a network interface; and	Blank discloses at least inherently that the media synch players 110 have processors (see claims 26 and 35-41) and network interfaces ([0023], [0028], [0043]), because it is well known that networked computers as disclosed at [0026] have processors and network interfaces.

'357 Patent	Blank in combination with Gray, SMPTE, RFC 1305, Microsoft File Sharing, pcAnywhere, the Handbook and Sonos APA under 35 U.S.C. 103(a)
	Gray discloses that the management system 212 includes one or more processors as processing unit 236 and a network interface as modem 266 or "any other available communication media." [0048] A person of ordinary skill in the art would consider the media synch players 110 of Blank or the management system 212 of Gray to be playback devices that could be implemented as PCs or in conjunction with PCs that have processors and network interfaces, and would understand that they could be implemented in conjunction with such commonplace PC hardware as disclosed in the Handbook.
tangible, non-transitory computer-readable memory comprising program instructions that, when executed by the one or more processors, cause the first playback device to:	Blank discloses that the media synch players 110 have computer readable media at [0026]-[0027] that includes "computer readable instructions, data structures, program logic or program modules." Gray discloses in regards to management system 212 that "[i]nstructions, data, and other program modules necessary for the operation of processing unit 236 and necessary for the operation of the ASIC 238 may be stored in mass storage device 250 and/or system memory 242, which includes read-only memory ("ROM") 246 and random-access memory ("RAM") 248. A person of ordinary skill in the art would consider the media synch players 110 of Blank or the management system 212 of Gray to be playback devices that could be implemented as PCs or in conjunction with PCs that have tangible, non-transitory computer-readable memory comprising program instructions that, when executed by the one or more processors, cause the first playback device to perform the claimed functions, and would understand that they could be implemented in conjunction with such commonplace PC hardware as disclosed in the Handbook.
receive, via the network interface from a network device configured to control the first playback device and communicatively coupled to the first playback device over a local area network (LAN), control information comprising	Blank discloses that recorded media that are distributed over a wide geographic area can be used for a multimedia presentation that requires synchronization of multiple displays at [0008]. Blank discloses that live playback system control console 125 at [0054] that provides control signals to interface 220 of media synch players 110, and that these control signals can include commands to "play" and "get file." Thus, at least live playback system control console 125 is a "network device configured to control the first playback device and communicatively coupled to the first playback device over a local area network (LAN)."

'357 Patent	Blank in combination with Gray, SMPTE, RFC 1305, Microsoft File Sharing, pcAnywhere, the Handbook and Sonos APA under 35 U.S.C. 103(a)
an address identifying a network location of audio information available at an audio information source, wherein the audio information source is outside of the LAN; and	[0054] "In the block 405, control signals from the control console 125 are received by the interface 220. In one embodiment, the control signals may comprise, for example, one of: play, pause, stop, seek to time, get file and show images. Blank discloses that the disclosed system elements can be connected over a WAN or the Internet at [0023]. Blank incorporates U.S. patent application Ser. No. 09/836,834 (Published Application No. 2002/0150053 to Gray et a., hereinafter "Gray") by reference at [0042] and [0045]. Gray discloses communication of multimedia packets 304 from a multimedia source 301 to a multimedia sink 302 over heterogeneous networks 303, which inherently requires an address identifying a network location of audio information outside of a LAN for a multimedia sink 302 on a local area network 313. See, Gray at Fig. 1, [0053], [0059], [0061]. A person of ordinary skill in the art would recognize that streaming audio content from a source outside of the LAN could be accomplished using software programs such as the Windows Media Player, as disclosed at [0037] of Blank. A person having ordinary skill in the art would thus understand that live playback system control console 125 can provide control information to a media synch player that comprises an address identifying a network location of audio information available at an audio information source, wherein the audio information source is outside of the LAN, as disclosed in Gray. To the extent it is considered that Blank does not disclose a playback device that can receive, via the network interface from a network device configured to control the first playback device and communicatively coupled to the first playback device over a local area network (LAN), control information comprising an address identifying a network location of audio information available at an audio information source, wherein the audio information source is outside of the LAN, the Handbook discloses that PCs could be used as playback devices and included the ability to obtain audio information from a source outside the LAN. See the Handbook, pages see pages 17-18, 28-34, 66-84, 109-116, 123-154, 243-261.

'357 Patent	Blank in combination with Gray, SMPTE, RFC 1305, Microsoft File Sharing, pcAnywhere, the Handbook and Sonos APA under 35 U.S.C. 103(a)
	In addition, to the extent that it is considered that Blank does not disclose remotely controlling a playback device over a LAN, it was also well known before the Critical Date of the '357 Patent to use commercially available PC software to receive control information via the network interface of a first PC from a second PC that was configured to control the first PC and that was communicatively coupled to the first PC over a LAN. See pcAnywhere at page 12 ("pcAnywhere lets you connect to another computer and perform your work as though you were sitting in front of that computer. You can view and edit files, access network resources, and run programs that you have permission to access. You can also print files located on another computer to your default printer.") Such control information could comprise an address identifying a network location of audio information available at an audio information source that is outside of the LAN, as disclosed in the Handbook.
after receiving the control information, (i) obtain, via the network interface from the audio information source outside of the LAN, the audio information;	Blank discloses that media files 210 can be stored at a media storage location for each media synch player 110, or that is shared by two or more media synch players 110 at [0037]. Gray discloses at [0036]-[0037] that management system 212 can receive audio data over the Internet for use with audio system 216, and that management system can be a playback device that is integral with audio system 216. A person of ordinary skill in the art would understand that management system 212 can be implemented as part of one or more media synch player 110. As such, a person having ordinary skill in the art would understand that audio data that is received over the Internet by the system of Gray can be stored as a media file 210 of a media synch player 110 of Blank. It was common as of the critical date of the '357 Patent (April 1, 2003) for users to obtain content over the Internet from sources outside of a user's LAN and to store that content on a personal computer or other playback device. See, e.g., the Handbook at Appendix A. A person of skill would also understand that the media synch players 110 of Blank or the management system 212 of Gray could also or alternatively be used as playback devices of Edens for synchronous playback, as members of the synchrony group of Edens, such as to allow the architecture of Edens to be used in a system other than the logical ring network of Edens. In addition, Edens discloses that one of the playback devices of Edens, such as multimedia PC 170 or MDV 5100, could be used to

'357 Patent	Blank in combination with Gray, SMPTE, RFC 1305, Microsoft File Sharing, pcAnywhere, the Handbook and Sonos APA under 35 U.S.C. 103(a)
	obtain audio data over the Internet and to provide that audio data to other playback devices, as discussed above for this limitation in regards to Eden. Also, see claim 3 of Eden.
(ii) transmit, via the network interface of the first playback device to a second playback device, the audio information, playback timing information associated with the audio information, and device clock information of the first playback device; and	Blank discloses clock module 212 of a media synch player 110 that can be slaved to another clocking system at [0038]. Blank also discloses the use of a time server 120 at [0029] and [0044]-[0051]. A person of ordinary skill in the art would recognize that the time server 120 could be located on a first media synch player 110, and could provide the master clock that is used to provide the playback timing information. The time server 120 would then transmit clock information to a second media synch players 110, to allow it to acquire lock with a clock contained in time server 120. See [0048] of Blank. As discussed below, the first media synch player 110 can obtain the audio information and provide it to the second media synch player 110 using Windows file sharing, and can then provide playback timing information by either 1) hosting live playback system control console 125 and transmitting a play command to the second media synch player 110, for "playback timing information" construction 1, or 2) add time stamps to the media data packets at the application layer that are used to control playback timing in accordance with the teachings of Gray, for "playback timing information" construction 2. Time information can also be transmitted from time server 120 to other media synch players 110 to cause them to "speed up or slow down rendering of clocks 212 in the individual media synch players 110." See [0045] of Blank. Time information that causes other media synch players 110 to speed up or slow down meets the broadest reasonable interpretation of "playback timing information," because it is used to control playback timing. A person of ordinary skill in the art would consider the media synch players 110 of Blank or the management system 212 of Gray to be playback devices that could be implemented as PCs or in conjunction with PCs that use SMPTE (as disclosed in Blank at [0008]) or RFC 1305(as disclosed in Blank at [0024] as NTP) to generate playback timing information associated with the audio information, under either construction 1 in the form of a "play" command or under construction 2 in the form of frame-specific playback timing information. A person of skill would also understand that the the architecture of Edens could be used in a system other than the logical ring network of Edens, such as with the media synch players 110 of Blank or the management system

'357 Patent	Blank in combination with Gray, SMPTE, RFC 1305, Microsoft File Sharing, pcAnywhere, the Handbook and Sonos APA under 35 U.S.C. 103(a)
	212 of Gray, and that by using the timing information architecture of Edens (i.e. designation of one of the playback devices as a network clock device), and serial streaming of audio data between devices in the synchrony group as taught by Edens, that the number of system components could be reduced and that redundancy and reliability could be increased. A person having skill in the art would recognize that live playback system control console 125 can also be implemented on a media synch player 110 with time server 120, and can be used to provide playback timing information to other media synch players 110 as disclosed at [0044] as a time stamp "t" and an indication of a delay "d" that is used to coordinate playback, which satisfies the broadest reasonable interpretation of "playback timing information," because it is used to control playback timing, either based on the knowledge of one of ordinary skill in the art, or based on the teachings of the MDV 5100 of Edens. Blank also discloses that the "exemplary media synch player 110 may be realized as a modified conventional personal computer, such as is available from a variety of commercial sources, employing a Windows ® operating system, available from many sources and from Microsoft Corporation of Redmond, Wash." [0034]. The Windows operating system permitted file sharing between personal computers, see, e.g., "File and Printer Sharing with Microsoft Windows," Microsoft Corporation, November 2003 at page 1 ("File and printer sharing is the ability of a computer running Windows to share a folder or attached printer with other computers on a network. File sharing allows you to make files and folders in a shared folder accessible to others on the network to view, copy, or modify. For example, with file sharing, you can store all of your documents on a central computer and share the folder that contains them. Then, from another computer attached to the same network as the computer that contains the files, you can connect to the shared folder and work with the documents as if they were locally stored. For example, you can access files that are stored on a central desktop computer from a wireless laptop computer that you can carry from room to room in your home.") As such, the system of Blank could allow a first media synch player 110 to obtain an audio file from a source outside of the LAN, store the audio file to a local media file 210 of the first media synch player 110, and then allow a second media synch player 110 to obtain that audio content over the

'357 Patent	Blank in combination with Gray, SMPTE, RFC 1305, Microsoft File Sharing, pcAnywhere, the Handbook and Sonos APA under 35 U.S.C. 103(a)
	LAN using the Windows operating system file sharing functionality, in response to a command from lice playback system control console 125. Gray discloses the use of time stamps in multimedia packets at [0062] that are used to control the time that a multimedia packet is to be rendered at, and further discloses at [0069] that the application layer can "maintain the common time reckoning across the devices, calculate the appropriate time stamp, and/or include the time stamp in the multimedia packet." A person of ordinary skill in the art would recognize from this teaching that the application layer on the media synch player 110 that includes a time server 120 could include the time stamp into the multimedia packets of the audio data from media file 210 (that has been obtained from outside the LAN and stored in media file 210) and which is then provided to other media synch players 110 as "playback timing data" for synchronized playback, because that would allow the system of Blank to be implemented on as few as two different devices, and would eliminate the need for a separate time server 120. Blank discloses the playback timing information associated with the audio information under construction 1, such as when a start time t+d is generated by a first playback device that is also used to implement system control console 125. See [0029] Gray discloses the playback timing information associated with the audio information under construction 2, such as when the application layer of a media synch player 110 inserts timestamps into frames of audio data. . See [0016], [0087], [0089]. A person of ordinary skill in the art would consider the media synch players 110 of Blank or the management system 212 of Gray to be playback devices that could be implemented as PCs or in conjunction with PCs, and which can transmit audio information, playback timing information and clock information to another playback device for synchronous playback. A person of skill would also understand that the media synch players 110 of Blank or the management system 212 of Gray could also or alternatively be used as playback devices of Edens for synchronous playback, as members of the synchrony group of Edens, such as to allow the architecture of Edens to be used in a system other than the logical ring network of Edens, as discussed for the corresponding element in the Edens claim chart.

'357 Patent	Blank in combination with Gray, SMPTE, RFC 1305, Microsoft File Sharing, pcAnywhere, the Handbook and Sonos APA under 35 U.S.C. 103(a)
	To the extent that it is considered that Blank or Gray do not disclose this limitation, the Sonos APA discloses that it was known to transmit audio information and playback timing information associated with the audio information (for synchronous playback) and device clock information of the first playback device (using RFC 1305 or SNTP), via the network interface of the first playback device to a second playback device. See '357 Patent at 1:47 to 2:28 and the '768 Provisional at pages 1-2. It would be obvious to use the Sonos APA with the system of Blank, because both Blank and the Sonos APA are directed to networked audio devices that play back audio in synchrony, and the Sonos APA would eliminate the need for an additional device for time server 120, because it teaches that the timing functionality can be provided by a playback device.
(iii) play back the audio information in synchrony with the second playback device by using the playback timing information associated with the audio information and the device clock information of the first playback device to play back the audio information,	Blank discloses that media synch players 110 play back the audio information in synchrony with each other by using the playback timing information associated with the audio information that is generated by live playback system control consoled 125 and the device clock information of the first playback device (which is used to generate the NTP timing information) to play back the audio information. See [0009], [0010], [0022], [0024], [0025], [0029], [0041], [0043]-[0045]. Each media synch player 110 uses the audio information and its own clock information and the playback timing information (the start time of Blank t+d under construction 1, or frame-specific time stamps of Gray under construction 2), but even if the claims are amended to positively recite the second playback device and to require the second playback device to use the playback timing information associated with the audio information and the device clock information of the first playback device to play back the audio information, Blank or Blank and Gray disclose that also. The management systems 212 of Gray can play back the audio information in synchrony with a second management system 212 by using the playback timing information associated with each frame of the audio information and the device clock information of the first playback device to play back the audio information, such as using an application synchronization process in conjunction with the management systems 212. See [0016], [0087], [0089]. A person of ordinary skill in the art would consider the media synch players 110 of Blank or the management system 212 of Gray to be playback devices that could be implemented as PCs or in

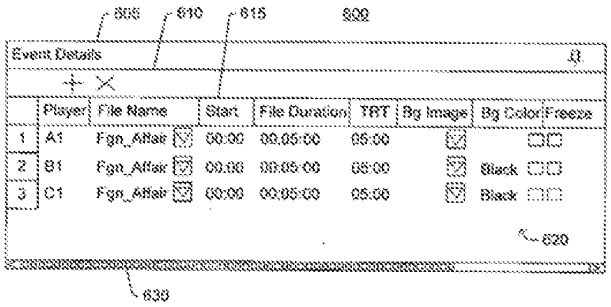
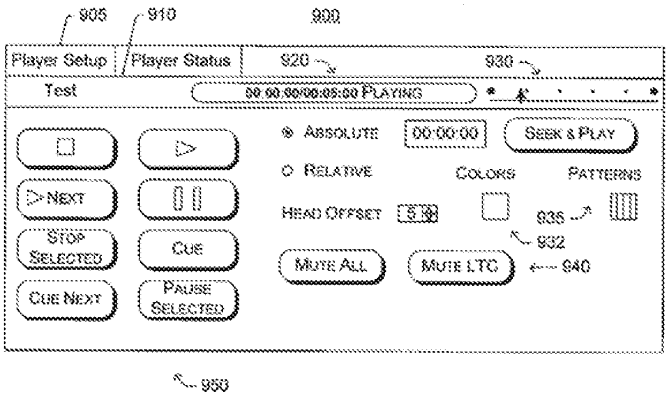
'357 Patent	Blank in combination with Gray, SMPTE, RFC 1305, Microsoft File Sharing, pcAnywhere, the Handbook and Sonos APA under 35 U.S.C. 103(a)
	conjunction with PCs, and which can play back audio in synchrony with each other using the playback timing information and clock time information of the first playback device, as discussed above. A person of skill would also understand that the media synch players 110 of Blank or the management system 212 of Gray could also or alternatively be used as playback devices of Edens for synchronous playback, as members of the synchrony group of Edens, such as to allow the architecture of Edens to be used in a system other than the logical ring network of Edens, and to playback the audio data using the playback timing information and clock information of a first playback device as described for the corresponding limitation of Edens. It is noted that this limitation does not require the second playback device to playback the audio information by using the playback timing information associated with the audio information and the device clock information of the first playback device to play back the audio information. That limitation only applies to the first playback device, and as long as the second playback device is playing back the audio information in synchrony with the first playback device while the first playback device uses the playback timing information associated with the audio information and the device clock information of the first playback device to play back the audio information, then the claim limitation is satisfied. To the extent that it is considered that Blank or Gray do not disclose this limitation, the Sonos APA discloses that it was known to transmit audio information and playback timing information associated with the audio information (for synchronous playback) and device clock information of the first playback device (using RFC 1305 or SNTP), via the network interface of the first playback device to a second playback device. See '357 Patent at 1:47 to 2:28 and the '768 Provisional at pages 1-2. It would be obvious to use the Sonos APA with the system of Blank, because both Blank and the Sonos APA are directed to networked audio devices that play back audio in synchrony, and the Sonos APA would allow Blank to provide the timing functionality on one of the media synch players 110 instead of a dedicated time server 120, thus reducing the need for an additional device.
wherein the first and second playback devices remain independently clocked	Each media synch player 110 of Blank includes a clock module or clocking system 212 that is an independent clock, where the media synch players 110 operating in accordance with their own respective clocks during synchronous playback.

'357 Patent	Blank in combination with Gray, SMPTE, RFC 1305, Microsoft File Sharing, pcAnywhere, the Handbook and Sonos APA under 35 U.S.C. 103(a)
during synchronous playback of the audio information.	A person of ordinary skill in the art would consider the media synch players 110 of Blank or the management system 212 of Gray to be playback devices that could be implemented as PCs or in conjunction with PCs, and which can remain independently clocked during synchronous playback, at least because PCs contain multiple clocks that can be independent. A person of skill would also understand that the media synch players 110 of Blank or the management system 212 of Gray could also or alternatively be used as playback devices of Edens for synchronous playback, as members of the synchrony group of Edens, such as to allow the architecture of Edens to be used in a system other than the logical ring network of Edens. To the extent that it is considered that Blank or Gray do not disclose this limitation, the Sonos APA discloses that playback devices can remain independently clocked during synchronous playback of audio information, see '357 Patent at 2:21-27 ("When an audio playback device converts the digital audio information from digital to analog form, it does so using a clock that provides timing information. Generally, the audio playback devices that are being developed have independent clocks, and, if they are not clocking at precisely the same rate, the audio playback provided by the various devices can get out of synchronization."). Thus, if the independent clocks of the audio playback devices are clocking at precisely the same rate by design, or if they are synchronized, then the audio playback provided by the various devices remains in synchronization. The claims do not address how to address the situation where the independent clocks of the audio playback devices are not clocking at precisely the same rate or are not synchronized, and how to accommodate/correct/address that condition.
10. The first playback device of claim 9, wherein the program instructions, when executed by the one or more processors, further cause the first playback device to: generate the playback timing information	Blank discloses that the software generates the playback timing information associated with the audio information under construction 1, such as when a start time t+d is generated by a first playback device that is also used to implement system control console 125. See [0029] Gray discloses that the software generates the playback timing information associated with the audio information under construction 2, such as when the application layer of a media synch player 110 inserts timestamps into frames of audio data. See [0016], [0087], [0089].

'357 Patent	Blank in combination with Gray, SMPTE, RFC 1305, Microsoft File Sharing, pcAnywhere, the Handbook and Sonos APA under 35 U.S.C. 103(a)
associated with the audio information; and	A person of ordinary skill in the art would consider the media synch players 110 of Blank or the management system 212 of Gray to be playback devices that could be implemented as PCs or in conjunction with PCs that use SMPTE (as disclosed in Blank at [0008]) or RFC 1305(as disclosed in Blank at [0024] as NTP) to generate playback timing information associated with the audio information, under either construction 1 in the form of a "play" command or under construction 2 in the form of frame-specific playback timing information. A person of skill would also understand that the media synch players 110 of Blank or the management system 212 of Gray could also or alternatively be used as playback devices of Edens for synchronous playback, as members of the synchrony group of Edens, such as to allow the architecture of Edens to be used in a system other than the logical ring network of Edens and by using the timing information architecture of Edens (i.e. designation of one of the playback devices as a network clock device, and serial streaming of audio data between devices in the synchrony group as taught by Edens.
generate the device clock information of the first playback device.	Blank discloses that the media synch player 110 software causes the media synch player 110 to generate device clock information of the first playback device, such as by activating the Network Time Protocol module 15. See [0038], [0046]-[0048]. A person of ordinary skill in the art would consider the media synch players 110 of Blank or the management system 212 of Gray to be playback devices that could be implemented as PCs or in conjunction with PCs that have tangible, non-transitory computer-readable memory comprising program instructions that, when executed by the one or more processors, cause the first playback device to generate the device clock information of the first playback device, such as for any device clock of the PC that can be actuated in response to such instructions (e.g. a sound card, a network card and so forth). A person of skill would also understand that the media synch players 110 of Blank or the management system 212 of Gray could also or alternatively be used as playback devices of Edens for synchronous playback, as members of the synchrony group of Edens, such as to allow the architecture of Edens to be used in a system other than the logical ring network of Edens.
11. The first playback device of claim 9, wherein the control information further	Blank discloses at [0029] that the "media synch players 110 each generate a content stream such as video or audiovisual data in synchrony at the behest of the live playback system control console 125. Synchronism is derived from the time server 120, facilitating

'357 Patent	Blank in combination with Gray, SMPTE, RFC 1305, Microsoft File Sharing, pcAnywhere, the Handbook and Sonos APA under 35 U.S.C. 103(a)
comprises one or more instructions for the first playback device and the second playback device to playback audio information.	orchestration of the content provided by the media synch players 110. The system control console 125 and the media synch players 110 are slaved to the time server 120. As such, the system control console 125 can transmit a start time t+d for the media synch players 110 to start providing content from media files 210 (FIG. 2), and the media synch players 110 are synchronized with respect to this start time." The start time is control information that includes one or more instructions for the first playback device and the second playback device to playback audio information. Claim 5 of Blank includes the "process of claim 1, wherein providing content comprises providing content from each of the multiple media players in response to commands from a control console at a time specified by the control console." See also Blank at [0044] ("In operation, a time stamp "t" is obtained by each device from the controller 125, which is synchronized with the time server 120. Also included with the time stamp t is a delay indication "d". In combination, these time related components instruct the media synch players 110 on when to render content available from the media files 210. Essentially, each media synch player 110 will wait to render content until a particular time t+d, derived from the time stamp from the controller 125. As such, content from all of the media synch players 110 will be synchronized to the same moment in time—t+d —regardless of when the time synchronization was initiated."); [0056] ("In a block 410, the media synch players 110 respond to the control signals and provide appropriate output signals via the signal paths 112 to the displays 105. Such may comprise start of synchronized operation of the media synch players 110 and associated displays 105, switching from one media file 210 to another (e.g., get file followed by start), cease operation (e.g., stop), which may include initiation of a predetermined state such as a blank or black display 105, and the like."). A person of ordinary skill in the art would consider the media synch players 110 of Blank or the management system 212 of Gray to be playback devices that could be implemented as PCs or in conjunction with PCs, and which can play back audio in synchrony with each other in response to a suitable playback command. A person of skill would also understand that the media synch players 110 of Blank or the management system 212 of Gray could also or alternatively be used as playback devices of Edens for synchronous

'357 Patent	Blank in combination with Gray, SMPTE, RFC 1305, Microsoft File Sharing, pcAnywhere, the Handbook and Sonos APA under 35 U.S.C. 103(a)
	playback, as members of the synchrony group of Edens, such as to allow the architecture of Edens to be used in a system other than the logical ring network of Edens.
12. The first playback device of claim 11, wherein the first and second playback devices are members of a synchrony group, and wherein the program instructions, when executed by the one or more processors, further cause the first playback device to:	Blank discloses that media synch players 110 are members of a synchrony group that play back the audio information in synchrony with each other by using the playback timing information associated with the audio information that is generated by live playback system control consoled 125 and the device clock information of the first playback device (which is used to generate the NTP timing information) to play back the audio information. See [0009], [0010], [0022], [0024], [0025], [0029], [0041], [0043]-[0045], The management systems 212 of Gray can play back the audio information in synchrony with a second management system 212 in a synchrony group by using the playback timing information associated with each frame of the audio information and the device clock information of the first playback device to play back the audio information, such as using an application synchronization process in conjunction with the management systems 212. See [0016], [0087], [0089]. A person of ordinary skill in the art would consider the media synch players 110 of Blank or the management system 212 of Gray to be playback devices that could be implemented as PCs or in conjunction with PCs, and which can play back audio in synchrony with each other, which would make then members of a synchrony group. A person of skill would also understand that the media synch players 110 of Blank or the management system 212 of Gray could also or alternatively be used as playback devices of Edens for synchronous playback, as members of the synchrony group of Edens, such as to allow the architecture of Edens to be used in a system other than the logical ring network of Edens.
transmit, to the network device, status information that comprises a status of the synchrony group.	Blank discloses that status information that comprises a status of the synchrony group can be displayed in Figure 6, which shows the status of players A1, B1 and C1, which are each playing the same audio source ("Fgn_Affair"). See [0064]-[0065]

'357 Patent	Blank in combination with Gray, SMPTE, RFC 1305, Microsoft File Sharing, pcAnywhere, the Handbook and Sonos APA under 35 U.S.C. 103(a)
	 Fig. 6 Blank discloses that status information can be displayed using a player status mode [0070], and that the status information can include a status such as "playing" [0071]. See Fig. 9, "player status," which is a "status of the synchrony group" because it is a status of a member of the synchrony group under the broadest reasonable construction of the term:  Fig. 9 See also Figures 7 and 8, [0066]-[0069]. A person of ordinary skill in the art would consider the media synch players 110 of Blank or the management system 212 of Gray to be playback devices that could be implemented as PCs or in conjunction with PCs that can transmit status information to a controller, such as a remote control interface in conjunction with

'357 Patent	Blank in combination with Gray, SMPTE, RFC 1305, Microsoft File Sharing, pcAnywhere, the Handbook and Sonos APA under 35 U.S.C. 103(a)
	pcAnywhere or the group status functionality as discussed for Edens for the corresponding element. To the extent that it is considered that Blank does not disclose this limitation, the Sonos APA discloses the existence of discovery protocols that can be used to learn about other components on the network and to establish communication with them, such as the Universal Plug and Play (UPnP) architecture, which defines discovery as the first step in UPnP networking. This allows devices to discover other devices and to exchange information about themselves and/or their services. See U.S. Provisional Application 60/490,768, filed July 28, 2003 (the '768 Provisional). A person of ordinary skill in the art would understand that such discovery protocols would result in the transmission of status information for each device in the synchrony group to a controller device, which could be implemented in conjunction with live playback system control console 125 or other suitable control devices.
19. The first playback device of claim 9, wherein the audio information source outside of the LAN is an Internet-accessible audio information source, and wherein obtaining, from the audio information source outside of the LAN, the audio information, comprises obtaining the audio information from the Internet-accessible audio information source.	Blank discloses that the system elements can be connected by LANs, WANs or the Internet. See [0023]. Gray discloses that audio content can be obtained from a remote source over the Internet. See [0035]-[0037], [0041], [0046]-[0048]. A person of ordinary skill in the art would consider the media synch players 110 of Blank or the management system 212 of Gray to be playback devices that could be implemented as PCs or in conjunction with PCs that can obtain audio information from an Internet-accessible source, as disclosed in Edens for multimedia PC 170 or MDV 5100, or the Handbook.

N. Meade in view of Goldberg and the Sonos APA, either alone under 35 U.S.C. 103(a) (Table 6) or in further combination with Edens, Blank, SMPTE, NTP, Nutshell, RTP and RTSP under 35 U.S.C. 103(a) (Table 7) presents a Substantial New Question of Patentability

Although the Challenged Claims were allowed over Meade in view of Goldberg following the amendments submitted on July 7, 2015, the Office did not explicitly consider the Sonos APA at that point (or at any time previous to that point). The claim amendments that were submitted on July 7, 2015, were disclosed in the Sonos APA, and should not have provided a basis for overcoming the rejections of the claims over Meade in view of Goldberg, if the Sonos APA had been considered.

For example, claim 21 as amended on July 7, 2015 is presented below for the convenience of the Office:

> 21. A first playback device comprising:
>
> **one or more processors**;
>
> a network interface; and
>
> **tangible, non-transitory computer-readable** memory comprising program instructions that, when executed by **[[a]] the one or more** processor**s**, cause the playback device to:
>
> receive, via the network interface from a network device configured to control the first playback device and communicatively coupled to the first playback device over a local area network (LAN), control information comprising ~~**(i) one or more instructions that cause the first playback device and a second playback device to playback audio information and (ii)**~~ an address identifying a network location of the audio information available at an audio information source, wherein the audio information source is outside of the LAN; and
>
> ~~**in response to**~~ **after** receiving the control information, (i) obtain, via the network interface from the audio information source outside of the LAN, the audio information; (ii) transmit, via the network interface of the first playback device to the second playback device, the audio information**, playback timing information associated with the audio information, and device clock information of the first playback device;** and (iii) play back the audio information **in synchrony with the second playback device by using the playback timing information associated with the audio information and the clock information of the first playback device to play back the audio information, wherein the first and second playback devices remain independently clocked during synchronous playback of the audio information**.

As shown above, the Sonos APA included admissions that playback timing information associated with the audio information (required for synchronous playback), device clock information of the first playback device (required for NTP and SNTP) and independently clocked

devices capable of synchronous playback using synchronized clocks were known in the art. See, e.g. Sonos APA nos. 1, 2, 6, 7, 9, 11 and 12. As shown in the claim chart below, Mead and Goldberg in combination with the Sonos APA discloses each element of the Challenged Claims of the '357 Patent in a manner that was not considered during the original prosecution of the '357 Patent, at least because Examiner Survillo did not explicitly consider the Sonos APA during the original prosecution, and did not appear to understand the full scope of what Sonos admitted was prior art to the '357 Patent.

In addition, while the Sonos APA explicitly discloses playing back the audio information in synchrony with playback devices using playback timing information associated with the audio information and clock information of a first playback device to play back the audio information, wherein the playback devices remain independently clocked during synchronous playback of the audio information, Edens and Blank also disclose these limitations in the same technical field (networked audio devices) and for the same purpose (synchronized playback of audio by networked audio devices). A person having skill in the art would understand that the use of playback timing information associated with the audio information and clock information of a first playback device to play back the audio information, wherein the playback devices remain independently clocked during synchronous playback of the audio information, as disclosed in Edens and Blank, could be applied to Meade in view of Goldberg, either with or without the benefit of the Sonos APA, to result in the claimed inventions of the Challenged Claims of the '357 Patent.

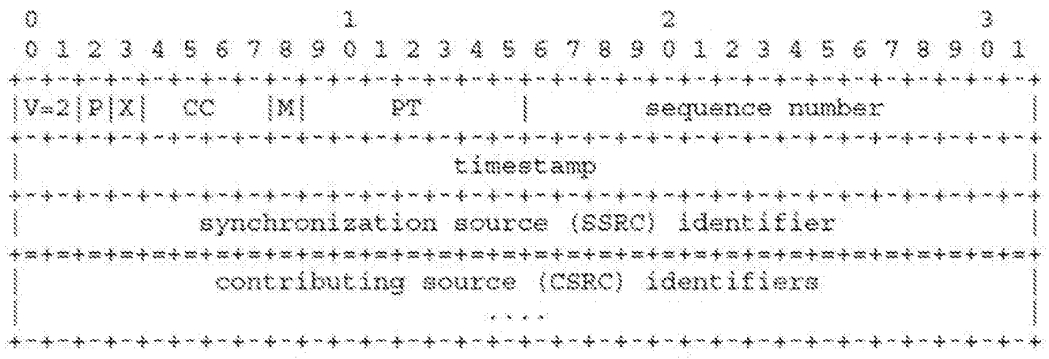
In addition, because Meade, Goldberg, Edens and Blank are each directed to the same technical field of networked audio devices and the same problem of providing synchronous playback of audio information on networked audio devices, which can include a PC in each reference, a person having ordinary skill in the art would understand that the devices and/or techniques of Edens and/or Blank (and the general disclosure regarding common features of multimedia PCs in the Handbook) could be used with Meade and Goldberg, to the extent that they were not inherent in such devices of Meade and Goldberg. The ability to exchange playback timing information and clock information of devices is generally a basic and necessary component of networked audio devices that playback audio in synchrony, and to the extent that Meade and Goldberg do not explicitly disclose that functionality, Edens and Blank demonstrate that it was well known in the art and that standards such as SMPTE and NTP were commonly used in such

systems to play back audio information in synchrony. In addition, the remote control functionality disclosed in pcAnywhere could be used with a PC on a network.

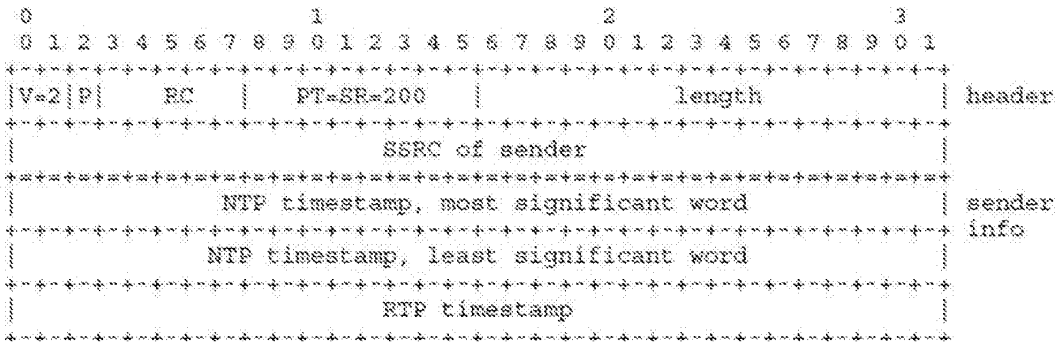
It is further noted that Goldberg discloses that it is compatible with streaming audio formats such as Real Audio, Windows Media Audio, Shockwave streaming audio, QuickTime audio or even streaming MP3 and others at [0171], which would include the use of real time streaming functionality such as the Realtime Transfer Protocol (RTP), see Nutshell at 24.4.2. Server Software and Protocols (pages 462-463 of 478) ("Streaming media takes advantage of either UDP (User Datagram Protocol), RTSP (RealTime Streaming Protocol), or RTP (RealTime Transfer Protocol) for the transmission of data."); RTSP at page 54, discussing the use of NTP and RTP timestamps; and RTP at pages 9 and 22-29, discussing use of NTP.

RTP discloses the use of a frame format that includes a frame sequence number, see RFC 1889 at page 10:

The RTP header has the following format:



In addition, RTP also discloses at page 23 a sender report and receiver report that includes both NTP and RTP timestamp data:



As such, RTP discloses the transmission of clock information of a first playback device, when the first playback device is a sender of an NTP timestamp or an RTP timestamp.

RTSP discloses at 35 that a "play" command can include a Range header, and that the "Range header may also contain a time parameter. This parameter specifies a time in UTC at which the playback should start. If the message is received after the specified time, playback is started immediately. The time parameter may be used to aid in synchronization of streams obtained from different sources." Thus, RTSP discloses the transmission of playback timing information.

To the extent that the use of RTSP and RTP in Goldberg is not considered to be inherent in the disclosure of the use of Real Audio, Windows Media Audio, Shockwave streaming audio, QuickTime audio, streaming MP3 and other real time streaming functionality in Goldberg, as explained in Nutshell, a person having skill in the art would consider it obvious to combine Nutshell, RTSP and RTP with Goldberg, because those references provide additional details on well-known and widely used streaming audio protocols that include enabling disclosure in the prior art for the use of playback timing information and clock time information of a playback device with another playback device to play back audio. While Nutshell, RTSP and RTP are not believed to be necessary, and are in fact duplicative of information disclosed in the other references and the Sonos APA, they are included herein for the convenience of the Office. It is noted that in the Concurrent Litigation, Sonos and its technical experts appear to have taken the position that NTP, RTP, RTSP and other standards that were in wide use as of the critical date of the '357 Patent were out of date and irrelevant, because their publication dates made them too old to have any applicability or relevance to the claimed inventions, which is flatly contradicted by the Sonos APA.

As such, Meade in view of Goldberg and the Sonos APA presents a Substantial New Question of Patentability, either alone or in combination with Edens, Blank, the Handbook, pcAnywhere, SMPTE, NTP, RTP and RTSP.

TABLE 6

SUBSTANTIAL NEW QUESTION OF PATENTABILITY FOR CLAIMS 9, 10, 12 AND 19 BASED ON MEADE IN VIEW OF GOLDBERG AND THE SONOS APA UNDER 35 U.S.C. 103(A)

'357 Patent	Meade in view of Goldberg and the Sonos APA
9. A first playback device comprising:	Final rejection dated March 9, 2015 ("Final Rejection") at page 7 ("As to claim 21, Meade in view of Goldberg teaches **a first playback device** [audio device 28 that is one of the appliances 13; appliance controller 50 that is one of the appliances 13; or any other appliance 13 depicted at Fig. 2 in Meade; DJ unit 200, broadcast unit 710 in Goldberg] comprising: a network interface [wireless communicator 86] (Fig. 4 in Meade) [inter-unit tx/rx 11 O] (par. [0096] in Goldberg); and memory comprising program instructions that, when executed by a processor, cause the playback device to perform the method steps, as discussed per claim 33, above." (emphasis added)
one or more processors; a network interface; and	Final rejection at page 7 ("As to claim 21, Meade in view of Goldberg teaches a first playback device [audio device 28 that is one of the appliances 13; appliance controller 50 that is one of the appliances 13; or any other appliance 13 depicted at Fig. 2 in Meade; DJ unit 200, broadcast unit 710 in Goldberg] comprising: **a network interface** [wireless communicator 86] (Fig. 4 in Meade) [inter-unit tx/rx 11 O] (par. [0096] in Goldberg); and memory comprising program instructions that, when executed by **a processor**, cause the playback device to perform the method steps, as discussed per claim 33, above." (emphasis added)
tangible, non-transitory computer-readable memory comprising program instructions that, when executed by the one or more processors, cause the first playback device to:	Final rejection at page 7 ("As to claim 21, Meade in view of Goldberg teaches a first playback device [audio device 28 that is one of the appliances 13; appliance controller 50 that is one of the appliances 13; or any other appliance 13 depicted at Fig. 2 in Meade; DJ unit 200, broadcast unit 710 in Goldberg] comprising: a network interface [wireless communicator 86] (Fig. 4 in Meade) [inter-unit tx/rx 11 O] (par. [0096] in Goldberg); and **memory comprising program instructions that, when executed by a processor, cause the playback device to perform the method steps**, as discussed per claim 33, above." (emphasis added).
receive, via the network interface from a network device configured to control the first playback device and communicatively coupled to the first playback device over a	Final rejection at page 5 ("As to claim 33, Meade teaches a method comprising: **receiving, by a first playback device** [audio device 28 that is one of the appliances 13; appliance controller 50 that is one of the appliances 13; or any other appliance 13 depicted at Fig. 2] (Fig. 2; par. [0034], [0039]) **from a network device** [mobile device 12] **configured to control the first playback device** [configured to apply user preferences 18 at the selected appliances for control of the selected appliances] (par. [0039]) **and communicatively**

'357 Patent	Meade in view of Goldberg and the Sonos APA
local area network (LAN), control information comprising an address identifying a network location of audio information available at an audio information source, wherein the audio information source is outside of the LAN; and	**coupled to the first playback device over a local area network (LAN)** [network communication link 70] (par. [0042], [0047]), **control information comprising (i) one or more instructions that cause the first playback device and a second playback device** [another appliance 13] (Fig. 2) **to playback multimedia information** [mobile device 12 coordinates different media aspects of the same content or related content to be performed simultaneously on multiple appliances 13] (par. [0083]-[0084]) and (ii) **an address identifying a location of the multimedia information available at an audio information source** [providing selection of a TV channel identification or radio station identification as part of user preferences 18 that the user desires to be output at the selected appliances 13] (par. [0026], [0059]), **wherein the audio information source is outside of the LAN** [TV and radio broadcast stations are well known in the art as being external sources outside of any local area networks formed by devices in proximity]." (emphasis added). The Sonos APA includes that it was known that the audio playback devices could be located in the same room or distributed in different rooms in a residence such as a house or an apartment, in different offices in an office building, or the like, that in this configuration, the audio information that is distributed to various audio playback devices may relate to the same audio program, or the information may relate to different audio programs, and that if the audio information source provides audio information relating to the same audio program to two or more audio playback devices at the same time, the audio playback devices will generally contemporaneously play the same program. All of these functions require control information to be provided over the network, and the Office concurred that this APA was disclosed in Meade.
after receiving the control information, (i) obtain, via the network interface from the audio information source outside of the LAN, the audio information;	Final Office action at page 6 ("**in response to receiving the control information** [in response to receiving user preferences 18 at the controlled appliance] (i) **obtaining, by the first playback device from the audio information source outside of the LAN, the audio information** [audio device 28 receiving radio (or TV) broadcast of audio information (i.e. songs) that are preferred by the user] (par. [0057]); and (iii) playing back, by the first playback device, the audio information (par. [0062])." (emphasis added). The Sonos APA includes that it was known that audio information that is distributed to various audio playback devices may relate to the same audio program, or the information may relate to different audio programs, and that if the audio information source provides audio information relating to the same audio program to two or

'357 Patent	Meade in view of Goldberg and the Sonos APA
	more audio playback devices at the same time, the audio playback devices will generally contemporaneously play the same program, and the Office concurred with Sonos that this functionality was in the prior art.
(ii) transmit, via the network interface of the first playback device to a second playback device, the audio information, playback timing information associated with the audio information, and device clock information of the first playback device; and	Final Office action at pages 6-7 ("Goldberg is directed to a method, system, and apparatus for playing an audio signal synchronously on a first mobile audio player and at least a second mobile audio player (abstract). In particular, Goldberg teaches a method comprising: obtaining, by the first playback device [DJ unit 200, broadcast unit 71 O] from the audio information source [distributor], the audio information [music files] (par. [0338], Fig. 25), wherein the audio information source is outside of the LAN [distributor is an Internet device located via Internet] (par. [0350], [0351], [0357]); **transmitting, by the first playback device to a second playback device** [member unit 100, receive unit 730], **the audio information** [step 1348] (Fig. 25, par. [0339]); and playing back, by the first playback device, the audio information (par. [0019]). It would have been obvious to one or ordinary skill in the art at the time of the invention to modify the method, the first playback device, and the program of Meade by having the audio information in the form of a user-preferred song being played by the at least two appliances in the group 40 of Meade, such that the radio broadcast of the football game would be played by the TV 14 (that is known to have audio output capability) and by the radio 28, in synchrony, in order to enhance the personal or social experience of the audio being played (par. [0101] in Goldberg)." The Sonos APA discloses the commonplace use of NTP or SNTP to transmit the audio information, playback timing information associated with the audio information, and device clock information of the first playback device (either under construction 1, such as a start time, or under construction 2, such as frame-specific timing), as well as clock time information of the first playback device (such as for NTP or SNTP timing synchronization).
(iii) play back the audio information in synchrony with the second playback device by using the playback timing information associated with the audio information and the device clock information of the first playback	Final Office action at pages 6-7 ("Goldberg is directed to a method, system, and apparatus for playing an audio signal synchronously on a first mobile audio player and at least a second mobile audio player (abstract). In particular, Goldberg teaches a method comprising: obtaining, by the first playback device [DJ unit 200, broadcast unit 71 O] from the audio information source [distributor], the audio information [music files] (par. [0338], Fig. 25), wherein the audio information source is outside of the LAN [distributor is an Internet device located via Internet] (par. [0350], [0351], [0357]); transmitting, by the first playback device to a second playback device [member unit 100, receive unit 730], the audio information

'357 Patent	Meade in view of Goldberg and the Sonos APA
device to play back the audio information,	[step 1348] (Fig. 25, par. [0339]); and **playing back, by the first playback device, the audio information** (par. [0019]). It would have been obvious to one or ordinary skill in the art at the time of the invention to modify the method, the first playback device, and the program of Meade by having the audio information in the form of a user-preferred song being played by the at least two appliances in the group 40 of Meade, such that the radio broadcast of the football game would be played by the TV 14 (that is known to have audio output capability) and by the radio 28, in synchrony, in order to enhance the personal or social experience of the audio being played (par. [0101] in Goldberg)." The Sonos APA discloses the commonplace use of NTP or SNTP to play back the audio information in synchrony using the playback timing information associated with the audio information, and device clock information of the first playback device (either under construction 1, such as a start time, or under construction 2, such as frame-specific timing), as well as clock time information of the first playback device (such as for NTP or SNTP timing synchronization).
wherein the first and second playback devices remain independently clocked during synchronous playback of the audio information.	While Meade and Goldberg do not explicitly disclose "independent clocks," it was known to use independent clocks during synchronous playback, as recognized by the Sonos APA.
10. The first playback device of claim 9, wherein the program instructions, when executed by the one or more processors, further cause the first playback device to: generate the playback timing information associated with the audio information; and	Final Office action, page 8 ("As to claims 22 and 34, Meade in view of Goldberg teaches that in response to receiving the control information [application of the user preferences 18 at the controller appliance 13 in Meade], additionally: **generating, by the first playback device, timing information based on the audio information** (par. [0201]-[0203] in Goldberg); and transmitting, by the first playback device to the second playback device, the timing information (par. [0201]-[0203] in Goldberg), and wherein playing back the audio information comprises playing back the audio information according to the timing information (par. [0201]-[0203] in Goldberg).") The Sonos APA discloses the commonplace use of NTP or SNTP to generate playback timing information associated with the audio information. The Office agreed that Goldberg disclosed this prior art functionality from the Sonos APA.
generate the device clock information of the first playback device.	The appliances depicted at Fig. 2 in Meade include the PC, which inherently use program instructions to generate device clock information. The Sonos APA discloses the commonplace use of

'357 Patent	Meade in view of Goldberg and the Sonos APA
	NTP or SNTP which uses the device clock of the first playback device to generate device clock information.
11. The first playback device of claim 9, wherein the control information further comprises one or more instructions for the first playback device and the second playback device to playback audio information.	Final Office action, page 8 ("As to claims 23 and 35, Meade in view of Goldberg teaches causing the first playback device to: before transmitting the audio information to the second playback device [before broadcast unit 710 of Goldberg begins broadcasting audio], **receive, by the first playback device from the network device, an instruction to join a synchrony group that includes the second playback device** [receiving, by the video device 14 of Meade from the mobile computing device 12, user preferences 18 instructing the video device 14 to play user-selected content simultaneously by a group of devices including the video device 14 and audio device 28, where the user preferences 18 include grouping information of appliances] (par. [0059], [0083], [0112] in Meade)." The Sonos APA includes that it was known that it was desirable to maintain synchrony of operations among a plurality of independently-clocked digital data processing devices in relation to information that was provided thereto by a common source, that systems were being developed in which one audio information source can distribute audio information in digital form to a number of audio playback devices for playback, that the audio playback devices were known to be for receiving the digital information and for converting it to analog form for playback, that it was known that the audio playback devices could be located in the same room or distributed in different rooms in a residence such as a house or an apartment, in different offices in an office building, or the like, and that in this configuration, the audio information that is distributed to various audio playback devices may relate to the same audio program, or the information may relate to different audio programs, which would require one or more instructions for the first playback device and the second playback device to playback audio information. The Office agreed that Goldberg disclosed this prior art functionality from the Sonos APA.
12. The first playback device of claim 11, wherein the first and second playback devices are members of a synchrony group, and wherein the program instructions, when executed by the one or more processors, further	Final Office action, page 8 ("As to claims 23 and 35, Meade in view of Goldberg teaches causing the first playback device to: before transmitting the audio information to the second playback device [before broadcast unit 710 of Goldberg begins broadcasting audio], **receive, by the first playback device from the network device, an instruction to join a synchrony group that includes the second playback device** [receiving, by the video device 14 of Meade from the mobile computing device 12, user preferences 18 instructing the video device 14 to play user-selected content simultaneously by a

'357 Patent	Meade in view of Goldberg and the Sonos APA
cause the first playback device to:	group of devices including the video device 14 and audio device 28, where the user preferences 18 include grouping information of appliances] (par. [0059], [0083], [0112] in Meade)." The Sonos APA includes that it was known that it was desirable to maintain synchrony of operations among a plurality of independently-clocked digital data processing devices in relation to information that was provided thereto by a common source, that systems were being developed in which one audio information source can distribute audio information in digital form to a number of audio playback devices for playback, that the audio playback devices were known to be for receiving the digital information and for converting it to analog form for playback, that it was known that the audio playback devices could be located in the same room or distributed in different rooms in a residence such as a house or an apartment, in different offices in an office building, or the like, and that in this configuration, the audio information that is distributed to various audio playback devices may relate to the same audio program, or the information may relate to different audio programs, which would require the first playback device and the second playback device to be members of a synchrony group. The Office agreed that Goldberg disclosed this prior art functionality from the Sonos APA.
transmit, to the network device, status information that comprises a status of the synchrony group.	Final Office action, page 9 ("As to claims 24 and 36, Meade in view of Goldberg teaches **transmitting, by the first playback device to the network device, status information that comprises a status of the synchrony group** [transmitting status of the cluster broadcaster area 117 4 to all members of the cluster, the status information including information about the number of members of the cluster] (par. [0029], [0187], [0224] in Goldberg)." The Sonos APA includes that it was known that it was desirable to maintain synchrony of operations among a plurality of independently-clocked digital data processing devices in relation to information that was provided thereto by a common source, that systems were being developed in which one audio information source can distribute audio information in digital form to a number of audio playback devices for playback, that the audio playback devices were known to be for receiving the digital information and for converting it to analog form for playback, that it was known that the audio playback devices could be located in the same room or distributed in different rooms in a residence such as a house or an apartment, in different offices in an office building, or the like, and that in this configuration, the audio information that is distributed to various audio playback devices may relate to the same audio

'357 Patent	Meade in view of Goldberg and the Sonos APA
	program, or the information may relate to different audio programs, which would require the first playback device to transmit, to a network device, status information that comprises a status of the synchrony group. The Office agreed that Goldberg disclosed this prior art functionality from the Sonos APA.
19. The first playback device of claim 9, wherein the audio information source outside of the LAN is an Internet-accessible audio information source, and wherein obtaining, from the audio information source outside of the LAN, the audio information, comprises obtaining the audio information from the Internet-accessible audio information source.	Final Office action, page 10 ("As to claim 31, Meade in view of Goldberg teaches that obtaining, from the audio information source outside of the LAN, the audio information, comprises **obtaining, from the audio information source via the Internet, the audio information** (par. [0042] in Meade; par. [0338], [0350], [0351], [0357] in Goldberg)." The Sonos APA includes that it was known that it was desirable to maintain synchrony of operations among a plurality of independently-clocked digital data processing devices in relation to information that was provided thereto by a common source, that systems were being developed in which one audio information source can distribute audio information in digital form to a number of audio playback devices for playback, that the audio playback devices were known to be for receiving the digital information, such as from an Internet source, and for converting it to analog form for playback, that it was known that the audio playback devices could be located in the same room or distributed in different rooms in a residence such as a house or an apartment, in different offices in an office building, or the like, and that in this configuration, the audio information that is distributed to various audio playback devices may relate to the same audio program, or the information may relate to different audio programs, which would require obtaining the audio information from the Internet-accessible audio information source. The Office agreed that Goldberg disclosed this prior art functionality from the Sonos APA.

TABLE 7

SUBSTANTIAL NEW QUESTION OF PATENTABILITY FOR CLAIMS 9, 10, 12 AND 19 BASED ON MEADE IN VIEW OF GOLDBERG, EDENS, BLANK, SMPTE, RFC 1305, THE HANDBOOK, RTP, RTSP AND SONOS APA UNDER 35 U.S.C. 103(A)

'357 Patent	Meade in view of Goldberg, Edens, Blank, RFC 1305, the Handbook, RTP, RTSP and the Sonos APA
9. A first playback device comprising:	Final rejection dated March 9, 2015 ("Final Rejection") at page 7 ("As to claim 21, Meade in view of Goldberg teaches **a first playback device** [audio device 28 that is one of the appliances 13; appliance controller 50 that is one of the appliances 13; or any other appliance 13 depicted at Fig. 2 in Meade; DJ unit 200, broadcast unit 710 in Goldberg] comprising: a network interface [wireless communicator 86] (Fig. 4 in Meade) [inter-unit tx/rx 11 O] (par. [0096] in Goldberg); and memory comprising program instructions that, when executed by a processor, cause the playback device to perform the method steps, as discussed per claim 33, above." (emphasis added) The appliances depicted at Fig. 2 in Meade include the PC. A person of skill in the art would have recognized that the PC of Meade could include features of PCs disclosed in Edens or Blank, as disclosed in the corresponding claims charts of this request for the corresponding element. Likewise, a person of skill in the art would have recognized that the appliances of Meade or player units of Goldberg could be used in Edens or Blank as playback devices in those references, and that the teachings of Meade in view of Goldberg could be used to improve Edens and Blank, either alone or in combination, to provide synchronous playback of audio information by multiple playback devices.
one or more processors; a network interface; and	Final rejection at page 7 ("As to claim 21, Meade in view of Goldberg teaches a first playback device [audio device 28 that is one of the appliances 13; appliance controller 50 that is one of the appliances 13; or any other appliance 13 depicted at Fig. 2 in Meade; DJ unit 200, broadcast unit 710 in Goldberg] comprising: **a network interface** [wireless communicator 86] (Fig. 4 in Meade) [inter-unit tx/rx 11 O] (par. [0096] in Goldberg); and memory comprising program instructions that, when executed by **a processor**, cause the playback device to perform the method steps, as discussed per claim 33, above." (emphasis added) The appliances depicted at Fig. 2 in Meade include the PC. A person of skill in the art would have recognized that the PC of Meade could include features of PCs disclosed in Edens or Blank, or the

'357 Patent	Meade in view of Goldberg, Edens, Blank, RFC 1305, the Handbook, RTP, RTSP and the Sonos APA
	processors/network interfaces disclosed in the Handbook, as disclosed in the corresponding claims charts of this request for the corresponding element. Likewise, a person of skill in the art would have recognized that the appliances of Meade or player units of Goldberg could be used in Edens or Blank as playback devices in those references, and that the teachings of Meade in view of Goldberg could be used to improve Edens and Blank, either alone or in combination, to provide synchronous playback of audio information by multiple playback devices.
tangible, non-transitory computer-readable memory comprising program instructions that, when executed by the one or more processors, cause the first playback device to:	Final rejection at page 7 ("As to claim 21, Meade in view of Goldberg teaches a first playback device [audio device 28 that is one of the appliances 13; appliance controller 50 that is one of the appliances 13; or any other appliance 13 depicted at Fig. 2 in Meade; DJ unit 200, broadcast unit 710 in Goldberg] comprising: a network interface [wireless communicator 86] (Fig. 4 in Meade) [inter-unit tx/rx 11 O] (par. [0096] in Goldberg); and **memory comprising program instructions that, when executed by a processor, cause the playback device to perform the method steps**, as discussed per claim 33, above." (emphasis added). The appliances depicted at Fig. 2 in Meade include the PC. A person of skill in the art would have recognized that the PC of Meade could include features of PCs disclosed in Edens or Blank, or the processors/network interfaces disclosed in the Handbook, as disclosed in the corresponding claims charts of this request for the corresponding element. Likewise, a person of skill in the art would have recognized that the appliances of Meade or player units of Goldberg could be used in Edens or Blank as playback devices in those references, and that the teachings of Meade in view of Goldberg could be used to improve Edens and Blank, either alone or in combination, to provide synchronous playback of audio information by multiple playback devices.
receive, via the network interface from a network device configured to control the first playback device and communicatively coupled to the first playback device over a local area network (LAN), control information comprising an address identifying a	Final rejection at page 5 ("As to claim 33, Meade teaches a method comprising: **receiving, by a first playback device** [audio device 28 that is one of the appliances 13; appliance controller 50 that is one of the appliances 13; or any other appliance 13 depicted at Fig. 2] (Fig. 2; par. [0034], [0039]) **from a network device** [mobile device 12] **configured to control the first playback device** [configured to apply user preferences 18 at the selected appliances for control of the selected appliances] (par. [0039]) a**nd communicatively coupled to the first playback device over a local area network (LAN)** [network communication link 70] (par. [0042], [0047]), **control information comprising (i) one or more instructions that cause the first playback device and a second playback device**

'357 Patent	Meade in view of Goldberg, Edens, Blank, RFC 1305, the Handbook, RTP, RTSP and the Sonos APA
network location of audio information available at an audio information source, wherein the audio information source is outside of the LAN; and	[another appliance 13] (Fig. 2) **to playback multimedia information** [mobile device 12 coordinates different media aspects of the same content or related content to be performed simultaneously on multiple appliances 13] (par. [0083]-[0084]) and (ii) **an address identifying a location of the multimedia information available at an audio information source** [providing selection of a TV channel identification or radio station identification as part of user preferences 18 that the user desires to be output at the selected appliances 13] (par. [0026], [0059]), **wherein the audio information source is outside of the LAN** [TV and radio broadcast stations are well known in the art as being external sources outside of any local area networks formed by devices in proximity]." (emphasis added). The appliances depicted at Fig. 2 in Meade include the PC. A person of skill in the art would have recognized that the PC of Meade could include features of PCs disclosed in Edens or Blank, or the processors/network interfaces disclosed in the Handbook, which include the ability to obtain audio information from a source outside of the LAN in response to controls from a network-based controller or from another PC, as disclosed in the corresponding claims charts of this request for the corresponding element. Likewise, a person of skill in the art would have recognized that the appliances of Meade or player units of Goldberg could be used in Edens or Blank as playback devices in those references, and that the teachings of Meade in view of Goldberg could be used to improve Edens and Blank, either alone or in combination, to provide synchronous playback of audio information by multiple playback devices.
after receiving the control information, (i) obtain, via the network interface from the audio information source outside of the LAN, the audio information;	Final Office action at page 6 ("**in response to receiving the control information** [in response to receiving user preferences 18 at the controlled appliance] (i) **obtaining, by the first playback device from the audio information source outside of the LAN, the audio information** [audio device 28 receiving radio (or TV) broadcast of audio information (i.e. songs) that are preferred by the user] (par. [0057]); and (iii) playing back, by the first playback device, the audio information (par. [0062])." (emphasis added). The appliances depicted at Fig. 2 in Meade include the PC. A person of skill in the art would have recognized that the PC of Meade could include features of PCs disclosed in Edens or Blank, or the multimedia PCs disclosed in the Handbook, which included the commonplace functionality of obtaining via the network interface from the audio information source outside of the LAN, the audio information, as disclosed in the corresponding claims charts of this

'357 Patent	Meade in view of Goldberg, Edens, Blank, RFC 1305, the Handbook, RTP, RTSP and the Sonos APA
	request for the corresponding element. Likewise, a person of skill in the art would have recognized that the appliances of Meade or player units of Goldberg could be used in Edens or Blank as playback devices in those references, and that the teachings of Meade in view of Goldberg could be used to improve Edens and Blank, either alone or in combination, to provide synchronous playback of audio information by multiple playback devices.
(ii) transmit, via the network interface of the first playback device to a second playback device, the audio information, playback timing information associated with the audio information, and device clock information of the first playback device; and	Final Office action at pages 6-7 ("Goldberg is directed to a method, system, and apparatus for playing an audio signal synchronously on a first mobile audio player and at least a second mobile audio player (abstract). In particular, Goldberg teaches a method comprising: obtaining, by the first playback device [DJ unit 200, broadcast unit 71 O] from the audio information source [distributor], the audio information [music files] (par. [0338], Fig. 25), wherein the audio information source is outside of the LAN [distributor is an Internet device located via Internet] (par. [0350], [0351], [0357]); **transmitting, by the first playback device to a second playback device** [member unit 100, receive unit 730], **the audio information** [step 1348] (Fig. 25, par. [0339]); and playing back, by the first playback device, the audio information (par. [0019]). It would have been obvious to one or ordinary skill in the art at the time of the invention to modify the method, the first playback device, and the program of Meade by having the audio information in the form of a user-preferred song being played by the at least two appliances in the group 40 of Meade, such that the radio broadcast of the football game would be played by the TV 14 (that is known to have audio output capability) and by the radio 28, in synchrony, in order to enhance the personal or social experience of the audio being played (par. [0101] in Goldberg)." The appliances depicted at Fig. 2 in Meade include the PC. A person of skill in the art would have recognized that the PC of Meade could include features of PCs disclosed in Edens or Blank, or the multimedia PCs disclosed in the Handbook, which included the commonplace functionality of using SMTPE or NTP or the Sonos APA use of NTP or SNTP to transmit the audio information, playback timing information associated with the audio information, and device clock information of the first playback device (either under construction 1, such as a start time, or under construction 2, such as frame-specific timing), as well as clock time information of the first playback device (such as for NTP or SNTP timing synchronization), as disclosed in the corresponding claims charts of this request for the corresponding element. In addition, SMPTE, RFC 1305, RTP and RTSP are either incorporated by reference into

'357 Patent	Meade in view of Goldberg, Edens, Blank, RFC 1305, the Handbook, RTP, RTSP and the Sonos APA
	Goldberg, Edens, Blank and the Sonos APA, and would be obvious to combine with those references in the view of a person of ordinary skill in the art because those standards were well known and widely used in the field of networked audio devices to enable synchronous playback, and as further disclosed in the corresponding claims charts of this request for the corresponding element. Likewise, a person of skill in the art would have recognized that the appliances of Meade or player units of Goldberg could be used in Edens or Blank as playback devices in those references, and that the teachings of Meade in view of Goldberg could be used to improve Edens and Blank, either alone or in combination, to provide synchronous playback of audio information by multiple playback devices.
(iii) play back the audio information in synchrony with the second playback device by using the playback timing information associated with the audio information and the device clock information of the first playback device to play back the audio information,	Final Office action at pages 6-7 ("Goldberg is directed to a method, system, and apparatus for playing an audio signal synchronously on a first mobile audio player and at least a second mobile audio player (abstract). In particular, Goldberg teaches a method comprising: obtaining, by the first playback device [DJ unit 200, broadcast unit 71 O] from the audio information source [distributor], the audio information [music files] (par. [0338], Fig. 25), wherein the audio information source is outside of the LAN [distributor is an Internet device located via Internet] (par. [0350], [0351], [0357]); transmitting, by the first playback device to a second playback device [member unit 100, receive unit 730], the audio information [step 1348] (Fig. 25, par. [0339]); and **playing back, by the first playback device, the audio information** (par. [0019]). It would have been obvious to one or ordinary skill in the art at the time of the invention to modify the method, the first playback device, and the program of Meade by having the audio information in the form of a user-preferred song being played by the at least two appliances in the group 40 of Meade, such that the radio broadcast of the football game would be played by the TV 14 (that is known to have audio output capability) and by the radio 28, in synchrony, in order to enhance the personal or social experience of the audio being played (par. [0101] in Goldberg)." The appliances depicted at Fig. 2 in Meade include the PC. A person of skill in the art would have recognized that the PC of Meade could include features of PCs disclosed in Edens or Blank, or the multimedia PCs disclosed in the Handbook, which included the commonplace functionality of using SMTPE or NTP or the Sonos APA use of NTP or SNTP to playback the audio information in synchrony with another playback devices using playback timing information associated with the audio information, and device clock

'357 Patent	Meade in view of Goldberg, Edens, Blank, RFC 1305, the Handbook, RTP, RTSP and the Sonos APA
	information of the first playback device (either under construction 1, such as a start time, or under construction 2, such as frame-specific timing), as well as clock time information of the first playback device (such as for NTP or SNTP timing synchronization), as disclosed in the corresponding claims charts of this request for the corresponding element. In addition, SMPTE, RFC 1305, RTP and RTSP are either incorporated by reference into Goldberg, Edens, Blank and/or the Sonos APA, or would be obvious to combine with those references in the view of a person of ordinary skill in the art because those standards were well known and widely used in the field of networked audio devices to enable synchronous playback, and as disclosed in the corresponding claims charts of this request for the corresponding element. Likewise, a person of skill in the art would have recognized that the appliances of Meade or player units of Goldberg could be used in Edens or Blank as playback devices in those references, and that the teachings of Meade in view of Goldberg could be used to improve Edens and Blank, either alone or in combination, to provide synchronous playback of audio information by multiple playback devices.
wherein the first and second playback devices remain independently clocked during synchronous playback of the audio information.	While Meade and Goldberg do not explicitly disclose "independent clocks," the appliances depicted at Fig. 2 in Meade include the PC, which inherently use multiple different and independent clocks. A person of skill in the art would have recognized that the PC of Meade could include features of PCs disclosed in Edens or Blank, or the multimedia PCs disclosed in the Handbook, which included the commonplace functionality of using independent clocks during synchronous playback, as recognized by the Sonos APA, and as disclosed in the corresponding claims charts of this request for the corresponding element. Likewise, a person of skill in the art would have recognized that the appliances of Meade or player units of Goldberg could be used in Edens or Blank as playback devices in those references, and that the teachings of Meade in view of Goldberg could be used to improve Edens and Blank, either alone or in combination, to provide synchronous playback of audio information by multiple playback devices.
10. The first playback device of claim 9, wherein the program instructions, when executed by the one or more processors, further cause the first playback device to:	Final Office action, page 8 ("As to claims 22 and 34, Meade in view of Goldberg teaches that in response to receiving the control information [application of the user preferences 18 at the controller appliance 13 in Meade], additionally: **generating, by the first playback device, timing information based on the audio information** (par. [0201]-[0203] in Goldberg); and transmitting, by the first playback device to the second playback device, the timing information (par. [0201]-[0203] in Goldberg), and wherein playing back the audio information comprises playing back the audio

'357 Patent	Meade in view of Goldberg, Edens, Blank, RFC 1305, the Handbook, RTP, RTSP and the Sonos APA
generate the playback timing information associated with the audio information; and	information according to the timing information (par. [0201]-[0203] in Goldberg).") The appliances depicted at Fig. 2 in Meade include the PC, which inherently use program instructions to perform functions as discussed in regards to claim 9. A person of skill in the art would have recognized that the PC of Meade could include features of PCs disclosed in Edens or Blank, or the multimedia PCs disclosed in the Handbook, which included the commonplace functionality of instructions governing the generation of playback timing information under either construction during synchronous playback, as recognized by the Sonos APA, and as disclosed in the corresponding claims charts of this request for the corresponding element. Likewise, a person of skill in the art would have recognized that the appliances of Meade or player units of Goldberg could be used in Edens or Blank as playback devices in those references, and that the teachings of Meade in view of Goldberg could be used to improve Edens and Blank, either alone or in combination, to provide synchronous playback of audio information by multiple playback devices.
generate the device clock information of the first playback device.	The appliances depicted at Fig. 2 in Meade include the PC, which inherently use program instructions to perform functions as discussed in regards to claim 9. A person of skill in the art would have recognized that the PC of Meade could include features of PCs disclosed in Edens or Blank, or the multimedia PCs disclosed in the Handbook, which included the commonplace functionality of instructions governing the generation of device clock information, as recognized by the Sonos APA, and as disclosed in the corresponding claims charts of this request for the corresponding element. Likewise, a person of skill in the art would have recognized that the appliances of Meade or player units of Goldberg could be used in Edens or Blank as playback devices in those references, and that the teachings of Meade in view of Goldberg could be used to improve Edens and Blank, either alone or in combination, to provide synchronous playback of audio information by multiple playback devices.
11. The first playback device of claim 9, wherein the control information further comprises one or more instructions for the first playback device and the second playback device	Final Office action, page 8 ("As to claims 23 and 35, Meade in view of Goldberg teaches causing the first playback device to: before transmitting the audio information to the second playback device [before broadcast unit 710 of Goldberg begins broadcasting audio], **receive, by the first playback device from the network device, an instruction to join a synchrony group that includes the second playback device** [receiving, by the video device 14 of Meade from

'357 Patent	Meade in view of Goldberg, Edens, Blank, RFC 1305, the Handbook, RTP, RTSP and the Sonos APA
to playback audio information.	the mobile computing device 12, user preferences 18 instructing the video device 14 to play user-selected content simultaneously by a group of devices including the video device 14 and audio device 28, where the user preferences 18 include grouping information of appliances] (par. [0059], [0083], [0112] in Meade)." The appliances depicted at Fig. 2 in Meade include the PC, which inherently use program instructions to perform functions as discussed in regards to claim 9. A person of skill in the art would have recognized that the PC of Meade could include features of PCs disclosed in Edens or Blank, or the multimedia PCs disclosed in the Handbook, which included the commonplace functionality of instructions to play back audio, as recognized by the Sonos APA, and as disclosed in the corresponding claims charts of this request for the corresponding element. Likewise, a person of skill in the art would have recognized that the appliances of Meade or player units of Goldberg could be used in Edens or Blank as playback devices in those references, and that the teachings of Meade in view of Goldberg could be used to improve Edens and Blank, either alone or in combination, to provide synchronous playback of audio information by multiple playback devices.
12. The first playback device of claim 11, wherein the first and second playback devices are members of a synchrony group, and wherein the program instructions, when executed by the one or more processors, further cause the first playback device to:	Final Office action, page 8 ("As to claims 23 and 35, Meade in view of Goldberg teaches causing the first playback device to: before transmitting the audio information to the second playback device [before broadcast unit 710 of Goldberg begins broadcasting audio], **receive, by the first playback device from the network device, an instruction to join a synchrony group that includes the second playback device** [receiving, by the video device 14 of Meade from the mobile computing device 12, user preferences 18 instructing the video device 14 to play user-selected content simultaneously by a group of devices including the video device 14 and audio device 28, where the user preferences 18 include grouping information of appliances] (par. [0059], [0083], [0112] in Meade)." The appliances depicted at Fig. 2 in Meade include the PC, which can be used as members of a synchrony group as discussed in regards to claim 9. A person of skill in the art would have recognized that the PC of Meade could include features of PCs disclosed in Edens or Blank, or the multimedia PCs disclosed in the Handbook, which included the commonplace functionality of synchronized audio playback, as recognized by the Sonos APA, and as disclosed in the corresponding claims charts of this request for the corresponding element. Likewise, a person of skill in the art

'357 Patent	Meade in view of Goldberg, Edens, Blank, RFC 1305, the Handbook, RTP, RTSP and the Sonos APA
	would have recognized that the appliances of Meade or player units of Goldberg could be used in Edens or Blank as playback devices in those references, and that the teachings of Meade in view of Goldberg could be used to improve Edens and Blank, either alone or in combination, to provide synchronous playback of audio information by multiple playback devices.
transmit, to the network device, status information that comprises a status of the synchrony group.	Final Office action, page 9 ("As to claims 24 and 36, Meade in view of Goldberg teaches **transmitting, by the first playback device to the network device, status information that comprises a status of the synchrony group** [transmitting status of the cluster broadcaster area 117 4 to all members of the cluster, the status information including information about the number of members of the cluster] (par. [0029], [0187], [0224] in Goldberg)." The appliances depicted at Fig. 2 in Meade include the PC, which can be used to transmit status information of at least the PC (which would be a "status of the synchrony group" under the BRI) as well as other status information of the synchrony group, such as the current song that is being played, and whether the song is playing, paused or other status information. A person of skill in the art would have recognized that the PC of Meade could include features of PCs disclosed in Edens or Blank, which included the commonplace functionality of transmitting status information, as recognized by the Sonos APA, and as disclosed in the corresponding claims charts of this request for the corresponding element. Likewise, a person of skill in the art would have recognized that the appliances of Meade or player units of Goldberg could be used in Edens or Blank as playback devices in those references, and that the teachings of Meade in view of Goldberg could be used to improve Edens and Blank, either alone or in combination, to provide synchronous playback of audio information by multiple playback devices.
19. The first playback device of claim 9, wherein the audio information source outside of the LAN is an Internet-accessible audio information source, and wherein obtaining, from the audio information source outside of the LAN, the audio information, comprises obtaining the audio	Final Office action, page 10 ("As to claim 31, Meade in view of Goldberg teaches that obtaining, from the audio information source outside of the LAN, the audio information, comprises **obtaining, from the audio information source via the Internet, the audio information** (par. [0042] in Meade; par. [0338], [0350], [0351], [0357] in Goldberg)." The appliances depicted at Fig. 2 in Meade include the PC, which can be used as members of a synchrony group as discussed in regards to claim 9. A person of skill in the art would have recognized that the PC of Meade could include features of PCs disclosed in Edens or Blank, or the multimedia PCs disclosed in the Handbook, which included the commonplace functionality of

'357 Patent	Meade in view of Goldberg, Edens, Blank, RFC 1305, the Handbook, RTP, RTSP and the Sonos APA
information from the Internet-accessible audio information source.	obtaining audio information over the Internet, as recognized by the Sonos APA, and as disclosed in the corresponding claims charts of this request for the corresponding element. Likewise, a person of skill in the art would have recognized that the appliances of Meade or player units of Goldberg could be used in Edens or Blank as playback devices in those references, and that the teachings of Meade in view of Goldberg could be used to improve Edens and Blank, either alone or in combination, to provide synchronous playback of audio information by multiple playback devices.

VI. CONCLUSION

For these reasons, Substantial New Questions of Patentability exist, and claims 9, 10, 12 and 19 of the '357 Patent do not satisfy the requirements of Title 35 U.S.C. §101 et seq. A Notice to this effect is requested.

Date: June 16, 2017

Respectfully submitted,

By _____
Christopher J. Rourk
Registration No. 39,348
JACKSON WALKER LLP

ATTORNEYS FOR REQUESTORS

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re *Ex Parte* Reexamination Control No.: 90/013,959 Filed: Herewith Title: OBTAINING CONTENT FROM REMOTE SOURCE FOR PLAYBACK	U.S. Patent No. 9,213,357 CERTIFICATE OF SERVICE UNDER 37 C.F.R. § 1.510(B)(5) AND MPEP § 2220

CERTIFICATE OF SERVICE

It is hereby certified that the attached Renewed Request for Ex Parte Reexamination is being served by first class mail on the patent owner at the correspondence address provided in the USPTO PAIR system:

McDonnell Boehnen Hulbert & Berghoff LLP
c/o Sonos, Inc.
300 South Wacker Drive
Chicago, IL 60606

Date: June 16, 2017

Respectfully submitted,

By: _____
Christopher J. Rourk
Reg. No. 39,348

Jackson Walker LLP
2323 Ross Avenue, Suite 600
Dallas, Texas 75201
Telephone: (214) 953-5990
Facsimile: (214) 661-6604
E-Mail: crourk@jw.com

Electronic Acknowledgement Receipt	
EFS ID:	29523100
Application Number:	90013959
International Application Number:	
Confirmation Number:	9548
Title of Invention:	OBTAINING CONTENT FROM REMOTE SOURCE FOR PLAYBACK
First Named Inventor/Applicant Name:	9213357
Customer Number:	107361
Filer:	Christopher Rourk/Debbie Sams
Filer Authorized By:	Christopher Rourk
Attorney Docket Number:	131131.00049.005
Receipt Date:	16-JUN-2017
Filing Date:	
Time Stamp:	14:33:46
Application Type:	Reexam (Third Party)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Receipt of Corrected Original Ex Parte Request	131131_00049_005_357_Patent_Renewed_Request_for_Ex_Parte_Reexam.pdf	1739715 2fc75e23a27e6c3103e69a0511492bf54e6d354b	no	126
Warnings:					

Information:					
2	Reexam Certificate of Service	131131_00049_005_Certificate_of_Service.pdf	29420 8ed710cdcf401352eed7239b4bde89b9270b8d59	no	1
Warnings:					
Information:					
			Total Files Size (in bytes):	1769135	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 90/013,959	Filing Date 01/01/2001	☐ To be Mailed

ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

	(Column 1)	(Column 2)		
FOR	NUMBER FILED	NUMBER EXTRA	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT	06/16/2017	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 20	Minus	** 20	= 0	X $80 =	0
	Independent (37 CFR 1.16(h))	* 3	Minus	***3	= 0	X $420 =	0
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	0

AMENDMENT		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

LIE
VIOLA ROGERS

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Patent Assignment Abstract of Title

Total Assignments: 2

Application #: 14516867 **Filing Dt:** 10/17/2014 **Patent #:** 9213357 **Issue Dt:** 12/15/2015
PCT #: NONE **Intl Reg #:** **Publication #:** US20150039109 **Pub Dt:** 02/05/2015
Inventor: Nicholas A.J. Millington
Title: Obtaining Content from Remote Source for Playback

Assignment: 1

Reel/Frame: 035518 / 0127 **Received:** 04/28/2015 **Recorded:** 04/28/2015 **Mailed:** 04/29/2015 **Pages:** 3
Conveyance: ASSIGNMENT OF ASSIGNORS INTEREST (SEE DOCUMENT FOR DETAILS).
Assignor: MILLINGTON, NICHOLAS A.J. **Exec Dt:** 03/06/2015
Assignee: SONOS, INC.
223 EAST DE LA GUERRA STREET
SANTA BARBARA, CALIFORNIA 93101
Correspondent: MCDONNELL BOEHNEN HULBERT & BERGHOFF LLP
300 SOUTH WACKER DRIVE
CHICAGO, IL 60606

Assignment: 2

Reel/Frame: 038329 / 0253 **Received:** 04/01/2016 **Recorded:** 04/01/2016 **Mailed:** 04/21/2016 **Pages:** 78
Conveyance: SECURITY INTEREST (SEE DOCUMENT FOR DETAILS).
Assignor: SONOS, INC. **Exec Dt:** 03/30/2016
Assignee: GORDON BROTHERS FINANCE COMPANY
800 BOYLSTON STREET
27TH FLOOR
BOSTON, MASSACHUSETTS 02199
Correspondent: CHOATE HALL & STEWART LLP
2 INTERNATIONAL PLACE
BOSTON, MA 02110

Search Results as of: 06/28/2017 11:45 AM

If you have any comments or questions concerning the data displayed, contact PRD / Assignments at 571-272-3350. v.2.5
Web interface last modified: Aug 20, 2015 v.2.5

Patent Assignment Abstract of Title

Total Assignments: 2

Application #: 14516867 **Filing Dt:** 10/17/2014 **Patent #:** 9213357 **Issue Dt:** 12/15/2015
PCT #: NONE **Intl Reg #:** **Publication #:** US20150039109 **Pub Dt:** 02/05/2015
Inventor: Nicholas A.J. Millington
Title: Obtaining Content from Remote Source for Playback

Assignment: 1

Reel/Frame: 035518 / 0127 **Received:** 04/28/2015 **Recorded:** 04/28/2015 **Mailed:** 04/29/2015 **Pages:** 3
Conveyance: ASSIGNMENT OF ASSIGNORS INTEREST (SEE DOCUMENT FOR DETAILS).
Assignor: MILLINGTON, NICHOLAS A.J. **Exec Dt:** 03/06/2015
Assignee: SONOS, INC.
223 EAST DE LA GUERRA STREET
SANTA BARBARA, CALIFORNIA 93101
Correspondent: MCDONNELL BOEHNEN HULBERT & BERGHOFF LLP
300 SOUTH WACKER DRIVE
CHICAGO, IL 60606

Assignment: 2

Reel/Frame: 038329 / 0253 **Received:** 04/01/2016 **Recorded:** 04/01/2016 **Mailed:** 04/21/2016 **Pages:** 78
Conveyance: SECURITY INTEREST (SEE DOCUMENT FOR DETAILS).
Assignor: SONOS, INC. **Exec Dt:** 03/30/2016
Assignee: GORDON BROTHERS FINANCE COMPANY
800 BOYLSTON STREET
27TH FLOOR
BOSTON, MASSACHUSETTS 02199
Correspondent: CHOATE HALL & STEWART LLP
2 INTERNATIONAL PLACE
BOSTON, MA 02110

Search Results as of: 06/28/2017 11:45 AM

If you have any comments or questions concerning the data displayed, contact PRD / Assignments at 571-272-3350. v.2.5
Web interface last modified: Aug 20, 2015 v.2.5

P.O. BOX 1450
ALEXANDRIA, VA 22313-1450
IF UNDELIVERABLE RETURN I

OFFICIAL BUSINESS
Penalty for Private Use, $300

AN EQUAL OPPORTUNITY EMPLOYER

UNITED STATES POSTAGE
PITNEY BOWES
02 1M $ 01.40⁰
0004244975 MAY 26 2017
MAILED FROM ZIPCODE 22314

BC: 22313145050 2326N1551SS-03606

RETURN TO SENDER
ATTEMPTED - NOT KNOWN
UNABLE TO FORWARD

NIXIE 731 SE 1 0306/04/17

Reexam



UNITED STATES PATENT AND TRADEMARK OFFICE

Commissioner for Patents
United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450
www.uspto.gov

DO NOT USE IN PALM PRINTER

(THIRD PARTY REQUESTER'S CORRESPONDENCE ADDRESS)

CHRISTOPHER J. ROURK

JACKSON WALKER LLP

2323 ROSS AVENUE, SUITE 600

DALLAS, TX 75201

EX PARTE REEXAMINATION COMMUNICATION TRANSMITTAL FORM

REEXAMINATION CONTROL NO. *90/013,959*.

PATENT NO. *9,213,357*.

ART UNIT *3992*.

Enclosed is a copy of the latest communication from the United States Patent and Trademark Office in the above identified *ex parte* reexamination proceeding (37 CFR 1.550(f)).

Where this copy is supplied after the reply by requester, 37 CFR 1.535, or the time for filing a reply has passed, no submission on behalf of the *ex parte* reexamination requester will be acknowledged or considered (37 CFR 1.550(g)).

PTOL-465 (Rev.07-04)

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
90/013,959		9213357	131131.00049.005	9548

107361 7590 05/25/2017
McDonnell Boehnen Hulbert & Berghoff LLP
Sonos, Inc.
300 South Wacker Drive
Chicago, IL 60606

EXAMINER	
ART UNIT	PAPER NUMBER

MAIL DATE	DELIVERY MODE
05/25/2017	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

NOTICE OF FAILURE TO COMPLY WITH *EX PARTE* REEXAMINATION REQUEST FILING REQUIREMENTS (37 CFR 1.510(c))	**Control Number** 90/013,959	**Patent Under Reexamination** 9,213,357
	Examiner	**Art Unit** 3992

Requester's Name and Address: Christopher J. Rourk
Jackson Walker LLP
2323 Ross Ave.,Suite 600
Dallas TX 75201

Request Receipt Date: May 22, 2017

The Central Reexamination Unit (CRU) in the United States Patent and Trademark Office (USPTO) has received a request for *ex parte* reexamination. The request cannot be processed, because the below-identified filing date requirements for an *ex parte* reexamination request have not been satisfied. If a fully compliant response is not received within 30 days of the mailing date of this notice, the request will be treated as a prior art citation under 37 CFR 1.501 or closed from public view, at the Office's option. A **filing date** will **NOT** be assigned to the request until the deficiencies noted below are corrected (37 CFR 1.510(d)):

The following items required by **37 CFR 1.510(a) and (b)** are missing:

☐ 1. The *ex parte s* reexamination filing fee under 37 CFR 1.20(c)(1) – see attached Form PTO-2057.
☐ 2. An identification of the patent by its patent number, and of every claim of the patent for which reexamination is requested.
☐ 3. A citation of the patents and printed publications that are presented to raise a substantial new question of patentability.
☒ 4. A statement pointing out each substantial new question of patentability based on the cited patents & printed publications, and a detailed explanation of the pertinency and manner of applying the patents & printed publications to every claim for which reexamination is requested.
☐ 5. A legible copy of every patent or printed publication (other than U.S. patents or U.S. patent publications) relied upon or referred to in (3) and (4) above, accompanied by an English language translation of all the necessary and pertinent parts of any non-English language document.

☐ 6. A legible copy of the entire patent including the front face, drawings, and specification/claims (in **double** column format) for which reexamination is requested, and a legible copy of any disclaimer, certificate of correction, or reexamination certificate issued in the patent. All copies must have each page plainly written on only one side of a sheet of paper.
☐ 7. A certification by the third party requester that a copy of the request has been served in its entirety on the patent owner at the address provided for in 37 CFR 1.33(c). The name and address of the party served must be indicated. If service was not possible, a duplicate copy of the request must be supplied to the Office
☒ 8. Other :

Explanation of above item(s): See Attachment.

Any written correspondence in response to this notice must include a submission pursuant to the attached instructions. **The instructions for a detailed explanation for an *ex parte* reexamination request differ from those for an *inter partes* reexamination request.** Any written correspondence in response to this notice should be mailed to the Central Reexamination Unit (CRU), ATTN: "Box *Ex Parte* Reexam" at the USPTO address indicated at the top of this notice. Any "replacement documents" may be facsimile transmitted to the CRU at the FAX number indicated below. A REPLACEMENT STATEMENT AND EXPLANATION UNDER 37 CFR 1.510(b)(1) and (2) MAY NOT BE FACSIMILE TRANSMITTED.

/Patricia Volpe/
Paralegal Specialist, Central Reexamination Unit
(571) 6825; FAX No. (571) 273-9900

cc: Patent Owner's Name and Address: McDonnell Boehnen Hulbert & Berghoff LLP
c/o Sonos, Inc.
300 South Wacker Drive
Chicago IL 60606

INSTRUCTIONS TO NOTICE OF FAILURE TO COMPLY WITH *EX PARTE* REEXAMINATION REQUEST FILING REQUIREMENTS (37 CFR 1.510(c))

HOW TO REPLY TO THIS NOTICE

Any written correspondence in response to this notice must include either a **replacement document**, or, **if item #4 is checked and/or it is otherwise specifically required by the Office, a paper containing a replacement statement and explanation under 37 CFR 1.510(b)(1) and (2)** that either replaces the originally-filed statement and explanation or provides a previously missing statement and explanation. A replacement document either replaces an originally-filed document, or provides a previously missing document, that contains part(s) of the request other than the statement and explanation as set forth in 37 CFR 1.510(b)(1) and (2). For example, a replacement to the originally-filed listing of cited patents and printed publications, PTO/SB/08 (formerly designated as PTO-1449) or its equivalent, is a replacement document.

If a paper containing a replacement statement and explanation, or a replacement document (other than a replacement certificate of service), is submitted by a third party requester, it must be **accompanied by a certification that a copy of the replacement statement and explanation under 37 CFR 1.510(b)(1) and (2), or that a copy of the replacement document, has been served** in its entirety on the patent owner at the address provided for in 37 CFR 1.33(c). The name and address of the party served must be indicated. If service was not possible, a duplicate copy of the replacement statement and explanation (or replacement document) must be supplied to the Office.

REPLACEMENT STATEMENT AND EXPLANATION UNDER 37 CFR 1.510(b)(1) and (2) (ITEM #4 IS CHECKED)

The **statement and explanation under 37 CFR 1.510(b)(1) and (2)** (see item #4) must discuss **EVERY patent or printed publication cited in the information disclosure statement** in at least one proposed rejection or statement identifying a substantial new question of patentability (SNQ), AND in a corresponding detailed explanation (see the below discussion). Furthermore, **EVERY claim for which reexamination is requested** must be discussed in at least one proposed rejection or statement identifying an SNQ and in the corresponding detailed explanation. If item #4 is missing or incomplete, a paper containing a **replacement statement and explanation under 37 CFR 1.510(b)(1) and (2) is required.**

A paper containing a replacement statement and explanation under 37 CFR 1.510(b)(1) and (2) may NOT be facsimile transmitted. It must be received by first class mail or by USPS Express Mail.

If an originally-filed information disclosure statement cites patents or printed publications that are NOT discussed in at least one proposed rejection or statement identifying an SNQ AND in the corresponding detailed explanation **in the originally-filed request**, the requester must file either (a) a **replacement document, i.e., a replacement PTO/SB/08 (former PTO-1449)** or its equivalent, listing **ONLY** those patents and printed publications that are so discussed, or (b) a paper containing a **replacement statement and explanation under 37 CFR 1.510(b)(1) and (2).** If the first option is chosen, the replacement PTO/SB/08 or its equivalent should include a cover letter expressly withdrawing from the request any previously cited references that are being omitted by the replacement PTO/SB/08 or its equivalent. The requester may, if desired, file both a replacement PTO/SB/08 or its equivalent and a paper containing a replacement statement and explanation, if the replacement statement and explanation discusses EVERY patent or printed publication, cited in the replacement PTO/SB/08 or its equivalent, in at least one proposed rejection or statement identifying an SNQ and in the corresponding detailed explanation.

Requester is NOT required to, and should not, additionally file a replacement copy of any exhibits, references, etc., or other replacement parts of the request (i.e., replacement documents) if a defect requiring a replacement document is not specifically identified by this notice.

Examples of When a Replacement Statement and Explanation under 37 CFR 1.510(b)(1) and (2) Is Required:

1. The originally-filed request fails to discuss **EVERY** patent or printed publication cited in the originally-filed information disclosure statement in at least one proposed rejection or statement identifying an SNQ and in the corresponding detailed explanation, and the requester does not wish to file a replacement PTO/SB/08 (formerly designated as PTO-1449) or its equivalent listing ONLY those patents and printed publications that are so discussed.

2. The originally-filed request discusses every patent or printed publication cited in the information disclosure statement in at least one proposed rejection or statement identifying an SNQ, but **fails to discuss EVERY patent or printed publication cited in the information disclosure statement in a detailed explanation that corresponds to the proposed rejection or statement identifying an SNQ.**

3. The originally-filed request fails to discuss **EVERY CLAIM** for which reexamination is requested in at least one proposed rejection or statement identifying an SNQ, and in the corresponding detailed explanation.

Examples of Proposed Rejections and Statements Identifying a Substantial New Question of Patentability (SNQ)

Proposed rejections

Claims 1-3 are obvious over reference A in view of reference B.
Claims 4-6 are obvious over reference A in view of references B and C.
Claims 7-10 are obvious over reference Q in view of reference R.

Statements identifying a substantial new question of patentability

A substantial new question of patentability as to claims 1-3 is raised by reference A in view of reference B.

A substantial new question of patentability as to claims 4-6 is raised by reference A in view of references B and C.

A substantial new question of patentability as to claims 7-10 is raised by reference Q in view of reference R.

A proposed rejection or statement identifying an SNQ must be repeated with any *replacement* detailed explanation that corresponds to the proposed rejection or statement identifying an SNQ, in any paper containing a replacement statement and explanation under 37 CFR 1.510(b)(1) and (2).

In addition, the requester should include an explanation of *how the SNQ is raised.*

1. Assume that claim 1 of the patent recites, as one of the limitations, widget W. Requester would state that the XYZ reference, cited in the information disclosure statement, contains a teaching of widget W as recited in claim 1, and that this teaching was not present during the prior examination of the patent under reexamination (i.e., the teaching is "new"). Requester would also state that he believes that a reasonable examiner would consider this teaching important in determining whether or not the claims are patentable. For this reason, requester would state that this teaching by the XYZ reference raises a substantial new question of patentability (SNQ) with respect to at least claim 1 of the patent. Similarly, if dependent claim 6 adds widget H, the requester would state that the ABC reference, cited in the information disclosure statement, contains a teaching of widget H as recited in claim 6, that this teaching was not present during the prior concluded examination of the patent, that a reasonable examiner would consider this teaching important in determining whether or not the claims are patentable, and that this teaching raises an SNQ with respect to dependent claim 6 of the patent.

2. Assume that claim 1 of the patent recites, as one of its limitations, limitation W. Assume either that reference XYZ was applied in a rejection during the prior examination of the patent, or that the teachings of reference XYZ are purely cumulative to a reference cited in a rejection during the prior examination of the patent. Assume further that reference ABC teaches that limitation W would have been either inherent given the teachings of reference XYZ, or would have been obvious in view of the combination of XYZ and ABC. Reference ABC was cited in an information disclosure statement but was never discussed or applied in a rejection ***in combination with the XYZ reference*** during the prior examination of the patent under reexamination. **Requester would state** that reference XYZ was present during the prior examination of the patent under reexamination because it was applied in a rejection during the prosecution of the patent, and that reference ABC was cited in an information disclosure statement but never applied in a rejection (or never discussed), **in combination with the XYZ reference** during the prior examination of the patent under reexamination Requester would then state (1) that the ***combination*** of the XYZ reference and the ABC reference, both of which are cited in the information disclosure statement, contains a teaching of limitation W as recited in claim 1, (2) that this teaching provided by the **combination** of the XYZ and ABC references was not present during the prior examination of the patent under reexamination, (3) that a reasonable examiner would consider this teaching important in determining whether or not the claims are patentable, and (4) that this teaching raises an SNQ with respect to claim 1 of the patent.

Example of a Detailed Explanation

Assume, for example, that a requester believes that the XYZ reference, alone, anticipates claims 1-5. The requester would expressly propose a rejection of claims 1-5 under 35 USC 102(b) as being anticipated by the XYZ reference. In a claim chart, the requester would then show how **each limitation** of claims 1-5 is anticipated by the XYZ reference. If the requester believes that the XYZ reference, in view of the ABC reference, renders obvious claims 6-10, the requester would expressly propose a rejection of claims 6-10 under 35 USC 103 as being obvious over the XYZ reference in view of the ABC reference. In a claim chart, the requester would then show which limitations of claims 6-10 are taught by the XYZ reference, and which limitations of claims 6-10 are taught by the ABC reference. The requester should quote each pertinent teaching in the prior art reference, referencing each quote by page, column and line number, and any relevant figure numbers.

A **patent owner**, when filing a request for reexamination in an *ex parte* reexamination proceeding, may satisfy the requirement under 37 CFR 1.510(b) for supplying a detailed explanation by comparing, limitation-by-limitation, the claim(s) under reexamination with the teachings of each reference cited in the information disclosure statement and in the statement pointing out an SNQ. Each limitation of the claim(s) must be separately discussed. For each claim limitation, the patent owner must do one of the following: (a) show how at least one reference teaches or suggests the limitation, (b) admit that the limitation is "old", or (c) state that the limitation is believed to be missing from the reference. In a claim chart, the patent owner should quote each pertinent teaching in the prior art reference,

referencing each quote by page, column and line number, and any relevant figure numbers. Proposed applications of the cited references and/or proposed combinations of the cited references should separately identified. The patent owner is not required to

expressly propose a rejection of the claim(s) or provide a statement of why the claim(s) under reexamination would have been obvious over a proposed reference combination.

REPLACEMENT DOCUMENTS

If the originally-filed PTO/SB/08 (former PTO-1449) or its equivalent lists patents or printed publications that are NOT discussed in at least one proposed rejection or statement identifying an SNQ AND in the corresponding detailed explanation **in the originally-filed request**, the requester may file a paper containing a **replacement PTO/SB/08 (former PTO-1449) or its equivalent** listing **ONLY** those patents and printed publications that are so discussed. The replacement PTO/SB/08 or its equivalent should include a cover letter expressly withdrawing from the request any formerly cited references that are now being omitted by the replacement PTO/SB/08 or its equivalent. Similarly, if **any patent or printed publication discussed** in at least one proposed rejection or statement identifying an SNQ AND in the corresponding detailed explanation **in the originally-filed request is not listed in the originally-filed PTO/SB/08 (former PTO-1449)** or its equivalent, the requester must file a **replacement PTO/SB/08 (former PTO-1449)** or its equivalent listing all of the patents and printed publications, including the previously omitted reference(s), and provide copies of the missing references if copies were not provided with the originally-filed request

If a copy of a patent, printed publication, or an English-language translation of a patent or printed publication, that is cited in the PTO/SB/08 (former PTO-1449) or its equivalent, is illegible, missing, or incomplete (i.e., it does not contain all of the pages indicated in the PTO/SB/08 (former PTO-1449) or its equivalent), a replacement copy of the patent or printed publication is required.

If a copy of any disclaimer, certificate of correction, or reexamination certificate issued in the patent, or a copy of the entire patent for which reexamination is requested as described in item #6, is missing, or if the copy that was received by the Office was illegible or incomplete, a replacement document (i.e., a replacement copy of the disclaimer, certificate of correction, reexamination certificate, or entire patent under reexamination as described in item #6) is required.

If the requester fails to correctly identify the patent number or the claims for which reexamination is requested on the transmittal form for the request (PTO/SB/57, or an equivalent) as described in item #2, and the patent number and the claims for which reexamination is requested are correctly identified in the originally-filed request, a **replacement transmittal form** is required.

If a certificate of service on the patent owner, as described in item #7, is missing, or if the certificate of service received by the Office is inaccurate or incomplete, a replacement certificate of service is required.

Replacement documents may be facsimile transmitted. A paper containing a replacement statement and explanation may NOT be facsimile transmitted.

ATTACHMENT TO PTOL 2077

Control Number: 90/013,959
Patent Number: 9,213,357
Request Receipt Date: May 22, 2017

The request for *Ex Parte* Reexamination of U.S. Patent 9,213,357, filed on May 22, 2017 does not comply with the filing requirements of *ex parte* reexamination proceedings under 37 CFR 1.510(b)(1)(2).

Reexamination was requested for U.S. Patent No. 9,213,357 (in this instance claims 9, 10, 12 and 19 are requested). The request does not provide a "statement pointing out each substantial new question of patentability based on the prior patents and printed publications" for each cited document, as is required by 37 CFR 1.510(b) (1).

The request is incomplete as to compliance with 37 CFR 1.510(b) (1) for the following reason:

The request has failed to provide the requisite identification and explanation, in compliance with 37 CFR 1.510(b) (1), of what substantial new questions of patentability (SNQs) are being raised by the cited prior art documents under 37 CFR 1.510(b). In other words, the request fails to clearly point out and explain how each asserted SNQ is substantially different from those raised in the previous examination of the patent before the Office. It is not sufficient to merely state that the references were not of record in the prior prosecution of the '357 patent. Also, as pointed out in MPEP 2216, "[i]t is not sufficient that a request for reexamination merely proposes one or more rejections of a patent claim or claims as a basis for reexamination. It must first be demonstrated that a patent or printed publication that is relied upon in a proposed rejection presents **a new, non-cumulative technological teaching** that was not previously considered and discussed on the record during the prosecution of the application that resulted in the patent for which reexamination is requested, and during prosecution of any other prior proceeding involving the patent for which reexamination is requested." [Emphasis added]

The request is incomplete as to compliance with 37 CFR 1.510(b) (2) for the following reason:

The request does not provide a "detailed explanation of the pertinency and manner of applying the cited prior art to every claim for which reexamination is requested," as is required by 37 CFR 1.510(b) (2).

Requester is proposing to combine 13 prior art references which will result in a very large number of permutations.

Specifically, the request is not clear as to the proposed rejections that are being set forth, because it fails to provide a clear explanation of the proposed rejections due to the lumping together of multiple proposed rejections.

For one example, at page 3 of the request it is stated:

6. Claims 9, 10, 12 and 19 are invalid under 35 U.S.C. 103(a) over Meade, Goldberg, Blank, Gray, SMPTE, RFC 1305, Microsoft File Sharing, pcAnywhere, the Handbook, the Sonos APA, Nutshell, RTSP ***and/or*** RTP.

Since the request relies upon grounds, which would suggest multiple combinations of references, and there is no analysis as to how a substantial new question is raised for each of the proposed rejections, there is no explanation as to the pertinency and manner of applying the cited prior art to each claim identified in the request.
See MPEP 2217, which states:

> The explanation **must not** lump together the proposed rejections or proposed combinations of references.
>
> **Examples of inappropriate language:**
>
> - Claim 1 is unpatentable under 35 U.S.C. 103 as being obvious over Smith **and/or** Charles.
>
> - Claim 2 is unpatentable under 35 U.S.C. 103 as being obvious over Smith in view of Jones **or** Harvey. (This could however be used if both Jones and Harvey provide a minor teaching which can be articulated in a sentence or two.)
>
> - Claims 3 - 10 are unpatentable under 35 U.S.C. 103 as being obvious over Smith in view of either Jones **and** Cooper **or** Harvey **and** Cooper.
>
> **Examples of appropriate language:**
>
> - Claim 1 is unpatentable under 35 U.S.C. 103 as being obvious over Smith.
>
> - Claim 1 is unpatentable under 35 U.S.C. 103 as being obvious over Charles.
>
> - Claim 2 is unpatentable under 35 U.S.C. 103 as being obvious over Smith in view of Jones.
>
> - Claim 2 is unpatentable under 35 U.S.C. 103 as being obvious over Smith in view of Harvey.
>
> - Claims 3 - 10 are unpatentable under 35 U.S.C. 103 as being obvious over Smith in view of Jones, and further in view of Cooper.
>
> - Claims 3 - 10 are unpatentable under 35 U.S.C. 103 as being obvious over Smith in view of Harvey, and further in view of Cooper.

If the requester were permitted to omit an explanation of how such documents cited in the request are applied to the patent claims, an undue burden would be placed on the Office to address each document in the determination on the request, without an explanation of the relevance to the patent claims. Accordingly, such an omission is prohibited by law.

REQUESTER'S RECOURSE

Requester has the option to respond to this identification of defects in the request papers by applying the appropriate option(s) set forth below:

Providing an explanation of the manner and pertinence of applying each cited document to the patent claims for which reexamination is requested, as required by 37 CFR 1.510(b)(2). Every limitation in each patent claim for which reexamination is requested must be addressed. Where references are applied in combination, each combination must be individually identified, and the basis for forming each combination of references must be supplied.

Serving the corrected request (including all supporting documents such as the listing of references, copies of the references, appendices, etc.) on the patent owner at the current correspondence address under 37 CFR 1.33(a) in the patent record at the time the corrected request was filed, or alternatively, if such service cannot be made, providing an explanation of the efforts taken to provide service and why those efforts were not successful, and a second copy of the request papers.

For any document for which no explanation is to be provided for any of the patent claims, explicitly withdrawing the reference from the request and replacing the presently submitted listing of documents with a new listing confined to the documents for which a discussion required and 1449 would be expressly withdrawn by requester, and replaced with a newly provided form or forms.

In order to obtain a filing date for the request papers, the requester must, within thirty (30) days of the mailing date of this decision, file a response to this decision which makes the request papers filing date complaint. A request for *ex parte* reexamination must now meet all the applicable statutory and regulatory requirements before a filing date is accorded to the request. See MPEP 2227 Part B.1 and MPEP 2217, Part 1. See also *Clarification of Filing Date Requirements for Ex Parte and Inter Partes Reexamination Proceedings*, 71 Fed. Reg. 44219 (August 4, 2006), 1309 *Off. Gaz. Pat. Office* 216 (August 29, 2006) (Final Rule).

Failure to submit a proper response to this Notice may result in the termination of the request, with no filing date accorded.

All correspondence related to this ex parte reexamination proceeding should be directed:

By EFS: Registered users may submit via the electronic filing system EFS-Web.
https://efs.uspto.gov/efile/myportal/efs-registered

By Mail to: Mail Stop Ex Parte Reexam
Central Reexamination Unit
Commissioner for Patents
United States Patent & Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
90/013,959		9213357	131131.00049.005	9548

107361 7590 05/25/2017
McDonnell Boehnen Hulbert & Berghoff LLP
Sonos, Inc.
300 South Wacker Drive
Chicago, IL 60606

EXAMINER	
ART UNIT	PAPER NUMBER

MAIL DATE	DELIVERY MODE
05/25/2017	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

UNITED STATES PATENT AND TRADEMARK OFFICE

Commissioner for Patents
United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450
www.uspto.gov

DO NOT USE IN PALM PRINTER

(THIRD PARTY REQUESTER'S CORRESPONDENCE ADDRESS)

CHRISTOPHER J. ROURK

JACKSON WALKER LLP

2323 ROSS AVENUE, SUITE 600

DALLAS, TX 75201

EX PARTE REEXAMINATION COMMUNICATION TRANSMITTAL FORM

REEXAMINATION CONTROL NO. *90/013,959*.

PATENT NO. *9,213,357*.

ART UNIT *3992*.

Enclosed is a copy of the latest communication from the United States Patent and Trademark Office in the above identified *ex parte* reexamination proceeding (37 CFR 1.550(f)).

Where this copy is supplied after the reply by requester, 37 CFR 1.535, or the time for filing a reply has passed, no submission on behalf of the *ex parte* reexamination requester will be acknowledged or considered (37 CFR 1.550(g)).

PTOL-465 (Rev.07-04)

NOTICE OF FAILURE TO COMPLY WITH *EX PARTE* REEXAMINATION REQUEST FILING REQUIREMENTS (37 CFR 1.510(c))	**Control Number** 90/013,959	**Patent Under Reexamination** 9,213,357
	Examiner	**Art Unit** 3992

Requester's Name and Address: Christopher J. Rourk
Jackson Walker LLP
2323 Ross Ave.,Suite 600
Dallas TX 75201

Request Receipt Date: May 22, 2017

The Central Reexamination Unit (CRU) in the United States Patent and Trademark Office (USPTO) has received a request for *ex parte* reexamination. The request cannot be processed, because the below-identified filing date requirements for an *ex parte* reexamination request have not been satisfied. If a fully compliant response is not received within 30 days of the mailing date of this notice, the request will be treated as a prior art citation under 37 CFR 1.501 or closed from public view, at the Office's option. A **filing date** will **NOT** be assigned to the request until the deficiencies noted below are corrected (37 CFR 1.510(d)):

The following items required by **37 CFR 1.510(a) and (b)** are missing:

☐ 1. The *ex parte* reexamination filing fee under 37 CFR 1.20(c)(1) – see attached Form PTO-2057.
☐ 2. An identification of the patent by its patent number, and of every claim of the patent for which reexamination is requested.
☐ 3. A citation of the patents and printed publications that are presented to raise a substantial new question of patentability.
☒ 4. A statement pointing out each substantial new question of patentability based on the cited patents & printed publications, and a detailed explanation of the pertinency and manner of applying the patents & printed publications to every claim for which reexamination is requested.
☐ 5. A legible copy of every patent or printed publication (other than U.S. patents or U.S. patent publications) relied upon or referred to in (3) and (4) above, accompanied by an English language translation of all the necessary and pertinent parts of any non-English language document.

☐ 6. A legible copy of the entire patent including the front face, drawings, and specification/claims (in **double** column format) for which reexamination is requested, and a legible copy of any disclaimer, certificate of correction, or reexamination certificate issued in the patent. All copies must have each page plainly written on only one side of a sheet of paper.
☐ 7. A certification by the third party requester that a copy of the request has been served in its entirety on the patent owner at the address provided for in 37 CFR 1.33(c). The name and address of the party served must be indicated. If service was not possible, a duplicate copy of the request must be supplied to the Office
☒ 8. Other :

Explanation of above item(s): See Attachment.

Any written correspondence in response to this notice must include a submission pursuant to the attached instructions. **The instructions for a detailed explanation for an *ex parte* reexamination request differ from those for an *inter partes* reexamination request.** Any written correspondence in response to this notice should be mailed to the Central Reexamination Unit (CRU), ATTN: "Box *Ex Parte* Reexam" at the USPTO address indicated at the top of this notice. Any "replacement documents" may be facsimile transmitted to the CRU at the FAX number indicated below. A REPLACEMENT STATEMENT AND EXPLANATION UNDER 37 CFR 1.510(b)(1) and (2) MAY NOT BE FACSIMILE TRANSMITTED.

/Patricia Volpe/
Paralegal Specialist, Central Reexamination Unit
(571) 6825; FAX No. (571) 273-9900

cc: Patent Owner's Name and Address: McDonnell Boehnen Hulbert & Berghoff LLP
c/o Sonos, Inc.
300 South Wacker Drive
Chicago IL 60606

INSTRUCTIONS TO NOTICE OF FAILURE TO COMPLY WITH *EX PARTE* REEXAMINATION REQUEST FILING REQUIREMENTS (37 CFR 1.510(c))

HOW TO REPLY TO THIS NOTICE

Any written correspondence in response to this notice must include either a **replacement document**, or, **if item #4 is checked and/or it is otherwise specifically required by the Office, a paper containing a replacement statement and explanation under 37 CFR 1.510(b)(1) and (2)** that either replaces the originally-filed statement and explanation or provides a previously missing statement and explanation. A replacement document either replaces an originally-filed document, or provides a previously missing document, that contains part(s) of the request other than the statement and explanation as set forth in 37 CFR 1.510(b)(1) and (2). For example, a replacement to the originally-filed listing of cited patents and printed publications, PTO/SB/08 (formerly designated as PTO-1449) or its equivalent, is a replacement document.

If a paper containing a replacement statement and explanation, or a replacement document (other than a replacement certificate of service), is submitted by a third party requester, it must be **accompanied by a certification that a copy of the replacement statement and explanation under 37 CFR 1.510(b)(1) and (2), or that a copy of the replacement document, has been served** in its entirety on the patent owner at the address provided for in 37 CFR 1.33(c). The name and address of the party served must be indicated. If service was not possible, a duplicate copy of the replacement statement and explanation (or replacement document) must be supplied to the Office.

REPLACEMENT STATEMENT AND EXPLANATION UNDER 37 CFR 1.510(b)(1) and (2) (ITEM #4 IS CHECKED)

The **statement and explanation under 37 CFR 1.510(b)(1) and (2)** (see item #4) must discuss **EVERY patent or printed publication cited in the information disclosure statement** in at least one proposed rejection or statement identifying a substantial new question of patentability (SNQ), AND in a corresponding detailed explanation (see the below discussion). Furthermore, **EVERY claim for which reexamination is requested** must be discussed in at least one proposed rejection or statement identifying an SNQ and in the corresponding detailed explanation. If item #4 is missing or incomplete, a paper containing a **replacement statement and explanation under 37 CFR 1.510(b)(1) and (2) is required.**

A paper containing a replacement statement and explanation under 37 CFR 1.510(b)(1) and (2) may NOT be facsimile transmitted. It must be received by first class mail or by USPS Express Mail.

If an originally-filed information disclosure statement cites patents or printed publications that are NOT discussed in at least one proposed rejection or statement identifying an SNQ AND in the corresponding detailed explanation **in the originally-filed request**, the requester must file either (a) a **replacement document, i.e., a replacement PTO/SB/08 (former PTO-1449)** or its equivalent, listing **ONLY** those patents and printed publications that are so discussed, or (b) a paper containing a **replacement statement and explanation under 37 CFR 1.510(b)(1) and (2).** If the first option is chosen, the replacement PTO/SB/08 or its equivalent should include a cover letter expressly withdrawing from the request any previously cited references that are being omitted by the replacement PTO/SB/08 or its equivalent. The requester may, if desired, file both a replacement PTO/SB/08 or its equivalent and a paper containing a replacement statement and explanation, if the replacement statement and explanation discusses EVERY patent or printed publication, cited in the replacement PTO/SB/08 or its equivalent, in at least one proposed rejection or statement identifying an SNQ and in the corresponding detailed explanation.

Requester is NOT required to, and should not, additionally file a replacement copy of any exhibits, references, etc., or other replacement parts of the request (i.e., replacement documents) if a defect requiring a replacement document is not specifically identified by this notice.

Examples of When a Replacement Statement and Explanation under 37 CFR 1.510(b)(1) and (2) Is Required:

1. The originally-filed request fails to discuss **EVERY** patent or printed publication cited in the originally-filed information disclosure statement in at least one proposed rejection or statement identifying an SNQ and in the corresponding detailed explanation, and the requester does not wish to file a replacement PTO/SB/08 (formerly designated as PTO-1449) or its equivalent listing ONLY those patents and printed publications that are so discussed.

2. The originally-filed request discusses every patent or printed publication cited in the information disclosure statement in at least one proposed rejection or statement identifying an SNQ, but **fails to discuss EVERY patent or printed publication cited in the information disclosure statement in a detailed explanation that corresponds to the proposed rejection or statement identifying an SNQ.**

3. The originally-filed request fails to discuss **EVERY CLAIM** for which reexamination is requested in at least one proposed rejection or statement identifying an SNQ, and in the corresponding detailed explanation.

Examples of Proposed Rejections and Statements Identifying a Substantial New Question of Patentability (SNQ)

Proposed rejections

Claims 1-3 are obvious over reference A in view of reference B.
Claims 4-6 are obvious over reference A in view of references B and C.
Claims 7-10 are obvious over reference Q in view of reference R.

Statements identifying a substantial new question of patentability

A substantial new question of patentability as to claims 1-3 is raised by reference A in view of reference B.

A substantial new question of patentability as to claims 4-6 is raised by reference A in view of references B and C.

A substantial new question of patentability as to claims 7-10 is raised by reference Q in view of reference R.

A proposed rejection or statement identifying an SNQ must be repeated with any *replacement* detailed explanation that corresponds to the proposed rejection or statement identifying an SNQ, in any paper containing a replacement statement and explanation under 37 CFR 1.510(b)(1) and (2).

In addition, the requester should include an explanation of *how the SNQ is raised.*

1. Assume that claim 1 of the patent recites, as one of the limitations, widget W. Requester would state that the XYZ reference, cited in the information disclosure statement, contains a teaching of widget W as recited in claim 1, and that this teaching was not present during the prior examination of the patent under reexamination (i.e., the teaching is "new"). Requester would also state that he believes that a reasonable examiner would consider this teaching important in determining whether or not the claims are patentable. For this reason, requester would state that this teaching by the XYZ reference raises a substantial new question of patentability (SNQ) with respect to at least claim 1 of the patent. Similarly, if dependent claim 6 adds widget H, the requester would state that the ABC reference, cited in the information disclosure statement, contains a teaching of widget H as recited in claim 6, that this teaching was not present during the prior concluded examination of the patent, that a reasonable examiner would consider this teaching important in determining whether or not the claims are patentable, and that this teaching raises an SNQ with respect to dependent claim 6 of the patent.

2. Assume that claim 1 of the patent recites, as one of its limitations, limitation W. Assume either that reference XYZ was applied in a rejection during the prior examination of the patent, or that the teachings of reference XYZ are purely cumulative to a reference cited in a rejection during the prior examination of the patent. Assume further that reference ABC teaches that limitation W would have been either inherent given the teachings of reference XYZ, or would have been obvious in view of the combination of XYZ and ABC. Reference ABC was cited in an information disclosure statement but was never discussed or applied in a rejection ***in combination with the XYZ reference*** during the prior examination of the patent under reexamination. **Requester would state** that reference XYZ was present during the prior examination of the patent under reexamination because it was applied in a rejection during the prosecution of the patent, and that reference ABC was cited in an information disclosure statement but never applied in a rejection (or never discussed), **in combination with the XYZ reference** during the prior examination of the patent under reexamination Requester would then state (1) that the ***combination*** of the XYZ reference and the ABC reference, both of which are cited in the information disclosure statement, contains a teaching of limitation W as recited in claim 1, (2) that this teaching provided by the **combination** of the XYZ and ABC references was not present during the prior examination of the patent under reexamination, (3) that a reasonable examiner would consider this teaching important in determining whether or not the claims are patentable, and (4) that this teaching raises an SNQ with respect to claim 1 of the patent.

Example of a Detailed Explanation

Assume, for example, that a requester believes that the XYZ reference, alone, anticipates claims 1-5. The requester would expressly propose a rejection of claims 1-5 under 35 USC 102(b) as being anticipated by the XYZ reference. In a claim chart, the requester would then show how **each limitation** of claims 1-5 is anticipated by the XYZ reference. If the requester believes that the XYZ reference, in view of the ABC reference, renders obvious claims 6-10, the requester would expressly propose a rejection of claims 6-10 under 35 USC 103 as being obvious over the XYZ reference in view of the ABC reference. In a claim chart, the requester would then show which limitations of claims 6-10 are taught by the XYZ reference, and which limitations of claims 6-10 are taught by the ABC reference. The requester should quote each pertinent teaching in the prior art reference, referencing each quote by page, column and line number, and any relevant figure numbers.

A **patent owner**, when filing a request for reexamination in an *ex parte* reexamination proceeding, may satisfy the requirement under 37 CFR 1.510(b) for supplying a detailed explanation by comparing, limitation-by-limitation, the claim(s) under reexamination with the teachings of each reference cited in the information disclosure statement and in the statement pointing out an SNQ. Each limitation of the claim(s) must be separately discussed. For each claim limitation, the patent owner must do one of the following: (a) show how at least one reference teaches or suggests the limitation, (b) admit that the limitation is "old", or (c) state that the limitation is believed to be missing from the reference. In a claim chart, the patent owner should quote each pertinent teaching in the prior art reference,

referencing each quote by page, column and line number, and any relevant figure numbers. Proposed applications of the cited references and/or proposed combinations of the cited references should separately identified. The patent owner is not required to

expressly propose a rejection of the claim(s) or provide a statement of why the claim(s) under reexamination would have been obvious over a proposed reference combination.

REPLACEMENT DOCUMENTS

If the originally-filed PTO/SB/08 (former PTO-1449) or its equivalent lists patents or printed publications that are NOT discussed in at least one proposed rejection or statement identifying an SNQ AND in the corresponding detailed explanation **in the originally-filed request**, the requester may file a paper containing a **replacement PTO/SB/08 (former PTO-1449) or its equivalent** listing **ONLY** those patents and printed publications that are so discussed. The replacement PTO/SB/08 or its equivalent should include a cover letter expressly withdrawing from the request any formerly cited references that are now being omitted by the replacement PTO/SB/08 or its equivalent. Similarly, if **any patent or printed publication discussed** in at least one proposed rejection or statement identifying an SNQ AND in the corresponding detailed explanation **in the originally-filed request is not listed in the originally-filed PTO/SB/08 (former PTO-1449)** or its equivalent, the requester must file a **replacement PTO/SB/08 (former PTO-1449)** or its equivalent listing all of the patents and printed publications, including the previously omitted reference(s), and provide copies of the missing references if copies were not provided with the originally-filed request

If a copy of a patent, printed publication, or an English-language translation of a patent or printed publication, that is cited in the PTO/SB/08 (former PTO-1449) or its equivalent, is illegible, missing, or incomplete (i.e., it does not contain all of the pages indicated in the PTO/SB/08 (former PTO-1449) or its equivalent), a replacement copy of the patent or printed publication is required.

If a copy of any disclaimer, certificate of correction, or reexamination certificate issued in the patent, or a copy of the entire patent for which reexamination is requested as described in item #6, is missing, or if the copy that was received by the Office was illegible or incomplete, a replacement document (i.e., a replacement copy of the disclaimer, certificate of correction, reexamination certificate, or entire patent under reexamination as described in item #6) is required.

If the requester fails to correctly identify the patent number or the claims for which reexamination is requested on the transmittal form for the request (PTO/SB/57, or an equivalent) as described in item #2, and the patent number and the claims for which reexamination is requested are correctly identified in the originally-filed request, a **replacement transmittal form** is required.

If a certificate of service on the patent owner, as described in item #7, is missing, or if the certificate of service received by the Office is inaccurate or incomplete, a replacement certificate of service is required.

Replacement documents may be facsimile transmitted. A paper containing a replacement statement and explanation may NOT be facsimile transmitted.

ATTACHMENT TO PTOL 2077

Control Number: 90/013,959
Patent Number: 9,213,357
Request Receipt Date: May 22, 2017

The request for *Ex Parte* Reexamination of U.S. Patent 9,213,357, filed on May 22, 2017 does not comply with the filing requirements of *ex parte* reexamination proceedings under 37 CFR 1.510(b)(1)(2).

Reexamination was requested for U.S. Patent No. 9,213,357 (in this instance claims 9, 10, 12 and 19 are requested). The request does not provide a "statement pointing out each substantial new question of patentability based on the prior patents and printed publications" for each cited document, as is required by 37 CFR 1.510(b) (1).

The request is incomplete as to compliance with 37 CFR 1.510(b) (1) for the following reason:

The request has failed to provide the requisite identification and explanation, in compliance with 37 CFR 1.510(b) (1), of what substantial new questions of patentability (SNQs) are being raised by the cited prior art documents under 37 CFR 1.510(b). In other words, the request fails to clearly point out and explain how each asserted SNQ is substantially different from those raised in the previous examination of the patent before the Office. It is not sufficient to merely state that the references were not of record in the prior prosecution of the '357 patent. Also, as pointed out in MPEP 2216, "[i]t is not sufficient that a request for reexamination merely proposes one or more rejections of a patent claim or claims as a basis for reexamination. It must first be demonstrated that a patent or printed publication that is relied upon in a proposed rejection presents **a new, non-cumulative technological teaching** that was not previously considered and discussed on the record during the prosecution of the application that resulted in the patent for which reexamination is requested, and during prosecution of any other prior proceeding involving the patent for which reexamination is requested." [Emphasis added]

The request is incomplete as to compliance with 37 CFR 1.510(b) (2) for the following reason:

The request does not provide a "detailed explanation of the pertinency and manner of applying the cited prior art to every claim for which reexamination is requested," as is required by 37 CFR 1.510(b) (2).

Requester is proposing to combine 13 prior art references which will result in a very large number of permutations.

Specifically, the request is not clear as to the proposed rejections that are being set forth, because it fails to provide a clear explanation of the proposed rejections due to the lumping together of multiple proposed rejections.

For one example, at page 3 of the request it is stated:

6. Claims 9, 10, 12 and 19 are invalid under 35 U.S.C. 103(a) over Meade, Goldberg, Blank, Gray, SMPTE, RFC 1305, Microsoft File Sharing, pcAnywhere, the Handbook, the Sonos APA, Nutshell, RTSP ***and/or*** RTP.

Since the request relies upon grounds, which would suggest multiple combinations of references, and there is no analysis as to how a substantial new question is raised for each of the proposed rejections, there is no explanation as to the pertinency and manner of applying the cited prior art to each claim identified in the request.
See MPEP 2217, which states:

The explanation **must not** lump together the proposed rejections or proposed combinations of references.

Examples of inappropriate language:

- Claim 1 is unpatentable under 35 U.S.C. 103 as being obvious over Smith **and/or** Charles.

- Claim 2 is unpatentable under 35 U.S.C. 103 as being obvious over Smith in view of Jones **or** Harvey. (This could however be used if both Jones and Harvey provide a minor teaching which can be articulated in a sentence or two.)

- Claims 3 - 10 are unpatentable under 35 U.S.C. 103 as being obvious over Smith in view of either Jones **and** Cooper **or** Harvey **and** Cooper.

Examples of appropriate language:

- Claim 1 is unpatentable under 35 U.S.C. 103 as being obvious over Smith.

- Claim 1 is unpatentable under 35 U.S.C. 103 as being obvious over Charles.

- Claim 2 is unpatentable under 35 U.S.C. 103 as being obvious over Smith in view of Jones.

- Claim 2 is unpatentable under 35 U.S.C. 103 as being obvious over Smith in view of Harvey.

- Claims 3 - 10 are unpatentable under 35 U.S.C. 103 as being obvious over Smith in view of Jones, and further in view of Cooper.

- Claims 3 - 10 are unpatentable under 35 U.S.C. 103 as being obvious over Smith in view of Harvey, and further in view of Cooper.

If the requester were permitted to omit an explanation of how such documents cited in the request are applied to the patent claims, an undue burden would be placed on the Office to address each document in the determination on the request, without an explanation of the relevance to the patent claims. Accordingly, such an omission is prohibited by law.

REQUESTER'S RECOURSE

Requester has the option to respond to this identification of defects in the request papers by applying the appropriate option(s) set forth below:

Providing an explanation of the manner and pertinence of applying each cited document to the patent claims for which reexamination is requested, as required by 37 CFR 1.510(b)(2). Every limitation in each patent claim for which reexamination is requested must be addressed. Where references are applied in combination, each combination must be individually identified, and the basis for forming each combination of references must be supplied.

Serving the corrected request (including all supporting documents such as the listing of references, copies of the references, appendices, etc.) on the patent owner at the current correspondence address under 37 CFR 1.33(a) in the patent record at the time the corrected request was filed, or alternatively, if such service cannot be made, providing an explanation of the efforts taken to provide service and why those efforts were not successful, and a second copy of the request papers.

For any document for which no explanation is to be provided for any of the patent claims, explicitly withdrawing the reference from the request and replacing the presently submitted listing of documents with a new listing confined to the documents for which a discussion required and 1449 would be expressly withdrawn by requester, and replaced with a newly provided form or forms.

In order to obtain a filing date for the request papers, the requester must, within thirty (30) days of the mailing date of this decision, file a response to this decision which makes the request papers filing date complaint. A request for *ex parte* reexamination must now meet all the applicable statutory and regulatory requirements before a filing date is accorded to the request. See MPEP 2227 Part B.1 and MPEP 2217, Part 1. See also *Clarification of Filing Date Requirements for Ex Parte and Inter Partes Reexamination Proceedings*, 71 Fed. Reg. 44219 (August 4, 2006), 1309 *Off. Gaz. Pat. Office* 216 (August 29, 2006) (Final Rule).

Failure to submit a proper response to this Notice may result in the termination of the request, with no filing date accorded.

All correspondence related to this ex parte reexamination proceeding should be directed:

By EFS: Registered users may submit via the electronic filing system EFS-Web.
https://efs.uspto.gov/efile/myportal/efs-registered

By Mail to: Mail Stop Ex Parte Reexam
Central Reexamination Unit
Commissioner for Patents
United States Patent & Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450

Patent Assignment Abstract of Title

Total Assignments: 2

Application #: 14516867 **Filing Dt:** 10/17/2014 **Patent #:** 9213357 **Issue Dt:** 12/15/2015
PCT #: NONE **Intl Reg #:** **Publication #:** US20150039109 **Pub Dt:** 02/05/2015
Inventor: Nicholas A.J. Millington
Title: Obtaining Content from Remote Source for Playback

Assignment: 1

Reel/Frame: 035518 / 0127 **Received:** 04/28/2015 **Recorded:** 04/28/2015 **Mailed:** 04/29/2015 **Pages:** 3
Conveyance: ASSIGNMENT OF ASSIGNORS INTEREST (SEE DOCUMENT FOR DETAILS).
Assignor: MILLINGTON, NICHOLAS A.J. **Exec Dt:** 03/06/2015
Assignee: SONOS, INC.
223 EAST DE LA GUERRA STREET
SANTA BARBARA, CALIFORNIA 93101
Correspondent: MCDONNELL BOEHNEN HULBERT & BERGHOFF LLP
300 SOUTH WACKER DRIVE
CHICAGO, IL 60606

Assignment: 2

Reel/Frame: 038329 / 0253 **Received:** 04/01/2016 **Recorded:** 04/01/2016 **Mailed:** 04/21/2016 **Pages:** 78
Conveyance: SECURITY INTEREST (SEE DOCUMENT FOR DETAILS).
Assignor: SONOS, INC. **Exec Dt:** 03/30/2016
Assignee: GORDON BROTHERS FINANCE COMPANY
800 BOYLSTON STREET
27TH FLOOR
BOSTON, MASSACHUSETTS 02199
Correspondent: CHOATE HALL & STEWART LLP
2 INTERNATIONAL PLACE
BOSTON, MA 02110

Search Results as of: 05/24/2017 01:26 PM

If you have any comments or questions concerning the data displayed, contact PRD / Assignments at 571-272-3350. v.2.5
Web interface last modified: Aug 20, 2015 v.2.5

US009213357B2

(12) **United States Patent**
Millington

(10) **Patent No.: US 9,213,357 B2**
(45) **Date of Patent: Dec. 15, 2015**

(54) **OBTAINING CONTENT FROM REMOTE SOURCE FOR PLAYBACK**

(71) Applicant: **Sonos, Inc.**, Santa Barbara, CA (US)

(72) Inventor: **Nicholas A. J. Millington**, Santa Barbara, CA (US)

(73) Assignee: **Sonos, Inc.**, Santa Barbara, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/516,867**

(22) Filed: **Oct. 17, 2014**

(65) **Prior Publication Data**

US 2015/0039109 A1 Feb. 5, 2015

Related U.S. Application Data

(63) Continuation of application No. 13/297,000, filed on Nov. 15, 2011, which is a continuation of application No. 10/816,217, filed on Apr. 1, 2004, now Pat. No. 8,234,395.

(60) Provisional application No. 60/490,768, filed on Jul. 28, 2003.

(51) **Int. Cl.**
G06F 15/16 (2006.01)
G06F 1/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***G06F 1/00*** (2013.01); ***G05B 15/02*** (2013.01); ***G06F 3/048*** (2013.01); ***G06F 3/0482*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC G06F 3/167; G06F 17/00; G06F 17/3074; G06F 3/048; G06F 3/0482; G06F 3/0484; G06F 3/126; G06F 3/16; H04L 65/60; H04L 12/2812
USPC 709/219, 220, 231
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,296,278 A 10/1981 Cullison et al.
4,816,989 A 3/1989 Finn et al.
(Continued)

FOREIGN PATENT DOCUMENTS

EP 0251584 A2 1/1988
EP 0672985 A1 9/1995
(Continued)

OTHER PUBLICATIONS

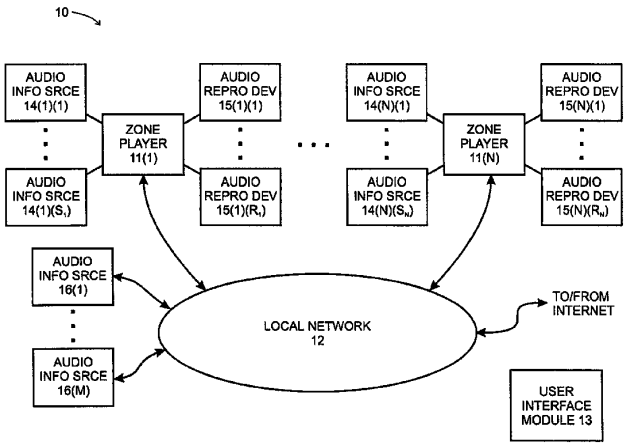
"Advisory Action mailed Sep. 18, 2008 for U.S. Appl. No. 10/816,217, filed Apr. 1, 2004, 8 pages".
(Continued)

Primary Examiner — Oleg Survillo
(74) *Attorney, Agent, or Firm* — McDonnell Boehnen Hulbert & Berghoff LLP

(57) **ABSTRACT**

Examples include a playback device with a network interface and memory with program instructions that, when executed by the processor, cause the playback device to (a) receive, via the network interface from a network device communicatively coupled to the playback device over a LAN, an address identifying a network location of audio information available at an audio information source, where the audio information source is outside of the LAN, (b) obtain, via the network interface from the audio information source, the audio information, (c) transmit, via the network interface to another playback device, the audio information, and (d) play back the audio information.

20 Claims, 5 Drawing Sheets



(51) **Int. Cl.**

H04J 3/06	(2006.01)
H04R 27/00	(2006.01)
G06F 17/00	(2006.01)
H03G 3/20	(2006.01)
H04L 29/06	(2006.01)
G06F 3/048	(2013.01)
G06F 3/16	(2006.01)
H04L 29/08	(2006.01)
G06F 3/0484	(2013.01)
H04R 3/12	(2006.01)
G06F 17/30	(2006.01)
G06F 3/0482	(2013.01)
H03G 3/00	(2006.01)
H04H 20/10	(2008.01)
H04H 20/26	(2008.01)
G05B 15/02	(2006.01)
G11B 20/10	(2006.01)
H04N 5/04	(2006.01)
H04N 9/79	(2006.01)
H04N 21/43	(2011.01)
H04N 21/436	(2011.01)

(52) **U.S. Cl.**

CPC ***G06F 3/0484*** (2013.01); ***G06F 3/16*** (2013.01); ***G06F 3/165*** (2013.01); ***G06F 3/167*** (2013.01); ***G06F 17/00*** (2013.01); ***G06F 17/3074*** (2013.01); ***G11B 20/10527*** (2013.01); ***H03G 3/00*** (2013.01); ***H03G 3/20*** (2013.01); ***H04H 20/103*** (2013.01); ***H04H 20/26*** (2013.01); ***H04J 3/0664*** (2013.01); ***H04L 65/60*** (2013.01); ***H04L 65/80*** (2013.01); ***H04L 67/1095*** (2013.01); ***H04L 67/26*** (2013.01); ***H04L 69/28*** (2013.01); ***H04N 5/04*** (2013.01); ***H04N 9/7904*** (2013.01); ***H04N 21/4307*** (2013.01); ***H04N 21/43615*** (2013.01); ***H04R 3/12*** (2013.01); ***H04R 27/00*** (2013.01); *G11B 2020/10592* (2013.01); *H04H 2201/20* (2013.01); *H04L 65/4076* (2013.01); *H04R 2227/003* (2013.01); *H04R 2227/005* (2013.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,153,579	A		10/1992	Fisch et al.
5,182,552	A		1/1993	Paynting
5,239,458	A		8/1993	Suzuki
5,299,266	A		3/1994	Lumsden
5,406,634	A		4/1995	Anderson et al.
5,440,644	A		8/1995	Farinelli et al.
5,467,342	A		11/1995	Logston et al.
5,491,839	A		2/1996	Schotz
5,553,222	A		9/1996	Milne et al.
5,602,992	A		2/1997	Danneels
5,668,884	A		9/1997	Clair, Jr. et al.
5,673,323	A		9/1997	Schotz et al.
5,696,896	A		12/1997	Badovinatz et al.
5,726,989	A	*	3/1998	Dokic 370/509
5,751,819	A		5/1998	Dorrough
5,761,320	A		6/1998	Farinelli et al.
5,787,249	A		7/1998	Badovinatz et al.
5,808,662	A		9/1998	Kinney et al.
5,815,689	A		9/1998	Shaw et al.
5,867,691	A		2/1999	Shiraishi
5,875,354	A		2/1999	Charlton et al.
5,887,143	A		3/1999	Saito et al.
5,923,869	A	*	7/1999	Kashiwagi et al. 713/501
5,923,902	A		7/1999	Inagaki
5,946,343	A		8/1999	Schotz et al.
5,956,088	A		9/1999	Shen et al.
6,009,457	A		12/1999	Moller
6,026,150	A		2/2000	Frank et al.
6,031,818	A		2/2000	Lo et al.
6,108,485	A		8/2000	Kim
6,108,686	A		8/2000	Williams, Jr.
6,122,668	A		9/2000	Teng et al.
6,128,318	A		10/2000	Sato
6,157,957	A		12/2000	Berthaud
6,175,872	B1		1/2001	Neumann et al.
6,185,737	B1		2/2001	Northcutt et al.
6,195,436	B1		2/2001	Scibora et al.
6,199,169	B1		3/2001	Voth
6,255,961	B1		7/2001	Van Ryzin et al.
6,256,554	B1		7/2001	DiLorenzo
6,308,207	B1		10/2001	Tseng et al.
6,324,586	B1		11/2001	Johnson
6,332,147	B1		12/2001	Moran et al.
6,343,028	B1		1/2002	Kuwaoka
6,349,339	B1		2/2002	Williams
6,351,821	B1		2/2002	Voth
6,404,811	B1		6/2002	Cvetko et al.
6,430,353	B1		8/2002	Honda et al.
6,449,653	B2		9/2002	Klemets et al.
6,487,296	B1		11/2002	Allen et al.
6,522,886	B1		2/2003	Youngs et al.
6,526,325	B1		2/2003	Sussman et al.
6,535,121	B2		3/2003	Matheny
6,587,127	B1		7/2003	Leeke et al.
6,598,172	B1		7/2003	VanDeusen et al.
6,611,537	B1		8/2003	Edens et al.
6,631,410	B1		10/2003	Kowalski et al.
6,674,803	B1		1/2004	Kesselring
6,687,664	B1	*	2/2004	Sussman et al. 704/201
6,757,517	B2		6/2004	Chang
6,778,493	B1		8/2004	Ishii
6,778,869	B2		8/2004	Champion
6,816,818	B2		11/2004	Wolf et al.
6,823,225	B1		11/2004	Sass
6,826,283	B1		11/2004	Wheeler et al.
6,836,788	B2		12/2004	Kim et al.
6,839,752	B1		1/2005	Miller et al.
6,898,642	B2		5/2005	Chafle et al.
6,907,458	B2		6/2005	Tomassetti et al.
6,912,610	B2		6/2005	Spencer
6,920,373	B2		7/2005	Xi et al.
6,934,766	B1		8/2005	Russell
6,970,482	B2		11/2005	Kim
6,985,694	B1		1/2006	De et al.
7,007,106	B1		2/2006	Flood et al.
7,020,791	B1		3/2006	Aweya et al.
7,043,651	B2		5/2006	Aweya et al.
7,047,308	B2		5/2006	Deshpande
7,068,596	B1		6/2006	Mou
7,113,999	B2		9/2006	Pestoni et al.
7,115,017	B1		10/2006	Laursen et al.
7,130,368	B1		10/2006	Aweya et al.
7,130,608	B2		10/2006	Hollstrom et al.
7,130,616	B2		10/2006	Janik
7,136,934	B2		11/2006	Carter et al.
7,143,141	B1		11/2006	Morgan et al.
7,143,939	B2		12/2006	Henzerling
7,162,315	B2		1/2007	Gilbert
7,185,090	B2		2/2007	Kowalski et al.
7,187,947	B1		3/2007	White et al.
7,206,367	B1	*	4/2007	Moore 375/354
7,206,967	B1		4/2007	Marti et al.
7,209,795	B2		4/2007	Sullivan et al.
7,218,708	B2		5/2007	Berezowski et al.
7,236,739	B2		6/2007	Chang
7,236,773	B2		6/2007	Thomas
7,293,060	B2		11/2007	Komsi
7,312,785	B2		12/2007	Tsuk et al.
7,313,593	B1		12/2007	Pulito et al.
7,324,857	B2		1/2008	Goddard
7,333,519	B2		2/2008	Sullivan et al.
7,372,846	B2		5/2008	Zwack
7,392,102	B2		6/2008	Sullivan et al.
7,412,499	B2		8/2008	Chang et al.
7,483,538	B2		1/2009	McCarty et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,483,958 B1 1/2009 Elabbady et al.
7,519,667 B1 4/2009 Capps
7,571,014 B1 8/2009 Lambourne et al.
7,574,274 B2 8/2009 Holmes
7,599,685 B2 10/2009 Goldberg et al.
7,606,174 B2 10/2009 Ochi et al.
7,643,894 B2 1/2010 Braithwaite et al.
7,657,224 B2 2/2010 Goldberg et al.
7,657,644 B1 2/2010 Zheng
7,657,910 B1 2/2010 McAulay et al.
7,668,990 B2 2/2010 Krzyzanowski et al.
7,669,219 B2 2/2010 Scott, III
7,675,943 B2 3/2010 Mosig et al.
7,676,142 B1 3/2010 Hung
7,702,279 B2 4/2010 Ko et al.
7,702,403 B1 4/2010 Gladwin et al.
7,711,774 B1 * 5/2010 Rothschild 709/205
7,720,096 B2 5/2010 Klemets
7,742,740 B2 6/2010 Goldberg et al.
7,743,009 B2 6/2010 Hangartner et al.
RE41,608 E 8/2010 Blair et al.
7,835,689 B2 11/2010 Goldberg et al.
7,853,341 B2 12/2010 McCarty et al.
7,865,137 B2 1/2011 Goldberg et al.
7,885,622 B2 2/2011 Krampf et al.
7,916,877 B2 3/2011 Goldberg et al.
7,917,082 B2 3/2011 Goldberg et al.
7,934,239 B1 4/2011 Dagman
7,996,588 B2 8/2011 Subbiah et al.
8,014,423 B2 9/2011 Thaler et al.
8,020,023 B2 9/2011 Millington et al.
8,023,663 B2 9/2011 Goldberg
8,028,038 B2 9/2011 Weel
8,028,323 B2 9/2011 Weel
8,045,952 B2 10/2011 Qureshey et al.
8,050,652 B2 11/2011 Qureshey et al.
8,074,253 B1 12/2011 Nathan
8,086,752 B2 12/2011 Millington et al.
8,103,009 B2 1/2012 McCarty et al.
8,112,032 B2 2/2012 Ko et al.
8,131,390 B2 3/2012 Braithwaite et al.
8,169,938 B2 5/2012 Duchscher et al.
8,214,873 B2 7/2012 Weel
8,230,099 B2 7/2012 Weel
8,234,395 B2 7/2012 Millington
8,290,603 B1 10/2012 Lambourne
8,315,555 B2 11/2012 Ko et al.
8,370,678 B2 2/2013 Millington et al.
8,423,659 B2 4/2013 Millington
8,473,844 B2 6/2013 Kreifeldt et al.
8,588,949 B2 11/2013 Lambourne et al.
8,775,546 B2 7/2014 Millington
2001/0009604 A1 7/2001 Ando et al.
2001/0022823 A1 9/2001 Renaud
2001/0027498 A1 10/2001 Van et al.
2001/0032188 A1 10/2001 Miyabe et al.
2001/0042107 A1 11/2001 Palm
2001/0046235 A1 11/2001 Trevitt et al.
2001/0047377 A1 11/2001 Sincaglia et al.
2002/0002039 A1 1/2002 Qureshey et al.
2002/0002562 A1 1/2002 Moran et al.
2002/0002565 A1 1/2002 Ohyama
2002/0003548 A1 1/2002 Krusche et al.
2002/0022453 A1 2/2002 Balog et al.
2002/0026442 A1 2/2002 Lipscomb et al.
2002/0034374 A1 3/2002 Barton
2002/0042844 A1 4/2002 Chiazzese
2002/0049843 A1 4/2002 Barone et al.
2002/0062406 A1 5/2002 Chang et al.
2002/0065926 A1 5/2002 Hackney et al.
2002/0072816 A1 6/2002 Shdema et al.
2002/0073228 A1 6/2002 Cognet et al.
2002/0080783 A1 6/2002 Fujimori
2002/0090914 A1 7/2002 Kang et al.
2002/0093478 A1 7/2002 Yeh
2002/0095460 A1 7/2002 Benson
2002/0109710 A1 8/2002 Holtz et al.
2002/0112244 A1 8/2002 Liou et al.
2002/0114354 A1 8/2002 Sinha et al.
2002/0114359 A1 8/2002 Ibaraki et al.
2002/0124097 A1 9/2002 Isely et al.
2002/0129156 A1 9/2002 Yoshikawa
2002/0143998 A1 10/2002 Rajagopal et al.
2002/0159596 A1 10/2002 Durand et al.
2002/0163361 A1 11/2002 Parkin
2002/0165721 A1 11/2002 Chang et al.
2002/0165921 A1 11/2002 Sapieyevski
2002/0168938 A1 11/2002 Chang
2002/0173273 A1 11/2002 Spurgat et al.
2002/0177411 A1 * 11/2002 Yajima et al. 455/41
2002/0184310 A1 12/2002 Traversat et al.
2002/0188762 A1 12/2002 Tomassetti et al.
2002/0194309 A1 12/2002 Carter et al.
2003/0002609 A1 1/2003 Faller et al.
2003/0018797 A1 1/2003 Dunning et al.
2003/0020763 A1 1/2003 Mayer et al.
2003/0023741 A1 1/2003 Tomassetti et al.
2003/0035072 A1 2/2003 Hagg
2003/0035444 A1 2/2003 Zwack
2003/0041173 A1 2/2003 Hoyle
2003/0041174 A1 2/2003 Wen et al.
2003/0043924 A1 3/2003 Haddad et al.
2003/0055892 A1 3/2003 Huitema et al.
2003/0061428 A1 3/2003 Garney et al.
2003/0066094 A1 4/2003 Van et al.
2003/0067437 A1 4/2003 McClintock et al.
2003/0073432 A1 4/2003 Meade
2003/0099212 A1 5/2003 Anjum et al.
2003/0099221 A1 5/2003 Rhee
2003/0110329 A1 6/2003 Higaki et al.
2003/0126211 A1 7/2003 Anttila et al.
2003/0157951 A1 8/2003 Hasty
2003/0195964 A1 10/2003 Mane
2003/0198254 A1 10/2003 Sullivan et al.
2003/0198255 A1 10/2003 Sullivan et al.
2003/0198257 A1 10/2003 Sullivan et al.
2003/0200001 A1 * 10/2003 Goddard 700/94
2003/0204273 A1 10/2003 Dinker et al.
2003/0204509 A1 10/2003 Dinker et al.
2003/0210796 A1 11/2003 McCarty et al.
2003/0219007 A1 11/2003 Barrack et al.
2003/0227478 A1 12/2003 Chatfield
2003/0231871 A1 12/2003 Ushimaru
2003/0235304 A1 12/2003 Evans et al.
2004/0001484 A1 1/2004 Ozguner
2004/0001591 A1 1/2004 Mani et al.
2004/0008852 A1 1/2004 Also et al.
2004/0010727 A1 1/2004 Fujinami
2004/0012620 A1 1/2004 Buhler et al.
2004/0015252 A1 1/2004 Aiso et al.
2004/0019497 A1 1/2004 Volk et al.
2004/0024478 A1 2/2004 Hans et al.
2004/0024925 A1 2/2004 Cypher et al.
2004/0027166 A1 2/2004 Mangum et al.
2004/0032348 A1 2/2004 Lai et al.
2004/0041836 A1 3/2004 Zaner et al.
2004/0048569 A1 3/2004 Kawamura
2004/0066736 A1 4/2004 Kroeger
2004/0075767 A1 4/2004 Neuman et al.
2004/0078383 A1 4/2004 Mercer et al.
2004/0080671 A1 4/2004 Siemens et al.
2004/0093096 A1 * 5/2004 Huang et al. 700/17
2004/0098754 A1 * 5/2004 Vella et al. 725/135
2004/0131192 A1 7/2004 Metcalf
2004/0133689 A1 7/2004 Vasisht
2004/0143368 A1 * 7/2004 May et al. 700/241
2004/0143852 A1 * 7/2004 Meyers 725/133
2004/0148237 A1 7/2004 Bittmann et al.
2004/0170383 A1 9/2004 Mazur
2004/0203378 A1 10/2004 Powers
2004/0208158 A1 10/2004 Fellman et al.
2004/0213230 A1 * 10/2004 Douskalis et al. 370/390
2004/0224638 A1 11/2004 Fadell et al.
2004/0228367 A1 11/2004 Mosig et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2004/0248601	A1		12/2004	Chang
2004/0249965	A1		12/2004	Huggins et al.
2004/0249982	A1		12/2004	Arnold et al.
2004/0252400	A1		12/2004	Blank et al.
2005/0010691	A1		1/2005	Oyadomari et al.
2005/0011388	A1		1/2005	Kouznetsov
2005/0013394	A1		1/2005	Rausch et al.
2005/0015551	A1		1/2005	Eames et al.
2005/0021590	A1		1/2005	Debique et al.
2005/0027821	A1	*	2/2005	Alexander et al. 709/218
2005/0047605	A1		3/2005	Lee et al.
2005/0058149	A1		3/2005	Howe
2005/0062637	A1		3/2005	El et al.
2005/0081213	A1		4/2005	Suzuoki et al.
2005/0114538	A1		5/2005	Rose
2005/0120128	A1		6/2005	Willes et al.
2005/0125357	A1		6/2005	Saadat et al.
2005/0131558	A1		6/2005	Braithwaite et al.
2005/0166135	A1	*	7/2005	Burke et al. 715/500.1
2005/0168630	A1		8/2005	Yamada et al.
2005/0177643	A1		8/2005	Xu
2005/0181348	A1		8/2005	Carey et al.
2005/0195205	A1		9/2005	Abrams
2005/0195823	A1		9/2005	Chen et al.
2005/0216556	A1		9/2005	Manion et al.
2005/0281255	A1		12/2005	Davies et al.
2005/0283820	A1		12/2005	Richards et al.
2005/0288805	A1		12/2005	Moore et al.
2005/0289224	A1		12/2005	Deslippe et al.
2006/0095516	A1		5/2006	Wijeratne
2006/0098936	A1	*	5/2006	Ikeda et al. 386/46
2006/0119497	A1		6/2006	Miller et al.
2006/0143236	A1		6/2006	Wu
2006/0193454	A1		8/2006	Abou-chakra et al.
2007/0038999	A1		2/2007	Millington
2007/0043847	A1		2/2007	Carter et al.
2007/0047712	A1		3/2007	Gross et al.
2007/0048713	A1		3/2007	Plastina et al.
2007/0054680	A1		3/2007	Mo et al.
2007/0142022	A1		6/2007	Madonna et al.
2007/0142944	A1		6/2007	Goldberg et al.
2007/0143493	A1		6/2007	Mullig et al.
2007/0169115	A1		7/2007	Ko et al.
2007/0180137	A1		8/2007	Rajapakse
2007/0192156	A1		8/2007	Gauger
2007/0249295	A1	*	10/2007	Ukita et al. 455/88
2007/0271388	A1		11/2007	Bowra et al.
2007/0299778	A1		12/2007	Haveson et al.
2008/0022320	A1		1/2008	Ver
2008/0091771	A1		4/2008	Allen et al.
2008/0120429	A1		5/2008	Millington et al.
2008/0126943	A1		5/2008	Parasnis et al.
2008/0144861	A1		6/2008	Melanson et al.
2009/0031336	A1		1/2009	Chavez et al.
2009/0157905	A1		6/2009	Davis
2009/0193345	A1		7/2009	Wensley et al.
2009/0222115	A1		9/2009	Malcolm et al.
2009/0228919	A1		9/2009	Zott et al.
2010/0004983	A1		1/2010	Dickerson et al.
2010/0049835	A1		2/2010	Ko et al.
2010/0228740	A1		9/2010	Cannistraro et al.
2010/0284389	A1		11/2010	Ramsay et al.
2010/0299639	A1		11/2010	Ramsay et al.
2011/0066943	A1		3/2011	Brillon et al.
2012/0029671	A1		2/2012	Millington et al.
2012/0030366	A1		2/2012	Collart et al.
2012/0060046	A1		3/2012	Millington
2012/0129446	A1		5/2012	Ko et al.
2012/0290621	A1		11/2012	Heitz, III et al.
2013/0018960	A1		1/2013	Knysz et al.
2013/0022221	A1		1/2013	Kallai et al.
2013/0080599	A1		3/2013	Ko et al.
2013/0174100	A1		7/2013	Seymour et al.
2013/0191454	A1		7/2013	Oliver et al.
2013/0197682	A1		8/2013	Millington
2014/0181569	A1		6/2014	Millington et al.

FOREIGN PATENT DOCUMENTS

EP	1111527	A2	6/2001
EP	1122931	A2	8/2001
EP	2713281		4/2004
GB	2284327	A	5/1995
GB	2338374		12/1999
JP	07-210129		8/1995
JP	2003037585		2/2003
JP	03101958		4/2003
JP	2005108427		4/2005
WO	9525313	A1	9/1995
WO	9961985	A1	12/1999
WO	0153994		7/2001
WO	02073851		9/2002
WO	03093950	A2	11/2003
WO	2005013047	A2	2/2005

OTHER PUBLICATIONS

"Advisory Action mailed Sep. 5, 2014 for U.S. Appl. No. 13/907,666, filed May 31, 2013, 3 pages".

Akyildiz I.F., et al., "Multimedia Group Synchronization Protocols for Integrated Services Networks," IEEE Journal on Selected Areas in Communications, 1996, vol. 14 (1), pp. 162-173.

"AudioTron Quick Start Guide, Version 1.0", Voyetra Turtle Beach, Inc., Mar. 2001, 24 pages.

"AudioTron Reference Manual, Version 3.0", Voyetra Turtle Beach, Inc., May 2002, 70 pages.

"AudioTron Setup Guide, Version 3.0", Voyetra Turtle Beach, Inc., May 2002, 38 pages.

Benslimane A., "A Multimedia Synchronization Protocol for Multicast Groups," Proceedings of the 26th Euromicro Conference, 2000, vol. 1, pp. 456-463.

Biersack E., et al., "Intra- and Inter-Stream Synchronisation for Stored Multimedia Streams," IEEE International Conference on Multimedia Computing and Systems, 1996, pp. 372-381.

Blakowski G. et al., "A Media Synchronization Survey: Reference Model, Specification, and Case Studies", Jan. 1996, vol. 14, No. 1, 5-35.

"Bluetooth. "Specification of the Bluetooth System: The ad hoc SCATTERNET for affordable and highly functional wireless connectivity" Core, Version 1.0 A, Jul. 26, 1999, 1068 pages".

"Bluetooth. "Specification of the Bluetooth System: Wireless connections made easy" Core, Version 1.0 B, Dec. 1, 1999, 1076 pages".

Bretl W.E., et al., MPEG2 Tutorial [online], 2000 [retrieved on Jan. 13, 2009] Retrieved from the Internet< http://www.bretl.com/mpeghtml/MPEGindex.htm>, pp. 1-23.

"Dell, Inc. "Dell Digital Audio Receiver: Reference Guide" Jun. 2000, 70 pages".

"Dell, Inc. "Start Here" Jun. 2000, 2 pages".

"European Extended Search Report for Application No. 13184747.7 mailed on Feb. 28, 2014, 8 pages".

"Final Office Action mailed Jun. 5, 2014 for U.S. Appl. No. 13/907,666, filed May 31, 2013".

Final Office Action mailed Jul. 13, 2009 for U.S. Appl. No. 10/816,217, filed Apr. 1, 2004.

"Final Office Action mailed Sep. 13, 2012 for U.S. Appl. No. 13/297,000", United States Patent and Trademark Office, Sep. 13, 2012, 17 pages.

Final Office Action mailed Oct. 21, 2011 for U.S. Appl. No. 10/816,217, filed Apr. 1, 2004.

"Final Office Action mailed Mar. 27, 2014 for U.S. Appl. No. 13/533,105, filed Jun. 26, 2012.".

Final Office Action mailed Jan. 28, 2011 for U.S. Appl. No. 10/816,217, filed Apr. 1, 2004.

"Final Office Action mailed Jul. 3, 2012 for U.S. Appl. No. 13/298,090, filed Nov. 16, 2011".

Final Office Action mailed Jun. 30, 2008 for U.S. Appl. No. 10/816,217, filed Apr. 1, 2004.

(56) **References Cited**

OTHER PUBLICATIONS

"Final Office Action mailed on Oct. 22, 2014, issued in connection with U.S. Appl. No. 14/186,850, filed on Feb. 21, 2014, 12 pages".
"Final Office Action mailed on Oct. 23, 2014, issued in conection with U.S. Appl. No. 13/705,176, filed Dec. 5, 2012, 23 pages".
"Final Rejection mailed on Jan. 21, 2010 for U.S. Appl. No. 11/906,702, filed Oct. 2, 2007".
Huang C.M., et al., "A Synchronization Infrastructure for Multicast Multimedia at the Presentation Layer," IEEE Transactions on Consumer Electronics, 1997, vol. 43 (3), pp. 370-380.
"International Bureau,"Search Report" issued in connection with International Patent application No. PCT/US2013/046372, mailed Aug. 26, 2013, 3 pages.".
"International Bureau,"Written opinion" issued in connection with International Patent application No. PCT/US2013/046372, mailed Aug. 26, 2013, 4 pages.".
International Search Report for Application No. PCT/US04/23102, mailed on Aug. 1, 2008, 5 pages.
"International Search Report, issued by the International Searching Authority in connection with PCT Application No. PCT/US2013/046386, on Sep. 30, 2013, 3 pages.".
Ishibashi Y., "A Group Synchronization Mechanism for Live Media in Multicast Communications," IEEE Global Telecommunications Conference, 1997, vol. 2, pp. 746-752.
Ishibashi Y., "A Group Synchronization Mechanism for Stored Media in Multicast Communications," IEEE Information Revolution and Communications, 1997, vol. 2, pp. 692-700.
"Japanese Intellectual Property Office, "Decision of Rejection," issued in connection with Japanese patent application No. 2012-178711, mailed on Jul. 4, 2014, 3 pages".
"Japanese Intellectual Property Office, "Office Action Summary," issued in connection with Japanese patent application No. 2012-178711, mailed on Nov. 19, 2013, 5 pages".
Jo J., et al., "Synchronized One-to-many Media Streaming with Adaptive Playout Control," Proceedings of SPIE, 2002, vol. 4861, pp. 71-82.
"Jones, Stephen. "Dell Digital Audio Receiver: Digital upgrade for your analog stereo" Analog Stereo. Jun. 24, 2000 <http://www.reviewsonline.com/articles/961906864.htm> retrieved Jun. 18, 2014, 2 pages".
"Louderback, Jim. "Affordable Audio Receiver Furnishes Homes With MP3" TechTV Vault. Jun. 28, 2000 <http://www.g4tv.com/articles/17923/affordable-audio-receiver-furnishes-homes-with-mp3/> retrieved Jul. 10, 2014, 2 pages".
M. Nilsson., "ID3 Tag Version 2", Mar. 26, 1998, 28 Pages.
"Maniactools, "Identify Duplicate Files by Sound," Sep. 28, 2010, http://www.maniactools.com/soft/music-duplicate-remover/identify-duplicate-files-by-sound.shtml".
Mills D.L., "Network Time Protocol (Version 3) Specification, Implementation and Analysis," Network Working Group, Mar. 1992, <http://www.ietf.org/rfc/rfc1305.txt>.
Mills D.L., "Precision Synchronization of Computer Network Clocks," ACM SIGCOMM Computer Communication Review, 1994, vol. 24 (2), pp. 28-43.
Motorola., "Simplefi, Wireless Digital Audio Receiver, Installation and User Guide", Dec. 31, 2001.
"Non-final Office Action in connection with U.S. Appl. No. 13/619,237, mailed Apr. 10, 2013", United States Patent and Trademark Office, 10 pages.
"Non-Final Office Action mailed May 1, 2014 for U.S. Appl. No. 14/184,522, filed Feb. 19, 2014".
"Non-Final Office Action mailed Dec. 5, 2013 for U.S. Appl. No. 13/827,653, filed Mar. 14, 2013".
"Non-Final Office Action mailed Jan. 5, 2012 for U.S. Appl. No. 13/298,090, filed Nov. 16, 2011, 40 pages".
"Non-Final Office Action mailed May 6, 2014 for U.S. Appl. No. 13/705,176, filed Dec. 5, 2012".
"Non-Final Office Action mailed May 12, 2014 for U.S. Appl. No. 14/184,528, filed Feb. 19, 2014".
"Non-Final Office Action mailed May 14, 2014 for U.S. Appl. No. 13/848,932, filed Mar. 22, 2013".
"Non-Final Office Action mailed Jun. 17, 2014 for U.S. Appl. No. 14/176,808, filed Feb. 10, 2014".
"Non-Final Office Action mailed Dec. 18, 2013 for U.S. Appl. No. 13/907,666, filed May 31, 2013".
Non-Final Office Action mailed Jan. 18, 2008 for U.S. Appl. No. 10/816,217, filed Apr. 1, 2004.
"Non-Final Office Action mailed Apr. 19, 2010 for U.S. Appl. No. 11/801,468, filed May 9, 2007, 16 pages".
"Non-Final Office Action mailed Mar. 19, 2013 for U.S. Appl. No. 13/724,048, filed Dec. 21, 2012".
Non-Final Office Action mailed Jun. 21, 2011 for U.S. Appl. No. 10/816,217, filed Apr. 1, 2004.
Non-Final Office Action mailed Jan. 22, 2009 for U.S. Appl. No. 10/816,217, filed Apr. 1, 2004.
"Non-Final Office Action mailed Jul. 25, 2014 for U.S. Appl. No. 14/184,526, filed Feb. 19, 2014".
"Non-Final Office Action mailed Jul. 25, 2014 for U.S. Appl. No. 14/184,935, filed Feb. 20, 2014".
Non-Final Office Action mailed Jun. 25, 2010 for U.S. Appl. No. 10/816,217, filed Apr. 1, 2004.
"Non-Final Office Action mailed Nov. 25, 2013 for U.S. Appl. No. 13/533,105, filed Jun. 26, 2012.".
"Non-Final Office Action mailed May 27, 2014 for U.S. Appl. No. 14/186,850, filed Feb. 21, 2014".
Non-Final Office Action mailed Feb. 29, 2012 for U.S. Appl. No. 13/297,000, filed Nov. 15, 2011.
"Non-Final Office Action mailed Nov. 29, 2010 for U.S. Appl. No. 11/801,468, filed May 9, 2007, 17 pages".
"Non-Final Office Action mailed Apr. 30, 2012 for U.S. Appl. No. 13/204,511, filed Aug. 5, 2011".
"Non-Final Office Action mailed Jul. 30, 2013 for U.S. Appl. No. 13/724,048, filed Dec. 21, 2012".
"Non-Final Office Action mailed Jul. 31, 2014 for U.S. Appl. No. 13/533,105, filed Jun. 26, 2012".
"Non-Final Office Action mailed on Oct. 23, 2014, issued in connection with U.S. Appl. No. 13/848,904, filed Mar. 22, 2013, 11 pages".
"Non-Final Office Action mailed on Oct. 23, 2014, issued in connection with U.S. Appl. No. 13/864,251, filed Apr. 17, 2013, 11 pages".
"Non-Final Office Action mailed on Oct. 23, 2014, issued in connection with U.S. Appl. No. 13/888,203, filed May 6, 2013, 9 pages".
"Non-final Office Action mailed on Oct. 24, 2014, issued in connection with U.S. Appl. No. 13/435,776, filed Mar. 30, 2012, 14 pages".
"Non-Final Rejection mailed on Aug. 20, 2009 for U.S. Appl. No. 11/906,702, filed Oct. 2, 2007".
"Notice of Allowability in U.S. Appl. No. 13/619,237", Sep. 6, 2013, 4 pages.
Notice of Allowance Dec. 27, 2011 for U.S. Appl. No. 10/816,217, filed Apr. 1, 2004.
"Notice of Allowance mailed Mar. 6, 2014 for U.S. Appl. No. 13/827,653, filed Mar. 14, 2013".
"Notice of Allowance mailed May 6, 2011 for U.S. Appl. No. 11/801,468, filed May 9, 2007, 10 pages".
"Notice of Allowance mailed Nov. 10, 2011 for U.S. Appl. No. 11/906,702, filed Oct. 2, 2007".
"Notice of Allowance mailed Nov. 13, 2013 for U.S. Appl. No. 13/724,048, filed Dec. 21, 2012".
"Notice of Allowance mailed Jan. 31, 2013 for U.S. Appl. No. 13/298,090, filed Nov. 16, 2011".
"Notice of Allowance mailed Oct. 5, 2012 for U.S. Appl. No. 13/204,511, filed Aug. 5, 2011".
"Notice of Allowance mailed on Sep. 25, 2014, issued in connection with U.S. Appl. No. 14/176,808, filed Feb. 10, 2014, 5 pages".
"Palm, Inc. "Handbook for the Palm VII Handheld" May 2000, 311 pages".
Park S., et al., "Group Synchronization in MultiCast Media Communications," Proceedings of the 5th Research on Multicast Technology Workshop, 2003.
"Polycom Conference Composer manual: copyright 2001".
PRISMIQ; Inc., "PRISMIQ Media Player User Guide", 2003, 44 pages.

(56) **References Cited**

OTHER PUBLICATIONS

Rothermel K., et al., "An Adaptive Stream Synchronization Protocol," 5th International Workshop on Network and Operating System Support for Digital Audio and Video, 1995.
Schulzrinne H., et al., "RTP: A Transport Protocol for Real-Time Applications, RFC 3550," Network Working Group, 2003, pp. 1-89.
The MPEG-2 Transport Stream. Retrieved from the Internet< URL: http://www.coolstf.com/mpeg/#ts>; retrieved on Aug. 24, 2006.
"UPnP; "Universal Plug and Play Device Architecture"; Jun. 8, 2000; version 1.0; Microsoft Corporation; pp. 1-54".
""Welcome. You're watching Apple TV." Apple TV 1st Generation Setup Guide, Apr. 8, 2008 <http://manuals.info.apple.com/MANUALS/0/MA403/en_US/AppleTV_SetupGuide.pdf> Retrieved Oct. 14, 2014, 40 pages".
""Welcome. You're watching Apple TV." Apple TV 2nd Generation Setup Guide, Mar. 10, 2011 <http://manuals.info.apple.com/MANUALS/1000/MA1555/en_US/Apple_TV_2nd_gen_Setup_Guide.pdf> Retrieved Oct. 16, 2014, 35 pages".
""Welcome. You're watching Apple TV." Apple TV 3rd Generation Setup Guide, Mar. 16, 2012 <http://http://manuals.info.apple.com/MANUALS/1000/MA1607/en_US/apple_tv_3rd_gen_setup.pdf> Retrieved Oct. 16, 2014, 35 pages".
"Presentations at WinHEC 2000" May 2000, 138 pages.
"Written Opinion of the International Searching Authority. issued by the International Searching Authority in connection with PCT Application No. PCT/US2013/046386, on Sep. 30, 2013, 6 pages.".
"Yamaha DME 32 manual: copyright 2001".
"Yamaha DME Designer software manual: Copyright 2004, 482 pages".
Advisory Action mailed on Nov. 12, 2014, issued in connection with U.S. Appl. No. 13/907,666, filed May 31, 2013, 6 pages.
Advisory Action mailed on Nov. 26, 2014, issued in connection with U.S. Appl. No. 14/186,850, filed Feb. 21, 2014, 9 pages.
Crown PIP Manual available for sale at least 2004, 6 pages.
Final Office Action mailed on Dec. 3, 2014, issued in connection with U.S. Appl. No. 14/184,528, filed Feb. 19, 2014, 12 pages.
Non-Final Office Action mailed on Nov. 17, 2014, issued in connection with U.S. Appl. No. 13/864,247, filed Apr. 17, 2013, 11 pages.
Non-Final Office Action mailed on Nov. 18, 2014, issued in connection with U.S. Appl. No. 13/435,739, filed Mar. 30, 2012, 10 pages.
Non-Final Office Action mailed on Nov. 19, 2014, issued in connection with U.S. Appl. No. 13/848,921, filed Mar. 22, 2013, 9 pages.
Renkus Heinz Manual; available for sale at least 2004, 68 pages.
"Advisory Action mailed on Jan. 8, 2015, issued in connection with U.S. Appl. No. 13/705,176, filed Dec. 5, 2012, 4 pages".
"Final Office Action mailed on Dec. 17, 2014, issued in connection with U.S. Appl. No. 13/533,105, filed Jun. 2012, 36 pages".
"Final Office Action mailed on Jan. 7, 2015, issued in connection with U.S. Appl. No. 13/848,932, filed Mar. 22, 2013, 14 pages".
"Advisory Action mailed on Mar. 2, 2015, issued in connection with U.S. Appl. No. 13/848,932, filed Mar. 22, 2013, 3 pages.".
"Advisory Action mailed on Feb. 26, 2015, issued in connection with U.S. Appl. No. 14/184,528, filed Feb. 19, 2014, 3 pages.".
"Final Office Action mailed on Feb. 11, 2015, issued in connection with U.S. Appl. No. 14/184,526, filed Feb. 19, 2014, 13 pages".
"Final Office Action mailed on Feb. 11, 2015, issued in connection with U.S. Appl. No. 14/184,935, filed Feb. 20, 2014, 17 pages".
"Final Office Action mailed on Feb. 12, 2015, issued in connection with U.S. Appl. No. 14/184,522, filed Feb. 19, 2014, 20 pages".
"International Bureau,"International Preliminary Report on Patentability" issued in connection with International Patent application No. PCT/US2013/046372, mailed Dec. 31, 2014, 5 pages.".
"International Preliminary Report on Patentability and Written Opinion, issued by the International Searching Authority in connection with International Patent Application No. PCT/US2013/046386, mailed on Jan. 8, 2015, 8 pages".
"Non-Final Office Action mailed on Feb. 26, 2015, issued in connection with U.S. Appl. No. 14/186,850, filed Feb. 21, 2014, 25 pages.".
"Non-Final Office Action mailed on Jan. 30, 2015, issued in connection with U.S. Appl. No. 14/504,812, filed Oct. 2, 2014, 13 pages".
"Non-Final Office Action mailed on Jan. 30, 2015, issued in connection with U.S. Appl. No. 14/290,493, filed May 29, 2014, 30 pages.".
Final Office Action mailed on Mar. 3, 2015, issued in connection with U.S. Appl. No. 13/864,251, filed Apr. 17, 2013, 13 pages.
Final Office Action mailed on Mar. 4, 2015, issued in connection with U.S. Appl. No. 13/848,904, filed Mar. 22, 2013, 16 pages.
Final Office Action mailed on Mar. 5, 2015, issued in connection with U.S. Appl. No. 13/888,203, filed May 6, 2013, 13 pages.
Non-Final Office Action mailed on Mar. 4, 2015, issued in connection with U.S. Appl. No. 13/435,776, filed Mar. 30, 2012, 16 pages.
Pre-Interview First Office Action mailed on Mar. 10, 2015, issued in connection with U.S. Appl. No. 14/505,027, filed Oct. 2, 2014, 4 pages.
"Advisory Action mailed on Apr. 15, 2015, issued in connection with U.S. Appl. No. 14/184,526, filed Feb. 19, 2014, 9 pages".
"Advisory Action mailed on Apr. 15, 2015, issued in connection with U.S. Appl. No. 14/184,935, filed Feb. 20, 2014, 9 pages".
"Advisory Action mailed on Mar. 25, 2015, issued in connection with U.S. Appl. No. 13/533,105, filed Jun. 26, 2012, 5 pages.".
"European Extended Search Report for Application No. 14181454.1 mailed on Mar. 31, 2015, 9 pages.".
"Final Office Action mailed on Apr. 28, 2015, issued in connection with U.S. Appl. No. 14/186,850, filed Feb. 21, 2014, 20 pages".
"Non-Final Office Action mailed on Mar. 12, 2015, issued in connection with U.S. Appl. No. 13/705,174, filed Dec. 5, 2012, 13 pages.".
"Non-Final Office Action mailed on Mar. 13, 2015, issued in connection with U.S. Appl. No. 13/705,177, filed Dec. 5, 2012, 15 pages.".
"Non-Final Office Action mailed on Mar. 26, 2015, issued in connection with U.S. Appl. No. 14/184,528, filed Feb. 19, 2014, 18 pages".
"Non-Final Office Action mailed on Mar. 27, 2015, issued in connection with U.S. Appl. No. 13/705,178, filed Dec. 5, 2012, 14 pages.".
"Notice of Allowance mailed on May 19, 2015, issued in connection with U.S. Appl. No. 13/907,666, filed May 31, 2013, 7 pages".
"Re-Exam Non-Final Office Action mailed on Apr. 22, 2015, issued in connection with U.S. Appl. No. 90/013,423, filed Jan. 5, 2015, 16 pages.".
"Baldwin, Roberto. "How-To: Setup iTunes DJ on Your Max and iPhone", available at http://www.maclife.com/article/howtos/howto_setup_itunes_dj_your_mac_and_iphone, archived on Mar. 17, 2009, 4 pages.".
"Final Office Action mailed on Jun. 15, 2015, issued in connection with U.S. Appl. No. 14/184,522, filed Feb. 19, 2014, 25 pages".
"Non-Final Office Action mailed on Jun. 12, 2015, issued in connection with U.S. Appl. No. 13/848,932, filed Mar. 22, 2013, 16 pages".
"Non-Final Office Action mailed on Jun. 19, 2015, issued in connection with U.S. Appl. No. 13/533,105, filed Jun. 26, 2012, 38 pages.".
"Non-Final Office Action mailed on Jun. 23, 2015, issued in connection with U.S. Appl. No. 13/705,176, filed Dec. 5, 2012, 30 pages".
"Non-Final Office Action mailed on Jun. 3, 2015, issued in connection with U.S. Appl. No. 14/564,544, filed Dec. 9, 2014, 7 pages.".
"Non-Final Office Action mailed on Jun. 4, 2015, issued in connection with U.S. Appl. No. 13/871,795, filed Apr. 26, 2013, 16 pages.".
"Notice of Allowance mailed on Jul. 2, 2015, issued in connection with U.S. Appl. No. 13/848,904, filed Mar. 22, 2013, 17 pages".
"Notice of Allowance mailed on Jul. 2, 2015, issued in connection with U.S. Appl. No. 13/888,203, filed May 6, 2013, 19 pages".
"Notice of Allowance mailed on Jul. 2, 2015, issued in connection with U.S. Appl. No. 14/184,935, filed Feb. 20, 2014, 23 pages".
"Notice of Allowance mailed on Jul. 6, 2015, issued in connection with U.S. Appl. No. 13/297,000, filed Nov. 15, 2011, 24 pages.".
Advisory Action mailed on Jul. 28, 2015, issued in connection with U.S. Appl. No. 14/184,522, filed Feb. 19, 2014, 7 pages.
Baudisch et al., "Flat Volume Control: Improving Usability by Hiding the Volume Control Hierarchy in the User Interface", 2004, 8 pages.
Chakrabarti et al., "A Remotely Controlled Bluetooth Enabled Environment", IEEE, 2004, pp. 77-81.
Schmandt et al., "Impromptu: Managing Networked Audio Applications for Mobile Users", 2004, 11 pages.

(56) **References Cited**

OTHER PUBLICATIONS

Final Office Action mailed on Aug. 10, 2015, issued in connection with U.S. Appl. No. 14/290,493, filed May 29, 2014, 26 pages.
Final Office Action mailed on Aug. 11, 2015, issued in connection with U.S. Appl. No. 13/864,247, filed Apr. 17, 2013, 15 pages.
Final Office Action mailed on Jul. 15, 2015, issued in connection with U.S. Appl. No. 14/504,812, filed Oct. 2, 2014, 18 pages.
Final Office Action mailed on Aug. 3, 2015, issued in connection with U.S. Appl. No. 13/848,921, filed Mar. 22, 2013, 13 pages.
Fulton et al., "The Network Audio System: Make Your Application Sing (As Well As Dance)!", The X Resource, 1994, 14 pages.
Hans et al., "Interacting with Audio Streams for Entertainment and Communication", 2003, 7 pages.
Levergood et al., "AudioFile: A Network-Transparent System for Distributed Audio Applications", Digital Equipment Corporation, 1993, 109 pages.
Notice of Allowance mailed on Aug. 10, 2015, issued in connection with U.S. Appl. No. 13/848,904, filed Mar. 22, 2013, 9 pages.
Notice of Allowance mailed on Aug. 12, 2015, issued in connection with U.S. Appl. No. 13/435,739, filed Mar. 30, 2012, 27 pages.
Notice of Allowance mailed on Jul. 13, 2015, issued in connection with U.S. Appl. No. 14/184,526, filed Feb. 19, 2014, 22 pages.
Notice of Allowance mailed on Jul. 15, 2015, issued in connection with U.S. Appl. No. 13/705,174, filed Dec. 5, 2012, 18 pages.
Notice of Allowance mailed on Jul. 17, 2015, issued in connection with U.S. Appl. No. 13/864,251, filed Apr. 17, 2013, 20 pages.
Notice of Allowance mailed on Jul. 29, 2015, issued in connection with U.S. Appl. No. 13/359,976, filed Jan. 27, 2012, 28 pages.
Notice of Allowance mailed on Jul. 29, 2015, issued in connection with U.S. Appl. No. 14/186,850, filed Feb. 21, 2014, 9 pages.
Notice of Allowance mailed on Jul. 30, 2015, issued in connection with U.S. Appl. No. 13/705,178, filed Dec. 5, 2012, 18 pages.
Notice of Allowance mailed on Aug. 5, 2015, issued in connection with U.S. Appl. No. 13/435,776, filed Mar. 30, 2012, 26 pages.
Nutzel et al., "Sharing Systems for Future HiFi Systems", IEEE, 2004, 9 pages.
Re-Exam Final Office Action mailed on Aug. 5, 2015, issued in connection with U.S. Appl. No. 90/013,423, filed Jan. 5, 2015, 25 pages.

* cited by examiner

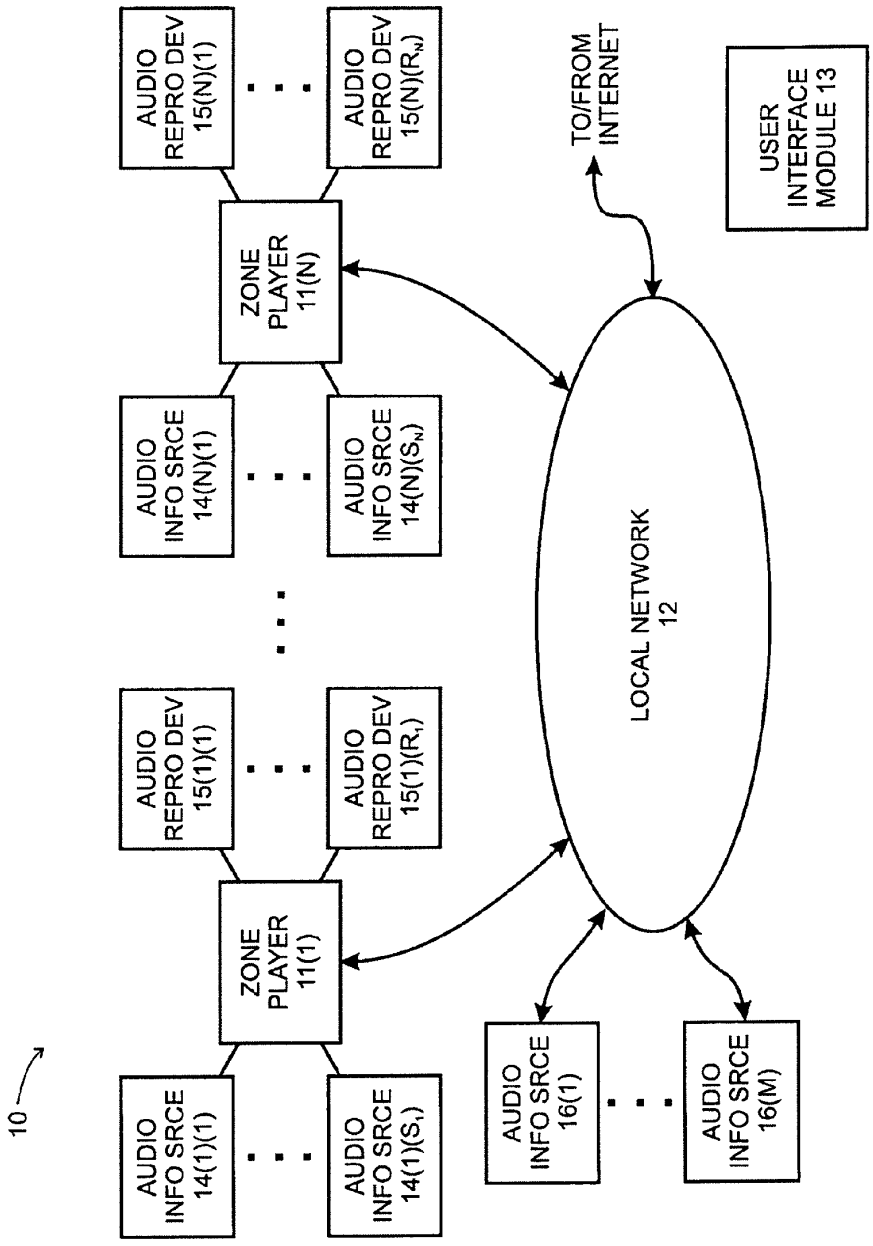

10
AUDIO INFO SRCE 14(1)(1)
AUDIO INFO SRCE 14(1)(S1)
AUDIO REPRO DEV 15(1)(1)
AUDIO REPRO DEV 15(1)(R1)
ZONE PLAYER 11(1)
AUDIO INFO SRCE 14(N)(1)
AUDIO INFO SRCE 14(N)(SN)
AUDIO REPRO DEV 15(N)(1)
AUDIO REPRO DEV 15(N)(RN)
ZONE PLAYER 11(N)
LOCAL NETWORK 12
AUDIO INFO SRCE 16(1)
AUDIO INFO SRCE 16(M)
TO/FROM INTERNET
USER INTERFACE MODULE 13

FIG. 1

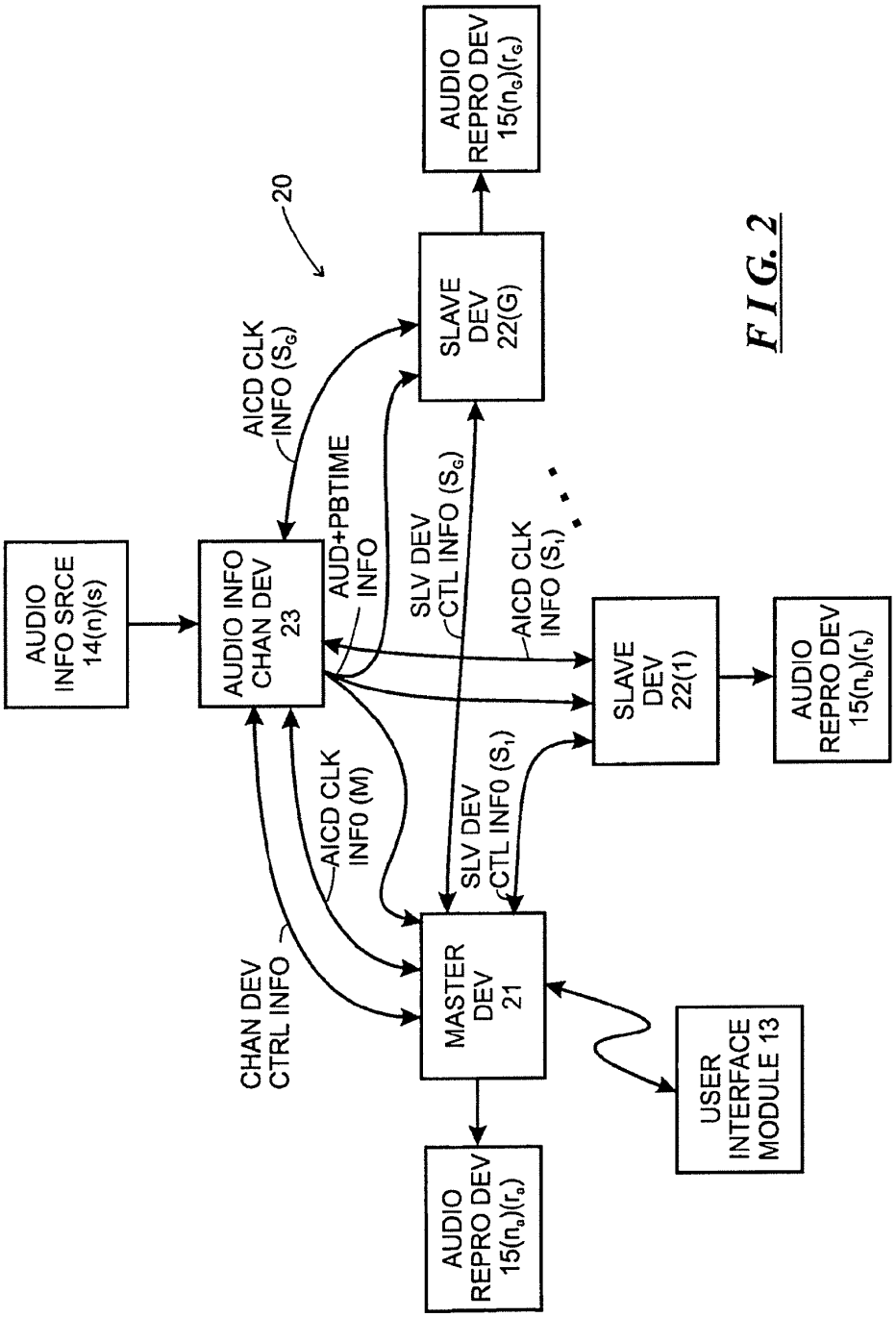

20
AUDIO INFO SRCE 14(n)(s)
AUDIO INFO CHAN DEV 23
AUD+PBTIME INFO
AICD CLK INFO (S_G)
SLV DEV CTL INFO (S_G)
AICD CLK INFO (S_1)
SLV DEV CTL INFO (S_1)
AICD CLK INFO (M)
CHAN DEV CTRL INFO
SLAVE DEV 22(G)
SLAVE DEV 22(1)
MASTER DEV 21
AUDIO REPRO DEV 15(n_G)(r_G)
AUDIO REPRO DEV 15(n_b)(r_b)
AUDIO REPRO DEV 15(n_a)(r_a)
USER INTERFACE MODULE 13

FIG. 2

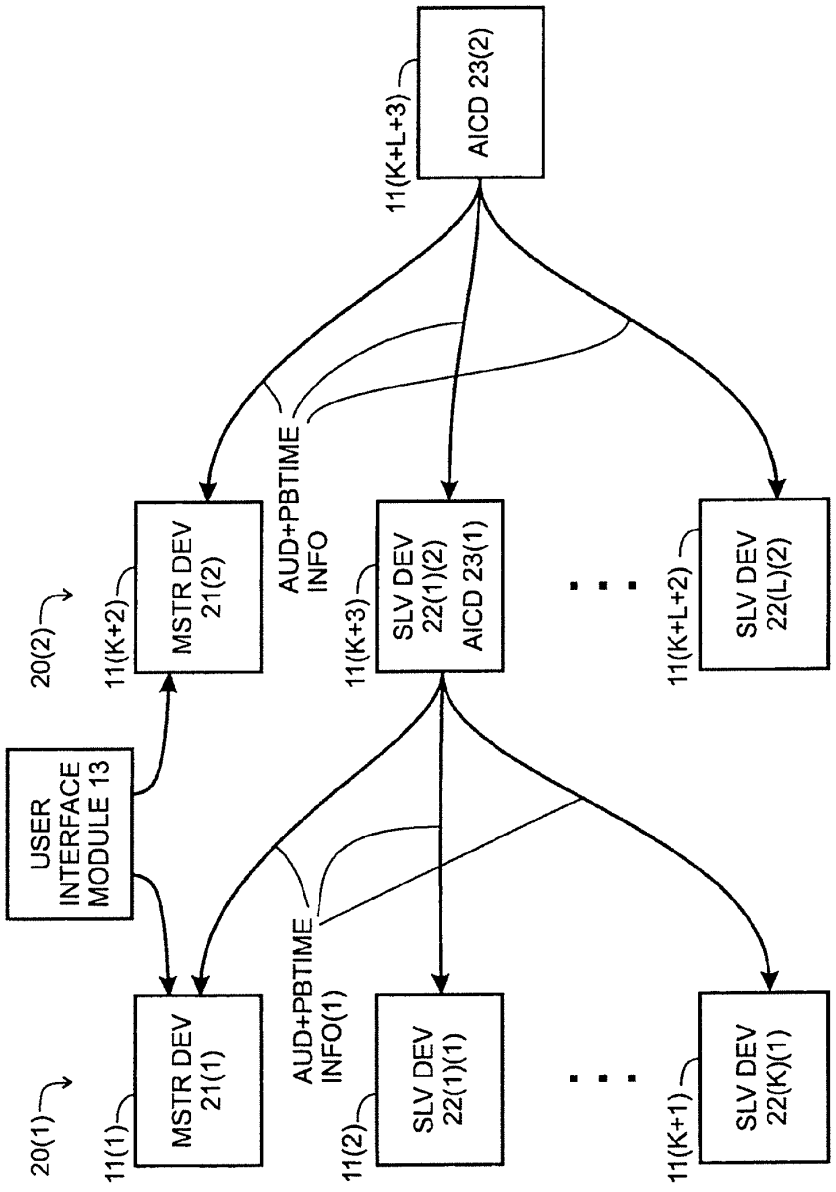

11(K+L+3)
AICD 23(2)
AUD+PBTIME INFO
20(2)
11(K+2)
MSTR DEV 21(2)
11(K+3)
SLV DEV 22(1)(2) AICD 23(1)
11(K+L+2)
SLV DEV 22(L)(2)
USER INTERFACE MODULE 13
AUD+PBTIME INFO(1)
20(1)
11(1)
MSTR DEV 21(1)
11(2)
SLV DEV 22(1)(1)
11(K+1)
SLV DEV 22(K)(1)

FIG. 2A

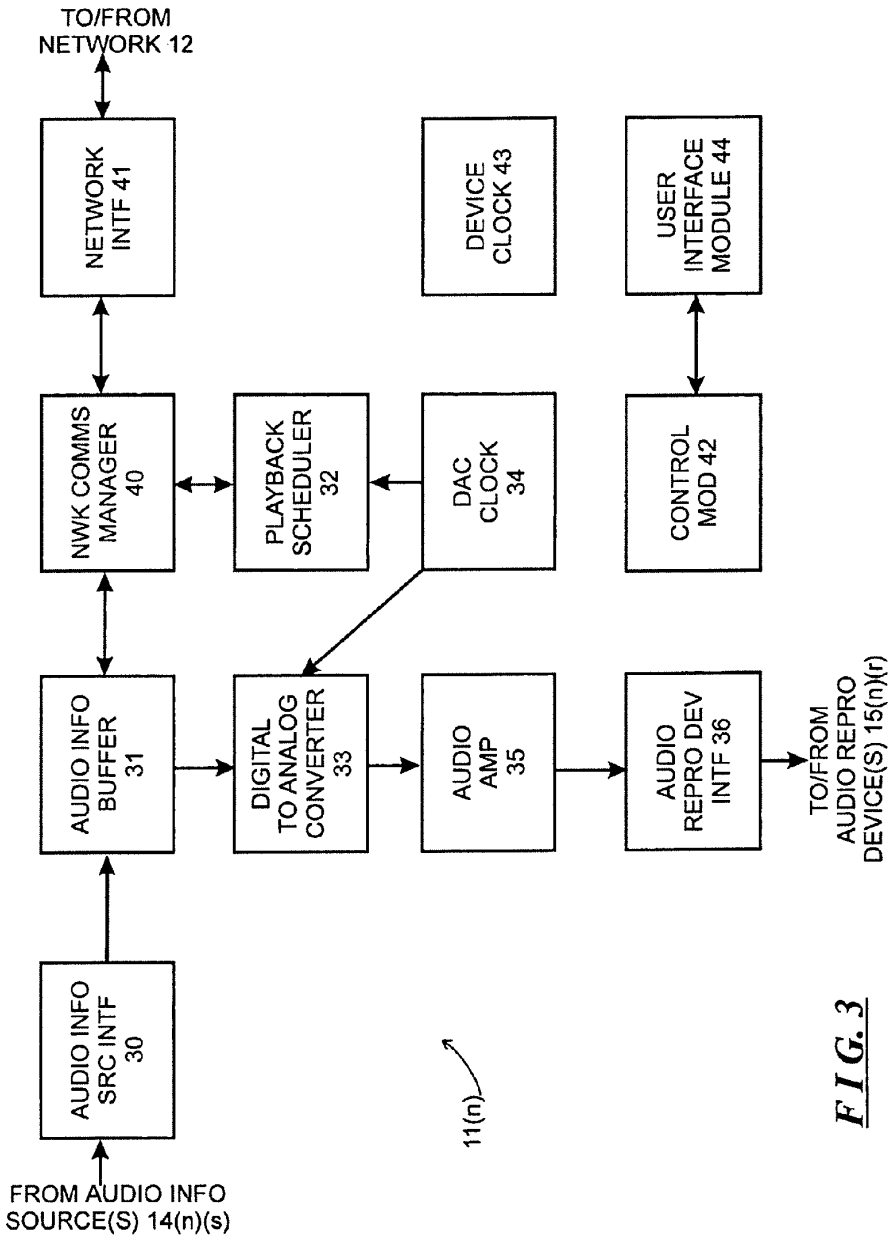

TO/FROM NETWORK 12
NETWORK INTF 41
DEVICE CLOCK 43
USER INTERFACE MODULE 44
NWK COMMS MANAGER 40
PLAYBACK SCHEDULER 32
DAC CLOCK 34
CONTROL MOD 42
AUDIO INFO BUFFER 31
DIGITAL TO ANALOG CONVERTER 33
AUDIO AMP 35
AUDIO REPRO DEV INTF 36
TO/FROM AUDIO REPRO DEVICE(S) 15(n)(r)
AUDIO INFO SRC INTF 30
11(n)
FROM AUDIO INFO SOURCE(S) 14(n)(s)

FIG. 3

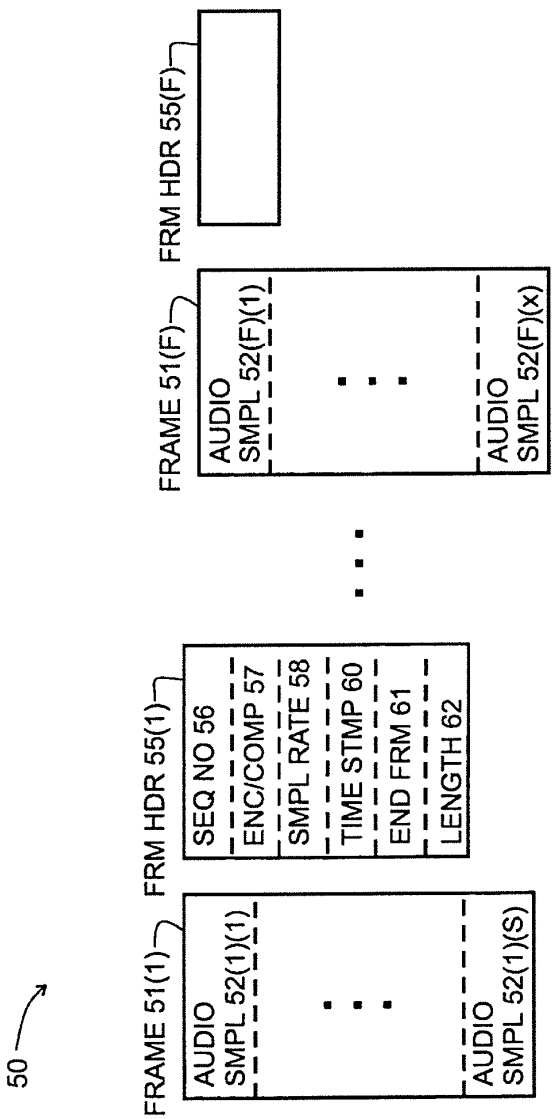

50
FRAME 51(1)
AUDIO SMPL 52(1)(1)
AUDIO SMPL 52(1)(S)
FRM HDR 55(1)
SEQ NO 56
ENC/COMP 57
SMPL RATE 58
TIME STMP 60
END FRM 61
LENGTH 62
FRAME 51(F)
AUDIO SMPL 52(F)(1)
AUDIO SMPL 52(F)(x)
FRM HDR 55(F)

FIG. 4

OBTAINING CONTENT FROM REMOTE SOURCE FOR PLAYBACK

INCORPORATION BY REFERENCE

This application claims priority under 35 U.S.C. §120 to, and is a continuation of, U.S. Non-provisional patent application Ser. No. 13/297,000, filed on Nov. 15, 2011, entitled "System and method for synchronizing operations among a plurality of independently clocked digital data processing devices," which claims priority under 35 U.S.C. 120 to, and is a continuation of, U.S. Non-provisional application Ser. No. 10/816,217, now issued as U.S. Pat. No. 8,234,395, filed on Apr. 1, 2004, entitled "System and method for synchronizing operations among a plurality of independently clocked digital data processing devices," which claims priority under 35 U.S.C. §119 to U.S. Provisional Application No. 60/490,768, filed on Jul. 28, 2003, entitled "Method for Synchronizing Audio Playback Between Multiple Networked Devices," each of which are assigned to the assignee of the present application and are incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates generally to the field of digital data processing devices, and more particularly to systems and methods for synchronizing operations among a plurality of independently-clocked digital data processing devices. The invention is embodied in a system for synchronizing operations among a plurality of devices, in relation to information that is provided by a common source. One embodiment of the invention enables synchronizing of audio playback as among two or more audio playback devices that receive audio information from a common information source, or channel.

More generally, the invention relates to the field of arrangements that synchronize output generated by a number of output generators, including audio output, video output, combinations of audio and video, as well as other types of output as will be appreciated by those skilled in the art, provided by a common channel. Generally, the invention will find utility in connection with any type of information for which synchrony among independently-clocked devices is desired.

BACKGROUND OF THE INVENTION

There are a number of circumstances under which it is desirable to maintain synchrony of operations among a plurality of independently-clocked digital data processing devices in relation to, for example, information that is provided thereto by a common source. For example, systems are being developed in which one audio information source can distribute audio information in digital form to a number of audio playback devices for playback. The audio playback devices receive the digital information and convert it to analog form for playback. The audio playback devices may be located in the same room or they may be distributed in different rooms in a residence such as a house or an apartment, in different offices in an office building, or the like. For example, in a system installed in a residence, one audio playback device may be located in a living room, while another audio playback device is be located in a kitchen, and yet other audio playback devices may be located in various bedrooms of a house. In such an arrangement, the audio information that is distributed to various audio playback devices may relate to the same audio program, or the information may relate to different audio programs. If the audio information source

provides audio information relating to the same audio program to two or more audio playback devices at the same time, the audio playback devices will generally contemporaneously play the same program. For example, if the audio information source provides audio information to audio playback devices located in the living room and kitchen in a house at the same time, they will generally contemporaneously play the same program.

One problem that can arise is to ensure that, if two or more audio playback devices are contemporaneously attempting to play back the same audio program, they do so simultaneously. Small differences in the audio playback devices' start times and/or playback speeds can be perceived by a listener as an echo effect, and larger differences can be very annoying. Differences can arise because for a number of reasons, including delays in the transfer of audio information over the network. Such delays can differ as among the various audio playback devices for a variety of reasons, including where they are connected into the network, message traffic and other reasons as will be apparent to those skilled in the art.

Another problem arises from the following. When an audio playback device converts the digital audio information from digital to analog form, it does so using a clock that provides timing information. Generally, the audio playback devices that are being developed have independent clocks, and, if they are not clocking at precisely the same rate, the audio playback provided by the various devices can get out of synchronization.

SUMMARY OF THE INVENTION

The invention provides a new and improved system and method for synchronizing operations among a number of digital data processing devices that are regulated by independent clocking devices. Generally, the invention will find utility in connection with any type of information for which synchrony among devices connected to a network is desired. The invention is described in connection with a plurality of audio playback devices that receive digital audio information that is to be played back in synchrony, but it will be appreciated that the invention can find usefulness in connection with any kind of information for which coordination among devices that have independent clocking devices would find utility.

In brief summary, the invention provides, in one aspect, a system for maintaining synchrony of operations among a plurality of devices that have independent clocking arrangements. The system includes a task distribution device that distributes tasks to a synchrony group comprising a plurality of devices that are to perform the tasks distributed by the task distribution device in synchrony. The task distribution device distributes each task to the members of the synchrony group over a network. Each task is associated with a time stamp that indicates a time, relative to a clock maintained by the task distribution device, at which the members of the synchrony group are to execute the task. Each member of the synchrony group periodically obtains from the task distribution device an indication of the current time indicated by its clock, determines a time differential between the task distribution device's clock and its respective clock and determines therefrom a time at which, according to its respective clock, the time stamp indicates that it is to execute the task.

In one embodiment, the tasks that are distributed include audio information for an audio track that is to be played by all of the devices comprising the synchrony group synchronously. The audio track is divided into a series of frames, each of which is associated with a time stamp indicating the time,

relative to the clock maintained by an audio information channel device, which, in that embodiment, serves as the task distribution device, at which the members of the synchrony group are to play the respective frame. Each member of the synchrony group, using a very accurate protocol, periodically obtains the time indicated by the audio information channel device, and determines a differential between the time as indicated by its local clock and the audio information channel device's clock. The member uses the differential and the time as indicated by the time stamp to determine the time, relative to its local clock, at which it is to play the respective frame. The members of the synchrony group do this for all of the frames, and accordingly are able to play the frames in synchrony.

BRIEF DESCRIPTION OF THE DRAWINGS

This invention is pointed out with particularity in the appended claims. The above and further advantages of this invention may be better understood by referring to the following description taken in conjunction with the accompanying drawings, in which:

FIG. **1** schematically depicts an illustrative networked audio system, constructed in accordance with the invention;

FIG. **2** schematically depicts a functional block diagram of a synchrony group utilizing a plurality of zone players formed within the networked audio system depicted in FIG. **1**;

FIG. **2**A schematically depicts two synchrony groups, illustrating how a member of one synchrony group can provide audio information to the members of another synchrony group;

FIG. **3** depicts an functional block diagram of a zone player for use in the networked audio system depicted in FIG. **1**; and

FIG. **4** is useful in understanding an digital audio information framing methodology useful in the network audio system depicted in FIG. **1**.

DETAILED DESCRIPTION OF AN ILLUSTRATIVE EMBODIMENT

FIG. **1** depicts an illustrative network audio system **10** constructed in accordance with the invention. With reference to FIG. **1**, the network audio system **10** includes a plurality of zone players **11**(**1**) through **11**(N) (generally identified by reference numeral **11**(*n*)) interconnected by a local network **12**, all of which operate under control of one or more user interface modules generally identified by reference numeral **13**. One or more of the zone players **11**(*n*) may also be connected to one or more audio information sources, which will generally be identified herein by reference numeral **14**(*n*)(*s*), and/or one or more audio reproduction devices, which will generally be identified by reference numeral **15**(*n*)(*r*). In the reference numeral **14**(*n*)(*s*), index "n" refers to the index "n" of the zone player **11**(*n*) to which the audio information source is connected, and the index "s" (s=1, . . . , S_n) refers to the "s-th" audio information source connected to that "n-th" zone player **11**(*n*). Thus, if, for example, a zone player **11**(*n*) is connected to four audio information sources **14**(*n*)(**1**) through **14**(*n*)(**4**), the audio information sources may be generally identified by reference numeral **14**(*n*)(*s*), with S_n=4. It will be appreciated that the number of audio information sources S_n may vary as among the various zone players **11**(*n*), and some zone players may not have any audio information sources connected thereto. Similarly, in the reference numeral **15**(*n*)(*r*), index "n" refers to the index "n" of the zone player **11**(*n*) to which the audio reproduction device is connected, and the index "r" (r=1, . . . , R_n) refers to the "r-th" audio information source connected to that "n-th" zone player **11**(*n*). In addition to the audio information sources **14**(*n*)(*s*), the network audio system **10** may include one or more audio information sources **16**(**1**) through **16**(M) connected through appropriate network interface devices (not separately shown) to the local network **12**. Furthermore, the local network may include one or more network interface devices (also not separately shown) that are configured to connect the local network **12** to other networks, including a wide area network such as the Internet, the public switched telephony network (PSTN) or other networks as will be apparent to those skilled in the art, over which connections to audio information sources may be established.

The zone players **11**(*n*) associated with system **10** may be distributed throughout an establishment such as residence, an office complex, a hotel, a conference hall, an amphitheater or auditorium, or other types of establishments as will be apparent to those skilled in the art or the like. For example, if the zone players **11**(*n*) and their associated audio information source(s) and/or audio reproduction device(s) are distributed throughout a residence, one, such as zone player **11**(**1**) and its associated audio information source(s) and audio reproduction device(s) may be located in a living room, another may be located in a kitchen, another may be located in a dining room, and yet others may be located in respective bedrooms, to selectively provide entertainment in those rooms. On the other hand, if the zone players **11**(*n*) and their associated audio information source(s) and/or audio reproduction device(s) are distributed throughout an office complex, one may, for example, be provided in each office to selectively provide entertainment to the employees in the respective offices. Similarly, if the zone players **11**(*n*) and associated audio information source(s) and/or audio reproduction device(s) are used in a hotel, they may be distributed throughout the rooms to provide entertainment to the guests. Similar arrangements may be used with zone players **11**(*n*) and associated audio information source(s) and/or audio reproduction device(s) used in an amphitheater or auditorium. Other arrangements in other types of environments will be apparent to those skilled in the art. In each case, the zone players **11**(*n*) can be used to selectively provide entertainment in the respective locations, as will be described below.

The audio information sources **14**(*n*)(*s*) and **16**(*m*) may be any of a number of types of conventional sources of audio information, including, for example, compact disc ("CD") players, AM and/or FM radio receivers, analog or digital tape cassette players, analog record turntables and the like. In addition, the audio information sources **14**(*n*)(*s*) and **16**(*m*) may comprise digital audio files stored locally on, for example, personal computers (PCs), personal digital assistants (PDAs), or similar devices capable of storing digital information in volatile or non-volatile form. As noted above, the local network **12** may also have an interface (not shown) to a wide area network, over which the network audio system **10** can obtain audio information. Moreover, one or more of the audio information sources **14**(*n*)(*s*) may also comprise an interface to a wide area network such as the Internet, the public switched telephony network (PSTN) or any other source of audio information. In addition, one or more of the audio information sources **14**(*n*)(*s*) and **16**(*m*) may comprise interfaces to radio services delivered over, for example, satellite. Audio information obtained over the wide area network may comprise, for example, streaming digital audio information such as Internet radio, digital audio files stored on servers, and other types of audio information and sources as will

be appreciated by those skilled in the art. Other arrangements and other types of audio information sources will be apparent to those skilled in the art.

Generally, the audio information sources **14**(*n*)(*s*) and **16**(*m*) provide audio information associated with audio programs to the zone players for playback. A zone player that receives audio information from an audio information source **14**(*n*)(*s*) that is connected thereto can provide playback and/or forward the audio information, along with playback timing information, over the local network **12** to other zone players for playback. Similarly, each audio information source **16**(*m*) that is not directly connected to a zone player can transmit audio information over the network **12** to any zone player **11**(*n*) for playback. In addition, as will be explained in detail below, the respective zone player **11**(*n*) can transmit the audio information that it receives either from an audio information source **14**(*n*)(*s*) connected thereto, or from an audio information source **16**(*m*), to selected ones of the other zone players **11**(*n*'), **11**(*n*"), . . . (n not equal to n', n", . . .) for playback by those other zone players. The other zone players **11**(*n*'), **11**(*n*"), . . . to which the zone player **11**(*n*) transmits the audio information for playback may be selected by a user using the user interface module **13**. In that operation, the zone player **11**(*n*) will transmit the audio information to the selected zone players **11**(*n*'), **11**(*n*"), . . . over the network **12**. As will be described below in greater detail, the zone players **11**(*n*), **11**(*n*), **11**(*n*"), . . . operate such that the zone players **11**(*n*'), **11**(*n*"), . . . synchronize their playback of the audio program with the playback by the zone player **11**(*n*), so that the zone players **11**(*n*), **11**(*n*'), **11**(*n*") provide the same audio program at the same time.

Users, using user interface module **13**, may also enable different groupings or sets of zone players to provide audio playback of different audio programs synchronously. For example, a user, using a user interface module **13**, may enable zone players **11**(**1**) and **11**(**2**) to play one audio program, audio information for which may be provided by, for example, one audio information source **14**(**1**)(**1**). The same or a different user may, using the same or a different user interface module **13**, enable zone players **11**(**4**) and **11**(**5**) to contemporaneously play another audio program, audio information for which may be provided by a second audio information source, such as audio information source **14**(**5**)(**2**). Further, a user may enable zone player **11**(**3**) to contemporaneously play yet another audio program, audio information for which may be provided by yet another audio information source, such as audio information source **16**(**1**). As yet another possibility, a user may contemporaneously enable zone player **11**(**1**) to provide audio information from an audio information source connected thereto, such as audio information source **14**(**1**)(**2**), to another zone player, such as zone player **11**(**6**) for playback.

In the following, the term "synchrony group" will be used to refer to a set of one or more zone players that are to play the same audio program synchronously. Thus, in the above example, zone players **11**(**1**) and **11**(**2**) comprise one synchrony group, zone player **11**(**3**) comprises a second synchrony group, zone players **11**(**4**) and **11**(**5**) comprise a third synchrony group, and zone player **11**(**6**) comprises yet a fourth synchrony group. Thus, while zone players **11**(**1**) and **11**(**2**) are playing the same audio program, they will play the audio program synchronously. Similarly, while zone players **11**(**4**) and **11**(**5**) are playing the same audio program, they will play the audio program synchronously. On the other hand, zone players that are playing different audio programs may do so with unrelated timings. That is, for example, the timing with which zone players **11**(**1**) and **11**(**2**) play their audio program may have no relationship to the timing with which zone player **11**(**3**), zone players **11**(**4**) and **11**(**5**), and zone player **11**(**6**) play their audio programs. It will be appreciated that, since "synchrony group" is used to refer to sets of zone players that are playing the same audio program synchronously, zone player **11**(**1**) will not be part of zone player **11**(**6**)'s synchrony group, even though zone player **11**(**1**) is providing the audio information for the audio program to zone player **11**(**6**).

In the network audio system **10**, the synchrony groups are not fixed. Users can enable them to be established and modified dynamically. Continuing with the above example, a user may enable the zone player **11**(**1**) to begin providing playback of the audio program provided thereto by audio information source **14**(**1**)(**1**), and subsequently enable zone player **11**(**2**) to join the synchrony group. Similarly, a user may enable the zone player **11**(**5**) to begin providing playback of the audio program provided thereto by audio information source **14**(**5**)(**2**), and subsequently enable zone player **11**(**4**) to join that synchrony group. In addition, a user may enable a zone player to leave a synchrony group and possibly join another synchrony group. For example, a user may enable the zone player **11**(**2**) to leave the synchrony group with zone player **11**(**1**), and join the synchrony group with zone player **11**(**6**). As another possibility, the user may enable the zone player **11**(**1**) to leave the synchrony group with zone player **11**(**2**) and join the synchrony group with zone player **11**(**6**). In connection with the last possibility, the zone player **11**(**1**) can continue providing audio information from the audio information source **14**(**1**)(**1**) to the zone player **11**(**2**) for playback thereby.

A user, using the user interface module **13**, can enable a zone player **11**(*n*) that is currently not a member of a synchrony group to join a synchrony group, after which it will be enabled to play the audio program that is currently being played by that synchrony group. Similarly, a user, also using the user interface module **13**, can enable a zone player **11**(*n*) that is currently a member of one synchrony group, to disengage from that synchrony group and join another synchrony group, after which that zone player will be playing the audio program associated with the other synchrony group. For example, if a zone player **11**(**6**) is currently not a member of any synchrony group, it, under control of the user interface module **13**, can become a member of a synchrony group, after which it will play the audio program being played by the other members of the synchrony group, in synchrony with the other members of the synchrony group. In becoming a member of the synchrony group, zone player **11**(**6**) can notify the zone player that is the master device for the synchrony group that it wishes to become a member of its synchrony group, after which that zone player will also transmit audio information associated with the audio program, as well as timing information, to the zone player **11**(**6**). As the zone player **11**(**6**) receives the audio information and the timing information from the master device, it will play the audio information with the timing indicated by the timing information, which will enable the zone player **11**(**6**) to play the audio program in synchrony with the other zone player(s) in the synchrony group.

Similarly, if a user, using the user interface module **13**, enables a zone player **11**(*n*) associated with a synchrony group to disengage from that synchrony group, and if the zone player **11**(*n*) is not the master device of the synchrony group, the zone player **11**(*n*) can notify the master device, after which the master device can terminate transmission of the audio information and timing information to the zone player **11**(*n*). If the user also enables the zone player **11**(*n*) to begin playing another audio program using audio information from

an audio information source **14**(*n*)(*s*) connected thereto, it will acquire the audio information from the audio information source **14**(*n*)(*s*) and initiate playback thereof. If the user enables another zone player **11**(*n'*) to join the synchrony group associated with zone player **11**(*n*), operations in connection therewith can proceed as described immediately above.

As yet another possibility, if a user, using the user interface module **13**, enables a zone player **11**(*n*) associated with a synchrony group to disengage from that synchrony group and join another synchrony group, and if the zone player is not the master device of the synchrony group from which it is disengaging, the zone player **11**(*n*) can notify the master device of the synchrony group from which it is disengaging, after which that zone player will terminate transmission of audio information and timing information to the zone player **11**(*n*) that is disengaging. Contemporaneously, the zone player **11**(*n*) can notify the master device of the synchrony group that it (that is, zone player **11**(*n*)) is joining, after which the master device can begin transmission of audio information and timing information to that zone player **11**(*n*). The zone player **11**(*n*) can thereafter begin playback of the audio program defined by the audio information, in accordance with the timing information so that the zone player **11**(*n*) will play the audio program in synchrony with the master device.

As yet another possibility, a user, using the user interface module **13**, may enable a zone player **11**(*n*) that is not associated with a synchrony group, to begin playing an audio program using audio information provided to it by an audio information source **14**(*n*)(*s*) connected thereto. In that case, the user, also using the user interface module **13** or a user interface device that is specific to the audio information source **14**(*n*)(*s*), can enable the audio information source **14**(*n*)(*s*) to provide audio information to the zone player **11**(*n*). After the zone player **11**(*n*) has begun playback, or contemporaneously therewith, the user, using the user interface module **13**, can enable other zone players **11**(*n'*), **11**(*n''*), . . . to join zone player **11**(*n*)'s synchrony group and enable that zone player **11**(*n*) to transmit audio information and timing information thereto as described above, to facilitate synchronous playback of the audio program by the other zone players **11**(*n'*), **11**(*n''*) . . . .

A user can use the user interface module **13** to control other aspects of the network audio system **10**, including but not limited to the selection of the audio information source **14**(*n*)(*s*) that a particular zone player **11**(*n*) is to utilize, the volume of the audio playback, and so forth. In addition, a user may use the user interface module **13** to turn audio information source(s) **14**(*n*)(*s*) on and off and to enable them to provide audio information to the respective zone players **11**(*n*).

Operations performed by the various devices associated with a synchrony group will be described in connection with FIG. **2**, which schematically depicts a functional block diagram of a synchrony group in the network audio system **10** described above in connection with FIG. **1**. With reference to FIG. **2**, a synchrony group **20** includes a master device **21** and zero or more slave devices **22**(**1**) through **22** (G) (generally identified by reference numeral **22**(*g*)), all of which synchronously play an audio program provided by an audio information channel device **23**. Each of the master device **21**, slave devices **22**(*g*) and audio information channel device **23** utilizes a zone player **11**(*n*) depicted in FIG. **1**, although it will be clear from the description below that a zone player may be utilized both for the audio information channel device for the synchrony group **20**, and the master device **21** or a slave device **22**(*g*) of the synchrony group **20**. As will be described below in more detail, the audio information channel device **23** obtains the audio information for the audio program from an audio information source, adds playback timing information, and transmits the combined audio and playback timing information to the master device **21** and slave devices **22**(*g*) over the network **12** for playback. The playback timing information that is provided with the audio information, together with clock timing information provided by the audio information channel device **23** to the various devices **21** and **22**(*g*) as will be described below, enables the master device **21** and slave devices **22**(*g*) of the synchrony group **20** to play the audio information simultaneously.

The master device **21** and the slave devices **22**(*g*) receive the audio and playback timing information, as well as the clock timing information, that are provided by the audio information channel device **23**, and play back the audio program defined by the audio information. The master device **21** is also the member of the synchrony group **20** that communicates with the user interface module **13** and that controls the operations of the slave devices **22**(*g*) in the synchrony group **20**. In addition, the master device **21** controls the operations of the audio information channel device **23** that provides the audio and playback timing information for the synchrony group **20**. Generally, the initial master device **21** for the synchrony group will be the first zone player **11**(*n*) that a user wishes to play an audio program. However, as will be described below, the zone player **11**(*n*) that operates as the master device **21** can be migrated from one zone player **11**(*n*) to another zone player **11**(*n'*), which preferably will be a zone player that is currently operating as a slave device **22**(*g*) in the synchrony group.

In addition, under certain circumstances, as will be described below, the zone player **11**(*n*) that operates as the audio information channel device **23** can be migrated from one zone player to another zone player, which also will preferably will be a zone player that is currently operating as a member of the synchrony group **20**. It will be appreciated that the zone player that operates as the master device **21** can be migrated to another zone player independently of the migration of the audio information channel device **23**. For example, if one zone player **11**(*n*) is operating as both the master device **21** and the audio information channel device **23** for a synchrony group **20**, the master device **21** can be migrated to another zone player **11**(*n'*) while the zone player **11**(*n*) is still operating as the audio information channel device **23**. Similarly, if one zone player **11**(*n*) is operating as both the master device **21** and the audio information channel device **23** for a synchrony group **20**, the audio information channel device **23** can be migrated to another zone player **11**(*n'*) while the zone player **11**(*n*) is still operating as the master device **21**. In addition, if one zone player **11**(*n*) is operating as both the master device **21** and the audio information channel device **23** for a synchrony group **20**, the master device **21** can be migrated to another zone player **11**(*n'*) and the audio information channel device can be migrated to a third zone player **11**(*n''*).

The master device **21** receives control information from the user interface module **13** for controlling the synchrony group **20** and provides status information indicating the operational status of the synchrony group to the user interface module **13**. Generally, the control information from the user interface module **13** enables the master device **21** to, in turn, enable the audio information channel device **23** to provide audio and playback timing information to the synchrony group to enable the devices **21** and **22**(*g*) that are members of the synchrony group **20** to play the audio program synchronously. In addition, the control information from the user interface module **13** enables the master device **21** to, in turn,

enable other zone players to join the synchrony group as slave devices **22**(*g*) and to enable slave devices **22**(*g*) to disengage from the synchrony group. Control information from the user interface module **13** can also enable the zone player **11**(*n*) that is currently operating as the master device **21** to disengage from the synchrony group, but prior to doing so that zone player will enable the master device **21** to transfer from that zone player **11**(*n*) to another zone player **11**(*n'*), preferably to a zone player **11**(*n'*) that is currently a slave device **22**(*g*) in the synchrony group **20**. The control information from the user interface module **13** can also enable the master device **21** to adjust its playback volume and to enable individual ones of the various slave devices **22**(*g*) to adjust their playback volumes. In addition, the control information from the user interface module **13** can enable the synchrony group **20** to terminate playing of a current track of the audio program and skip to the next track, and to re-order tracks in a play list of tracks defining the audio program that is to be played by the synchrony group **20**.

The status information that the master device **21** may provide to the user interface module **13** can include such information as a name or other identifier for the track of the audio work that is currently being played, the names or other identifiers for upcoming tracks, the identifier of the zone player **11**(*n*) that is currently operating as the master device **21**, and identifiers of the zone players that are currently operating as slave devices **22**(*g*). In one embodiment, the user interface module **13** includes a display (not separately shown) that can display the status information to the user.

It will be appreciated that the zone player **11**(*n*) that is operating as the audio information channel device **23** for one synchrony group may also comprise the master device **21** or any of the slave devices **22**(*g*) in another synchrony group. This may occur if, for example, the audio information source that is to provide the audio information that is to be played by the one synchrony group is connected to a zone player also being utilized as the master device or a slave device for the other synchrony group. This will be schematically illustrated below in connection with FIG. **2**A. Since, as noted above, the zone player **11**(*n*) that is operating as the audio information channel device **23** for the synchrony group **20** may also be operating as a master device **21** or slave device **22**(*g*) for another synchrony group, it can also be connected to one or more audio reproduction devices **15**(*n*)(*r*), although that is not depicted in FIG. **2**. Since the master device **21** and slave devices **22**(*g*) are all to provide playback of the audio program, they will be connected to respective audio reproduction devices **15**(*n*)(*r*). Furthermore, it will be appreciated that one or more of the zone players **11**(*n*) that operate as the master device **21** and slave devices **22**(*g*) in synchrony group **20** may also operate as an audio information channel device for that synchrony group or for another synchrony group and so they may be connected to one or more audio information sources **14**(*n*)(*s*), although that is also not depicted in FIG. **2**. In addition, it will be appreciated that a zone player **11**(*n*) can also operate as a audio information channel device **23** for multiple synchrony groups.

If the audio information channel device **23** does not utilize the same zone player as the master device **21**, the master device **21** controls the audio information channel device by exchanging control information over the network **12** with the audio information channel device **23**. The control information is represented in FIG. **2** by the arrow labeled CHAN_DEV_CTRL_INFO. The control information that the master device **21** provides to the audio information channel device **23** will generally depend on the nature of the audio information source that is to provide the audio information for the audio program that is to be played and the operation to be enabled by the control information. If, for example, the audio information source is a conventional compact disc, tape, or record player, broadcast radio receiver, or the like, which is connected to a zone player **11**(*n*), the master device **21** may merely enable the zone player serving as the audio information channel device **23** to receive the audio information for the program from the audio information source. It will be appreciated that, if the audio information is not in digital form, the audio information channel device **23** will convert it to digital form and provide the digitized audio information, along with the playback timing information, to the master device **21** and slave devices **22**(*g*).

On the other hand, if the audio information source is, for example, a digital data storage device, such as may be on a personal computer or similar device, the master device **21** can provide a play list to the audio information channel device **23** that identifies one or more files containing the audio information for the audio program. In that case, the audio information channel device **23** can retrieve the files from the digital data storage device and provide them, along with the playback timing information, to the master device **21** and the slave devices **22**(*g*). It will be appreciated that, in this case, the audio information source may be directly connected to the audio information channel device **23**, as, for example, an audio information source **14**(*n*)(*s*), or it may comprise an audio information source **16**(*m*) connected to the network **12**. As a further alternative, if the audio information source is a source available over the wide area network, the master device **21** can provide a play list comprising a list of web addresses identifying the files containing the audio information for the audio program that is to be played, and in that connection the audio information channel device **23** can initiate a retrieval of the files over the wide area network. As yet another alternative, if the audio information source is a source of streaming audio received over the wide area network, the master device **21** can provide a network address from which the streaming audio can be received. Other arrangements by which the master device **21** can control the audio information channel device **23** will be apparent to those skilled in the art.

The master device **21** can also provide control information to the synchrony group's audio information channel device **23** to enable a migration from one zone player **11**(*n*) to another zone player **11**(*n'*). This may occur if, for example, the audio information source is one of audio information sources **16** or a source accessible over the wide area network via the network **12**. The master device **21** can enable migration of the audio information channel device **23** for several reasons, including, for example, to reduce the loading of the zone player **11**(*n*), to improve latency of message transmission in the network **12**, and other reasons as will be appreciated by those skilled in the art.

As noted above, the audio information channel device **23** provides audio and playback timing information for the synchrony group to enable the master device **21** and slave devices **22**(*g*) to play the audio program synchronously. Details of the audio and playback timing information will be described in detail below in connection with FIGS. **3** and **4**, but, in brief, the audio information channel device **23** transmits the audio and playback timing information in messages over the network **12** using a multi-cast message transmission methodology. In that methodology, the audio information channel device **23** will transmit the audio and playback timing information in a series of messages, with each message being received by all of the zone players **11**(*n*) comprising the synchrony group **20**, that is, by the master device **21** and the slave devices **22**(*g*). Each of the messages includes a multi-

cast address, which the master device **21** and slave devices **22**(*g*) will monitor and, when they detect a message with that address, they will receive and use the contents of the message. The audio and playback timing information is represented in FIG. **2** by the arrow labeled "AUD+PBTIME_INF0," which has a single tail, representing a source for the information at the audio information channel device **23**, and multiple arrowheads representing the destinations of the information, with one arrowhead extending to the master device **21** and other arrowheads extending to each of the slave devices **22**(*g*) in the synchrony group **20**. The audio information channel device **23** may make use of any convenient multi-cast message transmission methodology in transmitting the audio and playback timing information to the synchrony group **20**. As will be described in detail in connection with FIG. **4**, the audio and playback timing information is in the form of a series of frames, with each frame having a time stamp. The time stamp indicates a time, relative to the time indicated by a clock maintained by the audio information channel device **23**, at which the frame is to be played. Depending on the size or sizes of the messages used in the selected multi-cast message transmission methodology and the size or sizes of the frames, a message may contain one frame, or multiple frames, or, alternatively, a frame may extend across several messages.

The audio information channel device **23** also provides clock time information to the master device **21** and each of the slave devices **22**(*g*) individually over network **12** using a highly accurate clock time information transmission methodology. The distribution of the clock time information is represented in FIG. **2** by the arrows labeled "AICD_CLK_INF (M)" (in the case of the clock time information provided to the master device **21**) and "AICD_CLK_INF (S_1)" through "AICD_CLK_INF (S_G)" (in the case of audio information channel device clock information provided to the slave devices **22**(*g*)). In one embodiment, the master device **21** and slave devices **22**(*g*) make use of the well-known SNTP (Simple Network Time Protocol) to obtain current clock time information from the audio information channel device **23**. The SNTP makes use of a unicast message transfer methodology, in which one device, such as the audio information channel device **23**, provides clock time information to a specific other device, such as the master device **21** or a slave device **22**(*g*), using the other device's network, or unicast, address. Each of the master device **21** and slave devices **22**(*g*) will periodically initiate SNTP transactions with the audio information channel device **23** to obtain the clock time information from the audio information channel device **23**. As will be described below in more detail, the master device **21** and each slave device **22**(*g*) make use of the clock time information to determine the time differential between the time indicated by the audio information channel device's clock and the time indicated by its respective clock, and use that time differential value, along with the playback time information associated with the audio information and the respective device's local time as indicated by its clock to determine when the various frames are to be played. This enables the master device **21** and the slave devices **22**(*g*) in the synchrony group **20** to play the respective frames simultaneously.

As noted above, the control information provided by the user to the master device **21** through the user interface module **13** can also enable the master device **21** to, in turn, enable another zone player **11**(*n'*) to join the synchrony group as a new slave device **22**(*g*). In that operation, the user interface module **13** will provide control information, including the identification of the zone player **11**(*n'*) that is to join the synchrony group to the master device **21**. After it receives the identification of the zone player **11**(*n'*) that is to join the synchrony group, the master device **21** will exchange control information, which is represented in FIG. **2** by the arrows labeled SLV_DEV_CTRL_INF (S_1) through SLV_DEV_CTRL_INF (S_G) group slave control information, over the network **12** with the zone player **11**(*n'*) that is identified in the control information from the user interface module **13**. The control information that the master device **21** provides to the new zone player **11**(*n'*) includes the network address of the zone player **11**(*n*) that is operating as the audio information channel device **23** for the synchrony group, as well as the multi-cast address that the audio information channel device **23** is using to broadcast the audio and playback timing information over the network. The zone player that is to operate as the new slave device **22**(*g'*) uses the multi-cast address to begin receiving the multi-cast messages that contain the audio information for the audio program being played by the synchrony group.

It will be appreciated that, if the zone player **11**(*n*) that is operating as the master device **21** for the synchrony group **20** is also operating the audio information channel device **23**, and if there are no slave devices **22**(*g*) in the synchrony group **20**, the audio information channel device **23** may not be transmitting audio and playback timing information over the network. In that case, if the new slave device **22**(*g'*) is the first slave device in the synchrony group, the zone player **11**(*n*) that is operating as both the master device **21** and audio information channel device **23**, can begin transmitting the audio and playback timing information over the network **12** when the slave device **22**(*g'*) is added to the synchrony group **20**. The zone player **11**(*n*) can maintain a count of the number of slave devices **22**(*g*) in the synchrony group **20** as they join and disengage, and, if the number drops to zero, it can stop transmitting the audio and playback timing information over the network **12** to reduce the message traffic over the network **12**.

The new slave device **22**(*g'*) added to the synchrony group **20** uses the network address of the audio information channel device **23** for several purposes. In particular, the new slave device **22**(*g'*) will, like the master device **21** (assuming the zone player **11**(*n*) operating as the master device **21** is not also the audio information channel device **23**), engage in SNTP transactions with the audio information channel device **23** to obtain the clock timing information from the audio information channel device **23**. In addition, the new slave device **22**(*g'*) can notify the audio information channel device **23** that it is a new slave device **22**(*g'*) for the synchrony group **20** and provide the audio information channel device **23** with its network address. As will be described below, in one embodiment, particularly in connection with audio information obtained from a source, such as a digital data storage device, which can provide audio information at a rate that is faster than the rate at which it will be played, the audio information channel device **23** will buffer audio and timing information and broadcast it over the network **12** to the synchrony group **20** generally at a rate at which it is provided by the source. Accordingly, when a new slave device **22**(*g'*) joins the synchrony group **20**, the playback timing information may indicate that the audio information that is currently being broadcast by the audio information channel device **23** using the multi-cast methodology is to be played back some time in the future. To reduce the delay with which the new slave device **22**(*g'*) will begin playback, the audio information channel device **23** can also retransmit previously transmitted audio and timing information that it had buffered to the new slave device **22**(*g'*) using the unicast network address of the slave device **22**(*g'*).

The master device **21** can also use the slave device control information exchanged with the slave devices **22**(*g*) for other purposes. For example, the master device **21** can use the slave device control information to initiate a migration of the master from its zone player **11**(*n*) to another zone player **11**(*n'*). This may occur for any of a number of reasons, including, for example, that the master device **21** is terminating playback by it of the audio program and is leaving the synchrony group **20**, but one or more of the other devices in the synchrony group is to continue playing the audio program. The master device **21** may also want to initiate a migration if it is overloaded, which can occur if, for example, the zone player **11**(*n*) that is the master device **21** for its synchrony group is also operating as an audio information channel device **23** for another synchrony group.

The user can also use the user interface module **13** to adjust playback volume by the individual zone players **11**(*n*) comprising the synchrony group. In that operation, the user interface module **13** provides information identifying the particular device whose volume is to be adjusted, and the level at which the volume is to be set to the master device **21**. If the device whose volume is to be adjusted is the master device **21**, the master device **21** can adjust its volume according to the information that it receives from the user interface module **13**. On the other hand, if the device whose volume is to be adjusted is a slave device **22**(*g*), the master device **21** can provide group slave control information to the respective slave device **22**(*g*), to enable it to adjust its volume.

The user can also use the user interface module **13** to enable a synchrony group **20** to cancel playing of the track in an audio program that is currently being played, and to proceed immediately to the next track. This may occur, for example, if the tracks for the program is in the form of a series of digital audio information files, and the user wishes to cancel playback of the track that is defined by one of the files. In that case, when the master device **21** receives the command to cancel playback of the current track, it will provide channel device control information to the audio information channel device **23** so indicating. In response, the audio information channel device **23** inserts control information into the audio and playback timing information, which will be referred to as a "resynchronize" command. In addition, the audio information channel device **23** will begin transmitting audio information for the next track, with timing information to enable it to be played immediately. The resynchronize command can also enable playback of a track to be cancelled before it has been played. Details of these operations will be described below.

As noted above, there may be multiple synchrony groups in the network audio system **10**, and further that, for example, a zone player **11**(*n*) may operate both as a master device **21** or a slave device **22**(*g*) in one synchrony group, and as the audio information channel device **23** providing audio and playback timing information and clock timing information for another synchrony group. An illustrative arrangement of this will be described in connection with FIG. **2**A. With reference to FIG. **2**A, that FIG. depicts elements of two synchrony groups, identified by reference numerals **20**(**1**) and **20**(**2**), respectively. For clarity, FIG. **2**A does not show a number of elements, the presence of which would be evident from FIGS. **1** and **2** as described above. For example, FIG. **2**A does not depict the audio information sources from which audio information is obtained for the synchrony groups or the audio reproduction devices that are used to produce sound for the master and slave devices, which are depicted in both FIGS. **1** and **2**. In addition, FIG. **2**A does not depict arrows that represent control information provided by the respective master devices to the slave devices in the respective synchrony groups, or to the audio information channel devices that provide audio and timing information for the respective synchrony groups, which are depicted in FIG. **2**. In addition, FIG. **2**A does not depict the arrows that represent the clock timing information provided by the audio information channel devices to the respective members of the respective synchrony groups, which are also depicted in FIG. **2**. As will be noted below, however, FIG. **2**A does depict arrows representing the audio and playback timing information provided by the respective audio information channel devices for the respective synchrony groups **20**(**1**), **20**(**2**), to the master and slave devices comprising the respective synchrony groups **20**(**1**), **20**(**2**).

Each synchrony group **20**(**1**), **20**(**2**) comprises elements of a number of zone players. A functional block diagram of a zone player will be described below in connection with FIG. **3**. Synchrony group **20**(**1**) includes a master device **21**(**1**) and "K" slave devices **22**(**1**)(**1**) through **22**(K)(**1**) (the index "1" in reference numeral **21**(**1**) and the last index in reference numeral **22**(**1**)(**1**) through **21**(K)(**1**) corresponds to the index of the synchrony group **20**(**1**) to which they belong) utilize zone players **11**(**1**) and **11**(K+1) respectively. Similarly, synchrony group **20**(**2**) includes a master device **21**(**2**) and "L" slave devices **22**(**1**)(**2**) through **22**(L)(**2**) that utilize zone players **11**(K+2) through **11**(K+L+2). In the illustrative arrangement depicted in FIG. **2**A, both synchrony groups **20**(**1**) and **20**(**2**) are controlled by the user interface module **13**, which can provide control information to, and receive status information from, the master devices **21**(**1**) and **21**(**2**) independently. It will be appreciated that separate user interface modules may be provided to provide control information to, and receive status information from, the respective master devices **21**(**1**), **21**(**2**).

As noted above, the slave device **22**(**1**)(**2**) in synchrony group **20**(**2**) utilizes zone player **11**(K+3). In the illustrative arrangement depicted in FIG. **2**A, the audio information channel device **23**(**1**) that provides audio and playback timing information to the master and slave devices **21**(**1**), **22**(**1**)(**1**), . . . , **22**(K)(**1**) of synchrony group **20**(**1**) also utilizes zone player **11**(K+3). As noted above, this may occur if, for example, the audio information source that is to provide audio information to be played by the synchrony group **20**(**1**) is connected to the zone player **11**(K+3). Thus, when the master device **21**(**1**) of synchrony group **20**(**1**) exchanges channel device control information with the audio information channel device **23**(**1**), it is effectively exchanging channel device control information with the zone player **11**(K+3). Similarly, when the master and slave devices **21**(**1**), **22**(**1**)(**1**), . . . , **22**(K)(**1**) of synchrony group **20**(**1**) receive audio and playback timing information, as well as clock timing information, from the audio information channel device **23**(**1**), they are effectively receiving the information from the zone player **11**(K+3). FIG. **2**A depicts a multi-headed arrow representing audio and playback timing information transmitted by the zone player **11**(K+3), as audio information channel device **23**(**1**), to the master and slave devices **21**(**1**), **22**(**1**)(**1**), . . . , **11**(K)(**1**) comprising synchrony group **20**(**1**).

On the other hand, in the illustrative arrangement depicted in FIG. **2**A, the synchrony group **20**(**2**) utilizes a zone player **11**(K+L+3) as its audio information channel device **23**(**2**). As with synchrony group **20**(**1**), when the master device **21**(**2**) of synchrony group **20**(**2**) exchanges channel device control information with the audio information channel device **23**(**2**), it is effectively exchanging channel device control information with the zone player **11**(K+L+3). Similarly, when the master and slave devices **21**(**2**), **22**(**1**)(**2**), . . . , **22**(L)(**2**) of synchrony group **20**(**2**) receive audio and playback timing

information, as well as clock timing information, from the audio information channel device **23**(**2**), they are effectively receiving the information from the zone player **11**(K+L+3). FIG. **2**A depicts a multi-headed arrow representing audio and playback timing information transmitted by the zone player **11**(K+3) as audio information channel device **23**(**2**) to the master and slave devices **21**(**2**), **22**(**1**)(**2**), . . . , **22**(L)(**2**) comprising synchrony group **20**(**2**).

In the illustrative arrangement depicted in FIG. **2**A, zone player **11**(K+L+3), which is the audio information channel device **23**(**2**) for synchrony group **20**(**2**), is not shown as being either a master or a slave device in another synchrony group. However, it will be appreciated that zone player **11**(K+L+3) could also be utilized as the master device or a slave device for another synchrony group. Indeed, it will be appreciated that the zone player that is utilized as the audio information channel device for synchrony group **20**(**2**) may also be a zone player that is utilized as the master device **21**(**1**) or a slave device **22**(**1**)(**1**), . . . , **22**(K)(**1**) in the synchrony group **20**(**1**).

A zone player **11**(*n*) that is utilized as a member of one synchrony group may also be utilized as the audio information channel device for another synchrony group if the audio information source that is to supply the audio information that is to be played by the other synchrony group is connected to that zone player **11**(*n*). A zone player **11**(*n*) may also be utilized as the audio information channel device for the other synchrony group if, for example, the audio information source is an audio information source **16**(*m*) (FIG. **1**) that is connected to the network **12** or an audio information source that is available over a wide area network such as the Internet. The latter may occur if, for example, the zone player **11**(*n*) has sufficient processing power to operate as the audio information channel device and it is in an optimal location in the network **12**, relative to the zone players comprising the other synchrony group (that is the synchrony group for which it is operating as audio information channel device) for providing the audio and playback timing information to the members of the other synchrony group. Other circumstances under which the zone player **11**(*n*) that is utilized as a member of one synchrony group may also be utilized as the audio information channel device for another synchrony group will be apparent to those skilled in the art.

As was noted above, the master device **21** for a synchrony group **20** may be migrated from one zone player **11**(*n*) to another zone player **11**(*n*'). As was further noted above, the audio information channel device **23** for a synchrony group **20** may be migrated from one zone player **11**(*n*) to another zone player **11**(*n*'). It will be appreciated that the latter may occur if, for example, the audio information source that provides the audio program for the synchrony group is not connected to the zone player **11**(*n*) that is operating as the audio information channel device **23**, but instead is one of the audio information sources **16**(*m*) connected to the network **12** or a source available over a wide area network such as the Internet. Operations performed during a migration of an audio information channel device **23** from one zone player **11**(*n*) to another zone player **11**(*n*') will generally depend on the nature of the audio information that is being channeled by the audio information channel device **23**. For example, if the audio information source provides streaming audio, the zone player **11**(*n*) that is currently operating as the audio information channel device **23** for the synchrony group **20**, can provide the following information to the other zone player **11**(*n*') that is to become the audio information channel device **23** for the synchrony group **20**:

(a) the identification of the source of the streaming audio information,

(b) the time stamp associated with the frame that the zone player **11**(*n*) is currently forming, and

(c) the identifications of the zone players that are operating as the master device **21** and slave devices **22**(*g*) comprising the synchrony group **20**.

After the zone player **11**(*n*') receives the information from the zone player **11**(*n*), it will begin receiving the streaming audio from the streaming audio information source identified by the zone player **11**(*n*), assemble the streaming audio information into frames, associate each frame with a time stamp, and transmit the resulting audio and playback timing information over the network **12**. The zone player **11**(*n*') will perform these operations in the same manner as described above, except that, instead of using the time indicated by its digital to analog converter clock **34** directly in generating the time stamps for the frames, the initial time stamp will be related to the value of the time stamp that is provided by the zone player **11**(*n*) (reference item (b) above), with the rate at which the time stamps are incremented corresponding to the rate at which its (that is, the zone player **11**(*n*')'s) clock increments. In addition, the zone player **11**(*n*') will notify the zone players that are operating as the master device **21** and slave devices **22**(*g*) of the synchrony group **20** that it is the new audio information channel device **23** for the synchrony group **20**, and provide the multi-cast address that it will be using to multi-cast the audio and playback timing information, as well as its unicast network address. After the members of the synchrony group **20** receive the notification from the zone player **11**(*n*') indicating that it is the new audio information channel device **23** for the synchrony group **20**, they will receive the audio and playback timing information from the zone player **11**(*n*') instead of the zone player **11**(*n*), using the multi-cast address provided by the zone player **11**(*n*'). In addition, they can utilize the zone player **11**(*n*')'s unicast network address to obtain current time information therefrom. It will be appreciated that the zone player **11**(*n*') will determine its current time in relation to the time stamp that is provided by the zone player **11**(*n*) (reference item (b) above) or the current time information that it received from the zone player **11**(*n*) using the SNTP protocol as described above.

Generally similar operations can be performed in connection with migrating the audio information channel device from one zone player **11**(*n*) to another zone player **11**(*n*') if the audio information is from one or more audio information files, such as may be the case if the audio information comprises MP3 or WAV files that are available from sources such as sources **16**(*m*) connected to the network **12** or over from sources available over a wide area network such as the Internet, except for differences to accommodate the fact that the audio information is in files. In that case, the zone player **11**(*n*) that is currently operating as the audio information channel device **23** for the synchrony group **20** can provide the following information to the zone player **11**(*n*') that is to become the audio information channel device **23** for the synchrony group **20**:

(d) a list of the audio information files containing the audio information that is to be played;

(e) the identification of the file for which the zone player **11**(*n*) is currently providing audio and playback timing information, along with the offset into the file for which the current item of audio and playback timing information is being generated and the time stamp that the zone player **11**(*n*) is associating with that frame, and

(f) the identifications of the zone players that comprise the master device **21** and slave devices **22**(*g*) comprising the synchrony group **20**.

After the zone player **11**(*n'*) receives the information from the zone player **11**(*n*), it will begin retrieving audio information from the file identified in item (e), starting at the identified offset. In addition, the zone player **11**(*n'*) can assemble the retrieved audio information into frames, associate each frame with a time stamp and transmit the resulting audio and playback timing information over the network **12**. The zone player **11**(*n'*) will perform these operations in the same manner as described above, except that, instead of using the time indicated by its digital to analog converter clock **34** directly in generating the time stamps for the frames, the value of the initial time stamp will be related to the time stamp that is provided by the zone player **11**(*n*) (reference item (e) above), with the rate at which the time stamps are incremented corresponding to the rate at which its (that is, the zone player **11**(*n'*)'s) clock increments. In addition, the zone player **11**(*n'*) will notify the zone players that are operating as the master device **21** and slave devices **22**(*g*) of the synchrony group **20** that it is the new audio information channel device **23** for the synchrony group **20**, and provide the multi-cast address that it will be using to multi-cast the audio and playback timing information, as well as its unicast network address. After the members of the synchrony group **20** receive the notification from the zone player **11**(*n'*) indicating that it is the new audio information channel device **23** for the synchrony group **20**, they will receive the audio and playback timing information from the zone player **11**(*n'*) instead of the zone player **11**(*n*), using the multi-cast address provided by the zone player **11**(*n'*). In addition, they can utilize the zone player **11**(*n'*)'s unicast network address to obtain current time information therefrom. It will be appreciated that the zone player **11**(*n'*) will determine its current time in relation to the time stamp that is provided by the zone player **11**(*n*) (reference item (b) above) or the current time information that it received from the zone player **11**(*n*) using the SNTP protocol as described above. The zone player **11**(*n'*) will process successive audio information files in the list that it receives from the zone player **11**(*n*) (reference item (d)).

Operations performed by the zone players **11**(*n*) and **11**(*n'*) in connection with migration of the audio information channel device **23** for other types of audio information will be apparent to those skilled in the art. In any case, preferably, the zone player **11**(*n*) will continue operating as an audio information channel device **23** for the synchrony group **20** for at least a brief time after it notifies the zone player **11**(*n'*) that it is to become audio information channel device for the synchrony group, so that the zone player **11**(*n'*) will have time to notify the zone players in the synchrony group **20** that it is the new audio information channel device **23** for the synchrony group.

Before proceeding further in describing operations performed by the network audio system **10**, it would be helpful to provide a detailed description of a zone player **11**(*n*) constructed in accordance with the invention. FIG. **3** depicts a functional block diagram of a zone player **11**(*n*) constructed in accordance with the invention. All of the zone players in the network audio system **10** may have similar construction. With reference to FIG. **3**, the zone player **11**(*n*) includes an audio information source interface **30**, an audio information buffer **31**, a playback scheduler **32**, a digital to analog converter **33**, an audio amplifier **35**, an audio reproduction device interface **36**, a network communications manager **40**, and a network interface **41**, all of which operate under the control of a control module **42**. The zone player **11**(*n*) also has a device clock **43** that provides timing signals that control the general operations of the zone player **11**(*n*). In addition, the zone player **11**(*n*) includes a user interface module interface **44** that can receive control signals from the user interface module **13** (FIGS. **1** and **2**) for controlling operations of the zone player **11**(*n*), and provide status information to the user interface module **13**.

Generally, the audio information buffer **31** buffers audio information, in digital form, along with playback timing information. If the zone player **11**(*n*) is operating as the audio information channel device **23** (FIG. **2**) for a synchrony group **20**, the information that is buffered in the audio information buffer **31** will include the audio and playback timing information that will be provided to the devices **21** and **22**(*g*) in the synchrony group **20**. If the zone player **11**(*n*) is operating as the master device **21** or a slave device **22**(*g*) for a synchrony group, the information that is buffered in the audio information buffer **31** will include the audio and playback timing information that the zone player **11**(*n*) is to play.

The audio information buffer **31** can receive audio and playback timing information from two sources, namely, the audio information source interface **30** and the network communications manager **40**. In particular, if the zone player **11**(*n*) is operating as the audio information channel device **23** for a synchrony group **20**, and if the audio information source is a source **14**(*n*)(*s*) connected to the zone player **11**(*n*), the audio information buffer **31** will receive and buffer audio and playback timing information from the audio information source interface **30**. On the other hand, if the zone player **11**(*n*) is operating as the audio information channel device **23** for a synchrony group **20**, and if the audio information source is a source **16**(*m*) connected to the network **12**, or a source available over the wide area network, the audio information buffer **31** will receive and buffer audio and playback timing information from the network communications manager **40**. It will be appreciated that, if the zone player **11**(*n*) is not a member of the synchrony group, the zone player **11**(*n*) will not play this buffered audio and playback timing information.

On yet another hand, if the zone player **11**(*n*) is operating as the master device **21** or a slave device **22**(*g*) in a synchrony group, and if the zone player **11**(*n*) is not also the audio information channel device **23** providing audio and playback timing information for the synchrony group **20**, the audio information buffer **31** will receive and buffer audio and playback timing information from the network communications manager **40**.

The audio information source interface **30** connects to the audio information source(s) **14**(*n*)(*s*) associated with the zone player **11**(*n*). While the zone player **11**(*n*) is operating as audio information channel device **23** for a synchrony group **20**, and if the audio information is to be provided by a source **14**(*n*)(*s*) connected to the zone player **11**(*n*), the audio information source interface **30** will selectively receive audio information from one of the audio information source(s) **14**(*n*)(*s*) to which the zone player is connected and store the audio information in the audio information buffer **21**. If the audio information from the selected audio information source **14**(*n*)(*s*) is in analog form, the audio information source interface **30** will convert it to digital form. The selection of the audio information source **14**(*n*)(*s*) from which the audio information source interface **30** receives audio information is under control of the control module **42**, which, in turn, receives control information from the user interface module through the user interface module interface **44**. The audio information source interface **30** adds playback timing infor-

mation to the digital audio information and buffers the combined audio and playback timing information in the audio information buffer **21**.

More specifically, as noted above, the audio information source interface **30** receives audio information from an audio information source **14**(*n*)(*s*), converts it to digital form if necessary, and buffers it along with playback timing information in the audio information buffer **21**. In addition, the audio information source interface **30** will also provide formatting and scheduling information for the digital audio information, whether as received from the selected audio information source **14**(*n*)(*s*) or as converted from an analog audio information source. As will be made clear below, the formatting and scheduling information will control not only playback by the zone player **11**(*n*) itself, but will also enable other zone players **11**(*n'*), **11**(*n''*), . . . that may be in a synchrony group for which the zone player **11**(*n*) is the master device, to play the audio program associated with the audio information in synchrony with the zone player **11**(*n*).

In one particular embodiment, the audio information source interface **30** divides the audio information associated with an audio work into a series of frames, with each frame comprising digital audio information for a predetermined period of time. As used herein, an audio track may comprise any unit of audio information that is to be played without interruption. On the other hand, an audio program may comprise a series of one or more audio tracks that are to be played in succession. It will be appreciated that the tracks comprising the audio program may also be played without interruption, or alternatively playback between tracks may be interrupted by a selected time interval. FIG. **4** schematically depicts an illustrative framing strategy used in connection with one embodiment of the invention for a digital audio stream comprising an audio work. More specifically, FIG. **4** depicts a framed digital audio stream **50** comprising a sequence of frames **51**(**1**) through **51**(F) (generally identified by reference numeral **51**(*f*)). Each frame **51**(*f*), in turn, comprises a series of audio samples **52**(*f*)(**1**) through **52**(*f*)(S) (generally identified by reference numeral **52**(*f*)(*s*)) of the audio track. Preferably all of the frames will have the same number "S" of audio samples, although it will be appreciated from the following that that is primarily for convenience. On the other hand, it will be appreciated that, the number of audio samples may differ from "S"; this may particularly be the case if the frame **51**(*f*) contains the last audio samples for the digital audio stream for a particular audio work. In that case, the last frame **51**(F) will preferably contain samples **52**(F)(**1**) through **52**(F)(x), where "x" is less than "S." Generally, it is desirable that the number of samples be consistent among all frames **51**(*f*), and in that case padding, which will not be played, can be added to the last frame **51**(F).

Associated with each frame **51**(*f*) is a header **55**(*f*) that includes a number of fields for storing other information that is useful in controlling playback of the audio samples in the respective frame **51**(*f*). In particular, the header **55**(*f*) associated with a frame **51**(*f*) includes a frame sequence number field **56**, an encoding type field **57**, a sampling rate information field **58**, a time stamp field **60**, an end of track flag **61**, and a length flag field **62**. The header **55**(*f*) may also include fields (not shown) for storing other information that is useful in controlling playback. Generally, the frame sequence number field **56** receives a sequence number "f" that identifies the relative position of the frame **51**(*f*) in the sequence of frames **51**(**1**) . . . **51**(*f*) . . . **51**(F) containing the digital audio stream **50**. The encoding type field **57** receives a value that identifies the type of encoding and/or compression that has been used in generating the digital audio stream. Conventional encoding or compression schemes include, for example, the well-known MP3 and WAV encoding and/or compression schemes, although it will be appreciated that other schemes may be provided for as well. The sampling rate information field **58** receives sampling rate information that indicates the sampling rate for the audio samples **52**(*f*)(*s*). As will be apparent to those skilled in the art, the sampling rate determines the rate at which the zone player **11**(*n*) is to play the audio samples **52**(*f*)(*s*) in the frame, and, as will be described below, determines the period of the digital to analog converter clock **34**.

The condition of the end of work flag **61** indicates whether the frame **51**(*f*) contains the last digital audio samples for the audio track associated with the framed digital audio work **50**. If the frame **51**(*f*) does not contain the audio samples that are associated with the end of the digital audio stream **50** for a respective audio work, the end of work flag will be clear. On the other hand, if the frame **51**(*f*) does contain the audio samples that are associated with the end of the digital audio stream **50** for a respective audio work, the end of work flag **61** will be set. In addition, since the number of valid audio samples **52**(F)(s) in the frame **51**(F), that is, the samples that are not padding, may be less than "S," the default number of audio samples in a frame **51**(*f*), the length flag field **62** will contain a value that identifies the number of audio samples in **52**(F)(s) in the last frame **51**(F) of the audio work **50**. If, as noted above, the frames have a consistent number "S" of samples, the samples **52**(F)(x+1) through **52**(F)(S) will contain padding, which will not be played.

The time stamp field **60** stores a time stamp that identifies the time at which the zone player **11**(*n*) is to play the respective frame. More specifically, for each frame of a framed digital audio stream **50** that is buffered in the audio information buffer **21**, the audio information source interface **30**, using timing information from the digital to analog converter clock **34**, will determine a time at which the zone player **11**(*n*) is to play the respective frame, and stores a time stamp identifying the playback time in the time stamp field **60**. The time stamp associated with each frame will later be used by the playback scheduler **32** to determine when the portion of the digital audio stream stored in the frame is to be coupled to the digital to analog converter **33** to initiate play back. It will be appreciated that the time stamps that are associated with frames in sequential frames **51**(**1**), **51**(**2**), . . . , **51**(F), will be such that they will be played back in order, and without an interruption between the sequential frames comprising the digital audio stream **50**. It will further be appreciated that, after a time stamp has been determined for the first frame, stored in frame **51**(**1**), of a digital audio stream **50**, the audio information source interface **30** can determine time stamps for the subsequent frame **51**(**2**), **51**(**3**), . . . , **51**(F) in relation to the number of samples "S" in the respective frames and the sample rate. The time stamps will also preferably be such that frames will be played back after some slight time delay after they have been buffered in the audio information buffer **21**; the purpose for the time delay will be made clear below.

Returning to FIG. **3**, in addition to dividing the digital audio information into frames, the audio information source interface **30** also aggregates and/or divides the frames **51**(*f*) as necessary into packets, each of which will be of a length that would fit into a message for transmission over the network, and associates each packet with a packet sequence number. For example, if a packet will accommodate multiple frames **51**(*f*), **51**(*f*+1), . . . **51**(*f*+*y*−1), it will aggregate them into a packet and associate them with a packet number, for example p(x). If the entire frames **51**(*f*) and **51**(*f*+*y*−1) was accommodated in packet p(x), where "x" is the sequence number,

which will occur if the size of a packet is an exact multiple of the frame size, the next packet, p(x+1) will begin with frame **51**(*f*+*y*) and will include frames **51**(*f*+*y*), . . . , **51**(*f*+2 y−1). Subsequent packets p(x+2), . . . will be formed in a similar manner. On the other hand, if the packet length will not accommodate an exact multiple of the frame size, the last frame in the packet will be continued at the beginning of the next packet.

If the audio information source interface **30** is aware of track boundaries, which may be the case if the tracks are divided into files, the packets will reflect the track boundaries, that is, the packets will not contain frames from two tracks. Thus, if the last frames associated with a track are insufficient to fill a packet, the packet will contain padding from the last frame associated with the track to the end of the packet, and the next packet will begin with the first frames associated with the next track.

In one embodiment, the audio information source interface **30** stores the packets in the audio information buffer **31** in a ring buffer. As is conventional, a ring buffer includes a series of storage locations in the buffer. Each entry will be sufficient to store one packet. Four pointers are used in connection with the ring buffer, a first pointer pointing to the beginning of the ring buffer, a second pointer pointing to the end of the ring buffer, an third "write" pointer pointing to the entry into which a packet will be written and a fourth "read" pointer pointing to the entry from which packet will be read for use in playback. When a packet is read from the ring buffer for playback, it will be read from the entry pointed to by the read pointer. After the packet has been read, the read pointer will be advanced. If the read pointer points beyond the end of the ring buffer, as indicated by the end pointer, it will be reset to point to the entry pointed to by the beginning pointer, and the operations can be repeated.

On the other hand, when the audio information source interface **30** stores a packet in the ring buffer, first determine whether the entry pointed to by the write pointer points to the same entry as the entry pointed to by the read pointer. If the write pointer points to the same entry as the entry pointed to by the read pointer, the entry contains at least a portion of a packet that has not yet been read for playback, and the audio information source interface **30** will delay storage of the packet until the entire packet has been read and the read pointer advanced. After the read pointer has been advanced, the audio information source interface **30** can store the packet in the entry pointed to by the write pointer. After the packet has been stored, the audio information source interface **30** will advance the write pointer. If the write pointer points beyond the end of the ring buffer, as indicated by the end pointer, it will be reset to point to the entry pointed to by the beginning pointer, and the operations can be repeated.

As noted above, the zone player **11**(*n*) can operate both as an audio information channel device **23** and a member of the synchrony group **20** of which it is a member. In that case, the audio information buffer **31** can contain one ring buffer. On the other hand, the zone player **11**(*n*) can operate as an audio information channel device **23** for one synchrony group **20**(**1**) (FIG. **2**A) and a member of another synchrony group **20**(**2**). In that case, the audio information buffer **31** would maintain two ring buffers, one for the audio and timing information associated with synchrony group **20**(**1**), and the other for the audio and timing information associated with synchrony group **20**(**2**). It will be appreciated that, in the latter case, the zone player **11**(*n*) will only use the audio and timing information that is associated with synchrony group **20**(**2**) for playback.

The playback scheduler **32** schedules playback of the audio information that is buffered in the audio information buffer **31** that is to be played by the zone player **11**(*n*). Accordingly, under control of the playback scheduler **32**, the digital audio information that is buffered in the audio information buffer **21** that is to be played by the zone player **11**(*n*) is transferred to the digital to analog converter **33** for playback. As noted above, if the zone player **11**(*n*) is operating as an audio information channel device **23** for a synchrony group **20** for which it is not a member, the playback scheduler **32** will not schedule the digital audio information that is to be played by that synchrony group **20** for playback. The playback scheduler **32** only schedules the digital audio information, if any, that is buffered in the audio information buffer **31** that is associated with a synchrony group for which the zone player **11**(*n*) is a member, whether as master device **21** or a slave device **22**(*g*).

Essentially, the playback scheduler **32** makes use of the read pointer associated with the circular buffer that contains the audio and playback timing information that is to be played by the zone player **11**(*n*). The playback scheduler **32** retrieves the packet information from the entry of the ring buffer pointed to by the read pointer, and then advances the ring pointer as described above. The playback scheduler **32** determines the boundaries of the frames in the packet and uses the time stamps in the time stamp fields **60** associated with the respective frame **51**(*f*), along with timing information provided by the zone player **11**(*n*)'s digital to analog converter clock **34**, to determine when the respective frame is to be transferred to the digital to analog converter **33**. Generally, when the time stamp associated with a buffered digital audio information frame corresponds to the current time as indicated by the digital to analog converter clock **34**, the playback scheduler **32** will enable the respective frame to be transferred to the digital to analog converter **33**.

The digital to analog converter **33**, also under control of the digital to analog converter clock **34**, converts the buffered digital audio information to analog form, and provides the analog audio information to the audio amplifier **35** for amplification. The amplified analog information, in turn, is provided to the audio reproduction devices **15**(*n*)(*r*) through the audio reproduction device interface **36**. The audio reproduction devices **15**(*n*)(*r*) transform the analog audio information signal to sound thereby to provide the audio program to a listener. The amount by which the audio amplifier **35** amplifies the analog signal is controlled by the control module **42**, in response to volume control information provided by the user through the user interface module **13**.

The network communications manager **40** controls network communications over the network **12**, and the network interface **41** transmits and receives message packets over the network **12**. The network communications manager **40** generates and receives messages to facilitate the transfer of the various types of information described above in connection with FIG. **2**, including the channel device control information, slave device control information, audio and playback timing information and the audio information channel device's clock timing information. In connection with the channel device control information and the slave device control information, the network communications manager **40** will generate messages for transfer over the network **12** in response to control information from the control module **42**. Similarly, when the network communications manager **40** receives messages containing channel device control information and slave device control information, the network communications manager will provide the information to the control module **42** for processing.

With regards to the audio information channel device's clock timing information, as noted above, the master device **21** and slave devices **22**(*g*) of the synchrony group **20** obtain

the clock timing information from the audio information channel device **23** using the well-known SNTP. If the zone player **11**(*n*) is operating as the audio information channel device **23** for a synchrony group, during the SNTP operation, it will provide its current time, particularly a current time as indicated by its digital to analog converter clock **34**. On the other hand, if the zone player **11**(*n*) is operating as the master device **21** or slave device **22**(*g*) of a synchrony group **20**, it will receive the clock timing information from the audio information channel device **23**. After the respective device **21**, **22**(*g*) has obtained the audio information channel device's clock timing information, it will generate a differential time value ΔT representing the difference between the time T indicated by its digital to analog converter clock **34** and the current time information from the audio information channel device **23**. The differential time value will be used to update the time stamps for the frames of the digital audio stream **50** (FIG. **4**) that are received from the audio information channel device.

With regards to the audio and playback timing information, operations performed by the network communications manager **40** will depend on whether

(i) the audio and playback timing information has been buffered in the audio information buffer **31** for transmission, as audio information channel device **23**, over the network **12** to the master device **21** and/or slave devices **22**(*g*) of a synchrony group, or

(ii) the audio and playback timing information has been received from the network **12** to be played by the zone player **11**(*n*) as either the master device **21** for a synchrony group or a slave device in a synchrony group.

It will be appreciated that the network communications manager **40** may be engaged in both (i) and (ii) contemporaneously, since the zone player **11**(*n*) may operate both as the audio information channel device **23**(**1**) for a synchrony group **20**(**1**) (reference FIG. **2**A) of which it is not a member, and a member of another synchrony group **20**(**2**) for which another zone player **11**(*n'*) is the audio information channel device **23**(**2**). With reference to item (i) above, after a packet that is to be transmitted has been buffered in the respective ring buffer, the network communications manager **40** retrieves the packet, packages it into a message and enables the network interface **41** to transmit the message over the network **12**. If the control module **42** receives control information from the user interface module **13** (if the master device **21** is also the audio information channel device **23** for the synchrony group **20**) or from the master device (if the master device **21** is not the audio information channel device **23** for the synchrony group **20**) that would require the transmission of a "resynchronize" command as described above, the control module **42** of the audio information channel device **23** enables the network communications manager **40** to insert the command into a message containing the audio and playback timing information. Details of the operations performed in connection with the "resynchronize" command will be described below. As noted above, the "resynchronize" command is used if the user enables a synchrony group to terminate the playback of a track that is currently being played, or cancel playback of a track whose playback has not begun.

On the other hand, with reference to item (ii) above, if network interface **41** receives a message containing a packet containing frames of audio and playback timing information that the zone player **11**(*n*) is to play either as a master device **21** or a slave device for a synchrony group **20**, the network interface **41** provides the audio and playback timing information to the network communications manager **40**. The network communications manager **40** will determine whether the packet contains a resynchronize command and, if so, notify the control module **42**, which will enable operations to be performed as described below. In any case, the network communications manager **40** will normally buffer the various frames comprising the audio and playback timing information in the audio information buffer **31**, and in that operation will generally operate as described above in connection with the audio information source interface **30**. Before buffering them, however, the network communications manager **40** will update their time stamps using the time differential value described above. It will be appreciated that the network communications manager **40** will perform similar operations whether the messages that contain the packets were multicast messages or unicast messages as described above

The updating of the time stamps by the master device **21** and the slave devices **22**(*g*) in the synchrony group **20** will ensure that they all play the audio information synchronously. In particular, after the network communications manager **40** has received a frame **51**(*f*) from the network interface **41**, it will also obtain, from the digital to analog converter clock **34**, the zone player **11**(*n*)'s current time as indicated by its digital to analog converter clock **34**. The network communications manager **40** will determine a time differential value that is the difference between the slave device's current clock time, as indicated by its digital to analog converter **34**, and the audio information channel device's time as indicated by the audio information channel device's clock timing information. Accordingly, if the master or slave device's current time has a value T_S and the audio information channel device's current time, as indicated by the clock timing information, has a value T_C, the time differential value $\Delta T = T_S - T_C$. If the current time of the master or slave device in the synchrony group **20**, as indicated by its digital to analog converter clock **34**, is ahead of the audio information channel device's clock time as indicated by the clock timing information received during the SNTP operation, the time differential value will have a positive value. On the other hand, if the master or slave device's current time is behind the audio information channel device's clock time, the time differential value ΔT will have a negative value. If the zone player **11**(*n*) obtains clock timing information from the audio information channel device **23** periodically while it is a member of the synchrony group **20**, the network communications manager **40** can generate an updated value for the time differential value ΔT when it receives the clock timing information from the audio information channel device **23**, and will subsequently use the updated time differential value.

The network communications manager **40** uses the time differential value ΔT that it generates from the audio information channel device timing information and zone player **11**(*n*)'s current time to update the time stamps that will be associated with the digital audio information frames that the zone player **11**(*n*) receives from the audio information channel device. For each digital audio information frame that is received from the audio information channel device, instead of storing the time stamp that is associated with the frame as received in the message in the audio information buffer **21**, the network communications manager **40** will store the updated time stamp with the digital audio information frame. The updated time stamp is generated in a manner so that, when the zone player **11**(*n*), as a member of the synchrony group plays back the digital audio information frame, it will do so in synchrony with other devices in the synchrony group.

More specifically, after the zone player **11**(*n*)'s network interface **41** receives a message containing a packet that, in turn, contains one or more frames **51**(*f*), it will provide the

packet to the network communications manager **40**. For each frame **51**(*f*) in the packet that the network communications manager **40** receives from the network interface **41**, the network communications manager **40** will add the time differential value ΔT to the frame's time stamp, to generate the updated time stamp for the frame **51**(*f*), and store the frame **51**(*f*), along with the header **55**(*f*) with the updated time stamp in the audio information buffer **31**. Thus, for example, if a frame's time stamp has a time value T_F, the network communications manager **40** will generate an updated time stamp T^U_F having a time value $T^U_F = T_F + \Delta T$. Since time value T^U_F according to the slave device's digital to analog converter clock **34** is simultaneous to the time value T_F according to the audio information channel device's digital to analog converter clock **34**, the zone player **11**(*n*) device will play the digital audio information frame at the time determined by the audio information channel device **23**. Since all of the members of the synchrony group **20** will perform the same operations, generating the updated time stamps T^U_F for the various frames **51**(*f*) in relation to their respective differential time values, all of the zone players **11**(*n*) in the synchrony group **20** will play them synchronously. The network communications manager **40** will generate updated time stamps T^U_F for all of the time stamps **60** in the packet, and then store the packet in the audio information buffer **31**.

It will be appreciated that, before storing a packet in the audio information buffer **21**, the network communications manager **40** can compare the updated time stamps T^U_F associated with the frames in the packet to the slave device's current time as indicated by its digital to analog converter clock **34**. If the network communications manager **40** determines the time indicated by the updated time stamps of frames **51**(*f*) in the packet are earlier than the zone player's current time, it can discard the packet instead of storing it in the audio information buffer **21**, since the zone player **11**(*n*) will not play them. That is, if the updated time stamp has a time value T^U_F that identifies a time that is earlier than the zone player's current time T_S as indicated by the zone player's digital to analog converter clock **34**, the network communications manager **40** can discard the packet.

If the zone player **11**(*n*) is operating as the master device **21** of a synchrony group **20**, when the user, through the user interface module **13**, notifies the zone player **11**(*n*) that another zone player **11**(*n'*) is to join the synchrony group **20** as a slave device **22**(*g*), the control module **42** of the zone player **11**(*n*) enables the network communications manager **40** to engage in an exchange of messages, described above in connection with FIG. **2**, to enable the other zone player **11**(*n'*) to join the synchrony group **20** as a slave device. As noted above, during the message exchange, the messages generated by the network communications manager **40** of the zone player **11**(*n*) will provide the network communications manager of the zone player **11**(*n*) that is to join the synchrony group **20** with information such as the multi-cast address being used by the audio information channel device **23** that is providing the audio program to the synchrony group **20**, as well as a unicast network address for the audio information channel device **23**. After receiving that information, the network communications manager and network interface of the zone player **11**(*n'*) that is to join the synchrony group **20** can begin receiving the multi-cast messages containing the audio program for the synchrony group, engage in SNTP transactions with the audio information channel device **23** to obtain the latter's current time, and also enable the audio information channel device **23** to send the zone player **11**(*n'*) frames **51**(*f*) that it had previously broadcast using the unicast message transmission methodology as described above.

On the other hand, if the network communications manager **40** and network interface **41** of the zone player **11**(*n*) receive a message over the network **12** indicating that it is to become a slave device **22**(*g*) of a synchrony group for which another zone player **11**(*n'*) is the master device, the network communications manager **40** for zone player **11**(*n*) will provide a notification to the control module **42** of zone player **11**(*n*). Thereafter, the control module **42** of zone player **11**(*n*) can enable the network communications manager **40** of zone player **11**(*n*) to perform the operations described above to enable it to join the synchrony group **20**.

As noted above, the user, using user interface module **13**, can enable the synchrony group to terminate playback of a track of an audio program that is currently being played. After playback of a track that is currently being played has been terminated, playback will continue in a conventional manner with the next track that has been buffered in the audio information buffer **31**. It will be appreciated that that could be the next track that is on the original play list, or a previous track. In addition, the user can enable the synchrony group **20** to cancel playback of a track that it has not yet begun to play, but for which buffering of packets has begun in the synchrony group **20**. Both of these operations make use of the "resynchronize" command that the master device **21** of the synchrony group **20** can enable the audio information channel device **23** to include in the multi-cast message stream that it transmits to the synchrony group **20**. Generally, in response to receipt of the resynchronize command, the members of the synchrony group **20** flush the ring buffer containing the packets that they are to play in the future. In addition, if the members of the synchrony group provide separate buffers for their respective digital to analog converters **33**, the members will also flush those buffers as well. After the audio information channel device transmits a packet containing the resynchronize command:

(i) in the case of the use of the resynchronize command to terminate playing of a track that is currently being played, the audio information channel device **23** will begin multi-casting packets for the next track, to begin play immediately, and will continue through the play list in the manner described above; and

(ii) in the case of the use of the resynchronize command to cancel play of a track for which buffering has begun, but which is to be played in the future, the audio information channel device **23** will begin multi-casting packets for the track after the track that has been cancelled, to be played beginning at the time the cancelled track was to begin play, and will also continue through the play list in the manner described above.

It will be appreciated that,

(a) in the first case (item (i) directly above), the resynchronize command can enable the read pointer to be set to point to the entry in the circular buffer into which the first packet for the next track will be written, which will correspond to the entry to which the write pointer points, but

(b) in the second case (item (ii) directly above), the resynchronize command can enable the write pointer for the circular buffer to be set to point to the entry that contains the first packet for the track whose play is being cancelled.

It will further be appreciated that, if a track is cancelled for which buffering has not begun, the resynchronize command will generally not be necessary, since the audio information channel device **23** for the synchrony group **20** need only delete that track from the play list.

Operations performed in connection with use of the resynchronize command to cancel playback of a track that is currently being played will be described in connection with

Packet Sequence A below, and operations performed in connection with the use of the resynchronize command to cancel playback of a track that is has not yet begun to play, but for which buffering of packets has begun, will be described in connection with Packet Sequence B below.

Packet Sequence A

(A1.0) [packet 57]
(A1.1 [continuation of frame 99]
(A1.2) [frame 100, time=0:00:01, type=mp3 audio]
(A1.3) [frame 101, time=0:00:02, type=mp3 audio]
(A1.4) [frame 102, time=0:00:03, type=mp3 audio]
(A2.0) [packet 58]
(A2.1) [continuation of frame 102]
(A2.2) [frame 103, time=0:00:04, type=mp3 audio]
(A2.3) [frame 104, time=0:00:05, type=mp3 audio]
(A2.4) [frame 105, time=0:00:06, type=mp3 audio]
(A3.0) [packet 59]
(A3.1) [continuation of frame 105]
(A3.2) [frame 106, time=0:00:07, type=mp3 audio]
(A3.3) [frame 107, time=0:00:08, type=mp3 audio]
(A3.4) [frame 108, time=0:00:09, type=mp3 audio]
(A4.0) [packet 60]
(A4.1) [continuation of frame 108]
(A4.2) [frame 109, time=0:00:10, type=mp3 audio]
(A4.3) [Resynchronize command]
(A4.4) [Padding, if necessary]
(A5.0) [packet 61]
(A5.1) [frame 1, time=0:00:07, type=mp3 audio]
(A5.2) [frame 2, time=0:00:08, type=mp3 audio]
(A5.3) [frame 3, time=0:00:09, type=mp3 audio]
(A5.4) [frame 4, time=0.00.10, type=mp3 audio]
(A6.0) [packet 62]
(A6.1) [continuation of frame 4]
(A6.2) [frame 5, time=0:00:11, type=mp3 audio]
(A6.3) [frame 6, time=0:00:12, type=mp3 audio]
(A6.4) [frame 7, time=0:00:13, type=mp3 audio]

Packet Sequence A comprises a sequence of six packets, identified by packet **57** through packet **62**, that the audio information channel device **23** multi-casts in respective messages to the members of a synchrony group **20**. It will be appreciated that the series of messages that the audio information channel device **23** may multi-cast to the synchrony group **20** may include a messages prior to the packet **57**, and may also include messages after packet **62**. Each packet comprises a packet header, which is symbolized by lines (A**1**.**0**), (A**2**.**0**), . . . (A**6**.**0**) in Packet Sequence A, and will generally also include information associated with at least a portion of a frame. In the packets represented in Packet Sequence A, each packet includes information associated with a plurality of frames. Depending on the lengths of the packets, each packet may contain information associated with a portion of a frame, an entire frame, or multiple frames. In the illustration represented by Packet Sequence A, it is assumed that each packet may contain information associated with multiple frames. In addition, it is assumed that a packet does not necessarily contain information associated with an integral number of frames; in that case, a packet may contain information associated with a portion of a frame, and the next packet will contain the information associated with the rest of a frame.

The frames and associated header playback timing information contained in the various packets are symbolized by lines (A**1**.**1**), (A**1**.**2**), . . . , (A**1**.**4**), (A**2**.**1**), . . . (A**6**.**4**) of Packet Sequence A. Thus, for example, line (A**1**.**2**) of packet **57** represents the one-hundredth frame, that is, frame **51**(**100**) (reference FIG. **4**), of the track whose audio information is being transmitted in the sequence Of packets that includes packet **57**. The frame **51**(**100**) is to be played at an illustrative time, according to the audio information channel device's digital to analog converter clock, of "time=0:00:01," and the frame is encoded and/or compressed using the well-known MP3 encoding and compression methodology. In that case, the legend"time=0:00:01" represents the time stamp that would be included in field **60** (FIG. **4**) of the header associated with the frame **50**(**100**) as multi-cast by the audio information channel device for the synchrony group. It will be appreciated that the playback time and encoding/compression methodology will be referred in the header **55**(**100**) that is associated with the frame **51**(**100**). It will also be appreciated that the header may also contain additional information as described above.

Similarly, line (A**1**.**3**) of packet **57** represents the one-hundred and first frame, that is, frame **51**(**101**), of the track whose audio information is being transmitted in the sequence of packets that includes packet **57**. The frame **51**(**101**) is to be played at an illustrative time, according to the audio information channel device's digital to analog converter clock, of "0:00:02," and the frame is also encoded and/or compressed using the MP3 encoding and compression methodology. Line (A**1**.**4**) of packet **57** represents similar information, although it will be appreciated that, depending on the length of packet **57**, the line may not represent the information for an entire frame **51**(**102**) and/or its associated header. If the length of packet **57** is not sufficient to accommodate the information for the entire frame **51**(**102**) and/or associated header, the information will continue in packet **58**, as represented by line (A**2**.**1**) in Packet Sequence A. Similarly, if the length of packet **56** was not sufficient to contain the information for an entire frame **51**(**99**) preceding frame **51**(**100**), packet **57** (lines (A**1**.**0**) through **1**.**4**) may contain any information from frame **51**(**99**) that packet **56** was unable to accommodate.

As noted above, when the master device **21** or a slave device **22**(*g*) in the synchrony group **20** receives the packet **57**, its respective network communications manager **40** will update the time stamps associated with the various frames **51**(*f*) as described above before buffering the respective frames in the respective audio information buffer **31**.

Packets **58** and **59** contain information that is organized along the lines described above in connection with packet **57**.

Packet **60** also contains, as represented by lines (A**4**.**1**) and (A**4**.**2**), information that is organized along the lines of the information represented by lines (Ax.**1**) and (Ax.**2**) ("x" equals an integer) described above in connection with packets **57** through **59**. On the other hand, packet **60** contains a resynchronize command, as represented by line (A**4**.**3**). Packet **60** also may contain padding, as represented by line **4**.**4**, following the resynchronize command. As noted above, the master device **21** of a synchrony group **20** will enable the audio information channel device **23** that is providing audio information to the synchrony group **20** to multi-cast a message containing the resynchronize command when it receives notification from the user interface module **13** that the user wishes to cancel playback of a track that is currently being played. In the example depicted in Packet Sequence A, as will be described below, the audio information channel device **23** receives notification from the master device **21** that the user wishes to cancel playback of a track at a time corresponding to "time=0:00:07" according to its digital to analog converter clock **34**, and, in line (A**4**.**3**) of packet **60** it will provide the resynchronize command, followed by padding, if necessary.

As will be apparent from examining lines (A**3**.**1**) through (A**3**.**4**) of packet **59** and lines (A**4**.**1**) and (A**4**.**2**) of packet **60**, although the audio information channel device **23** has received the notification from the synchrony group's master

device **21** to multi-cast the resynchronize command at a time corresponding to "time=0:00:07" according to the clock time indicated by its digital to analog converter clock **34**, it (that is, the audio information channel device **23**) has already multi-cast messages containing frames that are to be played at that time and subsequently. That is, the audio information channel device **23** has, multi-cast in packet **59**, frames **51**(**106**) through **51**(**108**) that contain time stamps "time=0:00:07," "time=0:00:08" and "time=0:00:09," respectively, and, in packet **60**, in addition to the continuation of frame **51**(**108**), frame **51**(**109**) that contains time stamp "time=0:00:10." (It will be appreciated that the times indicated by the illustrative time stamps are for illustration purposes only, and that in an actual embodiment the time stamps may have different values and differentials.)

As noted above, the audio information channel device **23** multi-casts a message containing a packet that, in turn, contains the resynchronize command when it receives the notification from the master device **21** to do so. In the example depicted in Packet Sequence A, the packet will be multi-cast when the audio information channel device's digital to analog converter clock time corresponds to "0:00:07." Subsequently, two things happen. In one, aspect, when the master device **21** and slave devices **22**(*g*) receive the packet that contains the resynchronize command, they will stop playing the audio program that they are playing.

In addition, the audio information channel device **23** will begin transmitting frames containing audio information for the next track, including therewith time stamps immediately following the digital to analog converter clock time at which the packet including the resynchronize command was transmitted. Accordingly, and with further reference to Packet Sequence A, the audio information channel device **23** will multi-cast a message containing packet **61**. As indicated above, packet **61** contains, as represented in lines (A**5**.**1**) through (A**5**.**3**), frames **51**(**1**) through **51**(**3**), which are the first three frames of the next track of the audio program that is to be played. It is also compressed and encoded using the MP3 encoding and compression scheme, and it is accompanied by time stamps "time=0:00:07," "time=0:00:08" and "time=0:00:10." As noted above, the time stamp "time=0:00:07" corresponds to the clock time at which the audio information channel device **23** multi-casts the resynchronize command, and, when the master device **21** and slave devices **22**(*g*) receive these frames, they would be expected to begin playing them very shortly, if not immediately after the audio information channel device **23** multi-casts the message containing the packet that, in turn, contains the resynchronize command. Packet **61** also includes at least a portion of the next frame, that is, frame **51**(**4**), for that track. In addition, Packet Sequence A depicted above further includes a subsequent packet, namely, packet **62**, that contains any necessary continuation of frame **51**(**4**), as well as three subsequent frames. If any additional packets are required for the track, as well as for subsequent tracks, they can be multi-cast in a similar manner.

As further noted above, the resynchronize command can also be used to cancel playing of one or more tracks for which playback has begun. This will be illustrated in connection with Packet Sequence B:

Packet Sequence B
(B**1**.**0**) [packet **157**]
(B**1**.**1**) [continuation of frame **99**]
(B**1**.**2**) [frame **100**, time=0:00:01, type=mp3 audio]
(B**1**.**3**) [frame **101**, time=0:00:02, type=mp3 audio]
(B**1**.**4**) [frame **102**, time=0:00:03, type=mp3 audio]
(B**2**.**0**) [packet **158**]
(B**2**.**1**) [continuation of frame **102**]
(B**2**.**2**) [frame **103**, time=0:00:04, type=mp3 audio]
(B**2**.**3**) [frame **104**, time=0:00:05, type=mp3 audio]
(B**2**.**4**) [frame **105**, time=0:00:06, type=mp3 audio]
(B**3**.**0**) [packet **159**]
(B**3**.**1**) [continuation of frame **105**]
(B**3**.**2**) [frame **106**, time=0:00:07, type=mp3 audio]
(B**3**.**3**) [track boundary notification]
(B**3**.**4**) [Padding, if necessary]
(B**4**.**0**) [packet **160**]
(B**4**.**1**) [frame **1**, time=0:00:08, type=mp3 audio]
(B**4**.**2**) [frame **2**, time=0:00:09, type=mp3 audio]
(B**4**.**3**) [frame **3**, time=0:00:10, type=mp3 audio]
(B**5**.**0**) [packet **161**]
(B**5**.**1**) [continuation of frame **3**]
(B**5**.**2**) [frame **4**, time=0:00:11, type=mp3 audio]
(B**5**.**3**) [Resynchronize, after packet **159**]
(B**5**.**4**) [Padding, if necessary]
(B**6**.**0**) [packet **162**]
(B**6**.**1**) [frame **1**, time=0:00:08, type=mp3 audio]
(B**6**.**2**) [frame **2**, time=0:00:09, type=mp3 audio]
(B**6**.**3**) [frame **3**, time=0:00:10, type=mp3 audio]
(B**6**.**4**) [frame **4**, time=0:00:11, type=mp3 audio]
(B**7**.**0**) [packet **163**]
(B**7**.**1**) [continuation of frame **4**]
(B**7**.**2**) [frame **5**, time=0:00:12, type=mp3 audio]
(B**7**.**3**) [frame **6**, time=0:00:13, type=mp3 audio]
(B**7**.**4**) [frame **7**, time=0:00:14, type=mp3 audio]

Packet Sequence B comprises a series of seven packets, identified by packet **157** through **163**, that the audio information channel device **23** multi-casts to the members of a synchrony group **20**. As with Packet Sequence A, it will be appreciated that the series of packets that the audio information channel device **23** may multi-cast to the synchrony group **20** may include packets prior to the packet **157**, and may also include packets after packet **162**. Each packet comprises a packet header, which is symbolized by lines (B**1**.**0**), (B**2**.**0**), . . . (B**7**.**0**) in Packet Sequence B. As in Packet Sequence A, each packet will also generally include information associated with at least a portion of a frame **51**(*f*) along with its associated frame **55**(*f*). As in the packets represented in Packet Sequence A, each packet includes information associated with a plurality of frames. Depending on the lengths of the packets, each packet may contain information associated with a portion of a frame, an entire frame, or multiple frames. Further, as with Packet Sequence A, it is assumed that each packet may contain information associated with multiple frames. In addition, it is assumed that a packet does not necessarily contain information associated with an integral number of frames; in that case, a packet may contain information associated with a portion of a frame, and the next packet will contain the information associated with the rest of a frame.

The structures of the packets represented by Packet Sequence B are similar to those described above in connection with Packet Sequence A, and will not be repeated here. Generally, Packet Sequence B illustratively contains a sequence of packets that represent at least portions of three tracks that may have been selected from, for example, a play list. In particular, packets **157** through **159** represent frames from a portion of one track, packets **160** and **161** represent frames from a second track and packets **162** and **163** represent frames from a third track. The play list indicated that the first, second and third tracks were to be played in that order. With particular reference to Packet Sequence B, it should be noted that line (B**3**.**3**) indicates that packet **159** includes an indication that that packet contains the last frame for the track, and

line (B3.4) provides for padding to the end of the packet. The first frame of the next track begins in packet **160**.

In connection with the use of the resynchronize command to cancel playback of a track, at least a portion of which the audio information channel device **23** has multi-cast to the members of the synchrony group, packet **161**, in line (B5.3) represents a resynchronize command that indicates that resynchronization is to occur after packet **159**, that is, immediately after the packet that contains the last frame of the first of the three tracks represented by the packets in Packet Sequence B. It should be noted that the resynchronize command is in the packet **161**, while the resynchronization is to occur at packet **160**, that is, the synchrony group is to not play the track starting with packet **160**, but instead is to begin playing the track frames for which begin with the next packet, that is, packet **162**. As with Packet Sequence A, in Packet Sequence B the audio information channel device **23**, in packet **162** and **163**, multi-casts frames whose time stamps indicate that they are to be played when the frames that were multi-cast in packets **160** and **161** were to be played. By use of the resynchronize command and specifying a packet in this manner, the audio information channel device can cancel playback of a track for which playback has not yet begun.

It will be appreciated that the resynchronize command is generally not necessary for cancelling play back of a track that the audio information channel device **23** has not started multi-casting to the synchrony group **20**, since the audio information channel device **23** itself can re-order the play list to accommodate the cancellation.

The invention provides a number of advantages. In particular, the invention provides a network audio system in which a number of devices share information can reproduce audio information synchronously, notwithstanding the fact that packets, which may contain digital audio information, transmitted over the network to the various zone players connected thereto may have differing delays and the zone players operate with independent clocks. Moreover, although the invention has been described in connection with audio information, it will be appreciated that the invention will find utility in connection with any type of isochronous information for which synchrony among devices is desired. The system is such that synchrony groups are created and destroyed dynamically, and in such a manner as to avoid requiring a dedicated device as the master device.

It will be appreciated that a number of changes and modifications may be made to the network audio system **10** as described above. For example, although the invention has been described as providing that the audio information channel device **23** provides digital audio information to the members synchrony group **20** that has been encoded using particular types of encoding and compression methodologies, it will be appreciated that the audio information channel device **23** can provide digital audio information to various members of the synchrony group **20** that have been encoded and compressed using different types of encoding and compression methodologies, and, moreover, for which different sampling rates have been used. For example, the audio information channel device **23** may provide digital audio information to the master device **21** and slave devices **22**(**1**) through **22**(g_1) using the MP3 methodology at a specified sampling rate, the digital audio information for the same program to slave devices **22**(g_1+1) through **22**(g_2) using the WAV methodology at one specified sampling rate, and to slave devices **22**(g_2+1) through **22**(G) using the WAV methodology at another specified sampling rate. In that case, the audio information channel device **23** can specify the particular encoding and compression methodology that has been used in the encoding type field **57** associated with each frame and the sampling rate in the sampling rate field **58**. Moreover, since the encoding and compression type and sampling rate are specified for each frame, the encoding and compression type and sampling rate can be changed from frame to frame. The audio information channel device **23** may use different multicast addresses for the different encoding and compression types and sampling rates, but it will be appreciated that that would not be required.

It will be appreciated that two advantages of providing that the encoding and compression methodology and the sampling rate is provided on a frame-by-frame basis, instead of on, for example, a track-by-track basis, is that that would facilitate a slave device joining the synchrony group **20** at a frame mid-track, without requiring, for example, the master device **21** or the audio information channel device **23** to notify it of the encoding and compression methodology or the sampling rate.

Another modification is that, instead of the network communications manager **40** of a member of a synchrony group **20** generating the updated time stamp T^{u}_{F} for a digital audio information frame by adding the time differential value ΔT to the time stamp T_F associated with a frame, the network communications manager **40** may instead generate the updated time stamp T^{U}_{F} by subtracting the differential time value ΔT from the member's current time T_S as indicated by the member's digital to analog converter clock **34** at the time at which the digital audio information is received. It will be appreciated, however, that there may be variable time delays in processing of messages by the slave device's network communications manager **40**, and so it may be preferable to generate the time differential value ΔT using the time stamp T_F provided by the audio information channel device **23**.

In addition, instead of the network communications manager **40** of a member of a synchrony group generating an updated time stamp to reflect the difference between the times indicated by the member's digital to analog converter clock and the audio information channel device's digital to analog converter clock, the network communications manager **40** can generate the time differential value ΔT and provide it to the member's playback scheduler **32**. In that case, the member's network communications manager **40** can store each digital audio information frame along with the time stamp T_F as received from the master device in the audio information buffer **21**. The playback scheduler **32** can utilize the time differential value ΔT, and the time stamps T_F associated with the digital audio information frames, to determine when the respective digital audio information frames are to be played. In determining when a digital audio information frame is to be played, the playback scheduler can add the time differential value to the time stamp T_F associated with the digital audio frame, and enable the digital audio frame to be coupled to the digital to analog converter **33** when the time indicated by the sum corresponds to the current time as indicated by the slave device's digital to analog converter clock **34**. Alternatively, when the member's digital to analog converter clock **34** updates its current time T_S, the playback scheduler can generate an updated current time T'_S by subtracting the differential time value ΔT from the current time T_S, and using the updated current time T'_S to determine when to play a digital audio information frame.

As described above, the members of a synchrony group **20** periodically obtain the audio information channel device's current time value and uses the current time value that it receives from the audio information channel device to periodically update the time differential value ΔT that it uses in updating the time stamps associated with the various frames.

It will be appreciated that, if the digital to analog converter clock(s) associated with the member(s) of a synchrony group **20** are ensured to have the same rate as the digital to analog converter clock, a member need only obtain the current time value from the audio information channel device once, at the beginning of playback.

As another alternative, if the zone players are provided with digital to analog converter clock **34** whose time and rate can be set by an element such as the network communications manager **40**, when a zone player **11**(*n*) is operating as a member of a synchrony group **20**, its network communications manager **40** can use the various types of timing information that it receives from the audio information channel device **23**, including the current time information and the playback timing information indicated by the time stamps that are associated with the various frames **51**(*f*) comprising the audio and playback timing information that it receives, to adjust the synchrony group member's digital to analog converter clock's time value and/or the clock rate that it uses for playback. If the clock's time value is to be adjusted, when the synchrony group member's network communications manager **40** initially receives the current time information from the audio information channel device **23** for the synchrony group **20**, the network communications manager **40** can set the synchrony group member's digital to analog converter clock **34** to the current time value as indicated by the audio information channel device's current time information. The network communications manager **40** can set the clock **34** to the current time value indicated by the audio information channel device's current time information once, or periodically as it receives the current time information.

Alternatively or in addition, the synchrony group member's network communications manager **40** can use one or both of the current time information and/or the playback timing information in the time stamps associated with the respective frames **51**(*f*) to adjust the clock rate of the clock **34** that it uses for playback. For example, when the synchrony group member's network communications manager **40** receives a frame **51**(f_X) having a time stamp having a time value T_{f_X}, it can generate the updated time value $T^{U}_{f_X}=T_{f_X}+\Delta T$ as described above, and store the frame with the time stamp with the updated time value in the audio information buffer **30**. In addition, since both the number of samples in a frame and the sampling rate, which determines the rate at which the frame is to be played, are known to the network communications manager **40**, it can use that information, along with the updated time value $T^{U}_{F_X}$ that is to be used for frame **51**(f_X) to generate an expected updated time value $T^{E}_{f_{X+1}}$ that is expected for the updated time stamp of the next frame **51**(f_{X+1}). After the synchrony group member's network communications manager **40** receives the next frame **51**(f_{X+1}), it can generate the updated time value $T^{U}_{f_{X+1}}$ and compare that value to the expected updated time value $T^{E}_{f_{X+1}}$. If the two time values do not correspond, or if the difference between them is above a selected threshold level, the clock that is used by the audio information channel device **23** to generate the time stamps is advancing at a different rate than the synchrony group member's digital to analog converter clock **34**, and so the network communications manager **40** can adjust the rate of the digital to analog converter clock **34** to approach that of the clock used by the audio information channel device **23** so that the differential time value ΔT is constant. On the other hand, if the two time values do correspond, then the time differential value ΔT is constant, or the difference is below a threshold level, and the network communications manager **40** need not change the clock rate of the digital to analog converter clock **34**. It will be appreciated that, if the clock rate is to be adjusted, the rate adjustment can be fixed, or it can vary based on; for example, the difference between the updated time value $T^{U}_{f_{X+1}}$ and the expected updated time value $T^{E}_{f_{X+1}}$.

It will also be appreciated that, if no rate adjustment is performed for one frame **51**(f_{X+1}), the synchrony group member's network communications manager **40** can generate an expected updated time value $T^{E}_{f_{X+2}}$ that is expected for the updated time stamp of the next frame **51**(f_{X+2}) using the updated time value $T^{U}_{F_X}$ determined for frame **51**(f_X), along with the number of samples in a frame and the sampling rate, and compare the expected updated time value $T^{E}_{f_{X+2}}$ to the updated time value $T^{U}_{f_{X+2}}$ that it generates when it receives frame **51**(f_{X+2}). At that point, if the network communications manager **41** determines that two time values do not correspond, or if the difference between them is above a selected threshold level, it can adjust the rate of the digital to analog converter clock **34**. Similar operations can be performed if no rate adjustment is performed for several successive frames **51**(f_{X+1}), **51**(f_{X+2}), ... This will accommodate the possibility that the rate differential between the clock **34** and the clock used by the audio information channel device **23** in generating the time stamps have rates that differ by an amount sufficiently small that it cannot be detected using time stamps of two or more successive frames.

Instead or in addition to adjusting the clock rate as described above, the synchrony group member's network communications manager **40** can perform similar operations in connection with adjusting the clock rate in connection with the current time information that it receives from the audio information channel device **23**.

Furthermore, although the network audio system **10** has been described such that the master device **21** of a synchrony group **20** can, in response to control information provided thereto by a user through the user interface module **13**, provide a notification to a zone player **11**(*n*) that it is to become a member of its synchrony group **20** as a slave device **22**(*g*), it will be appreciated that the user interface module **13** can provide the notification directly to the zone player **11**(*n*) that is to become a member of the synchrony group **20**. In that case, the zone player **11**(*n*) can notify the master device **21** that it is to become a slave device **22**(*g*) in the synchrony group **20**, after which the master device **21** can provide information regarding the synchrony group **20**, including the multi-cast and unicast addresses of the audio information channel device and other information as described above.

Similarly, although the network audio system **10** has been described such that the master device **21** of a synchrony group **20** can, in response to control information provided thereto by a user through the user interface module **13**, provide a command to a slave device **22**(*g*) to enable the slave device **22**(*g*) to adjust its volume, it will be appreciated that the user interface module **13** can provide control information directly to the slave device **22**(*g*) to enable the slave device **22**(*g*) to adjust its volume.

In addition, although the network audio system **10** has been described such that each frames **51**(*f*) is associated with a frame sequence number (reference field **56**, FIG. **4**), it will be appreciated that, if the packets described above in connection with Packet Sequence A and Packet Sequence B are provided with packet sequence numbers, the frame sequence numbers need not be provided, since the packet sequence numbers can suffice for defining the frame sequencing.

Furthermore, although the network audio system **10** has been described such that the zone players **11**(*n*) are provided with an audio amplifier **35** for amplifying the analog signal provided by the respective digital to analog converters **33**, it will be appreciated that a zone player may be provided that

does not itself include an audio amplifier. In that case, the analog signal may be coupled to an external amplifier for amplification as necessary before being provided to the audio reproduction device(s) **15**(*n*)(*r*). It will be appreciated that a single zone player **11**(*n*) may be provided with multiple audio amplifiers and audio reproduction device interfaces, and, if necessary, multiple digital to analog converters **33**, to provide audio programs for corresponding numbers of synchrony groups.

Similarly, although the zone players **11**(*n*) have been described such that they may be connected to one or more audio information sources, it will be appreciated that an audio information source may form part of and be integrated into a zone player **11**(*n*). For example, a zone player may include a compact disk player, cassette tape player, broadcast radio receiver, or the like, that has been integrated into it. In addition, as noted above, an individual zone player **11**(*n*) may be connected to multiple audio information sources and may contemporaneously operate as the audio information channel device **23** for multiple synchrony groups.

In addition, although FIG. **1** shows the network audio system **10** as including one user interface module **13**, it will be appreciated that the system **10** may include a plurality of user interface modules. Each user interface module be useful for controlling all of the zone players as described above, or alternatively one or more of the user interface modules may be useful for controlling selected subsets of the zone players.

Moreover, it will be appreciated that, although the invention has been described in connection with audio information, it will be appreciated that the invention will find utility in connection with any type of information for which synchrony among devices connected to a network is desired.

As noted above, while a zone player **11**(*n*) is operating as audio information channel device **23** for a synchrony group **20**, when the zone player **11**(*n*)'s audio information source interface **30** or network communications manager **40** stores digital audio information frames based on audio information from an audio information source **14**(*n*)(*s*) in the audio information buffer **31**, it will provide time stamps for the respective frames to schedule them for playback after some time delay after they have been buffered in the audio information buffer **31**. The delay is provided so that, for other zone players **11**(*n*'), **11**(*n*"), . . . that are operating as members of a synchrony group, there will be sufficient time for the audio and playback timing information to be transferred over the network **12** to those other zone players **11**(*n*'), **11**(*n*"), . . . so that it can be processed and played by them at the appropriate time as described above. The time period that is selected for the time delay may be fixed or variable, and in either case may be based on a number of factors. If the time period selected for the time delay is fixed, it may be based on, for example, factors such as an estimate of the maximum latency in the network **12**, the estimated maximum loading of the various components comprising the zone players **11**(*n*), and other estimates as will be appreciated by those skilled in the art.

The time delay may be the same for audio information from all types of audio information sources, and may be constant over the entire period that the synchrony group **20** is playing an audio work. Alternatively, different time delays may be utilized based on various criteria. For example, if the audio information is to be played independently of information associated with other types of media, the time delay may be selected to be relatively long, on the order of a significant fraction of a second, or longer. On the other hand, if the audio information is to be played contemporaneously with, for example, video information, which may be supplied by, for example, a video disk, video tape cassette, over cable, satellite, or broadcast television, which may not be buffered or which may be displayed independently of the network audio system **10**, it may be undesirable to provide for such a lengthy delay, since the time delay of the audio playback, in relation to the video display, may be noticeable. In that case, the zone player **11**(*n*) may provide for a much shorter time delay. In one embodiment, the time delay provided for audio information to be played concurrently with video information is selected to be generally on the order of fifty milliseconds, which would barely, if at all, be perceptible to someone viewing the video. Other desirable time delays for information from other types of sources will be apparent to those skilled in the art.

As yet a further possibility, the zone player **11**(*n*), when operating as an audio information channel device **23** for a synchrony group **20**, can dynamically determine the time delay based on a number of conditions in the network audio system **10**, including, for example, the message transfer latency in network **12**, the loading of microprocessors or other components that are used in the various zone players **11**(*n*'), **11**(*n*"), . . . that may comprise a synchrony group **20**, as well as other factors. For example, if the audio information channel device **23** determines that the latency in the network **12** has increased beyond a selected threshold, the audio information channel device **23** can adjust the delay to increase the likelihood that the members of the synchrony group **20** will be able to receive the packets and process the frames so that they will be able to play them at the appropriate times. Similarly, if the audio information channel device **23** is notified that a member of the synchrony group **20** to which it provides audio information requires additional time to receive and process the frames that it transmits, the audio information channel device **23** can adjust the delay accordingly. It will be appreciated that, to reduce or minimize possible discontinuities in the audio playback by the members of the synchrony group, the audio information channel device **23** can, instead of adjusting the time delay during a particular audio track, adjust the time delay between tracks, during silent periods of a track or otherwise as will be appreciated by those skilled in the art. In addition, the audio information channel device **23** can use conventional audio compression methodologies to facilitate a speeding up and/or slowing down of playback of an audio track while it is in the process of providing additional time delay. Generally, the members of the synchrony group **20** can provide notifications to the audio information channel device **23** if they determine that they will need an additional time delay, and the audio information channel device **23** can adjust the time delay in accordance with the notifications from the members of the synchrony group **20**.

It will be appreciated that a system in accordance with the invention can be constructed in whole or in part from special purpose hardware or a general purpose computer system, or any combination thereof, any portion of which may be controlled by a suitable program. Any program may in whole or in part comprise part of or be stored on the system in a conventional manner, or it may in whole or in part be provided in to the system over a network or other mechanism for transferring information in a conventional manner. In addition, it will be appreciated that the system may be operated and/or otherwise controlled by means of information provided by an operator using operator input elements (not shown) which may be connected directly to the system or which may transfer the information to the system over a network or other mechanism for transferring information in a conventional manner.

The foregoing description has been limited to a specific embodiment of this invention. It will be apparent, however,

that various variations and modifications may be made to the invention, with the attainment of some or all of the advantages of the invention. It is the object of the appended claims to cover these and such other variations and modifications as come within the true spirit and scope of the invention.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A method comprising:

receiving, by a first playback device from a network device configured to control the first playback device and communicatively coupled to the first playback device over a local area network (LAN), control information comprising an address identifying a location of audio information available at an audio information source, wherein the audio information source is outside of the LAN; and

after receiving the control information (i) obtaining, by the first playback device from the audio information source outside of the LAN, the audio information; (ii) transmitting, by the first playback device to a second playback device, the audio information, playback timing information associated with the audio information, and device clock information of the first playback device; and (iii) playing back, by the first playback device, the audio information in synchrony with the second playback device by using the playback timing information associated with the audio information and the device clock information of the first playback device to play back the audio information, wherein the first and second playback devices remain independently clocked during synchronous playback of the audio information.

2. The method of claim **1**, further comprising:

after receiving the control information, additionally (i) generating, by the first playback device, the playback timing information associated with the audio information; and (ii) generating, by the first playback device, the device clock information of the first playback device.

3. The method of claim **1**, wherein the control information further comprises one or more instructions for the first playback device and the second playback device to playback audio information.

4. The method of claim **3**, wherein the first and second playback devices are members of a synchrony group, and wherein the method further comprises:

transmitting, by the first playback device to the network device, status information that comprises a status of the synchrony group.

5. The method of claim **4**, wherein the status information further comprises an identification of each playback device in the synchrony group.

6. The method of claim **5**, wherein the status information further comprises an identification of a master playback device of the synchrony group.

7. The method of claim **6**, wherein the first playback device is the master playback device of the synchrony group.

8. A tangible non-transitory computer-readable medium having instructions stored thereon that, when executed, cause a first playback device to:

receive, from a network device configured to control the first playback device and communicatively coupled to the first playback device over a local area network (LAN), control information comprising an address identifying a location of audio information available at an audio information source, wherein the audio information source is outside of the LAN; and

after receiving the control information, (i) obtain, from the audio information source outside of the LAN, the audio information; (ii) transmit, to a second playback device, the audio information, playback timing information associated with the audio information, and clock time information for the first playback device; and (iii) play back the audio information in synchrony with the second playback device by using the playback timing information associated with the audio information and the clock time information of the first playback device to play back the audio information, wherein the first and second playback devices remain independently clocked during synchronous playback of the audio information.

9. A first playback device comprising:

one or more processors;

a network interface; and

tangible, non-transitory computer-readable memory comprising program instructions that, when executed by the one or more processors, cause the first playback device to:

receive, via the network interface from a network device configured to control the first playback device and communicatively coupled to the first playback device over a local area network (LAN), control information comprising an address identifying a network location of audio information available at an audio information source, wherein the audio information source is outside of the LAN; and

after receiving the control information, (i) obtain, via the network interface from the audio information source outside of the LAN, the audio information; (ii) transmit, via the network interface of the first playback device to a second playback device, the audio information, playback timing information associated with the audio information, and device clock information of the first playback device; and (iii) play back the audio information in synchrony with the second playback device by using the playback timing information associated with the audio information and the device clock information of the first playback device to play back the audio information, wherein the first and second playback devices remain independently clocked during synchronous playback of the audio information.

10. The first playback device of claim **9**, wherein the program instructions, when executed by the one or more processors, further cause the first playback device to:

generate the playback timing information associated with the audio information; and

generate the device clock information of the first playback device.

11. The first playback device of claim **9**, wherein the control information further comprises one or more instructions for the first playback device and the second playback device to playback audio information.

12. The first playback device of claim **11**, wherein the first and second playback devices are members of a synchrony group, and wherein the program instructions, when executed by the one or more processors, further cause the first playback device to:

transmit, to the network device, status information that comprises a status of the synchrony group.

13. The first playback device of claim **12**, wherein the status information further comprises an identification of each playback device in the synchrony group.

14. The first playback device of claim **12**, wherein the status information further comprises an identification of a master playback device of the synchrony group.

15. The first playback device of claim 14, wherein the first playback device is the master playback device of the synchrony group.

16. The first playback device of claim 12, wherein the status information further comprises an identification of one or more slave playback devices in the synchrony group, and wherein the second playback device is one of the one or more slave playback devices in the synchrony group.

17. The first playback device of claim 16, wherein the instructions, when executed by the one or more processors, further cause the first playback device to:

generate a plurality of frames, wherein an individual frame comprises at least a portion of the audio information and the playback timing information associated with the audio information, and wherein the first playback device transmitting to the second playback device the audio information, playback timing information, and device clock information of the first playback device comprises transmitting the plurality of frames to the second playback device.

18. The first playback device of claim 9, wherein the audio information comprises one of audio files or packetized streaming audio information.

19. The first playback device of claim 9, wherein the audio information source outside of the LAN is an Internet-accessible audio information source, and wherein obtaining, from the audio information source outside of the LAN, the audio information, comprises obtaining the audio information from the Internet-accessible audio information source.

20. The first playback device of claim 9, wherein obtaining, from the audio information source outside of the LAN, the audio information, comprises sending, to the audio information source, a request for the audio information.

* * * * *

PTO/SB/57 (09-16)
Approved for use through 09/30/2018. OMB 0651-0064
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

(Also referred to as FORM PTO-1465)

REQUEST FOR *EX PARTE* REEXAMINATION TRANSMITTAL FORM

Address to:
Mail Stop *Ex Parte* Reexam
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Attorney Docket No.: 131131.00049.005

Date: May 22, 2017

1. ☑ This is a request for *ex parte* reexamination pursuant to 37 CFR 1.510 of patent number 9,213,357 issued December 15, 2015. The request is made by:
   ☐ patent owner. ☑ third party requester.
2. ☑ The name and address of the person requesting reexamination is:
   Christopher J. Rourk, Reg. No. 39,348
   2323 Ross Avenue, Suite 600
   Dallas, TX 75201
3. Requester asserts ☐ small entity status (37 CFR 1.27) or ☐ certifies micro entity status (37 CFR 1.29). Only a patent owner requester can certify micro entity status. Form PTO/SB/15A or B must be attached to certify micro entity status.
4. ☐ a. A check in the amount of $_____ is enclosed to cover the reexamination fee, 37 CFR 1.20(c)(1);
   ☑ b. The Director is hereby authorized to charge the fee as set forth in 37 CFR 1.20(c)(1) to Deposit Account No. 10-0096;
   ☐ c. Payment by credit card. Form PTO-2038 is attached; **or**
   ☑ d. Payment made via EFS-Web.
5. ☑ Any refund should be made by ☐ check or ☑ credit to Deposit Account No. 10-0096. 37 CFR 1.26(c). If payment is made by credit card, refund must be to credit card account.
6. ☑ A copy of the patent to be reexamined having a double column format on one side of a separate paper is enclosed. 37 CFR 1.510(b)(4).
7. ☐ CD-ROM or CD-R in duplicate, Computer Program (Appendix) or large table
   ☐ Landscape Table on CD
8. ☐ Nucleotide and/or Amino Acid Sequence Submission
   If applicable, items a. – c. are required.
   a. ☐ Computer Readable Form (CRF)
   b. Specification Sequence Listing on:
      i. ☐ CD-ROM (2 copies) or CD-R (2 copies); **or**
      ii. ☐ paper
   c. ☐ Statements verifying identity of above copies
9. ☐ A copy of any disclaimer, certificate of correction or reexamination certificate issued in the patent is included.
10. ☑ Reexamination of claim(s) 9, 10, 12 and 19 is requested.
11. ☑ A copy of every patent or printed publication relied upon is submitted herewith including a listing thereof on Form PTO/SB/08, PTO-1449, or equivalent.
12. ☐ An English language translation of all necessary and pertinent non-English language patents and/or printed publications is included.

This collection of information is required by 37 CFR 1.510. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) a request for reexamination. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 18 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Mail Stop *Ex Parte* Reexam, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**
If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

13. ☑ The attached detailed request includes at least the following items:

a. A statement identifying each substantial new question of patentability based on prior patents and printed publications. 37 CFR 1.510(b)(1).

b. An identification of every claim for which reexamination is requested, and a detailed explanation of the pertinency and manner of applying the cited art to every claim for which reexamination is requested. 37 CFR 1.510(b)(2).

14. ☐ A proposed amendment is included (only where the patent owner is the requester). 37 CFR 1.510(e).

15. ☑ It is certified that the statutory estoppel provisions of 35 U.S.C. 315(e)(1) or 35 U.S.C. 325(e)(1) do not prohibit requester from filing this *ex parte* reexamination request. 37 CFR 1.510(b)(6).

16. ☑ a. It is certified that a copy of this request (if filed by other than the patent owner) has been served in its entirety on the patent owner as provided in 37 CFR 1.33(c).

The name and address of the party served and the date of service are:

McDonnell Boehnen Hulbert & Berghoff LLP

Sonos, Inc. , 300 South Wacker Drive, Chicago IL 60606

Date of Service: December 21, 2016; **or**

☐ b. A duplicate copy is enclosed since service on patent owner was not possible. An explanation of the efforts made to serve patent owner **is attached**. See MPEP 2220.

17. Correspondence Address: Direct all communication about the reexamination to:

☑ The address associated with Customer Number: 33649

OR

☐ Firm or Individual Name _____

Address

City	State	Zip
Country		
Telephone	Email	

18. ☑ The patent is currently the subject of the following concurrent proceeding(s):

☐ a. Copending reissue Application No. _____

☐ b. Copending reexamination Control No. _____

☐ c. Copending Interference No. _____

☑ d. Copending litigation styled:

Sonos Inc. v. D&M Holdings, Inc., United States District Court, District of Delaware,

C.A. NO. 14-1330(RGA)

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

/Christopher J. Rourk/ — Authorized Signature

May 22, 2017 — Date

Christopher J. Rourk — Typed/Printed Name

39,348 — Registration No.

☐ For Patent Owner Requester

☑ For Third Party Requester

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Doc Code: IDS
Document Description: Information Disclosure Statement filed

PTO/SB/42 (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U. S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

37 CFR 1.501 INFORMATION DISCLOSURE CITATION IN A PATENT (Sheet 1 of 2)	Docket Number (Optional) 131131.00049.005	Patent Number 9,213,357
	Applicant Sonos, Inc.	
	Issue Date December 15, 2015	Art Unit 2442

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
	9,213,357	2015/1	Millington			
	9,195,258	2015/1	Millington			
	6,611,537	2003/8	Edens et al.			
	2004/0252400	2004/1	Blank et al.			
	2002/0150053	2002/1	Gray, III et al.			
	2003/0073432	2003/0	Meade, II.			
	2007/0142944	2007/6	Goldberg et al.			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc.)

		Potter Anderson & Corroon LLP, First set of interrogatories(Nos. 1-11) to plaintiff, 10/10/2016
		Microsoft Corporation, File and Printer Sharing with Microsoft Windows, 11/2003
		Symantec, Symantec pcAnywhere User's Guide, 1/15/2002
		MILLS, Network Time Protocol (Version 3) Specification, Implementation and Analysis, 3/1992
		TimeLine Vista, Inc., Time coder Tutor, 1996
		FRIES et al., MP3 and Internet Audio Handbook, 2000

EXAMINER	DATE CONSIDERED

This collection of information is required by 37 CFR 1.501. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Doc Code: IDS
Document Description: Information Disclosure Statement filed

PTO/SB/42 (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U. S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

37 CFR 1.501 INFORMATION DISCLOSURE CITATION IN A PATENT (Sheet 2 of 2)	Docket Number (Optional) 131131.00049.005	Patent Number 9,213,357
	Applicant Sonos, Inc.	
	Issue Date December 15, 2015	Art Unit 2442

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc.)

		Niederst, Web Design in a Nutshell, 9/2001
		Schulzrinne et al., Real Time Streaming Protocol (RTSP), 4/1998
		Schulzrinne et al., RTP: A Transport Protocol for Real-Time Applications. 1/1996
		Potter Anderson & Corroon LLP, Supplemental Opening Brief on Claims Construction, 3/3/2017

EXAMINER	DATE CONSIDERED

This collection of information is required by 37 CFR 1.501. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

US009213357B2

(12) **United States Patent**
Millington

(10) **Patent No.: US 9,213,357 B2**
(45) **Date of Patent: Dec. 15, 2015**

(54) **OBTAINING CONTENT FROM REMOTE SOURCE FOR PLAYBACK**

(71) Applicant: **Sonos, Inc.**, Santa Barbara, CA (US)

(72) Inventor: **Nicholas A. J. Millington**, Santa Barbara, CA (US)

(73) Assignee: **Sonos, Inc.**, Santa Barbara, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/516,867**

(22) Filed: **Oct. 17, 2014**

(65) **Prior Publication Data**

US 2015/0039109 A1 Feb. 5, 2015

Related U.S. Application Data

(63) Continuation of application No. 13/297,000, filed on Nov. 15, 2011, which is a continuation of application No. 10/816,217, filed on Apr. 1, 2004, now Pat. No. 8,234,395.

(60) Provisional application No. 60/490,768, filed on Jul. 28, 2003.

(51) **Int. Cl.**
G06F 15/16 (2006.01)
G06F 1/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***G06F 1/00*** (2013.01); ***G05B 15/02*** (2013.01); ***G06F 3/048*** (2013.01); ***G06F 3/0482*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC G06F 3/167; G06F 17/00; G06F 17/3074; G06F 3/048; G06F 3/0482; G06F 3/0484; G06F 3/126; G06F 3/16; H04L 65/60; H04L 12/2812
USPC 709/219, 220, 231
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,296,278 A 10/1981 Cullison et al.
4,816,989 A 3/1989 Finn et al.
(Continued)

FOREIGN PATENT DOCUMENTS

EP 0251584 A2 1/1988
EP 0672985 A1 9/1995
(Continued)

OTHER PUBLICATIONS

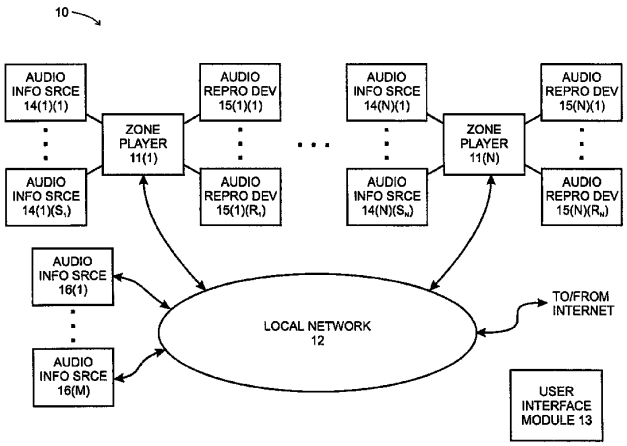
"Advisory Action mailed Sep. 18, 2008 for U.S. Appl. No. 10/816,217, filed Apr. 1, 2004, 8 pages".
(Continued)

Primary Examiner — Oleg Survillo
(74) *Attorney, Agent, or Firm* — McDonnell Boehnen Hulbert & Berghoff LLP

(57) **ABSTRACT**

Examples include a playback device with a network interface and memory with program instructions that, when executed by the processor, cause the playback device to (a) receive, via the network interface from a network device communicatively coupled to the playback device over a LAN, an address identifying a network location of audio information available at an audio information source, where the audio information source is outside of the LAN, (b) obtain, via the network interface from the audio information source, the audio information, (c) transmit, via the network interface to another playback device, the audio information, and (d) play back the audio information.

20 Claims, 5 Drawing Sheets



(51) **Int. Cl.**

H04J 3/06	(2006.01)
H04R 27/00	(2006.01)
G06F 17/00	(2006.01)
H03G 3/20	(2006.01)
H04L 29/06	(2006.01)
G06F 3/048	(2013.01)
G06F 3/16	(2006.01)
H04L 29/08	(2006.01)
G06F 3/0484	(2013.01)
H04R 3/12	(2006.01)
G06F 17/30	(2006.01)
G06F 3/0482	(2013.01)
H03G 3/00	(2006.01)
H04H 20/10	(2008.01)
H04H 20/26	(2008.01)
G05B 15/02	(2006.01)
G11B 20/10	(2006.01)
H04N 5/04	(2006.01)
H04N 9/79	(2006.01)
H04N 21/43	(2011.01)
H04N 21/436	(2011.01)

(52) **U.S. Cl.**

CPC ***G06F 3/0484*** (2013.01); ***G06F 3/16*** (2013.01); ***G06F 3/165*** (2013.01); ***G06F 3/167*** (2013.01); ***G06F 17/00*** (2013.01); ***G06F 17/3074*** (2013.01); ***G11B 20/10527*** (2013.01); ***H03G 3/00*** (2013.01); ***H03G 3/20*** (2013.01); ***H04H 20/103*** (2013.01); ***H04H 20/26*** (2013.01); ***H04J 3/0664*** (2013.01); ***H04L 65/60*** (2013.01); ***H04L 65/80*** (2013.01); ***H04L 67/1095*** (2013.01); ***H04L 67/26*** (2013.01); ***H04L 69/28*** (2013.01); ***H04N 5/04*** (2013.01); ***H04N 9/7904*** (2013.01); ***H04N 21/4307*** (2013.01); ***H04N 21/43615*** (2013.01); ***H04R 3/12*** (2013.01); ***H04R 27/00*** (2013.01); *G11B 2020/10592* (2013.01); *H04H 2201/20* (2013.01); *H04L 65/4076* (2013.01); *H04R 2227/003* (2013.01); *H04R 2227/005* (2013.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,153,579	A		10/1992	Fisch et al.
5,182,552	A		1/1993	Paynting
5,239,458	A		8/1993	Suzuki
5,299,266	A		3/1994	Lumsden
5,406,634	A		4/1995	Anderson et al.
5,440,644	A		8/1995	Farinelli et al.
5,467,342	A		11/1995	Logston et al.
5,491,839	A		2/1996	Schotz
5,553,222	A		9/1996	Milne et al.
5,602,992	A		2/1997	Danneels
5,668,884	A		9/1997	Clair, Jr. et al.
5,673,323	A		9/1997	Schotz et al.
5,696,896	A		12/1997	Badovinatz et al.
5,726,989	A	*	3/1998	Dokic 370/509
5,751,819	A		5/1998	Dorrough
5,761,320	A		6/1998	Farinelli et al.
5,787,249	A		7/1998	Badovinatz et al.
5,808,662	A		9/1998	Kinney et al.
5,815,689	A		9/1998	Shaw et al.
5,867,691	A		2/1999	Shiraishi
5,875,354	A		2/1999	Charlton et al.
5,887,143	A		3/1999	Saito et al.
5,923,869	A	*	7/1999	Kashiwagi et al. 713/501
5,923,902	A		7/1999	Inagaki
5,946,343	A		8/1999	Schotz et al.
5,956,088	A		9/1999	Shen et al.
6,009,457	A		12/1999	Moller
6,026,150	A		2/2000	Frank et al.
6,031,818	A		2/2000	Lo et al.
6,108,485	A		8/2000	Kim
6,108,686	A		8/2000	Williams, Jr.
6,122,668	A		9/2000	Teng et al.
6,128,318	A		10/2000	Sato
6,157,957	A		12/2000	Berthaud
6,175,872	B1		1/2001	Neumann et al.
6,185,737	B1		2/2001	Northcutt et al.
6,195,436	B1		2/2001	Scibora et al.
6,199,169	B1		3/2001	Voth
6,255,961	B1		7/2001	Van Ryzin et al.
6,256,554	B1		7/2001	DiLorenzo
6,308,207	B1		10/2001	Tseng et al.
6,324,586	B1		11/2001	Johnson
6,332,147	B1		12/2001	Moran et al.
6,343,028	B1		1/2002	Kuwaoka
6,349,339	B1		2/2002	Williams
6,351,821	B1		2/2002	Voth
6,404,811	B1		6/2002	Cvetko et al.
6,430,353	B1		8/2002	Honda et al.
6,449,653	B2		9/2002	Klemets et al.
6,487,296	B1		11/2002	Allen et al.
6,522,886	B1		2/2003	Youngs et al.
6,526,325	B1		2/2003	Sussman et al.
6,535,121	B2		3/2003	Matheny
6,587,127	B1		7/2003	Leeke et al.
6,598,172	B1		7/2003	VanDeusen et al.
6,611,537	B1		8/2003	Edens et al.
6,631,410	B1		10/2003	Kowalski et al.
6,674,803	B1		1/2004	Kesselring
6,687,664	B1	*	2/2004	Sussman et al. 704/201
6,757,517	B2		6/2004	Chang
6,778,493	B1		8/2004	Ishii
6,778,869	B2		8/2004	Champion
6,816,818	B2		11/2004	Wolf et al.
6,823,225	B1		11/2004	Sass
6,826,283	B1		11/2004	Wheeler et al.
6,836,788	B2		12/2004	Kim et al.
6,839,752	B1		1/2005	Miller et al.
6,898,642	B2		5/2005	Chafle et al.
6,907,458	B2		6/2005	Tomassetti et al.
6,912,610	B2		6/2005	Spencer
6,920,373	B2		7/2005	Xi et al.
6,934,766	B1		8/2005	Russell
6,970,482	B2		11/2005	Kim
6,985,694	B1		1/2006	De et al.
7,007,106	B1		2/2006	Flood et al.
7,020,791	B1		3/2006	Aweya et al.
7,043,651	B2		5/2006	Aweya et al.
7,047,308	B2		5/2006	Deshpande
7,068,596	B1		6/2006	Mou
7,113,999	B2		9/2006	Pestoni et al.
7,115,017	B1		10/2006	Laursen et al.
7,130,368	B1		10/2006	Aweya et al.
7,130,608	B2		10/2006	Hollstrom et al.
7,130,616	B2		10/2006	Janik
7,136,934	B2		11/2006	Carter et al.
7,143,141	B1		11/2006	Morgan et al.
7,143,939	B2		12/2006	Henzerling
7,162,315	B2		1/2007	Gilbert
7,185,090	B2		2/2007	Kowalski et al.
7,187,947	B1		3/2007	White et al.
7,206,367	B1	*	4/2007	Moore 375/354
7,206,967	B1		4/2007	Marti et al.
7,209,795	B2		4/2007	Sullivan et al.
7,218,708	B2		5/2007	Berezowski et al.
7,236,739	B2		6/2007	Chang
7,236,773	B2		6/2007	Thomas
7,293,060	B2		11/2007	Komsi
7,312,785	B2		12/2007	Tsuk et al.
7,313,593	B1		12/2007	Pulito et al.
7,324,857	B2		1/2008	Goddard
7,333,519	B2		2/2008	Sullivan et al.
7,372,846	B2		5/2008	Zwack
7,392,102	B2		6/2008	Sullivan et al.
7,412,499	B2		8/2008	Chang et al.
7,483,538	B2		1/2009	McCarty et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,483,958 B1 1/2009 Elabbady et al.
7,519,667 B1 4/2009 Capps
7,571,014 B1 8/2009 Lambourne et al.
7,574,274 B2 8/2009 Holmes
7,599,685 B2 10/2009 Goldberg et al.
7,606,174 B2 10/2009 Ochi et al.
7,643,894 B2 1/2010 Braithwaite et al.
7,657,224 B2 2/2010 Goldberg et al.
7,657,644 B1 2/2010 Zheng
7,657,910 B1 2/2010 McAulay et al.
7,668,990 B2 2/2010 Krzyzanowski et al.
7,669,219 B2 2/2010 Scott, III
7,675,943 B2 3/2010 Mosig et al.
7,676,142 B1 3/2010 Hung
7,702,279 B2 4/2010 Ko et al.
7,702,403 B1 4/2010 Gladwin et al.
7,711,774 B1 * 5/2010 Rothschild 709/205
7,720,096 B2 5/2010 Klemets
7,742,740 B2 6/2010 Goldberg et al.
7,743,009 B2 6/2010 Hangartner et al.
RE41,608 E 8/2010 Blair et al.
7,835,689 B2 11/2010 Goldberg et al.
7,853,341 B2 12/2010 McCarty et al.
7,865,137 B2 1/2011 Goldberg et al.
7,885,622 B2 2/2011 Krampf et al.
7,916,877 B2 3/2011 Goldberg et al.
7,917,082 B2 3/2011 Goldberg et al.
7,934,239 B1 4/2011 Dagman
7,996,588 B2 8/2011 Subbiah et al.
8,014,423 B2 9/2011 Thaler et al.
8,020,023 B2 9/2011 Millington et al.
8,023,663 B2 9/2011 Goldberg
8,028,038 B2 9/2011 Weel
8,028,323 B2 9/2011 Weel
8,045,952 B2 10/2011 Qureshey et al.
8,050,652 B2 11/2011 Qureshey et al.
8,074,253 B1 12/2011 Nathan
8,086,752 B2 12/2011 Millington et al.
8,103,009 B2 1/2012 McCarty et al.
8,112,032 B2 2/2012 Ko et al.
8,131,390 B2 3/2012 Braithwaite et al.
8,169,938 B2 5/2012 Duchscher et al.
8,214,873 B2 7/2012 Weel
8,230,099 B2 7/2012 Weel
8,234,395 B2 7/2012 Millington
8,290,603 B1 10/2012 Lambourne
8,315,555 B2 11/2012 Ko et al.
8,370,678 B2 2/2013 Millington et al.
8,423,659 B2 4/2013 Millington
8,473,844 B2 6/2013 Kreifeldt et al.
8,588,949 B2 11/2013 Lambourne et al.
8,775,546 B2 7/2014 Millington
2001/0009604 A1 7/2001 Ando et al.
2001/0022823 A1 9/2001 Renaud
2001/0027498 A1 10/2001 Van et al.
2001/0032188 A1 10/2001 Miyabe et al.
2001/0042107 A1 11/2001 Palm
2001/0046235 A1 11/2001 Trevitt et al.
2001/0047377 A1 11/2001 Sincaglia et al.
2002/0002039 A1 1/2002 Qureshey et al.
2002/0002562 A1 1/2002 Moran et al.
2002/0002565 A1 1/2002 Ohyama
2002/0003548 A1 1/2002 Krusche et al.
2002/0022453 A1 2/2002 Balog et al.
2002/0026442 A1 2/2002 Lipscomb et al.
2002/0034374 A1 3/2002 Barton
2002/0042844 A1 4/2002 Chiazzese
2002/0049843 A1 4/2002 Barone et al.
2002/0062406 A1 5/2002 Chang et al.
2002/0065926 A1 5/2002 Hackney et al.
2002/0072816 A1 6/2002 Shdema et al.
2002/0073228 A1 6/2002 Cognet et al.
2002/0080783 A1 6/2002 Fujimori
2002/0090914 A1 7/2002 Kang et al.
2002/0093478 A1 7/2002 Yeh
2002/0095460 A1 7/2002 Benson
2002/0109710 A1 8/2002 Holtz et al.
2002/0112244 A1 8/2002 Liou et al.
2002/0114354 A1 8/2002 Sinha et al.
2002/0114359 A1 8/2002 Ibaraki et al.
2002/0124097 A1 9/2002 Isely et al.
2002/0129156 A1 9/2002 Yoshikawa
2002/0143998 A1 10/2002 Rajagopal et al.
2002/0159596 A1 10/2002 Durand et al.
2002/0163361 A1 11/2002 Parkin
2002/0165721 A1 11/2002 Chang et al.
2002/0165921 A1 11/2002 Sapieyevski
2002/0168938 A1 11/2002 Chang
2002/0173273 A1 11/2002 Spurgat et al.
2002/0177411 A1 * 11/2002 Yajima et al. 455/41
2002/0184310 A1 12/2002 Traversat et al.
2002/0188762 A1 12/2002 Tomassetti et al.
2002/0194309 A1 12/2002 Carter et al.
2003/0002609 A1 1/2003 Faller et al.
2003/0018797 A1 1/2003 Dunning et al.
2003/0020763 A1 1/2003 Mayer et al.
2003/0023741 A1 1/2003 Tomassetti et al.
2003/0035072 A1 2/2003 Hagg
2003/0035444 A1 2/2003 Zwack
2003/0041173 A1 2/2003 Hoyle
2003/0041174 A1 2/2003 Wen et al.
2003/0043924 A1 3/2003 Haddad et al.
2003/0055892 A1 3/2003 Huitema et al.
2003/0061428 A1 3/2003 Garney et al.
2003/0066094 A1 4/2003 Van et al.
2003/0067437 A1 4/2003 McClintock et al.
2003/0073432 A1 4/2003 Meade
2003/0099212 A1 5/2003 Anjum et al.
2003/0099221 A1 5/2003 Rhee
2003/0110329 A1 6/2003 Higaki et al.
2003/0126211 A1 7/2003 Anttila et al.
2003/0157951 A1 8/2003 Hasty
2003/0195964 A1 10/2003 Mane
2003/0198254 A1 10/2003 Sullivan et al.
2003/0198255 A1 10/2003 Sullivan et al.
2003/0198257 A1 10/2003 Sullivan et al.
2003/0200001 A1 * 10/2003 Goddard 700/94
2003/0204273 A1 10/2003 Dinker et al.
2003/0204509 A1 10/2003 Dinker et al.
2003/0210796 A1 11/2003 McCarty et al.
2003/0219007 A1 11/2003 Barrack et al.
2003/0227478 A1 12/2003 Chatfield
2003/0231871 A1 12/2003 Ushimaru
2003/0235304 A1 12/2003 Evans et al.
2004/0001484 A1 1/2004 Ozguner
2004/0001591 A1 1/2004 Mani et al.
2004/0008852 A1 1/2004 Also et al.
2004/0010727 A1 1/2004 Fujinami
2004/0012620 A1 1/2004 Buhler et al.
2004/0015252 A1 1/2004 Aiso et al.
2004/0019497 A1 1/2004 Volk et al.
2004/0024478 A1 2/2004 Hans et al.
2004/0024925 A1 2/2004 Cypher et al.
2004/0027166 A1 2/2004 Mangum et al.
2004/0032348 A1 2/2004 Lai et al.
2004/0041836 A1 3/2004 Zaner et al.
2004/0048569 A1 3/2004 Kawamura
2004/0066736 A1 4/2004 Kroeger
2004/0075767 A1 4/2004 Neuman et al.
2004/0078383 A1 4/2004 Mercer et al.
2004/0080671 A1 4/2004 Siemens et al.
2004/0093096 A1 * 5/2004 Huang et al. 700/17
2004/0098754 A1 * 5/2004 Vella et al. 725/135
2004/0131192 A1 7/2004 Metcalf
2004/0133689 A1 7/2004 Vasisht
2004/0143368 A1 * 7/2004 May et al. 700/241
2004/0143852 A1 * 7/2004 Meyers 725/133
2004/0148237 A1 7/2004 Bittmann et al.
2004/0170383 A1 9/2004 Mazur
2004/0203378 A1 10/2004 Powers
2004/0208158 A1 10/2004 Fellman et al.
2004/0213230 A1 * 10/2004 Douskalis et al. 370/390
2004/0224638 A1 11/2004 Fadell et al.
2004/0228367 A1 11/2004 Mosig et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2004/0248601	A1	12/2004	Chang	
2004/0249965	A1	12/2004	Huggins et al.	
2004/0249982	A1	12/2004	Arnold et al.	
2004/0252400	A1	12/2004	Blank et al.	
2005/0010691	A1	1/2005	Oyadomari et al.	
2005/0011388	A1	1/2005	Kouznetsov	
2005/0013394	A1	1/2005	Rausch et al.	
2005/0015551	A1	1/2005	Eames et al.	
2005/0021590	A1	1/2005	Debique et al.	
2005/0027821	A1 *	2/2005	Alexander et al.	709/218
2005/0047605	A1	3/2005	Lee et al.	
2005/0058149	A1	3/2005	Howe	
2005/0062637	A1	3/2005	El et al.	
2005/0081213	A1	4/2005	Suzuoki et al.	
2005/0114538	A1	5/2005	Rose	
2005/0120128	A1	6/2005	Willes et al.	
2005/0125357	A1	6/2005	Saadat et al.	
2005/0131558	A1	6/2005	Braithwaite et al.	
2005/0166135	A1 *	7/2005	Burke et al.	715/500.1
2005/0168630	A1	8/2005	Yamada et al.	
2005/0177643	A1	8/2005	Xu	
2005/0181348	A1	8/2005	Carey et al.	
2005/0195205	A1	9/2005	Abrams	
2005/0195823	A1	9/2005	Chen et al.	
2005/0216556	A1	9/2005	Manion et al.	
2005/0281255	A1	12/2005	Davies et al.	
2005/0283820	A1	12/2005	Richards et al.	
2005/0288805	A1	12/2005	Moore et al.	
2005/0289224	A1	12/2005	Deslippe et al.	
2006/0095516	A1	5/2006	Wijeratne	
2006/0098936	A1 *	5/2006	Ikeda et al.	386/46
2006/0119497	A1	6/2006	Miller et al.	
2006/0143236	A1	6/2006	Wu	
2006/0193454	A1	8/2006	Abou-chakra et al.	
2007/0038999	A1	2/2007	Millington	
2007/0043847	A1	2/2007	Carter et al.	
2007/0047712	A1	3/2007	Gross et al.	
2007/0048713	A1	3/2007	Plastina et al.	
2007/0054680	A1	3/2007	Mo et al.	
2007/0142022	A1	6/2007	Madonna et al.	
2007/0142944	A1	6/2007	Goldberg et al.	
2007/0143493	A1	6/2007	Mullig et al.	
2007/0169115	A1	7/2007	Ko et al.	
2007/0180137	A1	8/2007	Rajapakse	
2007/0192156	A1	8/2007	Gauger	
2007/0249295	A1 *	10/2007	Ukita et al.	455/88
2007/0271388	A1	11/2007	Bowra et al.	
2007/0299778	A1	12/2007	Haveson et al.	
2008/0022320	A1	1/2008	Ver	
2008/0091771	A1	4/2008	Allen et al.	
2008/0120429	A1	5/2008	Millington et al.	
2008/0126943	A1	5/2008	Parasnis et al.	
2008/0144861	A1	6/2008	Melanson et al.	
2009/0031336	A1	1/2009	Chavez et al.	
2009/0157905	A1	6/2009	Davis	
2009/0193345	A1	7/2009	Wensley et al.	
2009/0222115	A1	9/2009	Malcolm et al.	
2009/0228919	A1	9/2009	Zott et al.	
2010/0004983	A1	1/2010	Dickerson et al.	
2010/0049835	A1	2/2010	Ko et al.	
2010/0228740	A1	9/2010	Cannistraro et al.	
2010/0284389	A1	11/2010	Ramsay et al.	
2010/0299639	A1	11/2010	Ramsay et al.	
2011/0066943	A1	3/2011	Brillon et al.	
2012/0029671	A1	2/2012	Millington et al.	
2012/0030366	A1	2/2012	Collart et al.	
2012/0060046	A1	3/2012	Millington	
2012/0129446	A1	5/2012	Ko et al.	
2012/0290621	A1	11/2012	Heitz, III et al.	
2013/0018960	A1	1/2013	Knysz et al.	
2013/0022221	A1	1/2013	Kallai et al.	
2013/0080599	A1	3/2013	Ko et al.	
2013/0174100	A1	7/2013	Seymour et al.	
2013/0191454	A1	7/2013	Oliver et al.	
2013/0197682	A1	8/2013	Millington	
2014/0181569	A1	6/2014	Millington et al.	

FOREIGN PATENT DOCUMENTS

EP	1111527	A2	6/2001
EP	1122931	A2	8/2001
EP	2713281		4/2004
GB	2284327	A	5/1995
GB	2338374		12/1999
JP	07-210129		8/1995
JP	2003037585		2/2003
JP	03101958		4/2003
JP	2005108427		4/2005
WO	9525313	A1	9/1995
WO	9961985	A1	12/1999
WO	0153994		7/2001
WO	02073851		9/2002
WO	03093950	A2	11/2003
WO	2005013047	A2	2/2005

OTHER PUBLICATIONS

"Advisory Action mailed Sep. 5, 2014 for U.S. Appl. No. 13/907,666, filed May 31, 2013, 3 pages".

Akyildiz I.F., et al., "Multimedia Group Synchronization Protocols for Integrated Services Networks," IEEE Journal on Selected Areas in Communications, 1996, vol. 14 (1), pp. 162-173.

"AudioTron Quick Start Guide, Version 1.0", Voyetra Turtle Beach, Inc., Mar. 2001, 24 pages.

"AudioTron Reference Manual, Version 3.0", Voyetra Turtle Beach, Inc., May 2002, 70 pages.

"AudioTron Setup Guide, Version 3.0", Voyetra Turtle Beach, Inc., May 2002, 38 pages.

Benslimane A., "A Multimedia Synchronization Protocol for Multicast Groups," Proceedings of the 26th Euromicro Conference, 2000, vol. 1, pp. 456-463.

Biersack E., et al., "Intra- and Inter-Stream Synchronisation for Stored Multimedia Streams," IEEE International Conference on Multimedia Computing and Systems, 1996, pp. 372-381.

Blakowski G. et al., "A Media Synchronization Survey: Reference Model, Specification, and Case Studies", Jan. 1996, vol. 14, No. 1, 5-35.

"Bluetooth. "Specification of the Bluetooth System: The ad hoc SCATTERNET for affordable and highly functional wireless connectivity" Core, Version 1.0 A, Jul. 26, 1999, 1068 pages".

"Bluetooth. "Specification of the Bluetooth System: Wireless connections made easy" Core, Version 1.0 B, Dec. 1, 1999, 1076 pages".

Bretl W.E., et al., MPEG2 Tutorial [online], 2000 [retrieved on Jan. 13, 2009] Retrieved from the Internet< http://www.bretl.com/mpeghtml/MPEGindex.htm>, pp. 1-23.

"Dell, Inc. "Dell Digital Audio Receiver: Reference Guide" Jun. 2000, 70 pages".

"Dell, Inc. "Start Here" Jun. 2000, 2 pages".

"European Extended Search Report for Application No. 13184747.7 mailed on Feb. 28, 2014, 8 pages".

"Final Office Action mailed Jun. 5, 2014 for U.S. Appl. No. 13/907,666, filed May 31, 2013".

Final Office Action mailed Jul. 13, 2009 for U.S. Appl. No. 10/816,217, filed Apr. 1, 2004.

"Final Office Action mailed Sep. 13, 2012 for U.S. Appl. No. 13/297,000", United States Patent and Trademark Office, Sep. 13, 2012, 17 pages.

Final Office Action mailed Oct. 21, 2011 for U.S. Appl. No. 10/816,217, filed Apr. 1, 2004.

"Final Office Action mailed Mar. 27, 2014 for U.S. Appl. No. 13/533,105, filed Jun. 26, 2012.".

Final Office Action mailed Jan. 28, 2011 for U.S. Appl. No. 10/816,217, filed Apr. 1, 2004.

"Final Office Action mailed Jul. 3, 2012 for U.S. Appl. No. 13/298,090, filed Nov. 16, 2011".

Final Office Action mailed Jun. 30, 2008 for U.S. Appl. No. 10/816,217, filed Apr. 1, 2004.

(56) **References Cited**

OTHER PUBLICATIONS

"Final Office Action mailed on Oct. 22, 2014, issued in connection with U.S. Appl. No. 14/186,850, filed on Feb. 21, 2014, 12 pages".
"Final Office Action mailed on Oct. 23, 2014, issued in conection with U.S. Appl. No. 13/705,176, filed Dec. 5, 2012, 23 pages".
"Final Rejection mailed on Jan. 21, 2010 for U.S. Appl. No. 11/906,702, filed Oct. 2, 2007".
Huang C.M., et al., "A Synchronization Infrastructure for Multicast Multimedia at the Presentation Layer," IEEE Transactions on Consumer Electronics, 1997, vol. 43 (3), pp. 370-380.
"International Bureau,"Search Report" issued in connection with International Patent application No. PCT/US2013/046372, mailed Aug. 26, 2013, 3 pages.".
"International Bureau,"Written opinion" issued in connection with International Patent application No. PCT/US2013/046372, mailed Aug. 26, 2013, 4 pages.".
International Search Report for Application No. PCT/US04/23102, mailed on Aug. 1, 2008, 5 pages.
"International Search Report, issued by the International Searching Authority in connection with PCT Application No. PCT/US2013/046386, on Sep. 30, 2013, 3 pages.".
Ishibashi Y., "A Group Synchronization Mechanism for Live Media in Multicast Communications," IEEE Global Telecommunications Conference, 1997, vol. 2, pp. 746-752.
Ishibashi Y., "A Group Synchronization Mechanism for Stored Media in Multicast Communications," IEEE Information Revolution and Communications, 1997, vol. 2, pp. 692-700.
"Japanese Intellectual Property Office, "Decision of Rejection," issued in connection with Japanese patent application No. 2012-178711, mailed on Jul. 4, 2014, 3 pages".
"Japanese Intellectual Property Office, "Office Action Summary," issued in connection with Japanese patent application No. 2012-178711, mailed on Nov. 19, 2013, 5 pages".
Jo J., et al., "Synchronized One-to-many Media Streaming with Adaptive Playout Control," Proceedings of SPIE, 2002, vol. 4861, pp. 71-82.
"Jones, Stephen. "Dell Digital Audio Receiver: Digital upgrade for your analog stereo" Analog Stereo. Jun. 24, 2000 <http://www.reviewsonline.com/articles/961906864.htm> retrieved Jun. 18, 2014, 2 pages".
"Louderback, Jim. "Affordable Audio Receiver Furnishes Homes With MP3" TechTV Vault. Jun. 28, 2000 <http://www.g4tv.com/articles/17923/affordable-audio-receiver-furnishes-homes-with-mp3/> retrieved Jul. 10, 2014, 2 pages".
M. Nilsson., "ID3 Tag Version 2", Mar. 26, 1998, 28 Pages.
"Maniactools, "Identify Duplicate Files by Sound," Sep. 28, 2010, http://www.maniactools.com/soft/music-duplicate-remover/identify-duplicate-files-by-sound.shtml".
Mills D.L., "Network Time Protocol (Version 3) Specification, Implementation and Analysis," Network Working Group, Mar. 1992, <http://www.ietf.org/rfc/rfc1305.txt>.
Mills D.L., "Precision Synchronization of Computer Network Clocks," ACM SIGCOMM Computer Communication Review, 1994, vol. 24 (2), pp. 28-43.
Motorola., "Simplefi, Wireless Digital Audio Receiver, Installation and User Guide", Dec. 31, 2001.
"Non-final Office Action in connection with U.S. Appl. No. 13/619,237, mailed Apr. 10, 2013", United States Patent and Trademark Office, 10 pages.
"Non-Final Office Action mailed May 1, 2014 for U.S. Appl. No. 14/184,522, filed Feb. 19, 2014".
"Non-Final Office Action mailed Dec. 5, 2013 for U.S. Appl. No. 13/827,653, filed Mar. 14, 2013".
"Non-Final Office Action mailed Jan. 5, 2012 for U.S. Appl. No. 13/298,090, filed Nov. 16, 2011, 40 pages".
"Non-Final Office Action mailed May 6, 2014 for U.S. Appl. No. 13/705,176, filed Dec. 5, 2012".
"Non-Final Office Action mailed May 12, 2014 for U.S. Appl. No. 14/184,528, filed Feb. 19, 2014".
"Non-Final Office Action mailed May 14, 2014 for U.S. Appl. No. 13/848,932, filed Mar. 22, 2013".
"Non-Final Office Action mailed Jun. 17, 2014 for U.S. Appl. No. 14/176,808, filed Feb. 10, 2014".
"Non-Final Office Action mailed Dec. 18, 2013 for U.S. Appl. No. 13/907,666, filed May 31, 2013".
Non-Final Office Action mailed Jan. 18, 2008 for U.S. Appl. No. 10/816,217, filed Apr. 1, 2004.
"Non-Final Office Action mailed Apr. 19, 2010 for U.S. Appl. No. 11/801,468, filed May 9, 2007, 16 pages".
"Non-Final Office Action mailed Mar. 19, 2013 for U.S. Appl. No. 13/724,048, filed Dec. 21, 2012".
Non-Final Office Action mailed Jun. 21, 2011 for U.S. Appl. No. 10/816,217, filed Apr. 1, 2004.
Non-Final Office Action mailed Jan. 22, 2009 for U.S. Appl. No. 10/816,217, filed Apr. 1, 2004.
"Non-Final Office Action mailed Jul. 25, 2014 for U.S. Appl. No. 14/184,526, filed Feb. 19, 2014".
"Non-Final Office Action mailed Jul. 25, 2014 for U.S. Appl. No. 14/184,935, filed Feb. 20, 2014".
Non-Final Office Action mailed Jun. 25, 2010 for U.S. Appl. No. 10/816,217, filed Apr. 1, 2004.
"Non-Final Office Action mailed Nov. 25, 2013 for U.S. Appl. No. 13/533,105, filed Jun. 26, 2012.".
"Non-Final Office Action mailed May 27, 2014 for U.S. Appl. No. 14/186,850, filed Feb. 21, 2014".
Non-Final Office Action mailed Feb. 29, 2012 for U.S. Appl. No. 13/297,000, filed Nov. 15, 2011.
"Non-Final Office Action mailed Nov. 29, 2010 for U.S. Appl. No. 11/801,468, filed May 9, 2007, 17 pages".
"Non-Final Office Action mailed Apr. 30, 2012 for U.S. Appl. No. 13/204,511, filed Aug. 5, 2011".
"Non-Final Office Action mailed Jul. 30, 2013 for U.S. Appl. No. 13/724,048, filed Dec. 21, 2012".
"Non-Final Office Action mailed Jul. 31, 2014 for U.S. Appl. No. 13/533,105, filed Jun. 26, 2012".
"Non-Final Office Action mailed on Oct. 23, 2014, issued in connection with U.S. Appl. No. 13/848,904, filed Mar. 22, 2013, 11 pages".
"Non-Final Office Action mailed on Oct. 23, 2014, issued in connection with U.S. Appl. No. 13/864,251, filed Apr. 17, 2013, 11 pages".
"Non-Final Office Action mailed on Oct. 23, 2014, issued in connection with U.S. Appl. No. 13/888,203, filed May 6, 2013, 9 pages".
"Non-final Office Action mailed on Oct. 24, 2014, issued in connection with U.S. Appl. No. 13/435,776, filed Mar. 30, 2012, 14 pages".
"Non-Final Rejection mailed on Aug. 20, 2009 for U.S. Appl. No. 11/906,702, filed Oct. 2, 2007".
"Notice of Allowability in U.S. Appl. No. 13/619,237", Sep. 6, 2013, 4 pages.
Notice of Allowance Dec. 27, 2011 for U.S. Appl. No. 10/816,217, filed Apr. 1, 2004.
"Notice of Allowance mailed Mar. 6, 2014 for U.S. Appl. No. 13/827,653, filed Mar. 14, 2013".
"Notice of Allowance mailed May 6, 2011 for U.S. Appl. No. 11/801,468, filed May 9, 2007, 10 pages".
"Notice of Allowance mailed Nov. 10, 2011 for U.S. Appl. No. 11/906,702, filed Oct. 2, 2007".
"Notice of Allowance mailed Nov. 13, 2013 for U.S. Appl. No. 13/724,048, filed Dec. 21, 2012".
"Notice of Allowance mailed Jan. 31, 2013 for U.S. Appl. No. 13/298,090, filed Nov. 16, 2011".
"Notice of Allowance mailed Oct. 5, 2012 for U.S. Appl. No. 13/204,511, filed Aug. 5, 2011".
"Notice of Allowance mailed on Sep. 25, 2014, issued in connection with U.S. Appl. No. 14/176,808, filed Feb. 10, 2014, 5 pages".
"Palm, Inc. "Handbook for the Palm VII Handheld" May 2000, 311 pages".
Park S., et al., "Group Synchronization in MultiCast Media Communications," Proceedings of the 5th Research on Multicast Technology Workshop, 2003.
"Polycom Conference Composer manual: copyright 2001".
PRISMIQ; Inc., "PRISMIQ Media Player User Guide", 2003, 44 pages.

(56) **References Cited**

OTHER PUBLICATIONS

Rothermel K., et al., "An Adaptive Stream Synchronization Protocol," 5th International Workshop on Network and Operating System Support for Digital Audio and Video, 1995.
Schulzrinne H., et al., "RTP: A Transport Protocol for Real-Time Applications, RFC 3550," Network Working Group, 2003, pp. 1-89.
The MPEG-2 Transport Stream. Retrieved from the Internet< URL: http://www.coolstf.com/mpeg/#ts>; retrieved on Aug. 24, 2006.
"UPnP; "Universal Plug and Play Device Architecture"; Jun. 8, 2000; version 1.0; Microsoft Corporation; pp. 1-54".
""Welcome. You're watching Apple TV." Apple TV 1st Generation Setup Guide, Apr. 8, 2008 <http://manuals.info.apple.com/MANUALS/0/MA403/en_US/AppleTV_SetupGuide.pdf> Retrieved Oct. 14, 2014, 40 pages".
""Welcome. You're watching Apple TV." Apple TV 2nd Generation Setup Guide, Mar. 10, 2011 <http://manuals.info.apple.com/MANUALS/1000/MA1555/en_US/Apple_TV_2nd_gen_Setup_Guide.pdf> Retrieved Oct. 16, 2014, 35 pages".
""Welcome. You're watching Apple TV." Apple TV 3rd Generation Setup Guide, Mar. 16, 2012 <http://http://manuals.info.apple.com/MANUALS/1000/MA1607/en_US/apple_tv_3rd_gen_setup.pdf> Retrieved Oct. 16, 2014, 35 pages".
"Presentations at WinHEC 2000" May 2000, 138 pages.
"Written Opinion of the International Searching Authority. issued by the International Searching Authority in connection with PCT Application No. PCT/US2013/046386, on Sep. 30, 2013, 6 pages.".
"Yamaha DME 32 manual: copyright 2001".
"Yamaha DME Designer software manual: Copyright 2004, 482 pages".
Advisory Action mailed on Nov. 12, 2014, issued in connection with U.S. Appl. No. 13/907,666, filed May 31, 2013, 6 pages.
Advisory Action mailed on Nov. 26, 2014, issued in connection with U.S. Appl. No. 14/186,850, filed Feb. 21, 2014, 9 pages.
Crown PIP Manual available for sale at least 2004, 6 pages.
Final Office Action mailed on Dec. 3, 2014, issued in connection with U.S. Appl. No. 14/184,528, filed Feb. 19, 2014, 12 pages.
Non-Final Office Action mailed on Nov. 17, 2014, issued in connection with U.S. Appl. No. 13/864,247, filed Apr. 17, 2013, 11 pages.
Non-Final Office Action mailed on Nov. 18, 2014, issued in connection with U.S. Appl. No. 13/435,739, filed Mar. 30, 2012, 10 pages.
Non-Final Office Action mailed on Nov. 19, 2014, issued in connection with U.S. Appl. No. 13/848,921, filed Mar. 22, 2013, 9 pages.
Renkus Heinz Manual; available for sale at least 2004, 68 pages.
"Advisory Action mailed on Jan. 8, 2015, issued in connection with U.S. Appl. No. 13/705,176, filed Dec. 5, 2012, 4 pages".
"Final Office Action mailed on Dec. 17, 2014, issued in connection with U.S. Appl. No. 13/533,105, filed Jun. 2012, 36 pages".
"Final Office Action mailed on Jan. 7, 2015, issued in connection with U.S. Appl. No. 13/848,932, filed Mar. 22, 2013, 14 pages".
"Advisory Action mailed on Mar. 2, 2015, issued in connection with U.S. Appl. No. 13/848,932, filed Mar. 22, 2013, 3 pages.".
"Advisory Action mailed on Feb. 26, 2015, issued in connection with U.S. Appl. No. 14/184,528, filed Feb. 19, 2014, 3 pages.".
"Final Office Action mailed on Feb. 11, 2015, issued in connection with U.S. Appl. No. 14/184,526, filed Feb. 19, 2014, 13 pages".
"Final Office Action mailed on Feb. 11, 2015, issued in connection with U.S. Appl. No. 14/184,935, filed Feb. 20, 2014, 17 pages".
"Final Office Action mailed on Feb. 12, 2015, issued in connection with U.S. Appl. No. 14/184,522, filed Feb. 19, 2014, 20 pages".
"International Bureau,"International Preliminary Report on Patentability" issued in connection with International Patent application No. PCT/US2013/046372, mailed Dec. 31, 2014, 5 pages.".
"International Preliminary Report on Patentability and Written Opinion, issued by the International Searching Authority in connection with International Patent Application No. PCT/US2013/046386, mailed on Jan. 8, 2015, 8 pages".
"Non-Final Office Action mailed on Feb. 26, 2015, issued in connection with U.S. Appl. No. 14/186,850, filed Feb. 21, 2014, 25 pages.".
"Non-Final Office Action mailed on Jan. 30, 2015, issued in connection with U.S. Appl. No. 14/504,812, filed Oct. 2, 2014, 13 pages".
"Non-Final Office Action mailed on Jan. 30, 2015, issued in connection with U.S. Appl. No. 14/290,493, filed May 29, 2014, 30 pages.".
Final Office Action mailed on Mar. 3, 2015, issued in connection with U.S. Appl. No. 13/864,251, filed Apr. 17, 2013, 13 pages.
Final Office Action mailed on Mar. 4, 2015, issued in connection with U.S. Appl. No. 13/848,904, filed Mar. 22, 2013, 16 pages.
Final Office Action mailed on Mar. 5, 2015, issued in connection with U.S. Appl. No. 13/888,203, filed May 6, 2013, 13 pages.
Non-Final Office Action mailed on Mar. 4, 2015, issued in connection with U.S. Appl. No. 13/435,776, filed Mar. 30, 2012, 16 pages.
Pre-Interview First Office Action mailed on Mar. 10, 2015, issued in connection with U.S. Appl. No. 14/505,027, filed Oct. 2, 2014, 4 pages.
"Advisory Action mailed on Apr. 15, 2015, issued in connection with U.S. Appl. No. 14/184,526, filed Feb. 19, 2014, 9 pages".
"Advisory Action mailed on Apr. 15, 2015, issued in connection with U.S. Appl. No. 14/184,935, filed Feb. 20, 2014, 9 pages".
"Advisory Action mailed on Mar. 25, 2015, issued in connection with U.S. Appl. No. 13/533,105, filed Jun. 26, 2012, 5 pages.".
"European Extended Search Report for Application No. 14181454.1 mailed on Mar. 31, 2015, 9 pages.".
"Final Office Action mailed on Apr. 28, 2015, issued in connection with U.S. Appl. No. 14/186,850, filed Feb. 21, 2014, 20 pages".
"Non-Final Office Action mailed on Mar. 12, 2015, issued in connection with U.S. Appl. No. 13/705,174, filed Dec. 5, 2012, 13 pages.".
"Non-Final Office Action mailed on Mar. 13, 2015, issued in connection with U.S. Appl. No. 13/705,177, filed Dec. 5, 2012, 15 pages.".
"Non-Final Office Action mailed on Mar. 26, 2015, issued in connection with U.S. Appl. No. 14/184,528, filed Feb. 19, 2014, 18 pages".
"Non-Final Office Action mailed on Mar. 27, 2015, issued in connection with U.S. Appl. No. 13/705,178, filed Dec. 5, 2012, 14 pages.".
"Notice of Allowance mailed on May 19, 2015, issued in connection with U.S. Appl. No. 13/907,666, filed May 31, 2013, 7 pages".
"Re-Exam Non-Final Office Action mailed on Apr. 22, 2015, issued in connection with U.S. Appl. No. 90/013,423, filed Jan. 5, 2015, 16 pages.".
"Baldwin, Roberto. "How-To: Setup iTunes DJ on Your Max and iPhone", available at http://www.maclife.com/article/howtos/howto_setup_itunes_dj_your_mac_and_iphone, archived on Mar. 17, 2009, 4 pages.".
"Final Office Action mailed on Jun. 15, 2015, issued in connection with U.S. Appl. No. 14/184,522, filed Feb. 19, 2014, 25 pages".
"Non-Final Office Action mailed on Jun. 12, 2015, issued in connection with U.S. Appl. No. 13/848,932, filed Mar. 22, 2013, 16 pages".
"Non-Final Office Action mailed on Jun. 19, 2015, issued in connection with U.S. Appl. No. 13/533,105, filed Jun. 26, 2012, 38 pages.".
"Non-Final Office Action mailed on Jun. 23, 2015, issued in connection with U.S. Appl. No. 13/705,176, filed Dec. 5, 2012, 30 pages".
"Non-Final Office Action mailed on Jun. 3, 2015, issued in connection with U.S. Appl. No. 14/564,544, filed Dec. 9, 2014, 7 pages.".
"Non-Final Office Action mailed on Jun. 4, 2015, issued in connection with U.S. Appl. No. 13/871,795, filed Apr. 26, 2013, 16 pages.".
"Notice of Allowance mailed on Jul. 2, 2015, issued in connection with U.S. Appl. No. 13/848,904, filed Mar. 22, 2013, 17 pages".
"Notice of Allowance mailed on Jul. 2, 2015, issued in connection with U.S. Appl. No. 13/888,203, filed May 6, 2013, 19 pages".
"Notice of Allowance mailed on Jul. 2, 2015, issued in connection with U.S. Appl. No. 14/184,935, filed Feb. 20, 2014, 23 pages".
"Notice of Allowance mailed on Jul. 6, 2015, issued in connection with U.S. Appl. No. 13/297,000, filed Nov. 15, 2011, 24 pages.".
Advisory Action mailed on Jul. 28, 2015, issued in connection with U.S. Appl. No. 14/184,522, filed Feb. 19, 2014, 7 pages.
Baudisch et al., "Flat Volume Control: Improving Usability by Hiding the Volume Control Hierarchy in the User Interface", 2004, 8 pages.
Chakrabarti et al., "A Remotely Controlled Bluetooth Enabled Environment", IEEE, 2004, pp. 77-81.
Schmandt et al., "Impromptu: Managing Networked Audio Applications for Mobile Users", 2004, 11 pages.

(56) **References Cited**

OTHER PUBLICATIONS

Final Office Action mailed on Aug. 10, 2015, issued in connection with U.S. Appl. No. 14/290,493, filed May 29, 2014, 26 pages.
Final Office Action mailed on Aug. 11, 2015, issued in connection with U.S. Appl. No. 13/864,247, filed Apr. 17, 2013, 15 pages.
Final Office Action mailed on Jul. 15, 2015, issued in connection with U.S. Appl. No. 14/504,812, filed Oct. 2, 2014, 18 pages.
Final Office Action mailed on Aug. 3, 2015, issued in connection with U.S. Appl. No. 13/848,921, filed Mar. 22, 2013, 13 pages.
Fulton et al., "The Network Audio System: Make Your Application Sing (As Well As Dance)!", The X Resource, 1994, 14 pages.
Hans et al., "Interacting with Audio Streams for Entertainment and Communication", 2003, 7 pages.
Levergood et al., "AudioFile: A Network-Transparent System for Distributed Audio Applications", Digital Equipment Corporation, 1993, 109 pages.
Notice of Allowance mailed on Aug. 10, 2015, issued in connection with U.S. Appl. No. 13/848,904, filed Mar. 22, 2013, 9 pages.
Notice of Allowance mailed on Aug. 12, 2015, issued in connection with U.S. Appl. No. 13/435,739, filed Mar. 30, 2012, 27 pages.
Notice of Allowance mailed on Jul. 13, 2015, issued in connection with U.S. Appl. No. 14/184,526, filed Feb. 19, 2014, 22 pages.
Notice of Allowance mailed on Jul. 15, 2015, issued in connection with U.S. Appl. No. 13/705,174, filed Dec. 5, 2012, 18 pages.
Notice of Allowance mailed on Jul. 17, 2015, issued in connection with U.S. Appl. No. 13/864,251, filed Apr. 17, 2013, 20 pages.
Notice of Allowance mailed on Jul. 29, 2015, issued in connection with U.S. Appl. No. 13/359,976, filed Jan. 27, 2012, 28 pages.
Notice of Allowance mailed on Jul. 29, 2015, issued in connection with U.S. Appl. No. 14/186,850, filed Feb. 21, 2014, 9 pages.
Notice of Allowance mailed on Jul. 30, 2015, issued in connection with U.S. Appl. No. 13/705,178, filed Dec. 5, 2012, 18 pages.
Notice of Allowance mailed on Aug. 5, 2015, issued in connection with U.S. Appl. No. 13/435,776, filed Mar. 30, 2012, 26 pages.
Nutzel et al., "Sharing Systems for Future HiFi Systems", IEEE, 2004, 9 pages.
Re-Exam Final Office Action mailed on Aug. 5, 2015, issued in connection with U.S. Appl. No. 90/013,423, filed Jan. 5, 2015, 25 pages.

* cited by examiner

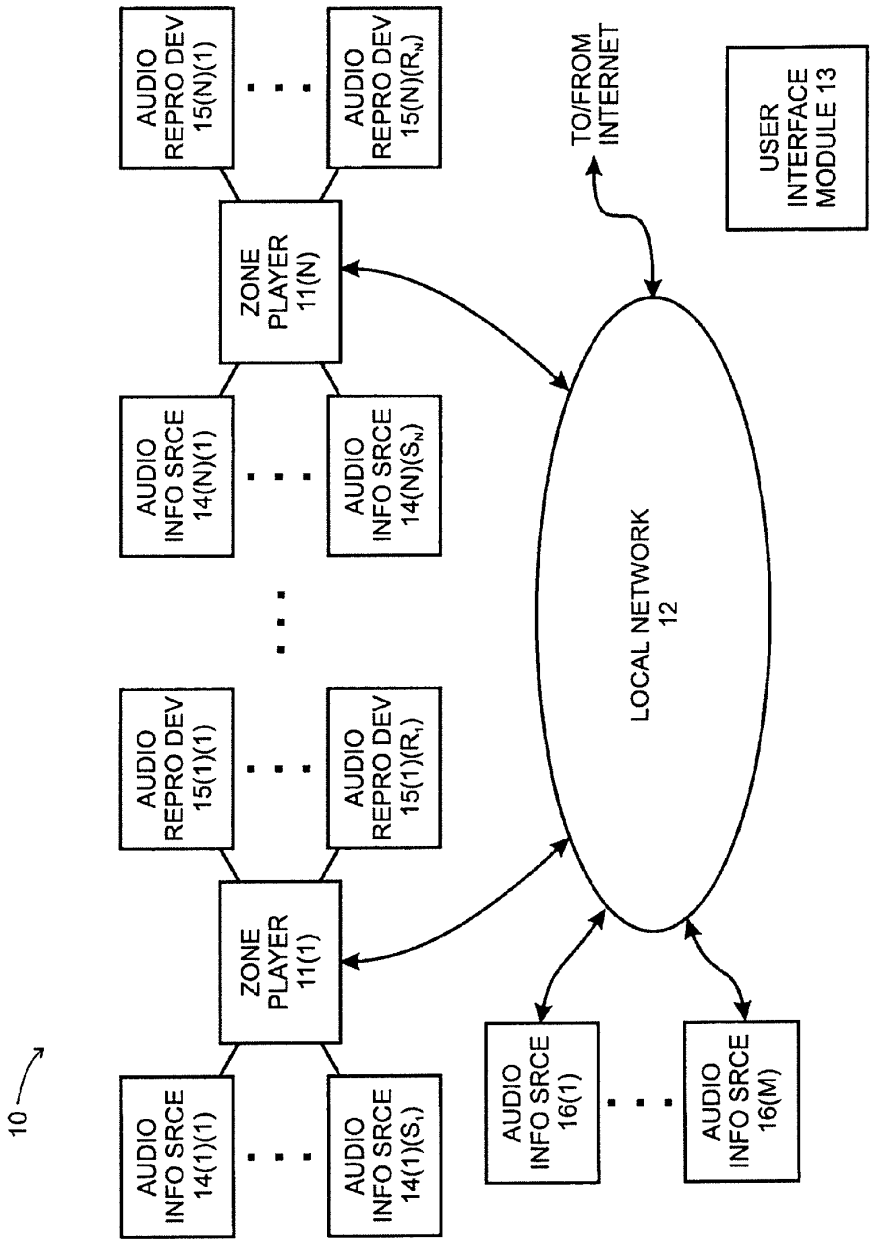

10
AUDIO INFO SRCE 14(1)(1)
AUDIO INFO SRCE 14(1)(S1)
AUDIO REPRO DEV 15(1)(1)
AUDIO REPRO DEV 15(1)(R1)
ZONE PLAYER 11(1)
AUDIO INFO SRCE 14(N)(1)
AUDIO INFO SRCE 14(N)(SN)
AUDIO REPRO DEV 15(N)(1)
AUDIO REPRO DEV 15(N)(RN)
ZONE PLAYER 11(N)
LOCAL NETWORK 12
TO/FROM INTERNET
USER INTERFACE MODULE 13
AUDIO INFO SRCE 16(1)
AUDIO INFO SRCE 16(M)

FIG. 1

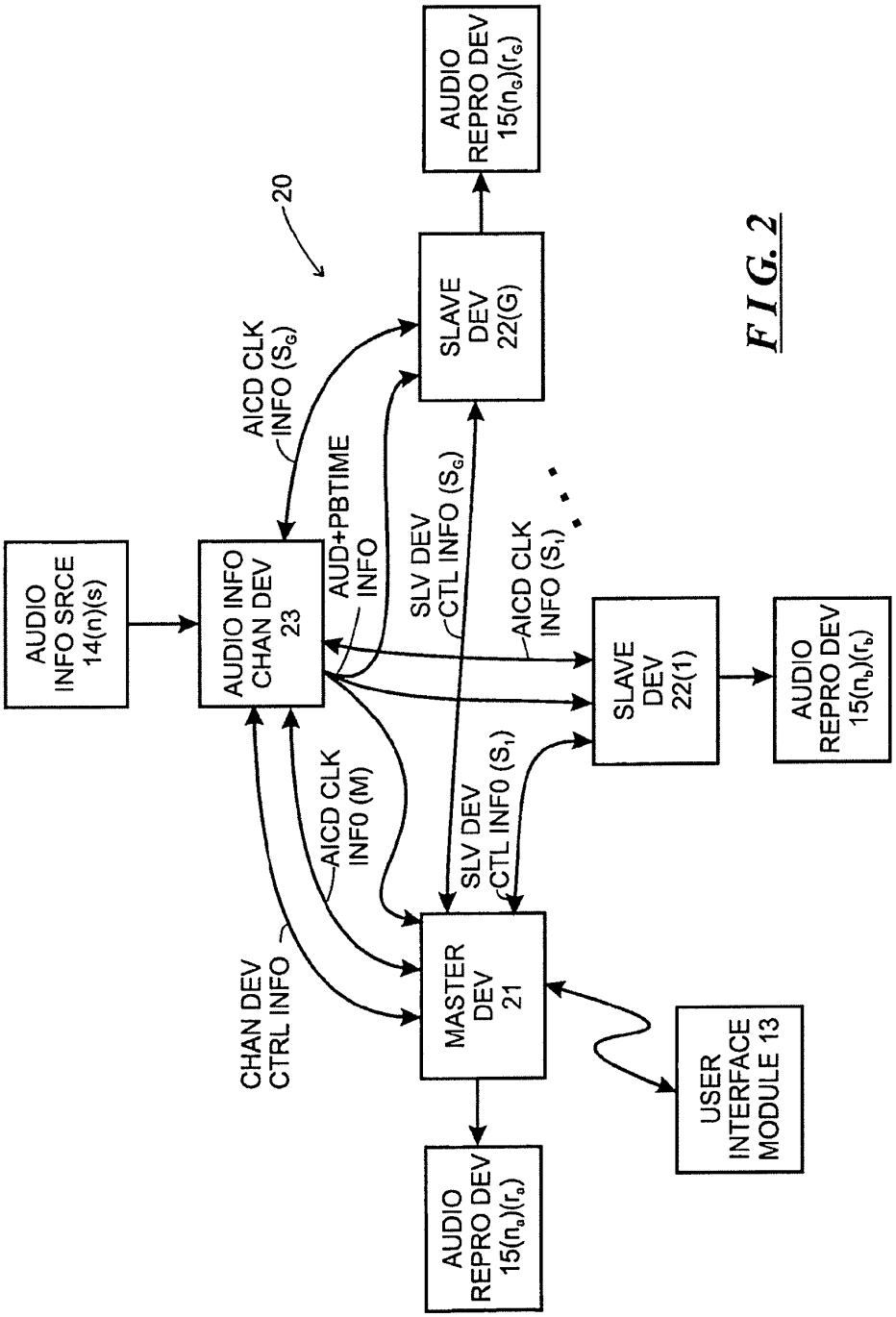

20
AUDIO INFO SRCE 14(n)(s)
AUDIO INFO CHAN DEV 23
AUD+PBTIME INFO
AICD CLK INFO (S_G)
SLV DEV CTL INFO (S_G)
AICD CLK INFO (S_1)
SLV DEV CTL INFO (S_1)
AICD CLK INFO (M)
CHAN DEV CTRL INFO
SLAVE DEV 22(G)
SLAVE DEV 22(1)
MASTER DEV 21
AUDIO REPRO DEV 15(n_G)(r_G)
AUDIO REPRO DEV 15(n_b)(r_b)
AUDIO REPRO DEV 15(n_a)(r_a)
USER INTERFACE MODULE 13

FIG. 2

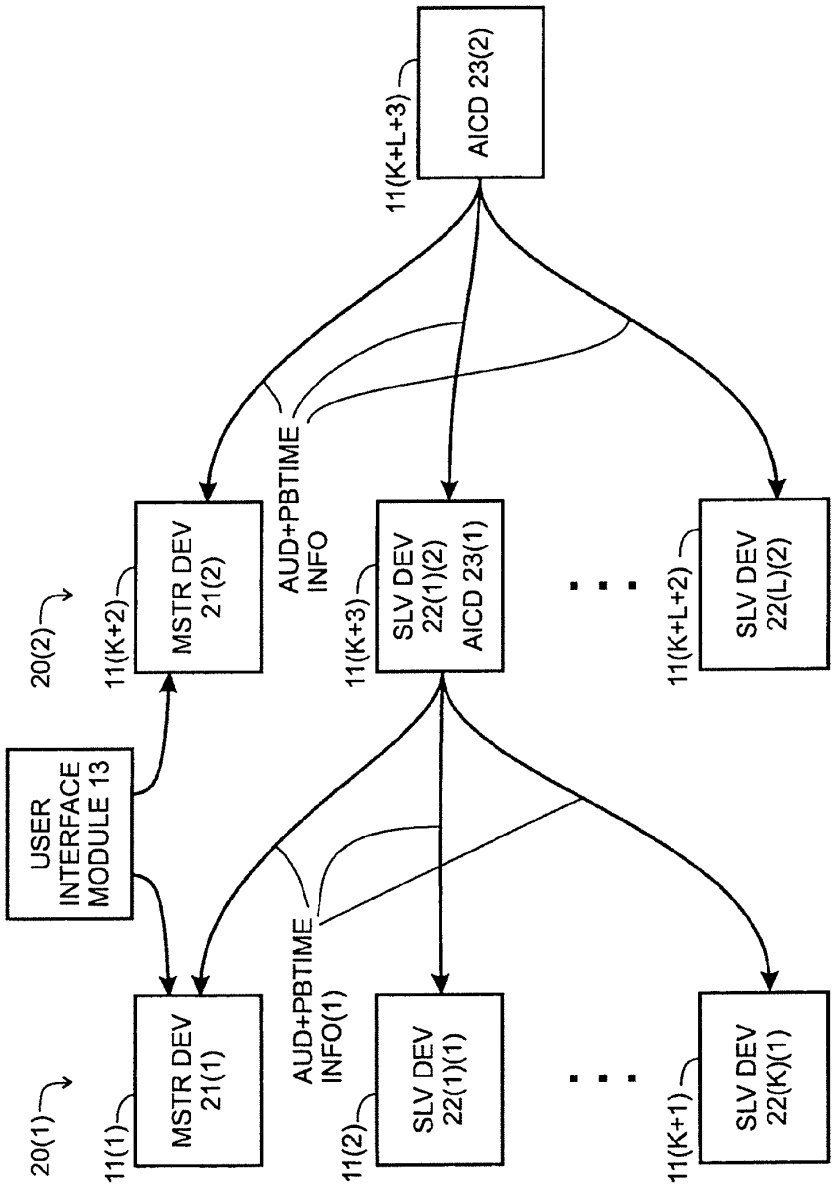

11(K+L+3)
AICD 23(2)
AUD+PBTIME INFO
20(2)
11(K+2)
MSTR DEV 21(2)
11(K+3)
SLV DEV 22(1)(2) AICD 23(1)
11(K+L+2)
SLV DEV 22(L)(2)
USER INTERFACE MODULE 13
AUD+PBTIME INFO(1)
20(1)
11(1)
MSTR DEV 21(1)
11(2)
SLV DEV 22(1)(1)
11(K+1)
SLV DEV 22(K)(1)

FIG. 2A

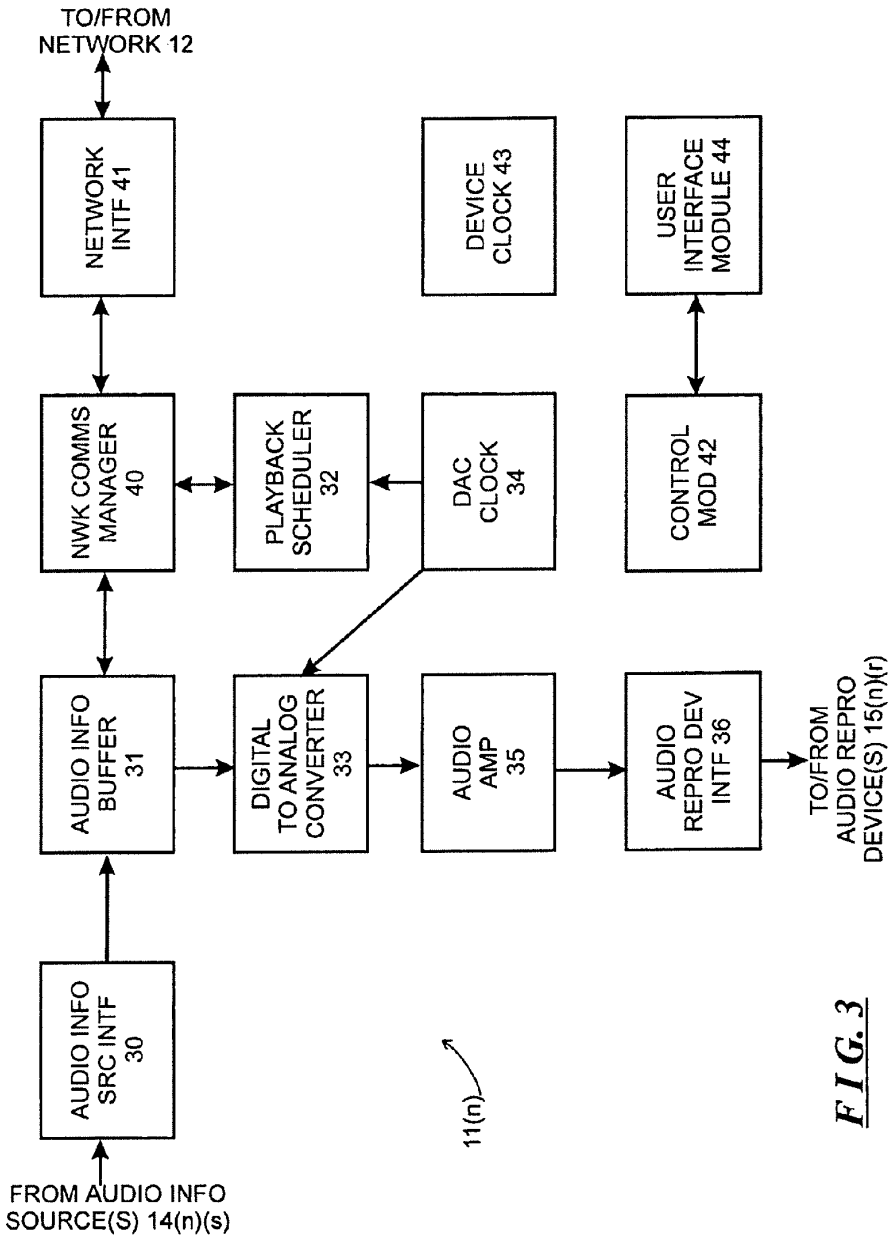

TO/FROM NETWORK 12
NETWORK INTF 41
DEVICE CLOCK 43
USER INTERFACE MODULE 44
NWK COMMS MANAGER 40
PLAYBACK SCHEDULER 32
DAC CLOCK 34
CONTROL MOD 42
AUDIO INFO BUFFER 31
DIGITAL TO ANALOG CONVERTER 33
AUDIO AMP 35
AUDIO REPRO DEV INTF 36
TO/FROM AUDIO REPRO DEVICE(S) 15(n)(r)
AUDIO INFO SRC INTF 30
11(n)
FROM AUDIO INFO SOURCE(S) 14(n)(s)

FIG. 3

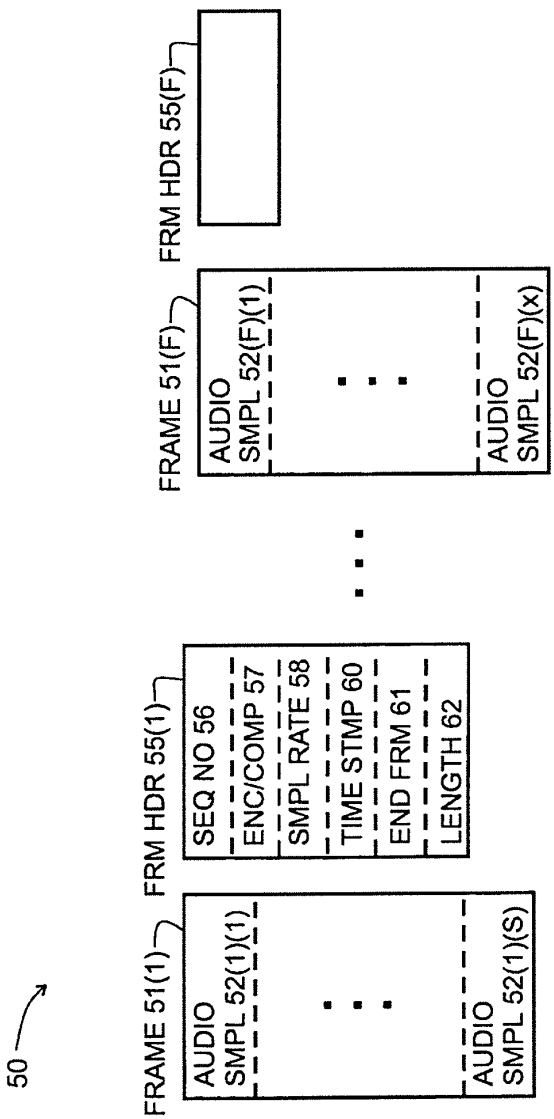

50
FRAME 51(1)
AUDIO SMPL 52(1)(1)
AUDIO SMPL 52(1)(S)
FRM HDR 55(1)
SEQ NO 56
ENC/COMP 57
SMPL RATE 58
TIME STMP 60
END FRM 61
LENGTH 62
FRAME 51(F)
AUDIO SMPL 52(F)(1)
AUDIO SMPL 52(F)(x)
FRM HDR 55(F)

FIG. 4

OBTAINING CONTENT FROM REMOTE SOURCE FOR PLAYBACK

INCORPORATION BY REFERENCE

This application claims priority under 35 U.S.C. §120 to, and is a continuation of, U.S. Non-provisional patent application Ser. No. 13/297,000, filed on Nov. 15, 2011, entitled "System and method for synchronizing operations among a plurality of independently clocked digital data processing devices," which claims priority under 35 U.S.C. 120 to, and is a continuation of, U.S. Non-provisional application Ser. No. 10/816,217, now issued as U.S. Pat. No. 8,234,395, filed on Apr. 1, 2004, entitled "System and method for synchronizing operations among a plurality of independently clocked digital data processing devices," which claims priority under 35 U.S.C. §119 to U.S. Provisional Application No. 60/490,768, filed on Jul. 28, 2003, entitled "Method for Synchronizing Audio Playback Between Multiple Networked Devices," each of which are assigned to the assignee of the present application and are incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates generally to the field of digital data processing devices, and more particularly to systems and methods for synchronizing operations among a plurality of independently-clocked digital data processing devices. The invention is embodied in a system for synchronizing operations among a plurality of devices, in relation to information that is provided by a common source. One embodiment of the invention enables synchronizing of audio playback as among two or more audio playback devices that receive audio information from a common information source, or channel.

More generally, the invention relates to the field of arrangements that synchronize output generated by a number of output generators, including audio output, video output, combinations of audio and video, as well as other types of output as will be appreciated by those skilled in the art, provided by a common channel. Generally, the invention will find utility in connection with any type of information for which synchrony among independently-clocked devices is desired.

BACKGROUND OF THE INVENTION

There are a number of circumstances under which it is desirable to maintain synchrony of operations among a plurality of independently-clocked digital data processing devices in relation to, for example, information that is provided thereto by a common source. For example, systems are being developed in which one audio information source can distribute audio information in digital form to a number of audio playback devices for playback. The audio playback devices receive the digital information and convert it to analog form for playback. The audio playback devices may be located in the same room or they may be distributed in different rooms in a residence such as a house or an apartment, in different offices in an office building, or the like. For example, in a system installed in a residence, one audio playback device may be located in a living room, while another audio playback device is be located in a kitchen, and yet other audio playback devices may be located in various bedrooms of a house. In such an arrangement, the audio information that is distributed to various audio playback devices may relate to the same audio program, or the information may relate to different audio programs. If the audio information source

provides audio information relating to the same audio program to two or more audio playback devices at the same time, the audio playback devices will generally contemporaneously play the same program. For example, if the audio information source provides audio information to audio playback devices located in the living room and kitchen in a house at the same time, they will generally contemporaneously play the same program.

One problem that can arise is to ensure that, if two or more audio playback devices are contemporaneously attempting to play back the same audio program, they do so simultaneously. Small differences in the audio playback devices' start times and/or playback speeds can be perceived by a listener as an echo effect, and larger differences can be very annoying. Differences can arise because for a number of reasons, including delays in the transfer of audio information over the network. Such delays can differ as among the various audio playback devices for a variety of reasons, including where they are connected into the network, message traffic and other reasons as will be apparent to those skilled in the art.

Another problem arises from the following. When an audio playback device converts the digital audio information from digital to analog form, it does so using a clock that provides timing information. Generally, the audio playback devices that are being developed have independent clocks, and, if they are not clocking at precisely the same rate, the audio playback provided by the various devices can get out of synchronization.

SUMMARY OF THE INVENTION

The invention provides a new and improved system and method for synchronizing operations among a number of digital data processing devices that are regulated by independent clocking devices. Generally, the invention will find utility in connection with any type of information for which synchrony among devices connected to a network is desired. The invention is described in connection with a plurality of audio playback devices that receive digital audio information that is to be played back in synchrony, but it will be appreciated that the invention can find usefulness in connection with any kind of information for which coordination among devices that have independent clocking devices would find utility.

In brief summary, the invention provides, in one aspect, a system for maintaining synchrony of operations among a plurality of devices that have independent clocking arrangements. The system includes a task distribution device that distributes tasks to a synchrony group comprising a plurality of devices that are to perform the tasks distributed by the task distribution device in synchrony. The task distribution device distributes each task to the members of the synchrony group over a network. Each task is associated with a time stamp that indicates a time, relative to a clock maintained by the task distribution device, at which the members of the synchrony group are to execute the task. Each member of the synchrony group periodically obtains from the task distribution device an indication of the current time indicated by its clock, determines a time differential between the task distribution device's clock and its respective clock and determines therefrom a time at which, according to its respective clock, the time stamp indicates that it is to execute the task.

In one embodiment, the tasks that are distributed include audio information for an audio track that is to be played by all of the devices comprising the synchrony group synchronously. The audio track is divided into a series of frames, each of which is associated with a time stamp indicating the time,

relative to the clock maintained by an audio information channel device, which, in that embodiment, serves as the task distribution device, at which the members of the synchrony group are to play the respective frame. Each member of the synchrony group, using a very accurate protocol, periodically obtains the time indicated by the audio information channel device, and determines a differential between the time as indicated by its local clock and the audio information channel device's clock. The member uses the differential and the time as indicated by the time stamp to determine the time, relative to its local clock, at which it is to play the respective frame. The members of the synchrony group do this for all of the frames, and accordingly are able to play the frames in synchrony.

BRIEF DESCRIPTION OF THE DRAWINGS

This invention is pointed out with particularity in the appended claims. The above and further advantages of this invention may be better understood by referring to the following description taken in conjunction with the accompanying drawings, in which:

FIG. **1** schematically depicts an illustrative networked audio system, constructed in accordance with the invention;

FIG. **2** schematically depicts a functional block diagram of a synchrony group utilizing a plurality of zone players formed within the networked audio system depicted in FIG. **1**;

FIG. **2**A schematically depicts two synchrony groups, illustrating how a member of one synchrony group can provide audio information to the members of another synchrony group;

FIG. **3** depicts an functional block diagram of a zone player for use in the networked audio system depicted in FIG. **1**; and

FIG. **4** is useful in understanding an digital audio information framing methodology useful in the network audio system depicted in FIG. **1**.

DETAILED DESCRIPTION OF AN ILLUSTRATIVE EMBODIMENT

FIG. **1** depicts an illustrative network audio system **10** constructed in accordance with the invention. With reference to FIG. **1**, the network audio system **10** includes a plurality of zone players **11**(**1**) through **11**(N) (generally identified by reference numeral **11**(*n*)) interconnected by a local network **12**, all of which operate under control of one or more user interface modules generally identified by reference numeral **13**. One or more of the zone players **11**(*n*) may also be connected to one or more audio information sources, which will generally be identified herein by reference numeral **14**(*n*)(*s*), and/or one or more audio reproduction devices, which will generally be identified by reference numeral **15**(*n*)(*r*). In the reference numeral **14**(*n*)(*s*), index "n" refers to the index "n" of the zone player **11**(*n*) to which the audio information source is connected, and the index "s" (s=1, . . . , S_n) refers to the "s-th" audio information source connected to that "n-th" zone player **11**(*n*). Thus, if, for example, a zone player **11**(*n*) is connected to four audio information sources **14**(*n*)(**1**) through **14**(*n*)(**4**), the audio information sources may be generally identified by reference numeral **14**(*n*)(*s*), with S_n=4. It will be appreciated that the number of audio information sources S_n may vary as among the various zone players **11**(*n*), and some zone players may not have any audio information sources connected thereto. Similarly, in the reference numeral **15**(*n*)(*r*), index "n" refers to the index "n" of the zone player **11**(*n*) to which the audio reproduction device is connected, and the index "r" (r=1, . . . , R_n) refers to the "r-th" audio information source connected to that "n-th" zone player **11**(*n*). In addition to the audio information sources **14**(*n*)(*s*), the network audio system **10** may include one or more audio information sources **16**(**1**) through **16**(M) connected through appropriate network interface devices (not separately shown) to the local network **12**. Furthermore, the local network may include one or more network interface devices (also not separately shown) that are configured to connect the local network **12** to other networks, including a wide area network such as the Internet, the public switched telephony network (PSTN) or other networks as will be apparent to those skilled in the art, over which connections to audio information sources may be established.

The zone players **11**(*n*) associated with system **10** may be distributed throughout an establishment such as residence, an office complex, a hotel, a conference hall, an amphitheater or auditorium, or other types of establishments as will be apparent to those skilled in the art or the like. For example, if the zone players **11**(*n*) and their associated audio information source(s) and/or audio reproduction device(s) are distributed throughout a residence, one, such as zone player **11**(**1**) and its associated audio information source(s) and audio reproduction device(s) may be located in a living room, another may be located in a kitchen, another may be located in a dining room, and yet others may be located in respective bedrooms, to selectively provide entertainment in those rooms. On the other hand, if the zone players **11**(*n*) and their associated audio information source(s) and/or audio reproduction device(s) are distributed throughout an office complex, one may, for example, be provided in each office to selectively provide entertainment to the employees in the respective offices. Similarly, if the zone players **11**(*n*) and associated audio information source(s) and/or audio reproduction device(s) are used in a hotel, they may be distributed throughout the rooms to provide entertainment to the guests. Similar arrangements may be used with zone players **11**(*n*) and associated audio information source(s) and/or audio reproduction device(s) used in an amphitheater or auditorium. Other arrangements in other types of environments will be apparent to those skilled in the art. In each case, the zone players **11**(*n*) can be used to selectively provide entertainment in the respective locations, as will be described below.

The audio information sources **14**(*n*)(*s*) and **16**(*m*) may be any of a number of types of conventional sources of audio information, including, for example, compact disc ("CD") players, AM and/or FM radio receivers, analog or digital tape cassette players, analog record turntables and the like. In addition, the audio information sources **14**(*n*)(*s*) and **16**(*m*) may comprise digital audio files stored locally on, for example, personal computers (PCs), personal digital assistants (PDAs), or similar devices capable of storing digital information in volatile or non-volatile form. As noted above, the local network **12** may also have an interface (not shown) to a wide area network, over which the network audio system **10** can obtain audio information. Moreover, one or more of the audio information sources **14**(*n*)(*s*) may also comprise an interface to a wide area network such as the Internet, the public switched telephony network (PSTN) or any other source of audio information. In addition, one or more of the audio information sources **14**(*n*)(*s*) and **16**(*m*) may comprise interfaces to radio services delivered over, for example, satellite. Audio information obtained over the wide area network may comprise, for example, streaming digital audio information such as Internet radio, digital audio files stored on servers, and other types of audio information and sources as will

be appreciated by those skilled in the art. Other arrangements and other types of audio information sources will be apparent to those skilled in the art.

Generally, the audio information sources **14**(*n*)(*s*) and **16**(*m*) provide audio information associated with audio programs to the zone players for playback. A zone player that receives audio information from an audio information source **14**(*n*)(*s*) that is connected thereto can provide playback and/or forward the audio information, along with playback timing information, over the local network **12** to other zone players for playback. Similarly, each audio information source **16**(*m*) that is not directly connected to a zone player can transmit audio information over the network **12** to any zone player **11**(*n*) for playback. In addition, as will be explained in detail below, the respective zone player **11**(*n*) can transmit the audio information that it receives either from an audio information source **14**(*n*)(*s*) connected thereto, or from an audio information source **16**(*m*), to selected ones of the other zone players **11**(*n*'), **11**(*n*"), . . . (n not equal to n', n", . . .) for playback by those other zone players. The other zone players **11**(*n*'), **11**(*n*"), . . . to which the zone player **11**(*n*) transmits the audio information for playback may be selected by a user using the user interface module **13**. In that operation, the zone player **11**(*n*) will transmit the audio information to the selected zone players **11**(*n*'), **11**(*n*"), . . . over the network **12**. As will be described below in greater detail, the zone players **11**(*n*), **11**(*n*), **11**(*n*"), . . . operate such that the zone players **11**(*n*'), **11**(*n*"), . . . synchronize their playback of the audio program with the playback by the zone player **11**(*n*), so that the zone players **11**(*n*), **11**(*n*'), **11**(*n*") provide the same audio program at the same time.

Users, using user interface module **13**, may also enable different groupings or sets of zone players to provide audio playback of different audio programs synchronously. For example, a user, using a user interface module **13**, may enable zone players **11**(**1**) and **11**(**2**) to play one audio program, audio information for which may be provided by, for example, one audio information source **14**(**1**)(**1**). The same or a different user may, using the same or a different user interface module **13**, enable zone players **11**(**4**) and **11**(**5**) to contemporaneously play another audio program, audio information for which may be provided by a second audio information source, such as audio information source **14**(**5**)(**2**). Further, a user may enable zone player **11**(**3**) to contemporaneously play yet another audio program, audio information for which may be provided by yet another audio information source, such as audio information source **16**(**1**). As yet another possibility, a user may contemporaneously enable zone player **11**(**1**) to provide audio information from an audio information source connected thereto, such as audio information source **14**(**1**)(**2**), to another zone player, such as zone player **11**(**6**) for playback.

In the following, the term "synchrony group" will be used to refer to a set of one or more zone players that are to play the same audio program synchronously. Thus, in the above example, zone players **11**(**1**) and **11**(**2**) comprise one synchrony group, zone player **11**(**3**) comprises a second synchrony group, zone players **11**(**4**) and **11**(**5**) comprise a third synchrony group, and zone player **11**(**6**) comprises yet a fourth synchrony group. Thus, while zone players **11**(**1**) and **11**(**2**) are playing the same audio program, they will play the audio program synchronously. Similarly, while zone players **11**(**4**) and **11**(**5**) are playing the same audio program, they will play the audio program synchronously. On the other hand, zone players that are playing different audio programs may do so with unrelated timings. That is, for example, the timing with which zone players **11**(**1**) and **11**(**2**) play their audio program may have no relationship to the timing with which zone player **11**(**3**), zone players **11**(**4**) and **11**(**5**), and zone player **11**(**6**) play their audio programs. It will be appreciated that, since "synchrony group" is used to refer to sets of zone players that are playing the same audio program synchronously, zone player **11**(**1**) will not be part of zone player **11**(**6**)'s synchrony group, even though zone player **11**(**1**) is providing the audio information for the audio program to zone player **11**(**6**).

In the network audio system **10**, the synchrony groups are not fixed. Users can enable them to be established and modified dynamically. Continuing with the above example, a user may enable the zone player **11**(**1**) to begin providing playback of the audio program provided thereto by audio information source **14**(**1**)(**1**), and subsequently enable zone player **11**(**2**) to join the synchrony group. Similarly, a user may enable the zone player **11**(**5**) to begin providing playback of the audio program provided thereto by audio information source **14**(**5**)(**2**), and subsequently enable zone player **11**(**4**) to join that synchrony group. In addition, a user may enable a zone player to leave a synchrony group and possibly join another synchrony group. For example, a user may enable the zone player **11**(**2**) to leave the synchrony group with zone player **11**(**1**), and join the synchrony group with zone player **11**(**6**). As another possibility, the user may enable the zone player **11**(**1**) to leave the synchrony group with zone player **11**(**2**) and join the synchrony group with zone player **11**(**6**). In connection with the last possibility, the zone player **11**(**1**) can continue providing audio information from the audio information source **14**(**1**)(**1**) to the zone player **11**(**2**) for playback thereby.

A user, using the user interface module **13**, can enable a zone player **11**(*n*) that is currently not a member of a synchrony group to join a synchrony group, after which it will be enabled to play the audio program that is currently being played by that synchrony group. Similarly, a user, also using the user interface module **13**, can enable a zone player **11**(*n*) that is currently a member of one synchrony group, to disengage from that synchrony group and join another synchrony group, after which that zone player will be playing the audio program associated with the other synchrony group. For example, if a zone player **11**(**6**) is currently not a member of any synchrony group, it, under control of the user interface module **13**, can become a member of a synchrony group, after which it will play the audio program being played by the other members of the synchrony group, in synchrony with the other members of the synchrony group. In becoming a member of the synchrony group, zone player **11**(**6**) can notify the zone player that is the master device for the synchrony group that it wishes to become a member of its synchrony group, after which that zone player will also transmit audio information associated with the audio program, as well as timing information, to the zone player **11**(**6**). As the zone player **11**(**6**) receives the audio information and the timing information from the master device, it will play the audio information with the timing indicated by the timing information, which will enable the zone player **11**(**6**) to play the audio program in synchrony with the other zone player(s) in the synchrony group.

Similarly, if a user, using the user interface module **13**, enables a zone player **11**(*n*) associated with a synchrony group to disengage from that synchrony group, and if the zone player **11**(*n*) is not the master device of the synchrony group, the zone player **11**(*n*) can notify the master device, after which the master device can terminate transmission of the audio information and timing information to the zone player **11**(*n*). If the user also enables the zone player **11**(*n*) to begin playing another audio program using audio information from

an audio information source **14**(*n*)(*s*) connected thereto, it will acquire the audio information from the audio information source **14**(*n*)(*s*) and initiate playback thereof. If the user enables another zone player **11**(*n'*) to join the synchrony group associated with zone player **11**(*n*), operations in connection therewith can proceed as described immediately above.

As yet another possibility, if a user, using the user interface module **13**, enables a zone player **11**(*n*) associated with a synchrony group to disengage from that synchrony group and join another synchrony group, and if the zone player is not the master device of the synchrony group from which it is disengaging, the zone player **11**(*n*) can notify the master device of the synchrony group from which it is disengaging, after which that zone player will terminate transmission of audio information and timing information to the zone player **11**(*n*) that is disengaging. Contemporaneously, the zone player **11**(*n*) can notify the master device of the synchrony group that it (that is, zone player **11**(*n*)) is joining, after which the master device can begin transmission of audio information and timing information to that zone player **11**(*n*). The zone player **11**(*n*) can thereafter begin playback of the audio program defined by the audio information, in accordance with the timing information so that the zone player **11**(*n*) will play the audio program in synchrony with the master device.

As yet another possibility, a user, using the user interface module **13**, may enable a zone player **11**(*n*) that is not associated with a synchrony group, to begin playing an audio program using audio information provided to it by an audio information source **14**(*n*)(*s*) connected thereto. In that case, the user, also using the user interface module **13** or a user interface device that is specific to the audio information source **14**(*n*)(*s*), can enable the audio information source **14**(*n*)(*s*) to provide audio information to the zone player **11**(*n*). After the zone player **11**(*n*) has begun playback, or contemporaneously therewith, the user, using the user interface module **13**, can enable other zone players **11**(*n'*), **11**(*n''*), . . . to join zone player **11**(*n*)'s synchrony group and enable that zone player **11**(*n*) to transmit audio information and timing information thereto as described above, to facilitate synchronous playback of the audio program by the other zone players **11**(*n'*), **11**(*n''*) . . . .

A user can use the user interface module **13** to control other aspects of the network audio system **10**, including but not limited to the selection of the audio information source **14**(*n*)(*s*) that a particular zone player **11**(*n*) is to utilize, the volume of the audio playback, and so forth. In addition, a user may use the user interface module **13** to turn audio information source(s) **14**(*n*)(*s*) on and off and to enable them to provide audio information to the respective zone players **11**(*n*).

Operations performed by the various devices associated with a synchrony group will be described in connection with FIG. **2**, which schematically depicts a functional block diagram of a synchrony group in the network audio system **10** described above in connection with FIG. **1**. With reference to FIG. **2**, a synchrony group **20** includes a master device **21** and zero or more slave devices **22**(**1**) through **22** (G) (generally identified by reference numeral **22**(*g*)), all of which synchronously play an audio program provided by an audio information channel device **23**. Each of the master device **21**, slave devices **22**(*g*) and audio information channel device **23** utilizes a zone player **11**(*n*) depicted in FIG. **1**, although it will be clear from the description below that a zone player may be utilized both for the audio information channel device for the synchrony group **20**, and the master device **21** or a slave device **22**(*g*) of the synchrony group **20**. As will be described below in more detail, the audio information channel device **23** obtains the audio information for the audio program from an audio information source, adds playback timing information, and transmits the combined audio and playback timing information to the master device **21** and slave devices **22**(*g*) over the network **12** for playback. The playback timing information that is provided with the audio information, together with clock timing information provided by the audio information channel device **23** to the various devices **21** and **22**(*g*) as will be described below, enables the master device **21** and slave devices **22**(*g*) of the synchrony group **20** to play the audio information simultaneously.

The master device **21** and the slave devices **22**(*g*) receive the audio and playback timing information, as well as the clock timing information, that are provided by the audio information channel device **23**, and play back the audio program defined by the audio information. The master device **21** is also the member of the synchrony group **20** that communicates with the user interface module **13** and that controls the operations of the slave devices **22**(*g*) in the synchrony group **20**. In addition, the master device **21** controls the operations of the audio information channel device **23** that provides the audio and playback timing information for the synchrony group **20**. Generally, the initial master device **21** for the synchrony group will be the first zone player **11**(*n*) that a user wishes to play an audio program. However, as will be described below, the zone player **11**(*n*) that operates as the master device **21** can be migrated from one zone player **11**(*n*) to another zone player **11**(*n'*), which preferably will be a zone player that is currently operating as a slave device **22**(*g*) in the synchrony group.

In addition, under certain circumstances, as will be described below, the zone player **11**(*n*) that operates as the audio information channel device **23** can be migrated from one zone player to another zone player, which also will preferably will be a zone player that is currently operating as a member of the synchrony group **20**. It will be appreciated that the zone player that operates as the master device **21** can be migrated to another zone player independently of the migration of the audio information channel device **23**. For example, if one zone player **11**(*n*) is operating as both the master device **21** and the audio information channel device **23** for a synchrony group **20**, the master device **21** can be migrated to another zone player **11**(*n'*) while the zone player **11**(*n*) is still operating as the audio information channel device **23**. Similarly, if one zone player **11**(*n*) is operating as both the master device **21** and the audio information channel device **23** for a synchrony group **20**, the audio information channel device **23** can be migrated to another zone player **11**(*n'*) while the zone player **11**(*n*) is still operating as the master device **21**. In addition, if one zone player **11**(*n*) is operating as both the master device **21** and the audio information channel device **23** for a synchrony group **20**, the master device **21** can be migrated to another zone player **11**(*n'*) and the audio information channel device can be migrated to a third zone player **11**(*n''*).

The master device **21** receives control information from the user interface module **13** for controlling the synchrony group **20** and provides status information indicating the operational status of the synchrony group to the user interface module **13**. Generally, the control information from the user interface module **13** enables the master device **21** to, in turn, enable the audio information channel device **23** to provide audio and playback timing information to the synchrony group to enable the devices **21** and **22**(*g*) that are members of the synchrony group **20** to play the audio program synchronously. In addition, the control information from the user interface module **13** enables the master device **21** to, in turn,

enable other zone players to join the synchrony group as slave devices **22**(*g*) and to enable slave devices **22**(*g*) to disengage from the synchrony group. Control information from the user interface module **13** can also enable the zone player **11**(*n*) that is currently operating as the master device **21** to disengage from the synchrony group, but prior to doing so that zone player will enable the master device **21** to transfer from that zone player **11**(*n*) to another zone player **11**(*n'*), preferably to a zone player **11**(*n'*) that is currently a slave device **22**(*g*) in the synchrony group **20**. The control information from the user interface module **13** can also enable the master device **21** to adjust its playback volume and to enable individual ones of the various slave devices **22**(*g*) to adjust their playback volumes. In addition, the control information from the user interface module **13** can enable the synchrony group **20** to terminate playing of a current track of the audio program and skip to the next track, and to re-order tracks in a play list of tracks defining the audio program that is to be played by the synchrony group **20**.

The status information that the master device **21** may provide to the user interface module **13** can include such information as a name or other identifier for the track of the audio work that is currently being played, the names or other identifiers for upcoming tracks, the identifier of the zone player **11**(*n*) that is currently operating as the master device **21**, and identifiers of the zone players that are currently operating as slave devices **22**(*g*). In one embodiment, the user interface module **13** includes a display (not separately shown) that can display the status information to the user.

It will be appreciated that the zone player **11**(*n*) that is operating as the audio information channel device **23** for one synchrony group may also comprise the master device **21** or any of the slave devices **22**(*g*) in another synchrony group. This may occur if, for example, the audio information source that is to provide the audio information that is to be played by the one synchrony group is connected to a zone player also being utilized as the master device or a slave device for the other synchrony group. This will be schematically illustrated below in connection with FIG. **2**A. Since, as noted above, the zone player **11**(*n*) that is operating as the audio information channel device **23** for the synchrony group **20** may also be operating as a master device **21** or slave device **22**(*g*) for another synchrony group, it can also be connected to one or more audio reproduction devices **15**(*n*)(*r*), although that is not depicted in FIG. **2**. Since the master device **21** and slave devices **22**(*g*) are all to provide playback of the audio program, they will be connected to respective audio reproduction devices **15**(*n*)(*r*). Furthermore, it will be appreciated that one or more of the zone players **11**(*n*) that operate as the master device **21** and slave devices **22**(*g*) in synchrony group **20** may also operate as an audio information channel device for that synchrony group or for another synchrony group and so they may be connected to one or more audio information sources **14**(*n*)(*s*), although that is also not depicted in FIG. **2**. In addition, it will be appreciated that a zone player **11**(*n*) can also operate as a audio information channel device **23** for multiple synchrony groups.

If the audio information channel device **23** does not utilize the same zone player as the master device **21**, the master device **21** controls the audio information channel device by exchanging control information over the network **12** with the audio information channel device **23**. The control information is represented in FIG. **2** by the arrow labeled CHAN_DEV_CTRL_INFO. The control information that the master device **21** provides to the audio information channel device **23** will generally depend on the nature of the audio information source that is to provide the audio information for the audio program that is to be played and the operation to be enabled by the control information. If, for example, the audio information source is a conventional compact disc, tape, or record player, broadcast radio receiver, or the like, which is connected to a zone player **11**(*n*), the master device **21** may merely enable the zone player serving as the audio information channel device **23** to receive the audio information for the program from the audio information source. It will be appreciated that, if the audio information is not in digital form, the audio information channel device **23** will convert it to digital form and provide the digitized audio information, along with the playback timing information, to the master device **21** and slave devices **22**(*g*).

On the other hand, if the audio information source is, for example, a digital data storage device, such as may be on a personal computer or similar device, the master device **21** can provide a play list to the audio information channel device **23** that identifies one or more files containing the audio information for the audio program. In that case, the audio information channel device **23** can retrieve the files from the digital data storage device and provide them, along with the playback timing information, to the master device **21** and the slave devices **22**(*g*). It will be appreciated that, in this case, the audio information source may be directly connected to the audio information channel device **23**, as, for example, an audio information source **14**(*n*)(*s*), or it may comprise an audio information source **16**(*m*) connected to the network **12**. As a further alternative, if the audio information source is a source available over the wide area network, the master device **21** can provide a play list comprising a list of web addresses identifying the files containing the audio information for the audio program that is to be played, and in that connection the audio information channel device **23** can initiate a retrieval of the files over the wide area network. As yet another alternative, if the audio information source is a source of streaming audio received over the wide area network, the master device **21** can provide a network address from which the streaming audio can be received. Other arrangements by which the master device **21** can control the audio information channel device **23** will be apparent to those skilled in the art.

The master device **21** can also provide control information to the synchrony group's audio information channel device **23** to enable a migration from one zone player **11**(*n*) to another zone player **11**(*n'*). This may occur if, for example, the audio information source is one of audio information sources **16** or a source accessible over the wide area network via the network **12**. The master device **21** can enable migration of the audio information channel device **23** for several reasons, including, for example, to reduce the loading of the zone player **11**(*n*), to improve latency of message transmission in the network **12**, and other reasons as will be appreciated by those skilled in the art.

As noted above, the audio information channel device **23** provides audio and playback timing information for the synchrony group to enable the master device **21** and slave devices **22**(*g*) to play the audio program synchronously. Details of the audio and playback timing information will be described in detail below in connection with FIGS. **3** and **4**, but, in brief, the audio information channel device **23** transmits the audio and playback timing information in messages over the network **12** using a multi-cast message transmission methodology. In that methodology, the audio information channel device **23** will transmit the audio and playback timing information in a series of messages, with each message being received by all of the zone players **11**(*n*) comprising the synchrony group **20**, that is, by the master device **21** and the slave devices **22**(*g*). Each of the messages includes a multi-

cast address, which the master device **21** and slave devices **22**(*g*) will monitor and, when they detect a message with that address, they will receive and use the contents of the message. The audio and playback timing information is represented in FIG. **2** by the arrow labeled "AUD+PBTIME_INF0," which has a single tail, representing a source for the information at the audio information channel device **23**, and multiple arrowheads representing the destinations of the information, with one arrowhead extending to the master device **21** and other arrowheads extending to each of the slave devices **22**(*g*) in the synchrony group **20**. The audio information channel device **23** may make use of any convenient multi-cast message transmission methodology in transmitting the audio and playback timing information to the synchrony group **20**. As will be described in detail in connection with FIG. **4**, the audio and playback timing information is in the form of a series of frames, with each frame having a time stamp. The time stamp indicates a time, relative to the time indicated by a clock maintained by the audio information channel device **23**, at which the frame is to be played. Depending on the size or sizes of the messages used in the selected multi-cast message transmission methodology and the size or sizes of the frames, a message may contain one frame, or multiple frames, or, alternatively, a frame may extend across several messages.

The audio information channel device **23** also provides clock time information to the master device **21** and each of the slave devices **22**(*g*) individually over network **12** using a highly accurate clock time information transmission methodology. The distribution of the clock time information is represented in FIG. **2** by the arrows labeled "AICD_CLK_INF (M)" (in the case of the clock time information provided to the master device **21**) and "AICD_CLK_INF (S_1)" through "AICD_CLK_INF (S_G)" (in the case of audio information channel device clock information provided to the slave devices **22**(*g*)). In one embodiment, the master device **21** and slave devices **22**(*g*) make use of the well-known SNTP (Simple Network Time Protocol) to obtain current clock time information from the audio information channel device **23**. The SNTP makes use of a unicast message transfer methodology, in which one device, such as the audio information channel device **23**, provides clock time information to a specific other device, such as the master device **21** or a slave device **22**(*g*), using the other device's network, or unicast, address. Each of the master device **21** and slave devices **22**(*g*) will periodically initiate SNTP transactions with the audio information channel device **23** to obtain the clock time information from the audio information channel device **23**. As will be described below in more detail, the master device **21** and each slave device **22**(*g*) make use of the clock time information to determine the time differential between the time indicated by the audio information channel device's clock and the time indicated by its respective clock, and use that time differential value, along with the playback time information associated with the audio information and the respective device's local time as indicated by its clock to determine when the various frames are to be played. This enables the master device **21** and the slave devices **22**(*g*) in the synchrony group **20** to play the respective frames simultaneously.

As noted above, the control information provided by the user to the master device **21** through the user interface module **13** can also enable the master device **21** to, in turn, enable another zone player **11**(*n'*) to join the synchrony group as a new slave device **22**(*g*). In that operation, the user interface module **13** will provide control information, including the identification of the zone player **11**(*n'*) that is to join the synchrony group to the master device **21**. After it receives the identification of the zone player **11**(*n'*) that is to join the synchrony group, the master device **21** will exchange control information, which is represented in FIG. **2** by the arrows labeled SLV_DEV_CTRL_INF (S_1) through SLV_DEV_CTRL_INF (S_G) group slave control information, over the network **12** with the zone player **11**(*n'*) that is identified in the control information from the user interface module **13**. The control information that the master device **21** provides to the new zone player **11**(*n'*) includes the network address of the zone player **11**(*n*) that is operating as the audio information channel device **23** for the synchrony group, as well as the multi-cast address that the audio information channel device **23** is using to broadcast the audio and playback timing information over the network. The zone player that is to operate as the new slave device **22**(*g'*) uses the multi-cast address to begin receiving the multi-cast messages that contain the audio information for the audio program being played by the synchrony group.

It will be appreciated that, if the zone player **11**(*n*) that is operating as the master device **21** for the synchrony group **20** is also operating the audio information channel device **23**, and if there are no slave devices **22**(*g*) in the synchrony group **20**, the audio information channel device **23** may not be transmitting audio and playback timing information over the network. In that case, if the new slave device **22**(*g'*) is the first slave device in the synchrony group, the zone player **11**(*n*) that is operating as both the master device **21** and audio information channel device **23**, can begin transmitting the audio and playback timing information over the network **12** when the slave device **22**(*g'*) is added to the synchrony group **20**. The zone player **11**(*n*) can maintain a count of the number of slave devices **22**(*g*) in the synchrony group **20** as they join and disengage, and, if the number drops to zero, it can stop transmitting the audio and playback timing information over the network **12** to reduce the message traffic over the network **12**.

The new slave device **22**(*g'*) added to the synchrony group **20** uses the network address of the audio information channel device **23** for several purposes. In particular, the new slave device **22**(*g'*) will, like the master device **21** (assuming the zone player **11**(*n*) operating as the master device **21** is not also the audio information channel device **23**), engage in SNTP transactions with the audio information channel device **23** to obtain the clock timing information from the audio information channel device **23**. In addition, the new slave device **22**(*g'*) can notify the audio information channel device **23** that it is a new slave device **22**(*g'*) for the synchrony group **20** and provide the audio information channel device **23** with its network address. As will be described below, in one embodiment, particularly in connection with audio information obtained from a source, such as a digital data storage device, which can provide audio information at a rate that is faster than the rate at which it will be played, the audio information channel device **23** will buffer audio and timing information and broadcast it over the network **12** to the synchrony group **20** generally at a rate at which it is provided by the source. Accordingly, when a new slave device **22**(*g'*) joins the synchrony group **20**, the playback timing information may indicate that the audio information that is currently being broadcast by the audio information channel device **23** using the multi-cast methodology is to be played back some time in the future. To reduce the delay with which the new slave device **22**(*g'*) will begin playback, the audio information channel device **23** can also retransmit previously transmitted audio and timing information that it had buffered to the new slave device **22**(*g'*) using the unicast network address of the slave device **22**(*g'*).

The master device **21** can also use the slave device control information exchanged with the slave devices **22**(*g*) for other purposes. For example, the master device **21** can use the slave device control information to initiate a migration of the master from its zone player **11**(*n*) to another zone player **11**(*n'*). This may occur for any of a number of reasons, including, for example, that the master device **21** is terminating playback by it of the audio program and is leaving the synchrony group **20**, but one or more of the other devices in the synchrony group is to continue playing the audio program. The master device **21** may also want to initiate a migration if it is overloaded, which can occur if, for example, the zone player **11**(*n*) that is the master device **21** for its synchrony group is also operating as an audio information channel device **23** for another synchrony group.

The user can also use the user interface module **13** to adjust playback volume by the individual zone players **11**(*n*) comprising the synchrony group. In that operation, the user interface module **13** provides information identifying the particular device whose volume is to be adjusted, and the level at which the volume is to be set to the master device **21**. If the device whose volume is to be adjusted is the master device **21**, the master device **21** can adjust its volume according to the information that it receives from the user interface module **13**. On the other hand, if the device whose volume is to be adjusted is a slave device **22**(*g*), the master device **21** can provide group slave control information to the respective slave device **22**(*g*), to enable it to adjust its volume.

The user can also use the user interface module **13** to enable a synchrony group **20** to cancel playing of the track in an audio program that is currently being played, and to proceed immediately to the next track. This may occur, for example, if the tracks for the program is in the form of a series of digital audio information files, and the user wishes to cancel playback of the track that is defined by one of the files. In that case, when the master device **21** receives the command to cancel playback of the current track, it will provide channel device control information to the audio information channel device **23** so indicating. In response, the audio information channel device **23** inserts control information into the audio and playback timing information, which will be referred to as a "resynchronize" command. In addition, the audio information channel device **23** will begin transmitting audio information for the next track, with timing information to enable it to be played immediately. The resynchronize command can also enable playback of a track to be cancelled before it has been played. Details of these operations will be described below.

As noted above, there may be multiple synchrony groups in the network audio system **10**, and further that, for example, a zone player **11**(*n*) may operate both as a master device **21** or a slave device **22**(*g*) in one synchrony group, and as the audio information channel device **23** providing audio and playback timing information and clock timing information for another synchrony group. An illustrative arrangement of this will be described in connection with FIG. **2**A. With reference to FIG. **2**A, that FIG. depicts elements of two synchrony groups, identified by reference numerals **20**(**1**) and **20**(**2**), respectively. For clarity, FIG. **2**A does not show a number of elements, the presence of which would be evident from FIGS. **1** and **2** as described above. For example, FIG. **2**A does not depict the audio information sources from which audio information is obtained for the synchrony groups or the audio reproduction devices that are used to produce sound for the master and slave devices, which are depicted in both FIGS. **1** and **2**. In addition, FIG. **2**A does not depict arrows that represent control information provided by the respective master devices to the slave devices in the respective synchrony groups, or to the audio information channel devices that provide audio and timing information for the respective synchrony groups, which are depicted in FIG. **2**. In addition, FIG. **2**A does not depict the arrows that represent the clock timing information provided by the audio information channel devices to the respective members of the respective synchrony groups, which are also depicted in FIG. **2**. As will be noted below, however, FIG. **2**A does depict arrows representing the audio and playback timing information provided by the respective audio information channel devices for the respective synchrony groups **20**(**1**), **20**(**2**), to the master and slave devices comprising the respective synchrony groups **20**(**1**), **20**(**2**).

Each synchrony group **20**(**1**), **20**(**2**) comprises elements of a number of zone players. A functional block diagram of a zone player will be described below in connection with FIG. **3**. Synchrony group **20**(**1**) includes a master device **21**(**1**) and "K" slave devices **22**(**1**)(**1**) through **22**(K)(**1**) (the index "1" in reference numeral **21**(**1**) and the last index in reference numeral **22**(**1**)(**1**) through **21**(K)(**1**) corresponds to the index of the synchrony group **20**(**1**) to which they belong) utilize zone players **11**(**1**) and **11**(K+1) respectively. Similarly, synchrony group **20**(**2**) includes a master device **21**(**2**) and "L" slave devices **22**(**1**)(**2**) through **22**(L)(**2**) that utilize zone players **11**(K+2) through **11**(K+L+2). In the illustrative arrangement depicted in FIG. **2**A, both synchrony groups **20**(**1**) and **20**(**2**) are controlled by the user interface module **13**, which can provide control information to, and receive status information from, the master devices **21**(**1**) and **21**(**2**) independently. It will be appreciated that separate user interface modules may be provided to provide control information to, and receive status information from, the respective master devices **21**(**1**), **21**(**2**).

As noted above, the slave device **22**(**1**)(**2**) in synchrony group **20**(**2**) utilizes zone player **11**(K+3). In the illustrative arrangement depicted in FIG. **2**A, the audio information channel device **23**(**1**) that provides audio and playback timing information to the master and slave devices **21**(**1**), **22**(**1**)(**1**), . . . , **22**(K)(**1**) of synchrony group **20**(**1**) also utilizes zone player **11**(K+3). As noted above, this may occur if, for example, the audio information source that is to provide audio information to be played by the synchrony group **20**(**1**) is connected to the zone player **11**(K+3). Thus, when the master device **21**(**1**) of synchrony group **20**(**1**) exchanges channel device control information with the audio information channel device **23**(**1**), it is effectively exchanging channel device control information with the zone player **11**(K+3). Similarly, when the master and slave devices **21**(**1**), **22**(**1**)(**1**), . . . , **22**(K)(**1**) of synchrony group **20**(**1**) receive audio and playback timing information, as well as clock timing information, from the audio information channel device **23**(**1**), they are effectively receiving the information from the zone player **11**(K+3). FIG. **2**A depicts a multi-headed arrow representing audio and playback timing information transmitted by the zone player **11**(K+3), as audio information channel device **23**(**1**), to the master and slave devices **21**(**1**), **22**(**1**)(**1**), . . . , **11**(K)(**1**) comprising synchrony group **20**(**1**).

On the other hand, in the illustrative arrangement depicted in FIG. **2**A, the synchrony group **20**(**2**) utilizes a zone player **11**(K+L+3) as its audio information channel device **23**(**2**). As with synchrony group **20**(**1**), when the master device **21**(**2**) of synchrony group **20**(**2**) exchanges channel device control information with the audio information channel device **23**(**2**), it is effectively exchanging channel device control information with the zone player **11**(K+L+3). Similarly, when the master and slave devices **21**(**2**), **22**(**1**)(**2**), . . . , **22**(L)(**2**) of synchrony group **20**(**2**) receive audio and playback timing

information, as well as clock timing information, from the audio information channel device **23**(**2**), they are effectively receiving the information from the zone player **11**(K+L+3). FIG. **2**A depicts a multi-headed arrow representing audio and playback timing information transmitted by the zone player **11**(K+3) as audio information channel device **23**(**2**) to the master and slave devices **21**(**2**), **22**(**1**)(**2**), . . . , **22**(L)(**2**) comprising synchrony group **20**(**2**).

In the illustrative arrangement depicted in FIG. **2**A, zone player **11**(K+L+3), which is the audio information channel device **23**(**2**) for synchrony group **20**(**2**), is not shown as being either a master or a slave device in another synchrony group. However, it will be appreciated that zone player **11**(K+L+3) could also be utilized as the master device or a slave device for another synchrony group. Indeed, it will be appreciated that the zone player that is utilized as the audio information channel device for synchrony group **20**(**2**) may also be a zone player that is utilized as the master device **21**(**1**) or a slave device **22**(**1**)(**1**), . . . , **22**(K)(**1**) in the synchrony group **20**(**1**).

A zone player **11**(*n*) that is utilized as a member of one synchrony group may also be utilized as the audio information channel device for another synchrony group if the audio information source that is to supply the audio information that is to be played by the other synchrony group is connected to that zone player **11**(*n*). A zone player **11**(*n*) may also be utilized as the audio information channel device for the other synchrony group if, for example, the audio information source is an audio information source **16**(*m*) (FIG. **1**) that is connected to the network **12** or an audio information source that is available over a wide area network such as the Internet. The latter may occur if, for example, the zone player **11**(*n*) has sufficient processing power to operate as the audio information channel device and it is in an optimal location in the network **12**, relative to the zone players comprising the other synchrony group (that is the synchrony group for which it is operating as audio information channel device) for providing the audio and playback timing information to the members of the other synchrony group. Other circumstances under which the zone player **11**(*n*) that is utilized as a member of one synchrony group may also be utilized as the audio information channel device for another synchrony group will be apparent to those skilled in the art.

As was noted above, the master device **21** for a synchrony group **20** may be migrated from one zone player **11**(*n*) to another zone player **11**(*n*'). As was further noted above, the audio information channel device **23** for a synchrony group **20** may be migrated from one zone player **11**(*n*) to another zone player **11**(*n*'). It will be appreciated that the latter may occur if, for example, the audio information source that provides the audio program for the synchrony group is not connected to the zone player **11**(*n*) that is operating as the audio information channel device **23**, but instead is one of the audio information sources **16**(*m*) connected to the network **12** or a source available over a wide area network such as the Internet. Operations performed during a migration of an audio information channel device **23** from one zone player **11**(*n*) to another zone player **11**(*n*') will generally depend on the nature of the audio information that is being channeled by the audio information channel device **23**. For example, if the audio information source provides streaming audio, the zone player **11**(*n*) that is currently operating as the audio information channel device **23** for the synchrony group **20**, can provide the following information to the other zone player **11**(*n*') that is to become the audio information channel device **23** for the synchrony group **20**:

(a) the identification of the source of the streaming audio information,

(b) the time stamp associated with the frame that the zone player **11**(*n*) is currently forming, and

(c) the identifications of the zone players that are operating as the master device **21** and slave devices **22**(*g*) comprising the synchrony group **20**.

After the zone player **11**(*n*') receives the information from the zone player **11**(*n*), it will begin receiving the streaming audio from the streaming audio information source identified by the zone player **11**(*n*), assemble the streaming audio information into frames, associate each frame with a time stamp, and transmit the resulting audio and playback timing information over the network **12**. The zone player **11**(*n*') will perform these operations in the same manner as described above, except that, instead of using the time indicated by its digital to analog converter clock **34** directly in generating the time stamps for the frames, the initial time stamp will be related to the value of the time stamp that is provided by the zone player **11**(*n*) (reference item (b) above), with the rate at which the time stamps are incremented corresponding to the rate at which its (that is, the zone player **11**(*n*')'s) clock increments. In addition, the zone player **11**(*n*') will notify the zone players that are operating as the master device **21** and slave devices **22**(*g*) of the synchrony group **20** that it is the new audio information channel device **23** for the synchrony group **20**, and provide the multi-cast address that it will be using to multi-cast the audio and playback timing information, as well as its unicast network address. After the members of the synchrony group **20** receive the notification from the zone player **11**(*n*') indicating that it is the new audio information channel device **23** for the synchrony group **20**, they will receive the audio and playback timing information from the zone player **11**(*n*') instead of the zone player **11**(*n*), using the multi-cast address provided by the zone player **11**(*n*'). In addition, they can utilize the zone player **11**(*n*')'s unicast network address to obtain current time information therefrom. It will be appreciated that the zone player **11**(*n*') will determine its current time in relation to the time stamp that is provided by the zone player **11**(*n*) (reference item (b) above) or the current time information that it received from the zone player **11**(*n*) using the SNTP protocol as described above.

Generally similar operations can be performed in connection with migrating the audio information channel device from one zone player **11**(*n*) to another zone player **11**(*n*') if the audio information is from one or more audio information files, such as may be the case if the audio information comprises MP3 or WAV files that are available from sources such as sources **16**(*m*) connected to the network **12** or over from sources available over a wide area network such as the Internet, except for differences to accommodate the fact that the audio information is in files. In that case, the zone player **11**(*n*) that is currently operating as the audio information channel device **23** for the synchrony group **20** can provide the following information to the zone player **11**(*n*') that is to become the audio information channel device **23** for the synchrony group **20**:

(d) a list of the audio information files containing the audio information that is to be played;

(e) the identification of the file for which the zone player **11**(*n*) is currently providing audio and playback timing information, along with the offset into the file for which the current item of audio and playback timing information is being generated and the time stamp that the zone player **11**(*n*) is associating with that frame, and

(f) the identifications of the zone players that comprise the master device **21** and slave devices **22**(*g*) comprising the synchrony group **20**.

After the zone player **11**(*n'*) receives the information from the zone player **11**(*n*), it will begin retrieving audio information from the file identified in item (e), starting at the identified offset. In addition, the zone player **11**(*n'*) can assemble the retrieved audio information into frames, associate each frame with a time stamp and transmit the resulting audio and playback timing information over the network **12**. The zone player **11**(*n'*) will perform these operations in the same manner as described above, except that, instead of using the time indicated by its digital to analog converter clock **34** directly in generating the time stamps for the frames, the value of the initial time stamp will be related to the time stamp that is provided by the zone player **11**(*n*) (reference item (e) above), with the rate at which the time stamps are incremented corresponding to the rate at which its (that is, the zone player **11**(*n'*)'s) clock increments. In addition, the zone player **11**(*n'*) will notify the zone players that are operating as the master device **21** and slave devices **22**(*g*) of the synchrony group **20** that it is the new audio information channel device **23** for the synchrony group **20**, and provide the multi-cast address that it will be using to multi-cast the audio and playback timing information, as well as its unicast network address. After the members of the synchrony group **20** receive the notification from the zone player **11**(*n'*) indicating that it is the new audio information channel device **23** for the synchrony group **20**, they will receive the audio and playback timing information from the zone player **11**(*n'*) instead of the zone player **11**(*n*), using the multi-cast address provided by the zone player **11**(*n'*). In addition, they can utilize the zone player **11**(*n'*)'s unicast network address to obtain current time information therefrom. It will be appreciated that the zone player **11**(*n'*) will determine its current time in relation to the time stamp that is provided by the zone player **11**(*n*) (reference item (b) above) or the current time information that it received from the zone player **11**(*n*) using the SNTP protocol as described above. The zone player **11**(*n'*) will process successive audio information files in the list that it receives from the zone player **11**(*n*) (reference item (d)).

Operations performed by the zone players **11**(*n*) and **11**(*n'*) in connection with migration of the audio information channel device **23** for other types of audio information will be apparent to those skilled in the art. In any case, preferably, the zone player **11**(*n*) will continue operating as an audio information channel device **23** for the synchrony group **20** for at least a brief time after it notifies the zone player **11**(*n'*) that it is to become audio information channel device for the synchrony group, so that the zone player **11**(*n'*) will have time to notify the zone players in the synchrony group **20** that it is the new audio information channel device **23** for the synchrony group.

Before proceeding further in describing operations performed by the network audio system **10**, it would be helpful to provide a detailed description of a zone player **11**(*n*) constructed in accordance with the invention. FIG. **3** depicts a functional block diagram of a zone player **11**(*n*) constructed in accordance with the invention. All of the zone players in the network audio system **10** may have similar construction. With reference to FIG. **3**, the zone player **11**(*n*) includes an audio information source interface **30**, an audio information buffer **31**, a playback scheduler **32**, a digital to analog converter **33**, an audio amplifier **35**, an audio reproduction device interface **36**, a network communications manager **40**, and a network interface **41**, all of which operate under the control of a control module **42**. The zone player **11**(*n*) also has a device clock **43** that provides timing signals that control the general operations of the zone player **11**(*n*). In addition, the zone player **11**(*n*) includes a user interface module interface **44** that can receive control signals from the user interface module **13** (FIGS. **1** and **2**) for controlling operations of the zone player **11**(*n*), and provide status information to the user interface module **13**.

Generally, the audio information buffer **31** buffers audio information, in digital form, along with playback timing information. If the zone player **11**(*n*) is operating as the audio information channel device **23** (FIG. **2**) for a synchrony group **20**, the information that is buffered in the audio information buffer **31** will include the audio and playback timing information that will be provided to the devices **21** and **22**(*g*) in the synchrony group **20**. If the zone player **11**(*n*) is operating as the master device **21** or a slave device **22**(*g*) for a synchrony group, the information that is buffered in the audio information buffer **31** will include the audio and playback timing information that the zone player **11**(*n*) is to play.

The audio information buffer **31** can receive audio and playback timing information from two sources, namely, the audio information source interface **30** and the network communications manager **40**. In particular, if the zone player **11**(*n*) is operating as the audio information channel device **23** for a synchrony group **20**, and if the audio information source is a source **14**(*n*)(*s*) connected to the zone player **11**(*n*), the audio information buffer **31** will receive and buffer audio and playback timing information from the audio information source interface **30**. On the other hand, if the zone player **11**(*n*) is operating as the audio information channel device **23** for a synchrony group **20**, and if the audio information source is a source **16**(*m*) connected to the network **12**, or a source available over the wide area network, the audio information buffer **31** will receive and buffer audio and playback timing information from the network communications manager **40**. It will be appreciated that, if the zone player **11**(*n*) is not a member of the synchrony group, the zone player **11**(*n*) will not play this buffered audio and playback timing information.

On yet another hand, if the zone player **11**(*n*) is operating as the master device **21** or a slave device **22**(*g*) in a synchrony group, and if the zone player **11**(*n*) is not also the audio information channel device **23** providing audio and playback timing information for the synchrony group **20**, the audio information buffer **31** will receive and buffer audio and playback timing information from the network communications manager **40**.

The audio information source interface **30** connects to the audio information source(s) **14**(*n*)(*s*) associated with the zone player **11**(*n*). While the zone player **11**(*n*) is operating as audio information channel device **23** for a synchrony group **20**, and if the audio information is to be provided by a source **14**(*n*)(*s*) connected to the zone player **11**(*n*), the audio information source interface **30** will selectively receive audio information from one of the audio information source(s) **14**(*n*)(*s*) to which the zone player is connected and store the audio information in the audio information buffer **21**. If the audio information from the selected audio information source **14**(*n*)(*s*) is in analog form, the audio information source interface **30** will convert it to digital form. The selection of the audio information source **14**(*n*)(*s*) from which the audio information source interface **30** receives audio information is under control of the control module **42**, which, in turn, receives control information from the user interface module through the user interface module interface **44**. The audio information source interface **30** adds playback timing infor-

mation to the digital audio information and buffers the combined audio and playback timing information in the audio information buffer **21**.

More specifically, as noted above, the audio information source interface **30** receives audio information from an audio information source **14**(*n*)(*s*), converts it to digital form if necessary, and buffers it along with playback timing information in the audio information buffer **21**. In addition, the audio information source interface **30** will also provide formatting and scheduling information for the digital audio information, whether as received from the selected audio information source **14**(*n*)(*s*) or as converted from an analog audio information source. As will be made clear below, the formatting and scheduling information will control not only playback by the zone player **11**(*n*) itself, but will also enable other zone players **11**(*n'*), **11**(*n''*), . . . that may be in a synchrony group for which the zone player **11**(*n*) is the master device, to play the audio program associated with the audio information in synchrony with the zone player **11**(*n*).

In one particular embodiment, the audio information source interface **30** divides the audio information associated with an audio work into a series of frames, with each frame comprising digital audio information for a predetermined period of time. As used herein, an audio track may comprise any unit of audio information that is to be played without interruption. On the other hand, an audio program may comprise a series of one or more audio tracks that are to be played in succession. It will be appreciated that the tracks comprising the audio program may also be played without interruption, or alternatively playback between tracks may be interrupted by a selected time interval. FIG. **4** schematically depicts an illustrative framing strategy used in connection with one embodiment of the invention for a digital audio stream comprising an audio work. More specifically, FIG. **4** depicts a framed digital audio stream **50** comprising a sequence of frames **51**(**1**) through **51**(F) (generally identified by reference numeral **51**(*f*)). Each frame **51**(*f*), in turn, comprises a series of audio samples **52**(*f*)(**1**) through **52**(*f*)(S) (generally identified by reference numeral **52**(*f*)(*s*)) of the audio track. Preferably all of the frames will have the same number "S" of audio samples, although it will be appreciated from the following that that is primarily for convenience. On the other hand, it will be appreciated that, the number of audio samples may differ from "S"; this may particularly be the case if the frame **51**(*f*) contains the last audio samples for the digital audio stream for a particular audio work. In that case, the last frame **51**(F) will preferably contain samples **52**(F)(**1**) through **52**(F)(x), where "x" is less than "S." Generally, it is desirable that the number of samples be consistent among all frames **51**(*f*), and in that case padding, which will not be played, can be added to the last frame **51**(F).

Associated with each frame **51**(*f*) is a header **55**(*f*) that includes a number of fields for storing other information that is useful in controlling playback of the audio samples in the respective frame **51**(*f*). In particular, the header **55**(*f*) associated with a frame **51**(*f*) includes a frame sequence number field **56**, an encoding type field **57**, a sampling rate information field **58**, a time stamp field **60**, an end of track flag **61**, and a length flag field **62**. The header **55**(*f*) may also include fields (not shown) for storing other information that is useful in controlling playback. Generally, the frame sequence number field **56** receives a sequence number "f" that identifies the relative position of the frame **51**(*f*) in the sequence of frames **51**(**1**) . . . **51**(*f*) . . . **51**(F) containing the digital audio stream **50**. The encoding type field **57** receives a value that identifies the type of encoding and/or compression that has been used in generating the digital audio stream. Conventional encoding or compression schemes include, for example, the well-known MP3 and WAV encoding and/or compression schemes, although it will be appreciated that other schemes may be provided for as well. The sampling rate information field **58** receives sampling rate information that indicates the sampling rate for the audio samples **52**(*f*)(*s*). As will be apparent to those skilled in the art, the sampling rate determines the rate at which the zone player **11**(*n*) is to play the audio samples **52**(*f*)(*s*) in the frame, and, as will be described below, determines the period of the digital to analog converter clock **34**.

The condition of the end of work flag **61** indicates whether the frame **51**(*f*) contains the last digital audio samples for the audio track associated with the framed digital audio work **50**. If the frame **51**(*f*) does not contain the audio samples that are associated with the end of the digital audio stream **50** for a respective audio work, the end of work flag will be clear. On the other hand, if the frame **51**(*f*) does contain the audio samples that are associated with the end of the digital audio stream **50** for a respective audio work, the end of work flag **61** will be set. In addition, since the number of valid audio samples **52**(F)(s) in the frame **51**(F), that is, the samples that are not padding, may be less than "S," the default number of audio samples in a frame **51**(*f*), the length flag field **62** will contain a value that identifies the number of audio samples in **52**(F)(s) in the last frame **51**(F) of the audio work **50**. If, as noted above, the frames have a consistent number "S" of samples, the samples **52**(F)(x+1) through **52**(F)(S) will contain padding, which will not be played.

The time stamp field **60** stores a time stamp that identifies the time at which the zone player **11**(*n*) is to play the respective frame. More specifically, for each frame of a framed digital audio stream **50** that is buffered in the audio information buffer **21**, the audio information source interface **30**, using timing information from the digital to analog converter clock **34**, will determine a time at which the zone player **11**(*n*) is to play the respective frame, and stores a time stamp identifying the playback time in the time stamp field **60**. The time stamp associated with each frame will later be used by the playback scheduler **32** to determine when the portion of the digital audio stream stored in the frame is to be coupled to the digital to analog converter **33** to initiate play back. It will be appreciated that the time stamps that are associated with frames in sequential frames **51**(**1**), **51**(**2**), . . . , **51**(F), will be such that they will be played back in order, and without an interruption between the sequential frames comprising the digital audio stream **50**. It will further be appreciated that, after a time stamp has been determined for the first frame, stored in frame **51**(**1**), of a digital audio stream **50**, the audio information source interface **30** can determine time stamps for the subsequent frame **51**(**2**), **51**(**3**), . . . , **51**(F) in relation to the number of samples "S" in the respective frames and the sample rate. The time stamps will also preferably be such that frames will be played back after some slight time delay after they have been buffered in the audio information buffer **21**; the purpose for the time delay will be made clear below.

Returning to FIG. **3**, in addition to dividing the digital audio information into frames, the audio information source interface **30** also aggregates and/or divides the frames **51**(*f*) as necessary into packets, each of which will be of a length that would fit into a message for transmission over the network, and associates each packet with a packet sequence number. For example, if a packet will accommodate multiple frames **51**(*f*), **51**(*f*+1), . . . **51**(*f*+*y*−1), it will aggregate them into a packet and associate them with a packet number, for example p(x). If the entire frames **51**(*f*) and **51**(*f*+*y*−1) was accommodated in packet p(x), where "x" is the sequence number,

which will occur if the size of a packet is an exact multiple of the frame size, the next packet, p(x+1) will begin with frame **51**(*f*+*y*) and will include frames **51**(*f*+*y*), . . . , **51**(*f*+2 y−1). Subsequent packets p(x+2), . . . will be formed in a similar manner. On the other hand, if the packet length will not accommodate an exact multiple of the frame size, the last frame in the packet will be continued at the beginning of the next packet.

If the audio information source interface **30** is aware of track boundaries, which may be the case if the tracks are divided into files, the packets will reflect the track boundaries, that is, the packets will not contain frames from two tracks. Thus, if the last frames associated with a track are insufficient to fill a packet, the packet will contain padding from the last frame associated with the track to the end of the packet, and the next packet will begin with the first frames associated with the next track.

In one embodiment, the audio information source interface **30** stores the packets in the audio information buffer **31** in a ring buffer. As is conventional, a ring buffer includes a series of storage locations in the buffer. Each entry will be sufficient to store one packet. Four pointers are used in connection with the ring buffer, a first pointer pointing to the beginning of the ring buffer, a second pointer pointing to the end of the ring buffer, an third "write" pointer pointing to the entry into which a packet will be written and a fourth "read" pointer pointing to the entry from which packet will be read for use in playback. When a packet is read from the ring buffer for playback, it will be read from the entry pointed to by the read pointer. After the packet has been read, the read pointer will be advanced. If the read pointer points beyond the end of the ring buffer, as indicated by the end pointer, it will be reset to point to the entry pointed to by the beginning pointer, and the operations can be repeated.

On the other hand, when the audio information source interface **30** stores a packet in the ring buffer, first determine whether the entry pointed to by the write pointer points to the same entry as the entry pointed to by the read pointer. If the write pointer points to the same entry as the entry pointed to by the read pointer, the entry contains at least a portion of a packet that has not yet been read for playback, and the audio information source interface **30** will delay storage of the packet until the entire packet has been read and the read pointer advanced. After the read pointer has been advanced, the audio information source interface **30** can store the packet in the entry pointed to by the write pointer. After the packet has been stored, the audio information source interface **30** will advance the write pointer. If the write pointer points beyond the end of the ring buffer, as indicated by the end pointer, it will be reset to point to the entry pointed to by the beginning pointer, and the operations can be repeated.

As noted above, the zone player **11**(*n*) can operate both as an audio information channel device **23** and a member of the synchrony group **20** of which it is a member. In that case, the audio information buffer **31** can contain one ring buffer. On the other hand, the zone player **11**(*n*) can operate as an audio information channel device **23** for one synchrony group **20**(**1**) (FIG. **2**A) and a member of another synchrony group **20**(**2**). In that case, the audio information buffer **31** would maintain two ring buffers, one for the audio and timing information associated with synchrony group **20**(**1**), and the other for the audio and timing information associated with synchrony group **20**(**2**). It will be appreciated that, in the latter case, the zone player **11**(*n*) will only use the audio and timing information that is associated with synchrony group **20**(**2**) for playback.

The playback scheduler **32** schedules playback of the audio information that is buffered in the audio information buffer **31** that is to be played by the zone player **11**(*n*). Accordingly, under control of the playback scheduler **32**, the digital audio information that is buffered in the audio information buffer **21** that is to be played by the zone player **11**(*n*) is transferred to the digital to analog converter **33** for playback. As noted above, if the zone player **11**(*n*) is operating as an audio information channel device **23** for a synchrony group **20** for which it is not a member, the playback scheduler **32** will not schedule the digital audio information that is to be played by that synchrony group **20** for playback. The playback scheduler **32** only schedules the digital audio information, if any, that is buffered in the audio information buffer **31** that is associated with a synchrony group for which the zone player **11**(*n*) is a member, whether as master device **21** or a slave device **22**(*g*).

Essentially, the playback scheduler **32** makes use of the read pointer associated with the circular buffer that contains the audio and playback timing information that is to be played by the zone player **11**(*n*). The playback scheduler **32** retrieves the packet information from the entry of the ring buffer pointed to by the read pointer, and then advances the ring pointer as described above. The playback scheduler **32** determines the boundaries of the frames in the packet and uses the time stamps in the time stamp fields **60** associated with the respective frame **51**(*f*), along with timing information provided by the zone player **11**(*n*)'s digital to analog converter clock **34**, to determine when the respective frame is to be transferred to the digital to analog converter **33**. Generally, when the time stamp associated with a buffered digital audio information frame corresponds to the current time as indicated by the digital to analog converter clock **34**, the playback scheduler **32** will enable the respective frame to be transferred to the digital to analog converter **33**.

The digital to analog converter **33**, also under control of the digital to analog converter clock **34**, converts the buffered digital audio information to analog form, and provides the analog audio information to the audio amplifier **35** for amplification. The amplified analog information, in turn, is provided to the audio reproduction devices **15**(*n*)(*r*) through the audio reproduction device interface **36**. The audio reproduction devices **15**(*n*)(*r*) transform the analog audio information signal to sound thereby to provide the audio program to a listener. The amount by which the audio amplifier **35** amplifies the analog signal is controlled by the control module **42**, in response to volume control information provided by the user through the user interface module **13**.

The network communications manager **40** controls network communications over the network **12**, and the network interface **41** transmits and receives message packets over the network **12**. The network communications manager **40** generates and receives messages to facilitate the transfer of the various types of information described above in connection with FIG. **2**, including the channel device control information, slave device control information, audio and playback timing information and the audio information channel device's clock timing information. In connection with the channel device control information and the slave device control information, the network communications manager **40** will generate messages for transfer over the network **12** in response to control information from the control module **42**. Similarly, when the network communications manager **40** receives messages containing channel device control information and slave device control information, the network communications manager will provide the information to the control module **42** for processing.

With regards to the audio information channel device's clock timing information, as noted above, the master device **21** and slave devices **22**(*g*) of the synchrony group **20** obtain

the clock timing information from the audio information channel device **23** using the well-known SNTP. If the zone player **11**(*n*) is operating as the audio information channel device **23** for a synchrony group, during the SNTP operation, it will provide its current time, particularly a current time as indicated by its digital to analog converter clock **34**. On the other hand, if the zone player **11**(*n*) is operating as the master device **21** or slave device **22**(*g*) of a synchrony group **20**, it will receive the clock timing information from the audio information channel device **23**. After the respective device **21**, **22**(*g*) has obtained the audio information channel device's clock timing information, it will generate a differential time value ΔT representing the difference between the time T indicated by its digital to analog converter clock **34** and the current time information from the audio information channel device **23**. The differential time value will be used to update the time stamps for the frames of the digital audio stream **50** (FIG. **4**) that are received from the audio information channel device.

With regards to the audio and playback timing information, operations performed by the network communications manager **40** will depend on whether

(i) the audio and playback timing information has been buffered in the audio information buffer **31** for transmission, as audio information channel device **23**, over the network **12** to the master device **21** and/or slave devices **22**(*g*) of a synchrony group, or

(ii) the audio and playback timing information has been received from the network **12** to be played by the zone player **11**(*n*) as either the master device **21** for a synchrony group or a slave device in a synchrony group.

It will be appreciated that the network communications manager **40** may be engaged in both (i) and (ii) contemporaneously, since the zone player **11**(*n*) may operate both as the audio information channel device **23**(**1**) for a synchrony group **20**(**1**) (reference FIG. **2**A) of which it is not a member, and a member of another synchrony group **20**(**2**) for which another zone player **11**(*n'*) is the audio information channel device **23**(**2**). With reference to item (i) above, after a packet that is to be transmitted has been buffered in the respective ring buffer, the network communications manager **40** retrieves the packet, packages it into a message and enables the network interface **41** to transmit the message over the network **12**. If the control module **42** receives control information from the user interface module **13** (if the master device **21** is also the audio information channel device **23** for the synchrony group **20**) or from the master device (if the master device **21** is not the audio information channel device **23** for the synchrony group **20**) that would require the transmission of a "resynchronize" command as described above, the control module **42** of the audio information channel device **23** enables the network communications manager **40** to insert the command into a message containing the audio and playback timing information. Details of the operations performed in connection with the "resynchronize" command will be described below. As noted above, the "resynchronize" command is used if the user enables a synchrony group to terminate the playback of a track that is currently being played, or cancel playback of a track whose playback has not begun.

On the other hand, with reference to item (ii) above, if network interface **41** receives a message containing a packet containing frames of audio and playback timing information that the zone player **11**(*n*) is to play either as a master device **21** or a slave device for a synchrony group **20**, the network interface **41** provides the audio and playback timing information to the network communications manager **40**. The network communications manager **40** will determine whether the packet contains a resynchronize command and, if so, notify the control module **42**, which will enable operations to be performed as described below. In any case, the network communications manager **40** will normally buffer the various frames comprising the audio and playback timing information in the audio information buffer **31**, and in that operation will generally operate as described above in connection with the audio information source interface **30**. Before buffering them, however, the network communications manager **40** will update their time stamps using the time differential value described above. It will be appreciated that the network communications manager **40** will perform similar operations whether the messages that contain the packets were multicast messages or unicast messages as described above

The updating of the time stamps by the master device **21** and the slave devices **22**(*g*) in the synchrony group **20** will ensure that they all play the audio information synchronously. In particular, after the network communications manager **40** has received a frame **51**(*f*) from the network interface **41**, it will also obtain, from the digital to analog converter clock **34**, the zone player **11**(*n*)'s current time as indicated by its digital to analog converter clock **34**. The network communications manager **40** will determine a time differential value that is the difference between the slave device's current clock time, as indicated by its digital to analog converter **34**, and the audio information channel device's time as indicated by the audio information channel device's clock timing information. Accordingly, if the master or slave device's current time has a value T_S and the audio information channel device's current time, as indicated by the clock timing information, has a value T_C, the time differential value $\Delta T = T_S - T_C$. If the current time of the master or slave device in the synchrony group **20**, as indicated by its digital to analog converter clock **34**, is ahead of the audio information channel device's clock time as indicated by the clock timing information received during the SNTP operation, the time differential value will have a positive value. On the other hand, if the master or slave device's current time is behind the audio information channel device's clock time, the time differential value ΔT will have a negative value. If the zone player **11**(*n*) obtains clock timing information from the audio information channel device **23** periodically while it is a member of the synchrony group **20**, the network communications manager **40** can generate an updated value for the time differential value ΔT when it receives the clock timing information from the audio information channel device **23**, and will subsequently use the updated time differential value.

The network communications manager **40** uses the time differential value ΔT that it generates from the audio information channel device timing information and zone player **11**(*n*)'s current time to update the time stamps that will be associated with the digital audio information frames that the zone player **11**(*n*) receives from the audio information channel device. For each digital audio information frame that is received from the audio information channel device, instead of storing the time stamp that is associated with the frame as received in the message in the audio information buffer **21**, the network communications manager **40** will store the updated time stamp with the digital audio information frame. The updated time stamp is generated in a manner so that, when the zone player **11**(*n*), as a member of the synchrony group plays back the digital audio information frame, it will do so in synchrony with other devices in the synchrony group.

More specifically, after the zone player **11**(*n*)'s network interface **41** receives a message containing a packet that, in turn, contains one or more frames **51**(*f*), it will provide the

packet to the network communications manager **40**. For each frame **51**(*f*) in the packet that the network communications manager **40** receives from the network interface **41**, the network communications manager **40** will add the time differential value ΔT to the frame's time stamp, to generate the updated time stamp for the frame **51**(*f*), and store the frame **51**(*f*), along with the header **55**(*f*) with the updated time stamp in the audio information buffer **31**. Thus, for example, if a frame's time stamp has a time value T_F, the network communications manager **40** will generate an updated time stamp T^U_F having a time value $T^U_F = T_F + \Delta T$. Since time value T^U_F according to the slave device's digital to analog converter clock **34** is simultaneous to the time value T_F according to the audio information channel device's digital to analog converter clock **34**, the zone player **11**(*n*) device will play the digital audio information frame at the time determined by the audio information channel device **23**. Since all of the members of the synchrony group **20** will perform the same operations, generating the updated time stamps T^U_F for the various frames **51**(*f*) in relation to their respective differential time values, all of the zone players **11**(*n*) in the synchrony group **20** will play them synchronously. The network communications manager **40** will generate updated time stamps T^U_F for all of the time stamps **60** in the packet, and then store the packet in the audio information buffer **31**.

It will be appreciated that, before storing a packet in the audio information buffer **21**, the network communications manager **40** can compare the updated time stamps T^U_F associated with the frames in the packet to the slave device's current time as indicated by its digital to analog converter clock **34**. If the network communications manager **40** determines the time indicated by the updated time stamps of frames **51**(*f*) in the packet are earlier than the zone player's current time, it can discard the packet instead of storing it in the audio information buffer **21**, since the zone player **11**(*n*) will not play them. That is, if the updated time stamp has a time value T^U_F that identifies a time that is earlier than the zone player's current time T_S as indicated by the zone player's digital to analog converter clock **34**, the network communications manager **40** can discard the packet.

If the zone player **11**(*n*) is operating as the master device **21** of a synchrony group **20**, when the user, through the user interface module **13**, notifies the zone player **11**(*n*) that another zone player **11**(*n'*) is to join the synchrony group **20** as a slave device **22**(*g*), the control module **42** of the zone player **11**(*n*) enables the network communications manager **40** to engage in an exchange of messages, described above in connection with FIG. **2**, to enable the other zone player **11**(*n'*) to join the synchrony group **20** as a slave device. As noted above, during the message exchange, the messages generated by the network communications manager **40** of the zone player **11**(*n*) will provide the network communications manager of the zone player **11**(*n*) that is to join the synchrony group **20** with information such as the multi-cast address being used by the audio information channel device **23** that is providing the audio program to the synchrony group **20**, as well as a unicast network address for the audio information channel device **23**. After receiving that information, the network communications manager and network interface of the zone player **11**(*n'*) that is to join the synchrony group **20** can begin receiving the multi-cast messages containing the audio program for the synchrony group, engage in SNTP transactions with the audio information channel device **23** to obtain the latter's current time, and also enable the audio information channel device **23** to send the zone player **11**(*n'*) frames **51**(*f*) that it had previously broadcast using the unicast message transmission methodology as described above.

On the other hand, if the network communications manager **40** and network interface **41** of the zone player **11**(*n*) receive a message over the network **12** indicating that it is to become a slave device **22**(*g*) of a synchrony group for which another zone player **11**(*n'*) is the master device, the network communications manager **40** for zone player **11**(*n*) will provide a notification to the control module **42** of zone player **11**(*n*). Thereafter, the control module **42** of zone player **11**(*n*) can enable the network communications manager **40** of zone player **11**(*n*) to perform the operations described above to enable it to join the synchrony group **20**.

As noted above, the user, using user interface module **13**, can enable the synchrony group to terminate playback of a track of an audio program that is currently being played. After playback of a track that is currently being played has been terminated, playback will continue in a conventional manner with the next track that has been buffered in the audio information buffer **31**. It will be appreciated that that could be the next track that is on the original play list, or a previous track. In addition, the user can enable the synchrony group **20** to cancel playback of a track that it has not yet begun to play, but for which buffering of packets has begun in the synchrony group **20**. Both of these operations make use of the "resynchronize" command that the master device **21** of the synchrony group **20** can enable the audio information channel device **23** to include in the multi-cast message stream that it transmits to the synchrony group **20**. Generally, in response to receipt of the resynchronize command, the members of the synchrony group **20** flush the ring buffer containing the packets that they are to play in the future. In addition, if the members of the synchrony group provide separate buffers for their respective digital to analog converters **33**, the members will also flush those buffers as well. After the audio information channel device transmits a packet containing the resynchronize command:

(i) in the case of the use of the resynchronize command to terminate playing of a track that is currently being played, the audio information channel device **23** will begin multi-casting packets for the next track, to begin play immediately, and will continue through the play list in the manner described above; and

(ii) in the case of the use of the resynchronize command to cancel play of a track for which buffering has begun, but which is to be played in the future, the audio information channel device **23** will begin multi-casting packets for the track after the track that has been cancelled, to be played beginning at the time the cancelled track was to begin play, and will also continue through the play list in the manner described above.

It will be appreciated that,

(a) in the first case (item (i) directly above), the resynchronize command can enable the read pointer to be set to point to the entry in the circular buffer into which the first packet for the next track will be written, which will correspond to the entry to which the write pointer points, but

(b) in the second case (item (ii) directly above), the resynchronize command can enable the write pointer for the circular buffer to be set to point to the entry that contains the first packet for the track whose play is being cancelled.

It will further be appreciated that, if a track is cancelled for which buffering has not begun, the resynchronize command will generally not be necessary, since the audio information channel device **23** for the synchrony group **20** need only delete that track from the play list.

Operations performed in connection with use of the resynchronize command to cancel playback of a track that is currently being played will be described in connection with

Packet Sequence A below, and operations performed in connection with the use of the resynchronize command to cancel playback of a track that is has not yet begun to play, but for which buffering of packets has begun, will be described in connection with Packet Sequence B below.

Packet Sequence A

(A1.0) [packet 57]
(A1.1 [continuation of frame 99]
(A1.2) [frame 100, time=0:00:01, type=mp3 audio]
(A1.3) [frame 101, time=0:00:02, type=mp3 audio]
(A1.4) [frame 102, time=0:00:03, type=mp3 audio]
(A2.0) [packet 58]
(A2.1) [continuation of frame 102]
(A2.2) [frame 103, time=0:00:04, type=mp3 audio]
(A2.3) [frame 104, time=0:00:05, type=mp3 audio]
(A2.4) [frame 105, time=0:00:06, type=mp3 audio]
(A3.0) [packet 59]
(A3.1) [continuation of frame 105]
(A3.2) [frame 106, time=0:00:07, type=mp3 audio]
(A3.3) [frame 107, time=0:00:08, type=mp3 audio]
(A3.4) [frame 108, time=0:00:09, type=mp3 audio]
(A4.0) [packet 60]
(A4.1) [continuation of frame 108]
(A4.2) [frame 109, time=0:00:10, type=mp3 audio]
(A4.3) [Resynchronize command]
(A4.4) [Padding, if necessary]
(A5.0) [packet 61]
(A5.1) [frame 1, time=0:00:07, type=mp3 audio]
(A5.2) [frame 2, time=0:00:08, type=mp3 audio]
(A5.3) [frame 3, time=0:00:09, type=mp3 audio]
(A5.4) [frame 4, time=0.00.10, type=mp3 audio]
(A6.0) [packet 62]
(A6.1) [continuation of frame 4]
(A6.2) [frame 5, time=0:00:11, type=mp3 audio]
(A6.3) [frame 6, time=0:00:12, type=mp3 audio]
(A6.4) [frame 7, time=0:00:13, type=mp3 audio]

Packet Sequence A comprises a sequence of six packets, identified by packet **57** through packet **62**, that the audio information channel device **23** multi-casts in respective messages to the members of a synchrony group **20**. It will be appreciated that the series of messages that the audio information channel device **23** may multi-cast to the synchrony group **20** may include a messages prior to the packet **57**, and may also include messages after packet **62**. Each packet comprises a packet header, which is symbolized by lines (A**1**.**0**), (A**2**.**0**), . . . (A**6**.**0**) in Packet Sequence A, and will generally also include information associated with at least a portion of a frame. In the packets represented in Packet Sequence A, each packet includes information associated with a plurality of frames. Depending on the lengths of the packets, each packet may contain information associated with a portion of a frame, an entire frame, or multiple frames. In the illustration represented by Packet Sequence A, it is assumed that each packet may contain information associated with multiple frames. In addition, it is assumed that a packet does not necessarily contain information associated with an integral number of frames; in that case, a packet may contain information associated with a portion of a frame, and the next packet will contain the information associated with the rest of a frame.

The frames and associated header playback timing information contained in the various packets are symbolized by lines (A**1**.**1**), (A**1**.**2**), . . . , (A**1**.**4**), (A**2**.**1**), . . . (A**6**.**4**) of Packet Sequence A. Thus, for example, line (A**1**.**2**) of packet **57** represents the one-hundredth frame, that is, frame **51**(**100**) (reference FIG. **4**), of the track whose audio information is being transmitted in the sequence Of packets that includes packet **57**. The frame **51**(**100**) is to be played at an illustrative time, according to the audio information channel device's digital to analog converter clock, of "time=0:00:01," and the frame is encoded and/or compressed using the well-known MP3 encoding and compression methodology. In that case, the legend"time=0:00:01" represents the time stamp that would be included in field **60** (FIG. **4**) of the header associated with the frame **50**(**100**) as multi-cast by the audio information channel device for the synchrony group. It will be appreciated that the playback time and encoding/compression methodology will be referred in the header **55**(**100**) that is associated with the frame **51**(**100**). It will also be appreciated that the header may also contain additional information as described above.

Similarly, line (A**1**.**3**) of packet **57** represents the one-hundred and first frame, that is, frame **51**(**101**), of the track whose audio information is being transmitted in the sequence of packets that includes packet **57**. The frame **51**(**101**) is to be played at an illustrative time, according to the audio information channel device's digital to analog converter clock, of "0:00:02," and the frame is also encoded and/or compressed using the MP3 encoding and compression methodology. Line (A**1**.**4**) of packet **57** represents similar information, although it will be appreciated that, depending on the length of packet **57**, the line may not represent the information for an entire frame **51**(**102**) and/or its associated header. If the length of packet **57** is not sufficient to accommodate the information for the entire frame **51**(**102**) and/or associated header, the information will continue in packet **58**, as represented by line (A**2**.**1**) in Packet Sequence A. Similarly, if the length of packet **56** was not sufficient to contain the information for an entire frame **51**(**99**) preceding frame **51**(**100**), packet **57** (lines (A**1**.**0**) through **1**.**4**) may contain any information from frame **51**(**99**) that packet **56** was unable to accommodate.

As noted above, when the master device **21** or a slave device **22**(*g*) in the synchrony group **20** receives the packet **57**, its respective network communications manager **40** will update the time stamps associated with the various frames **51**(*f*) as described above before buffering the respective frames in the respective audio information buffer **31**.

Packets **58** and **59** contain information that is organized along the lines described above in connection with packet **57**.

Packet **60** also contains, as represented by lines (A**4**.**1**) and (A**4**.**2**), information that is organized along the lines of the information represented by lines (Ax.**1**) and (Ax.**2**) ("x" equals an integer) described above in connection with packets **57** through **59**. On the other hand, packet **60** contains a resynchronize command, as represented by line (A**4**.**3**). Packet **60** also may contain padding, as represented by line **4**.**4**, following the resynchronize command. As noted above, the master device **21** of a synchrony group **20** will enable the audio information channel device **23** that is providing audio information to the synchrony group **20** to multi-cast a message containing the resynchronize command when it receives notification from the user interface module **13** that the user wishes to cancel playback of a track that is currently being played. In the example depicted in Packet Sequence A, as will be described below, the audio information channel device **23** receives notification from the master device **21** that the user wishes to cancel playback of a track at a time corresponding to "time=0:00:07" according to its digital to analog converter clock **34**, and, in line (A**4**.**3**) of packet **60** it will provide the resynchronize command, followed by padding, if necessary.

As will be apparent from examining lines (A**3**.**1**) through (A**3**.**4**) of packet **59** and lines (A**4**.**1**) and (A**4**.**2**) of packet **60**, although the audio information channel device **23** has received the notification from the synchrony group's master

device **21** to multi-cast the resynchronize command at a time corresponding to "time=0:00:07" according to the clock time indicated by its digital to analog converter clock **34**, it (that is, the audio information channel device **23**) has already multi-cast messages containing frames that are to be played at that time and subsequently. That is, the audio information channel device **23** has, multi-cast in packet **59**, frames **51**(**106**) through **51**(**108**) that contain time stamps "time=0:00:07," "time=0:00:08" and "time=0:00:09," respectively, and, in packet **60**, in addition to the continuation of frame **51**(**108**), frame **51**(**109**) that contains time stamp "time=0:00:10." (It will be appreciated that the times indicated by the illustrative time stamps are for illustration purposes only, and that in an actual embodiment the time stamps may have different values and differentials.)

As noted above, the audio information channel device **23** multi-casts a message containing a packet that, in turn, contains the resynchronize command when it receives the notification from the master device **21** to do so. In the example depicted in Packet Sequence A, the packet will be multi-cast when the audio information channel device's digital to analog converter clock time corresponds to "0:00:07." Subsequently, two things happen. In one, aspect, when the master device **21** and slave devices **22**(*g*) receive the packet that contains the resynchronize command, they will stop playing the audio program that they are playing.

In addition, the audio information channel device **23** will begin transmitting frames containing audio information for the next track, including therewith time stamps immediately following the digital to analog converter clock time at which the packet including the resynchronize command was transmitted. Accordingly, and with further reference to Packet Sequence A, the audio information channel device **23** will multi-cast a message containing packet **61**. As indicated above, packet **61** contains, as represented in lines (A**5**.**1**) through (A**5**.**3**), frames **51**(**1**) through **51**(**3**), which are the first three frames of the next track of the audio program that is to be played. It is also compressed and encoded using the MP3 encoding and compression scheme, and it is accompanied by time stamps "time=0:00:07," "time=0:00:08" and "time=0:00:10." As noted above, the time stamp "time=0:00:07" corresponds to the clock time at which the audio information channel device **23** multi-casts the resynchronize command, and, when the master device **21** and slave devices **22**(*g*) receive these frames, they would be expected to begin playing them very shortly, if not immediately after the audio information channel device **23** multi-casts the message containing the packet that, in turn, contains the resynchronize command. Packet **61** also includes at least a portion of the next frame, that is, frame **51**(**4**), for that track. In addition, Packet Sequence A depicted above further includes a subsequent packet, namely, packet **62**, that contains any necessary continuation of frame **51**(**4**), as well as three subsequent frames. If any additional packets are required for the track, as well as for subsequent tracks, they can be multi-cast in a similar manner.

As further noted above, the resynchronize command can also be used to cancel playing of one or more tracks for which playback has begun. This will be illustrated in connection with Packet Sequence B:

Packet Sequence B
(B**1**.**0**) [packet **157**]
(B**1**.**1**) [continuation of frame **99**]
(B**1**.**2**) [frame **100**, time=0:00:01, type=mp3 audio]
(B**1**.**3**) [frame **101**, time=0:00:02, type=mp3 audio]
(B**1**.**4**) [frame **102**, time=0:00:03, type=mp3 audio]
(B**2**.**0**) [packet **158**]
(B**2**.**1**) [continuation of frame **102**]
(B**2**.**2**) [frame **103**, time=0:00:04, type=mp3 audio]
(B**2**.**3**) [frame **104**, time=0:00:05, type=mp3 audio]
(B**2**.**4**) [frame **105**, time=0:00:06, type=mp3 audio]
(B**3**.**0**) [packet **159**]
(B**3**.**1**) [continuation of frame **105**]
(B**3**.**2**) [frame **106**, time=0:00:07, type=mp3 audio]
(B**3**.**3**) [track boundary notification]
(B**3**.**4**) [Padding, if necessary]
(B**4**.**0**) [packet **160**]
(B**4**.**1**) [frame **1**, time=0:00:08, type=mp3 audio]
(B**4**.**2**) [frame **2**, time=0:00:09, type=mp3 audio]
(B**4**.**3**) [frame **3**, time=0:00:10, type=mp3 audio]
(B**5**.**0**) [packet **161**]
(B**5**.**1**) [continuation of frame **3**]
(B**5**.**2**) [frame **4**, time=0:00:11, type=mp3 audio]
(B**5**.**3**) [Resynchronize, after packet **159**]
(B**5**.**4**) [Padding, if necessary]
(B**6**.**0**) [packet **162**]
(B**6**.**1**) [frame **1**, time=0:00:08, type=mp3 audio]
(B**6**.**2**) [frame **2**, time=0:00:09, type=mp3 audio]
(B**6**.**3**) [frame **3**, time=0:00:10, type=mp3 audio]
(B**6**.**4**) [frame **4**, time=0:00:11, type=mp3 audio]
(B**7**.**0**) [packet **163**]
(B**7**.**1**) [continuation of frame **4**]
(B**7**.**2**) [frame **5**, time=0:00:12, type=mp3 audio]
(B**7**.**3**) [frame **6**, time=0:00:13, type=mp3 audio]
(B**7**.**4**) [frame **7**, time=0:00:14, type=mp3 audio]

Packet Sequence B comprises a series of seven packets, identified by packet **157** through **163**, that the audio information channel device **23** multi-casts to the members of a synchrony group **20**. As with Packet Sequence A, it will be appreciated that the series of packets that the audio information channel device **23** may multi-cast to the synchrony group **20** may include packets prior to the packet **157**, and may also include packets after packet **162**. Each packet comprises a packet header, which is symbolized by lines (B**1**.**0**), (B**2**.**0**), . . . (B**7**.**0**) in Packet Sequence B. As in Packet Sequence A, each packet will also generally include information associated with at least a portion of a frame **51**(*f*) along with its associated frame **55**(*f*). As in the packets represented in Packet Sequence A, each packet includes information associated with a plurality of frames. Depending on the lengths of the packets, each packet may contain information associated with a portion of a frame, an entire frame, or multiple frames. Further, as with Packet Sequence A, it is assumed that each packet may contain information associated with multiple frames. In addition, it is assumed that a packet does not necessarily contain information associated with an integral number of frames; in that case, a packet may contain information associated with a portion of a frame, and the next packet will contain the information associated with the rest of a frame.

The structures of the packets represented by Packet Sequence B are similar to those described above in connection with Packet Sequence A, and will not be repeated here. Generally, Packet Sequence B illustratively contains a sequence of packets that represent at least portions of three tracks that may have been selected from, for example, a play list. In particular, packets **157** through **159** represent frames from a portion of one track, packets **160** and **161** represent frames from a second track and packets **162** and **163** represent frames from a third track. The play list indicated that the first, second and third tracks were to be played in that order. With particular reference to Packet Sequence B, it should be noted that line (B**3**.**3**) indicates that packet **159** includes an indication that that packet contains the last frame for the track, and

line (B3.4) provides for padding to the end of the packet. The first frame of the next track begins in packet **160**.

In connection with the use of the resynchronize command to cancel playback of a track, at least a portion of which the audio information channel device **23** has multi-cast to the members of the synchrony group, packet **161**, in line (B5.3) represents a resynchronize command that indicates that resynchronization is to occur after packet **159**, that is, immediately after the packet that contains the last frame of the first of the three tracks represented by the packets in Packet Sequence B. It should be noted that the resynchronize command is in the packet **161**, while the resynchronization is to occur at packet **160**, that is, the synchrony group is to not play the track starting with packet **160**, but instead is to begin playing the track frames for which begin with the next packet, that is, packet **162**. As with Packet Sequence A, in Packet Sequence B the audio information channel device **23**, in packet **162** and **163**, multi-casts frames whose time stamps indicate that they are to be played when the frames that were multi-cast in packets **160** and **161** were to be played. By use of the resynchronize command and specifying a packet in this manner, the audio information channel device can cancel playback of a track for which playback has not yet begun.

It will be appreciated that the resynchronize command is generally not necessary for cancelling play back of a track that the audio information channel device **23** has not started multi-casting to the synchrony group **20**, since the audio information channel device **23** itself can re-order the play list to accommodate the cancellation.

The invention provides a number of advantages. In particular, the invention provides a network audio system in which a number of devices share information can reproduce audio information synchronously, notwithstanding the fact that packets, which may contain digital audio information, transmitted over the network to the various zone players connected thereto may have differing delays and the zone players operate with independent clocks. Moreover, although the invention has been described in connection with audio information, it will be appreciated that the invention will find utility in connection with any type of isochronous information for which synchrony among devices is desired. The system is such that synchrony groups are created and destroyed dynamically, and in such a manner as to avoid requiring a dedicated device as the master device.

It will be appreciated that a number of changes and modifications may be made to the network audio system **10** as described above. For example, although the invention has been described as providing that the audio information channel device **23** provides digital audio information to the members synchrony group **20** that has been encoded using particular types of encoding and compression methodologies, it will be appreciated that the audio information channel device **23** can provide digital audio information to various members of the synchrony group **20** that have been encoded and compressed using different types of encoding and compression methodologies, and, moreover, for which different sampling rates have been used. For example, the audio information channel device **23** may provide digital audio information to the master device **21** and slave devices **22**(**1**) through **22**(g_1) using the MP3 methodology at a specified sampling rate, the digital audio information for the same program to slave devices **22**(g_1+1) through **22**(g_2) using the WAV methodology at one specified sampling rate, and to slave devices **22**(g_2+1) through **22**(G) using the WAV methodology at another specified sampling rate. In that case, the audio information channel device **23** can specify the particular encoding and compression methodology that has been used in the encoding type field **57** associated with each frame and the sampling rate in the sampling rate field **58**. Moreover, since the encoding and compression type and sampling rate are specified for each frame, the encoding and compression type and sampling rate can be changed from frame to frame. The audio information channel device **23** may use different multicast addresses for the different encoding and compression types and sampling rates, but it will be appreciated that that would not be required.

It will be appreciated that two advantages of providing that the encoding and compression methodology and the sampling rate is provided on a frame-by-frame basis, instead of on, for example, a track-by-track basis, is that that would facilitate a slave device joining the synchrony group **20** at a frame mid-track, without requiring, for example, the master device **21** or the audio information channel device **23** to notify it of the encoding and compression methodology or the sampling rate.

Another modification is that, instead of the network communications manager **40** of a member of a synchrony group **20** generating the updated time stamp T^{u}_{F} for a digital audio information frame by adding the time differential value ΔT to the time stamp T_F associated with a frame, the network communications manager **40** may instead generate the updated time stamp T^{U}_{F} by subtracting the differential time value ΔT from the member's current time T_S as indicated by the member's digital to analog converter clock **34** at the time at which the digital audio information is received. It will be appreciated, however, that there may be variable time delays in processing of messages by the slave device's network communications manager **40**, and so it may be preferable to generate the time differential value ΔT using the time stamp T_F provided by the audio information channel device **23**.

In addition, instead of the network communications manager **40** of a member of a synchrony group generating an updated time stamp to reflect the difference between the times indicated by the member's digital to analog converter clock and the audio information channel device's digital to analog converter clock, the network communications manager **40** can generate the time differential value ΔT and provide it to the member's playback scheduler **32**. In that case, the member's network communications manager **40** can store each digital audio information frame along with the time stamp T_F as received from the master device in the audio information buffer **21**. The playback scheduler **32** can utilize the time differential value ΔT, and the time stamps T_F associated with the digital audio information frames, to determine when the respective digital audio information frames are to be played. In determining when a digital audio information frame is to be played, the playback scheduler can add the time differential value to the time stamp T_F associated with the digital audio frame, and enable the digital audio frame to be coupled to the digital to analog converter **33** when the time indicated by the sum corresponds to the current time as indicated by the slave device's digital to analog converter clock **34**. Alternatively, when the member's digital to analog converter clock **34** updates its current time T_S, the playback scheduler can generate an updated current time T'_S by subtracting the differential time value ΔT from the current time T_S, and using the updated current time T'_S to determine when to play a digital audio information frame.

As described above, the members of a synchrony group **20** periodically obtain the audio information channel device's current time value and uses the current time value that it receives from the audio information channel device to periodically update the time differential value ΔT that it uses in updating the time stamps associated with the various frames.

It will be appreciated that, if the digital to analog converter clock(s) associated with the member(s) of a synchrony group **20** are ensured to have the same rate as the digital to analog converter clock, a member need only obtain the current time value from the audio information channel device once, at the beginning of playback.

As another alternative, if the zone players are provided with digital to analog converter clock **34** whose time and rate can be set by an element such as the network communications manager **40**, when a zone player **11**(*n*) is operating as a member of a synchrony group **20**, its network communications manager **40** can use the various types of timing information that it receives from the audio information channel device **23**, including the current time information and the playback timing information indicated by the time stamps that are associated with the various frames **51**(*f*) comprising the audio and playback timing information that it receives, to adjust the synchrony group member's digital to analog converter clock's time value and/or the clock rate that it uses for playback. If the clock's time value is to be adjusted, when the synchrony group member's network communications manager **40** initially receives the current time information from the audio information channel device **23** for the synchrony group **20**, the network communications manager **40** can set the synchrony group member's digital to analog converter clock **34** to the current time value as indicated by the audio information channel device's current time information. The network communications manager **40** can set the clock **34** to the current time value indicated by the audio information channel device's current time information once, or periodically as it receives the current time information.

Alternatively or in addition, the synchrony group member's network communications manager **40** can use one or both of the current time information and/or the playback timing information in the time stamps associated with the respective frames **51**(*f*) to adjust the clock rate of the clock **34** that it uses for playback. For example, when the synchrony group member's network communications manager **40** receives a frame **51**(f_X) having a time stamp having a time value T_{f_X}, it can generate the updated time value $T^{U}_{f_X}=T_{f_X}+\Delta T$ as described above, and store the frame with the time stamp with the updated time value in the audio information buffer **30**. In addition, since both the number of samples in a frame and the sampling rate, which determines the rate at which the frame is to be played, are known to the network communications manager **40**, it can use that information, along with the updated time value $T^{U}_{F_X}$ that is to be used for frame **51**(f_X) to generate an expected updated time value $T^{E}_{f_{X+1}}$ that is expected for the updated time stamp of the next frame **51**(f_{X+1}). After the synchrony group member's network communications manager **40** receives the next frame **51**(f_{X+1}), it can generate the updated time value $T^{U}_{f_{X+1}}$ and compare that value to the expected updated time value $T^{E}_{f_{X+1}}$. If the two time values do not correspond, or if the difference between them is above a selected threshold level, the clock that is used by the audio information channel device **23** to generate the time stamps is advancing at a different rate than the synchrony group member's digital to analog converter clock **34**, and so the network communications manager **40** can adjust the rate of the digital to analog converter clock **34** to approach that of the clock used by the audio information channel device **23** so that the differential time value ΔT is constant. On the other hand, if the two time values do correspond, then the time differential value ΔT is constant, or the difference is below a threshold level, and the network communications manager **40** need not change the clock rate of the digital to analog converter clock **34**. It will be appreciated that, if the clock rate is to be adjusted, the rate adjustment can be fixed, or it can vary based on; for example, the difference between the updated time value $T^{U}_{f_{X+1}}$ and the expected updated time value $T^{E}_{f_{X+1}}$.

It will also be appreciated that, if no rate adjustment is performed for one frame **51**(f_{X+1}), the synchrony group member's network communications manager **40** can generate an expected updated time value $T^{E}_{f_{X+2}}$ that is expected for the updated time stamp of the next frame **51**(f_{X+2}) using the updated time value $T^{U}_{F_X}$ determined for frame **51**(f_X), along with the number of samples in a frame and the sampling rate, and compare the expected updated time value $T^{E}_{f_{X+2}}$ to the updated time value $T^{U}_{f_{X+2}}$ that it generates when it receives frame **51**(f_{X+2}). At that point, if the network communications manager **41** determines that two time values do not correspond, or if the difference between them is above a selected threshold level, it can adjust the rate of the digital to analog converter clock **34**. Similar operations can be performed if no rate adjustment is performed for several successive frames **51**(f_{X+1}), **51**(f_{X+2}), ... This will accommodate the possibility that the rate differential between the clock **34** and the clock used by the audio information channel device **23** in generating the time stamps have rates that differ by an amount sufficiently small that it cannot be detected using time stamps of two or more successive frames.

Instead or in addition to adjusting the clock rate as described above, the synchrony group member's network communications manager **40** can perform similar operations in connection with adjusting the clock rate in connection with the current time information that it receives from the audio information channel device **23**.

Furthermore, although the network audio system **10** has been described such that the master device **21** of a synchrony group **20** can, in response to control information provided thereto by a user through the user interface module **13**, provide a notification to a zone player **11**(*n*) that it is to become a member of its synchrony group **20** as a slave device **22**(*g*), it will be appreciated that the user interface module **13** can provide the notification directly to the zone player **11**(*n*) that is to become a member of the synchrony group **20**. In that case, the zone player **11**(*n*) can notify the master device **21** that it is to become a slave device **22**(*g*) in the synchrony group **20**, after which the master device **21** can provide information regarding the synchrony group **20**, including the multi-cast and unicast addresses of the audio information channel device and other information as described above.

Similarly, although the network audio system **10** has been described such that the master device **21** of a synchrony group **20** can, in response to control information provided thereto by a user through the user interface module **13**, provide a command to a slave device **22**(*g*) to enable the slave device **22**(*g*) to adjust its volume, it will be appreciated that the user interface module **13** can provide control information directly to the slave device **22**(*g*) to enable the slave device **22**(*g*) to adjust its volume.

In addition, although the network audio system **10** has been described such that each frames **51**(*f*) is associated with a frame sequence number (reference field **56**, FIG. **4**), it will be appreciated that, if the packets described above in connection with Packet Sequence A and Packet Sequence B are provided with packet sequence numbers, the frame sequence numbers need not be provided, since the packet sequence numbers can suffice for defining the frame sequencing.

Furthermore, although the network audio system **10** has been described such that the zone players **11**(*n*) are provided with an audio amplifier **35** for amplifying the analog signal provided by the respective digital to analog converters **33**, it will be appreciated that a zone player may be provided that

does not itself include an audio amplifier. In that case, the analog signal may be coupled to an external amplifier for amplification as necessary before being provided to the audio reproduction device(s) **15**(*n*)(*r*). It will be appreciated that a single zone player **11**(*n*) may be provided with multiple audio amplifiers and audio reproduction device interfaces, and, if necessary, multiple digital to analog converters **33**, to provide audio programs for corresponding numbers of synchrony groups.

Similarly, although the zone players **11**(*n*) have been described such that they may be connected to one or more audio information sources, it will be appreciated that an audio information source may form part of and be integrated into a zone player **11**(*n*). For example, a zone player may include a compact disk player, cassette tape player, broadcast radio receiver, or the like, that has been integrated into it. In addition, as noted above, an individual zone player **11**(*n*) may be connected to multiple audio information sources and may contemporaneously operate as the audio information channel device **23** for multiple synchrony groups.

In addition, although FIG. **1** shows the network audio system **10** as including one user interface module **13**, it will be appreciated that the system **10** may include a plurality of user interface modules. Each user interface module be useful for controlling all of the zone players as described above, or alternatively one or more of the user interface modules may be useful for controlling selected subsets of the zone players.

Moreover, it will be appreciated that, although the invention has been described in connection with audio information, it will be appreciated that the invention will find utility in connection with any type of information for which synchrony among devices connected to a network is desired.

As noted above, while a zone player **11**(*n*) is operating as audio information channel device **23** for a synchrony group **20**, when the zone player **11**(*n*)'s audio information source interface **30** or network communications manager **40** stores digital audio information frames based on audio information from an audio information source **14**(*n*)(*s*) in the audio information buffer **31**, it will provide time stamps for the respective frames to schedule them for playback after some time delay after they have been buffered in the audio information buffer **31**. The delay is provided so that, for other zone players **11**(*n*'), **11**(*n*"), . . . that are operating as members of a synchrony group, there will be sufficient time for the audio and playback timing information to be transferred over the network **12** to those other zone players **11**(*n*'), **11**(*n*"), . . . so that it can be processed and played by them at the appropriate time as described above. The time period that is selected for the time delay may be fixed or variable, and in either case may be based on a number of factors. If the time period selected for the time delay is fixed, it may be based on, for example, factors such as an estimate of the maximum latency in the network **12**, the estimated maximum loading of the various components comprising the zone players **11**(*n*), and other estimates as will be appreciated by those skilled in the art.

The time delay may be the same for audio information from all types of audio information sources, and may be constant over the entire period that the synchrony group **20** is playing an audio work. Alternatively, different time delays may be utilized based on various criteria. For example, if the audio information is to be played independently of information associated with other types of media, the time delay may be selected to be relatively long, on the order of a significant fraction of a second, or longer. On the other hand, if the audio information is to be played contemporaneously with, for example, video information, which may be supplied by, for example, a video disk, video tape cassette, over cable, satellite, or broadcast television, which may not be buffered or which may be displayed independently of the network audio system **10**, it may be undesirable to provide for such a lengthy delay, since the time delay of the audio playback, in relation to the video display, may be noticeable. In that case, the zone player **11**(*n*) may provide for a much shorter time delay. In one embodiment, the time delay provided for audio information to be played concurrently with video information is selected to be generally on the order of fifty milliseconds, which would barely, if at all, be perceptible to someone viewing the video. Other desirable time delays for information from other types of sources will be apparent to those skilled in the art.

As yet a further possibility, the zone player **11**(*n*), when operating as an audio information channel device **23** for a synchrony group **20**, can dynamically determine the time delay based on a number of conditions in the network audio system **10**, including, for example, the message transfer latency in network **12**, the loading of microprocessors or other components that are used in the various zone players **11**(*n*'), **11**(*n*"), . . . that may comprise a synchrony group **20**, as well as other factors. For example, if the audio information channel device **23** determines that the latency in the network **12** has increased beyond a selected threshold, the audio information channel device **23** can adjust the delay to increase the likelihood that the members of the synchrony group **20** will be able to receive the packets and process the frames so that they will be able to play them at the appropriate times. Similarly, if the audio information channel device **23** is notified that a member of the synchrony group **20** to which it provides audio information requires additional time to receive and process the frames that it transmits, the audio information channel device **23** can adjust the delay accordingly. It will be appreciated that, to reduce or minimize possible discontinuities in the audio playback by the members of the synchrony group, the audio information channel device **23** can, instead of adjusting the time delay during a particular audio track, adjust the time delay between tracks, during silent periods of a track or otherwise as will be appreciated by those skilled in the art. In addition, the audio information channel device **23** can use conventional audio compression methodologies to facilitate a speeding up and/or slowing down of playback of an audio track while it is in the process of providing additional time delay. Generally, the members of the synchrony group **20** can provide notifications to the audio information channel device **23** if they determine that they will need an additional time delay, and the audio information channel device **23** can adjust the time delay in accordance with the notifications from the members of the synchrony group **20**.

It will be appreciated that a system in accordance with the invention can be constructed in whole or in part from special purpose hardware or a general purpose computer system, or any combination thereof, any portion of which may be controlled by a suitable program. Any program may in whole or in part comprise part of or be stored on the system in a conventional manner, or it may in whole or in part be provided in to the system over a network or other mechanism for transferring information in a conventional manner. In addition, it will be appreciated that the system may be operated and/or otherwise controlled by means of information provided by an operator using operator input elements (not shown) which may be connected directly to the system or which may transfer the information to the system over a network or other mechanism for transferring information in a conventional manner.

The foregoing description has been limited to a specific embodiment of this invention. It will be apparent, however,

that various variations and modifications may be made to the invention, with the attainment of some or all of the advantages of the invention. It is the object of the appended claims to cover these and such other variations and modifications as come within the true spirit and scope of the invention.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A method comprising:

receiving, by a first playback device from a network device configured to control the first playback device and communicatively coupled to the first playback device over a local area network (LAN), control information comprising an address identifying a location of audio information available at an audio information source, wherein the audio information source is outside of the LAN; and

after receiving the control information (i) obtaining, by the first playback device from the audio information source outside of the LAN, the audio information; (ii) transmitting, by the first playback device to a second playback device, the audio information, playback timing information associated with the audio information, and device clock information of the first playback device; and (iii) playing back, by the first playback device, the audio information in synchrony with the second playback device by using the playback timing information associated with the audio information and the device clock information of the first playback device to play back the audio information, wherein the first and second playback devices remain independently clocked during synchronous playback of the audio information.

2. The method of claim **1**, further comprising:

after receiving the control information, additionally (i) generating, by the first playback device, the playback timing information associated with the audio information; and (ii) generating, by the first playback device, the device clock information of the first playback device.

3. The method of claim **1**, wherein the control information further comprises one or more instructions for the first playback device and the second playback device to playback audio information.

4. The method of claim **3**, wherein the first and second playback devices are members of a synchrony group, and wherein the method further comprises:

transmitting, by the first playback device to the network device, status information that comprises a status of the synchrony group.

5. The method of claim **4**, wherein the status information further comprises an identification of each playback device in the synchrony group.

6. The method of claim **5**, wherein the status information further comprises an identification of a master playback device of the synchrony group.

7. The method of claim **6**, wherein the first playback device is the master playback device of the synchrony group.

8. A tangible non-transitory computer-readable medium having instructions stored thereon that, when executed, cause a first playback device to:

receive, from a network device configured to control the first playback device and communicatively coupled to the first playback device over a local area network (LAN), control information comprising an address identifying a location of audio information available at an audio information source, wherein the audio information source is outside of the LAN; and

after receiving the control information, (i) obtain, from the audio information source outside of the LAN, the audio information; (ii) transmit, to a second playback device, the audio information, playback timing information associated with the audio information, and clock time information for the first playback device; and (iii) play back the audio information in synchrony with the second playback device by using the playback timing information associated with the audio information and the clock time information of the first playback device to play back the audio information, wherein the first and second playback devices remain independently clocked during synchronous playback of the audio information.

9. A first playback device comprising:

one or more processors;

a network interface; and

tangible, non-transitory computer-readable memory comprising program instructions that, when executed by the one or more processors, cause the first playback device to:

receive, via the network interface from a network device configured to control the first playback device and communicatively coupled to the first playback device over a local area network (LAN), control information comprising an address identifying a network location of audio information available at an audio information source, wherein the audio information source is outside of the LAN; and

after receiving the control information, (i) obtain, via the network interface from the audio information source outside of the LAN, the audio information; (ii) transmit, via the network interface of the first playback device to a second playback device, the audio information, playback timing information associated with the audio information, and device clock information of the first playback device; and (iii) play back the audio information in synchrony with the second playback device by using the playback timing information associated with the audio information and the device clock information of the first playback device to play back the audio information, wherein the first and second playback devices remain independently clocked during synchronous playback of the audio information.

10. The first playback device of claim **9**, wherein the program instructions, when executed by the one or more processors, further cause the first playback device to:

generate the playback timing information associated with the audio information; and

generate the device clock information of the first playback device.

11. The first playback device of claim **9**, wherein the control information further comprises one or more instructions for the first playback device and the second playback device to playback audio information.

12. The first playback device of claim **11**, wherein the first and second playback devices are members of a synchrony group, and wherein the program instructions, when executed by the one or more processors, further cause the first playback device to:

transmit, to the network device, status information that comprises a status of the synchrony group.

13. The first playback device of claim **12**, wherein the status information further comprises an identification of each playback device in the synchrony group.

14. The first playback device of claim **12**, wherein the status information further comprises an identification of a master playback device of the synchrony group.

15. The first playback device of claim 14, wherein the first playback device is the master playback device of the synchrony group.

16. The first playback device of claim 12, wherein the status information further comprises an identification of one or more slave playback devices in the synchrony group, and wherein the second playback device is one of the one or more slave playback devices in the synchrony group.

17. The first playback device of claim 16, wherein the instructions, when executed by the one or more processors, further cause the first playback device to:

generate a plurality of frames, wherein an individual frame comprises at least a portion of the audio information and the playback timing information associated with the audio information, and wherein the first playback device transmitting to the second playback device the audio information, playback timing information, and device clock information of the first playback device comprises transmitting the plurality of frames to the second playback device.

18. The first playback device of claim 9, wherein the audio information comprises one of audio files or packetized streaming audio information.

19. The first playback device of claim 9, wherein the audio information source outside of the LAN is an Internet-accessible audio information source, and wherein obtaining, from the audio information source outside of the LAN, the audio information, comprises obtaining the audio information from the Internet-accessible audio information source.

20. The first playback device of claim 9, wherein obtaining, from the audio information source outside of the LAN, the audio information, comprises sending, to the audio information source, a request for the audio information.

* * * * *

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

SONOS, INC.,	)	
	)	
Plaintiff,	)	
	)	Civil Action No. 14-1330-RGA
v.	)	
	)	
D&M HOLDINGS INC. d/b/a THE D+M GROUP, D&M HOLDINGS U.S. INC., and DENON ELECTRONICS (USA), LLC,	)	JURY TRIAL DEMANDED
	)	
Defendants.	)	

SONOS, INC.'S AMENDED RESPONSES TO DEFENDANT D&M HOLDINGS INC.'S FIRST SET OF INTERROGATORIES (NOS. 1-11) TO PLAINTIFF

Plaintiff, Sonos, Inc. ("Sonos") responds to Defendant D&M Holdings Inc.'s ("D&M") first set of interrogatories (Nos. 1-11) as follows:

GENERAL OBJECTIONS

Sonos asserts each of the following General Objections to each of D&M's interrogatories. In addition to these General Objections, Sonos may also state Specific Objections to specific interrogatories where appropriate. By setting forth such additional Specific Objections, Sonos does not in any way intend to limit or restrict its General Objections. Moreover, to the extent Sonos provides a response to any of D&M's interrogatories to which Sonos objects, such response shall not constitute a waiver of any General or Specific Objection.

1. Sonos's amended responses to D&M's First Set of Interrogatories (Nos. 1-11) to Plaintiff are made to the best of Sonos's present knowledge, and Sonos reserves the right, at any time, to revise, correct, supplement, modify, or clarify the specific responses set forth below or the information disclosed therein. Discovery is in the early stages, and Sonos therefore reserves

the right to amend, supplement, and/or alter its responses as warranted during the course of discovery.

2. Sonos's objections are made without prejudice to Sonos's right to revise or supplement them based on the discovery in this case, on facts or circumstances that may come to Sonos's knowledge, or if D&M subsequently asserts an interpretation of any discovery request that differs from Sonos's understanding. Sonos reserves the right to offer additional information at trial that was obtained during discovery and/or investigation yet to be conducted in this case.

3. Sonos objects generally to these Interrogatories to the extent they purport to require supplementation of these responses beyond the obligations required by Fed. R. Civ. P. 26(e) and any applicable Local Rules.

4. Sonos objects generally to these Interrogatories as impermissibly premature to the extent they require Sonos to provide information or produce documents prior to the Federal Rules of Civil Procedure, the Local Rules of this Court, the Court's Scheduling Order, the Court's Default Standard for Discovery, and/or any agreement between the parties.

5. Sonos objects generally to these Interrogatories to the extent that they fail to comply with or seek to impose obligations in excess of those required by the Federal Rules of Civil Procedure, the Local Rules of this Court, the Court's Scheduling Order, the Court's Default Standard for Discovery, and/or any agreement between the parties.

6. Sonos objects generally to these Interrogatories to the extent that they seek information not in the possession, custody, or control of Sonos.

7. Sonos objects generally to these Interrogatories to the extent that they seek information protected by the attorney-client privilege, work product immunity, or any other applicable privilege or immunity. Sonos has registered its privilege and immunity objections

expressly to each interrogatory insofar as it recognizes that the interrogatory might be interpreted to encompass privileged or immune information; for such Specific Objections, Sonos hereby incorporates this General Objection 7. Moreover, the inadvertent production of any privileged or immune information shall not signify any intent by Sonos to waive any applicable privileges or immunities, nor shall Sonos be precluded from challenging the use of any inadvertently disclosed information during any subsequent proceedings.

8. Sonos objects to these Interrogatories to the extent that they are premature because Sonos's responses depend upon review and analysis of information that D&M has yet to provide in its responses to discovery requests, its disclosures under the Court's Scheduling Order, and/or its disclosures under the Court's Default Standard for Discovery.

9. Sonos objects to these Interrogatories to the extent that they are premature as fact discovery remains open in this case. Sonos further objects to these Interrogatories to the extent they seek information that cannot be determined at this time before the relevant claims of the Patents-in-Suit are construed and before Sonos has had full and complete discovery.

10. Sonos objects generally to these Interrogatories to the extent that they are unreasonably duplicative and/or cumulative or seek information and/or documents and things that are obtainable from a source that is more convenient, less expensive, or less burdensome under Fed. R. Civ. P. 26(b)(2).

11. Sonos objects generally to each Interrogatory to the extent that the information sought can be ascertained from documents that will be produced in discovery or that are uniquely in D&M's possession, custody, and control.

12. Sonos objects to these Interrogatories to the extent that they call for the production of information that is related to subject matter outside of the United States.

13. Sonos objects generally to these Interrogatories to the extent that they exceed D&M's limit on the number of interrogatories to be served under the Court's Scheduling Order and to the extent that they contain subparts requiring separate and distinct responses.

14. Sonos objects generally to the definitions from these Interrogatories. Sonos's responses to these Interrogatories do not constitute a representation that Sonos agrees with or adopts any of D&M's definitions.

15. Sonos objects to D&M's definition of "Plaintiff," "Sonos," "you," and "your" (*see* Definition/Instruction 2) to the extent such definitions are overbroad in encompassing related or unrelated entities that are not the owners of the Patents-in-Suit or in the business of researching, developing, making, using, selling, or offering for sale any products whose use is covered by the Patents-in-Suit in this litigation. Sonos objects to any purported obligation to act on behalf of persons or entities over which Sonos has no control. In addition, Sonos objects to any purported obligation to act on behalf of related persons or entities who hold no direct ownership of the Patents-in-Suit and who played no material role in the research, development, manufacture, use, sale, or offer for sale of any products whose use is covered by the Patents-in-Suit. Sonos will respond to these Interrogatories on its own behalf alone. Sonos also objects to the inclusion of Sonos's "attorneys" within these definitions, insofar as such definitions seek information protected by the attorney-client privilege and/or work product doctrine.

16. Sonos objects to the extent that these Interrogatories cover time periods not relevant to this lawsuit (*see* Definition/Instruction 24). For example, Sonos objects to the extent that these Interrogatories seek discovery from more than 6 years before the filing of the complaint that is not related to asserted prior art or the conception and reduction to practice of

the inventions claimed in any Patents-in-Suit, which is prohibited under the Court's Scheduling Order.

17. Sonos objects to D&M's definition of the term "document(s)" as overbroad and unduly burdensome, and seeking to impose requirements or obligations on Sonos in addition to, beyond the scope of, or different from those imposed by the Federal Rules of Civil Procedure and/or the Local Rules of this Court. "Document(s)" will be interpreted consistent with Rule 34 of the Federal Rules of Civil Procedure.

18. Sonos objects generally to these Interrogatories as vague and ambiguous to the extent they include terms or phrases that are undefined and/or unclear.

19. Sonos objects to any use of specific terms found in the claims of the Patents-in-Suit to the extent these terms are subject to construction by the Court.

20. Sonos objects generally to these Interrogatories to the extent that they seek information and/or the identification of individuals, documents and things relating to subjects not raised by the pleadings, not relevant to any claim or defense, not material and necessary to the prosecution or defense of this action, or not reasonably calculated to lead to the discovery of admissible evidence.

21. Sonos objects generally to these Interrogatories to the extent that they require Sonos to speculate or make judgments as to any future beliefs, contentions, or conduct.

22. Sonos's objections are based on Sonos's good-faith interpretation of these Interrogatories and are subject to correction for any errors or omissions.

23. Sonos objects generally to any Interrogatory requiring the identification of "any" or "all" documents, to the extent that such a request could be construed to place an undue burden

on Sonos, especially where the identification or production of less than "all" or "any" of the documents will supply all the information needed.

24. Sonos objects generally to any Interrogatory requiring the identification of "any" or "all" persons, to the extent that such a request could be construed to place an undue burden on Sonos, especially where the identification of less than "all" or "any" of the persons will supply all the information needed.

25. Sonos objects generally to any Interrogatory requiring the description of "any" or "all" facts and circumstances concerning a legal basis of liability, or any aspect thereof, which may arise from D&M's conduct to the extent that such a request could be construed to be overbroad or to place an undue burden on Sonos, especially where the description of less than "all" or "any" of the relevant facts and circumstances will supply all the information needed.

26. Sonos's agreement to produce documents responsive to a particular interrogatory pursuant to Fed. R. Civ. P. 33(d) indicates that Sonos will produce responsive documents to the extent that such documents are in its possession, custody, or control, subject to the objections Sonos has raised to that Interrogatory and the General Objections herein.

27. By agreeing to produce documents in response to these Interrogatories, Sonos makes no representation that any such documents exist, but only represents that such documents will be produced if they exist, can be located with reasonable diligence, and are not otherwise protected from disclosure.

28. Sonos provides these responses without waiver of or prejudice to its right, at any later time, to raise objections to: (a) the relevance, materiality, or admissibility of (i) these Interrogatories or any part thereof, (ii) statements made in these responses to these Interrogatories or any part thereof, or (iii) any document produced pursuant to these responses;

or (b) any further demand for discovery involving or relating to the matters raised in these Interrogatories.

29. All confidential documents produced in response to these Interrogatories shall be subject to any protective order entered in this case. Any confidential documents produced prior to the entry of a protective order shall be disclosed to outside counsel only pursuant to Delaware L.R. 26.2.

30. Sonos objects generally to these Interrogatories to the extent that they seek information or documents that are subject to the terms of protective orders and/or confidentiality agreements in other cases and/or with third parties.

31. These responses are made solely for the purpose of this action. Each response is subject to all objections as to competence, relevance, materiality, propriety, and admissibility.

32. Sonos objects generally to these Interrogatories as overly broad and unduly burdensome to the extent that they require Sonos to provide the same information in both a substantive textual response and by citation to specific documents. Sonos may provide the information called for by these Interrogatories, to the extent not otherwise objected to, either by citation to business records under Fed. R. Civ. P. 33(d) and/or with a substantive textual response.

33. Sonos objects to identifying documents or communications and/or the subject matter contained therein or thereof, in interrogatories calling for such identification, where such documents/communications that are being produced and/or made available for inspection and copying under Fed. R. Civ. P. 34 and/or Fed. R. Civ. P. 33(d) speak for themselves.

34. Sonos objects to each of these Interrogatories to the extent that they seek information that is or may be the subject of expert testimony as premature and unduly

burdensome. A schedule for providing such expert testimony has been established by the Federal Rules of Civil Procedure and the Court's Scheduling Order. Sonos intends to provide appropriate expert testimony according to that schedule and reserves its right to amend its responses in light of such expert testimony.

35. To the extent not already set forth herein, Sonos incorporates the General Objections and General Statements from its Objections and Responses to Defendants' First Set of Common Requests for Production of Documents herein by reference.

36. Sonos is willing to discuss its objections in a good-faith attempt to resolve or narrow any differences between the parties.

37. The foregoing General Objections shall be deemed continuous throughout and are hereby incorporated by reference in Sonos's responses to the specific interrogatories that follow.

RESPONSES

Subject to, and without waiving, any General Objection, Sonos responds to the Interrogatories below:

INTERROGATORY NO. 1:

For each Asserted Claim of the Patents-in-Suit, describe in detail the circumstances of its invention. A complete answer will include, without limitation, identifying the earliest claimed date(s) of conception and reduction to practice, when and where such conception and reduction to practice occurred, all Persons involved in or otherwise having knowledge of such conception and reduction to practice, the nature and extent of each individual's involvement in, and their relative contribution to such activities, including the substance of what each would testify to with regard to conception and reduction to practice, and all documents and tangible things related to Plaintiff's earliest claimed date(s) of conception and reduction to practice, including an identification of the specific document(s) that corroborate the conception and reduction to practice of each element of the Asserted Claims.

AMENDED RESPONSE TO INTERROGATORY NO. 1:

Sonos specifically objects to this Interrogatory as overly broad, unduly burdensome, and/or calling for information that is neither relevant nor reasonably calculated to lead to the discovery of admissible evidence. For example, this Interrogatory seeks an identification of "all Persons . . . having knowledge of such conception and reduction to practice," regardless of how such knowledge was acquired. Sonos further objects to this Interrogatory to the extent it seeks information protected by the attorney-client privilege and/or work product immunity. For example, invention disclosures are protected by the attorney-client privilege. *See, e.g., In re Spalding Sports Worldwide, Inc.*, 203 F. 3d 800, 805-06 (Fed. Cir. 2000); *Allergan Inc. v. Barr Labs. Inc.*, 2010 WL 3328270, at *1 (D. Del. August 18, 2010). Sonos also objects to this Interrogatory as premature to the extent it seeks expert discovery in advance of the date set forth in the Federal Rules of Civil Procedure and/or the Court's Scheduling Order. Sonos further objects to this Interrogatory as premature to the extent it seeks information concerning the scope of any asserted claim that will be the subject of claim construction proceedings before the Court. Sonos further objects to this Interrogatory on the ground that it is a premature contention interrogatory that has been filed before a substantial amount of discovery has been conducted in this lawsuit. *See* Fed. R. Civ. P. 33(a)(2) ("[T]he court may order that [a contention] interrogatory need not be answered until after designated discovery has been completed . . . .").

Subject to, and without waiving, the foregoing Specific and General Objections, Sonos states that:

- the subject matter claimed in the '014 Patent was conceived and reduced to practice at least as early as June 5, 2004;

- the subject matter claimed in the '949 Patent was conceived and reduced to practice at least as early as June 5, 2004;
- the subject matter claimed in the '224 Patent was conceived and reduced to practice at least as early as May 15, 2004;
- the subject matter claimed in the '312 Patent was conceived and reduced to practice at least as early as April 18, 2011;
- the subject matter claimed in the '637 Patent was conceived and reduced to practice at least as early as May 9, 2007;
- the subject matter claimed in the '556 Patent was conceived and reduced to practice at least as early as July 19, 2011;
- the subject matter claimed in the '258 Patent was conceived and reduced to practice at least as early as April 1, 2004;
- the subject matter claimed in the '509 Patent was conceived and reduced to practice at least as early as January 25, 2011;
- the subject matter claimed in the '357 Patent was conceived and reduced to practice at least as early as April 1, 2004;
- the subject matter claimed in the '959 Patent was conceived and reduced to practice at least as early as April 8, 2011; and
- the subject matter claimed in the '197 Design Patent was conceived and reduced to practice at least as early as the February 11, 2004.

Pursuant to Fed. R. Civ. P. Rule 33(d), Sonos has produced or will produce documents from which information sought in this Interrogatory may be ascertained. *See, e.g.,* Sonos's document production numbers SONDM000028935-9383; SONDM000045582-99;

SONDM000048734-38; SONDM000049348-72; SONDM000049373-97; SONDM000049398-422; SONDM000049801-25; SONDM000049826-50; SONDM000049851-75; SONDM000048847; SONDM000050053-56; SONDM000128315-17; SONDM000048341-496; SONDM000048831; SONDM000049053-54; SONDM000049075-77; SONDM000049215-60; SONDM000049423-52; SONDM000048805-808; SONDM000048944-62; SONDM000049051-52; SONDM000049071-72; SONDM000050058-76; SONDM000048497-673; SONDM000135935-6091; SONDM000133331-437; SONDM000136092-260; SONDM000136261-409; SONDM000128708-867; SONDM000128868-999; SONDM000129000-9150; SONDM000129300-431; SONDM000129432-593; SONDM000129594-678; SONDM000129679-722; SONDM000049007-42; SONDM000128158-71; SONDM000128311-12; SONDM000048730; SONDM000048731; SONDM000049876-82; SONDM000050270-73; SONDM000129735-45; SONDM000129747-49; SONDM000133917-21; SONDM000047772-74; SONDM000047775-92; SONDM000047793-99; SONDM000048795-97; SONDM000048798-99; SONDM000048817-18; SONDM000051014-1033; SONDM000051056-74; SONDM000051075-90; SONDM000114698-700; SONDM000114701-702; SONDM000114708-710; SONDM000114742-49; SONDM000118539-46; SONDM000118548-52; SONDM000133922-24; SONDM000133932-35; SONDM000134227-28; SONDM000132813-16; SONDM000132822; SONDM000132822-26; SONDM000145032; SONDM000145033; SONDM000145035; SONDM000145036; SONDM000145736-37; SONDM000146447-49; SONDM000146450-52; SONDM0000000318-19444; SONDM000052046-SONDM000108803; SONDM000044681-714; SONDM000126223; SONDM000126431-33; SONDM000126434-36; SONDM000121322-26; SONDM000121327-37; SONDM000121338; SONDM000121304;

SONDM000121305-306; SONDM000132827-28; SONDM000132829; SONDM000132830-31; SONDM000125282-364; SONDM000125365; SONDM000125366-68; SONDM000125369; SONDM000125370; SONDM000125371; SONDM000125372; SONDM000125373; SONDM000125374.

Sonos reserves the right to revise, correct, add to, supplement, or clarify its response to this Interrogatory as additional information is discovered and/or becomes available.

INTERROGATORY NO. 2:

Identify any embodiments of any of the Asserted Claims of the Patents-in-Suit, including all products or services, if any, that Plaintiff contends practice or embody (or has at any time practiced or embodied) any alleged invention described or claimed in the Patents-in-Suit, including any products or services made by Plaintiff or third parties and including, without limitation, all licensed products or services, but excluding any products or services of Defendants, and explain how each element of each claim of the Patents-in-Suit are present in each of the alleged embodiments. A complete answer will include the dates of creation and use, the Persons and entities involved, the surrounding circumstances, and all supporting documents and facts.

AMENDED RESPONSE TO INTERROGATORY NO. 2:

Sonos specifically objects to this Interrogatory as vague and ambiguous, as it appears to cover Defendants' products and services, while at the same time exclude them. The reference to "licensed products or services" in this Interrogatory is also objectionable as vague and ambiguous, as it is unclear what "license" or "licenses" are being referred to. Sonos also objects to this Interrogatory as overly broad, unduly burdensome, and/or calling for information that is neither relevant nor reasonably calculated to lead to the discovery of admissible evidence. For example, this Interrogatory seeks a legal analysis of products and services of third parties that have not been accused of infringing any of the Patents-in-Suit. As another example, this Interrogatory improperly seeks irrelevant embodiments that practice or embody descriptions in

the Patents-in-Suit that are not claimed. As yet another example, this Interrogatory improperly seeks discovery from more than 6 years before the filing of the complaint, which is prohibited under the Court's Scheduling Order. Sonos further objects to this Interrogatory to the extent it seeks information protected by the attorney-client privilege and/or work product immunity. Sonos also objects to this Interrogatory to the extent it seeks confidential, proprietary, and/or sensitive business information, prior to the entry of a Protective Order in this case. In addition, Sonos objects to this Interrogatory as premature to the extent it seeks expert discovery in advance of the date set forth in the Federal Rules of Civil Procedure and/or the Court's Scheduling Order. Sonos further objects to this Interrogatory as premature to the extent it seeks information concerning the scope of any asserted claim that will be the subject of claim construction proceedings before the Court. Sonos further objects to this Interrogatory on the ground that it is a premature contention interrogatory that has been filed before a substantial amount of discovery has been conducted in this lawsuit. *See* Fed. R. Civ. P. 33(a)(2) ("[T]he court may order that [a contention] interrogatory need not be answered until after designated discovery has been completed . . . .").

Subject to, and without waiving, the foregoing Specific and General Objections, as stated in Paragraph 14 of its Third Amended Complaint, Sonos provides a link to its U.S. Patents and published U.S. Patent Applications, as well as a table that correlates Sonos's patents to its products, on Sonos's website at www.sonos.com/legal/terms#patents. *See* Ex. E to the Third Amended Complaint. In addition, Sonos encloses notices of its patents with its product inserts and manuals for its products, which provide that "[o]ur patent-to-product information can be found here: sonos.com/legal/patents." *See, e.g.*, Ex. F to the Third Amended Complaint. Furthermore, to date, Sonos has not licensed any of the Patents-in-Suit to anyone.

The following table lists the devices that practice or embody one or more claims of one or more of the Patents-in-Suit and that Sonos offers for sale (or previously offered for sale), as well as the release dates and current availability for such products:

Sonos Product	**Release Date**	**Still available?**
ZP100	January 2005	No
CR100	January 2005	No
ZP80	January 2006	No
CONNECT:AMP (ZP120)	August 2008	Yes
CONNECT (ZP90)	August 2008	Yes
CR200	July 2009	No
PLAY:5 (gen 1)	November 3, 2009	No
PLAY:5 (gen 1 black)	June 2, 2010	No
PLAY:3	July 20, 2011	Yes
SUB	June 19, 2012	Yes
PLAYBAR	March 4, 2013	Yes
PLAY:1	October 14, 2013	Yes
PLAY:5 (gen 2)	November 20, 2015	Yes

Pursuant to Fed. R. Civ. P. Rule 33(d), Sonos has produced or will produce documents from which information sought in this Interrogatory may be ascertained. *See, e.g.*, Sonos's document production numbers SONDM000034916-78; SONDM000034979-024; SONDM000035025-154; SONDM000035424-25; SONDM000035426-27; SONDM000035428-29; SONDM000035432; SONDM000035433-654; SONDM000035655-56; SONDM000035657-58; SONDM000035659-60; SONDM000035661-959; SONDM000035960-6215; SONDM000036216-17; SONDM000036218-357; SONDM000036358-59; SONDM000036360-64; SONDM000036565-66; SONDM000036567-746; SONDM000036747-

48; SONDM000036749-803; SONDM000037002-03; SONDM000037004-05; SONDM000037006-50; SONDM000037076-88; SONDM000037089-102; SONDM000037103-40; SONDM000037141-48; SONDM000037159-204; SONDM000037205-49; SONDM000037250-370; SONDM000037371-85; SONDM000037386-99; SONDM000037400-14; SONDM000037415-28; SONDM000037429-45; SONDM000037446-494; SONDM000037495-553; SONDM000037564-78; SONDM000037579-91; SONDM000037592-605; SONDM000037616-720; SONDM000037721-34; SONDM000037735-48; SONDM000037749-58; SONDM000037759-72; SONDM000037773-828; SONDM000037829-894; SONDM000037920-34; SONDM000037935-47; SONDM000037948-61; SONDM000037962-8003; SONDM000038014-62; SONDM000038063-108; SONDM000038109-233; SONDM000038234-38; SONDM000038239-56; SONDM000038257-71; SONDM000038272-86; SONDM000038287-301; SONDM000038302-15; SONDM000038316-323; SONDM000038324-56; SONDM000038357-69; SONDM000038370-413; SONDM000038414-461; SONDM000038504-518; SONDM000038519-36; SONDM000038537-53; SONDM000038554-87; SONDM000038598-638; SONDM000038639-80; SONDM000038681-742; SONDM000038743-57; SONDM000038758-74; SONDM000038775-89; SONDM000038790-808; SONDM000038809-23; SONDM000038824-40; SONDM000038841-48; SONDM000038849-82; SONDM000038883-915; SONDM000038916-32; SONDM000038933-45; SONDM000038946-96; SONDM000038997-044; SONDM000039077-101; SONDM000039102-124; SONDM000039125-49; SONDM000039150-96; SONDM000039197-242; SONDM000039243-308; SONDM000039309-31; SONDM000039332-55; SONDM000039356-78; SONDM000039379-417; SONDM000039418-54; SONDM000039455-71; SONDM000039472-74;

SONDM000044854-90; SONDM000045210-37; SONDM000045238-65; SONDM000148449-90; SONDM000148502-725.

Sonos reserves the right to revise, correct, add to, supplement, or clarify its response to this Interrogatory as additional information is discovered and/or becomes available.

INTERROGATORY NO. 3:

If Plaintiff contends that there exists any secondary considerations or objective evidence of non-obviousness with respect to the Patents-in-Suit, state in detail the factual basis for Plaintiff's contention, state each fact that supports, relates to, or refutes such contention, identify each item of other evidence, including documents, that support, relate to or refute such contentions, and identify each Person with knowledge of such facts.

AMENDED RESPONSE TO INTERROGATORY NO. 3:

Sonos specifically objects to this Interrogatory to the extent it seeks information protected by the attorney-client privilege and/or work product immunity. Sonos also objects to this Interrogatory to the extent it seeks confidential, proprietary, and/or sensitive business information, prior to the entry of a Protective Order in this case. In addition, Sonos objects to this Interrogatory as premature in that it seeks information to be included in Sonos's Initial Disclosures in advance of the date set forth in the Court's Scheduling Order. Sonos also objects to this Interrogatory as premature to the extent it seeks expert discovery in advance of the date set forth in the Federal Rules of Civil Procedure and/or the Court's Scheduling Order. Sonos further objects to this Interrogatory as premature to the extent it seeks information concerning the scope of any asserted claim that will be the subject of claim construction proceedings before the Court. In addition, Sonos objects to this Interrogatory on the ground that it is a premature contention interrogatory that has been filed before a substantial amount of discovery has been conducted in this lawsuit. *See* Fed. R. Civ. P. 33(a)(2) ("[T]he court may order that [a

contention] interrogatory need not be answered until after designated discovery has been completed . . . .").

Subject to, and without waiving, the foregoing Specific and General Objections, Sonos states that: (i) evidence of commercial success and acceptance in the industry may be found, for example, in Sonos's and Defendants' sales and distribution of products embodying the inventions claimed in the Patents-in-Suit; (ii) evidence of copying by competitors may be found, for example, in Defendants' marketing and sales of such products; and (iii) evidence of praise by others may be found, for example, in the press and media coverage on Sonos's products. *See also* Paragraphs 12-24 of Sonos's Third Amended Complaint, and the exhibits cited therein, all of which are incorporated herein by reference.

Pursuant to Fed. R. Civ. P. Rule 33(d), Sonos has produced or will produce documents from which information sought in this Interrogatory may be ascertained. *See, e.g.,* Sonos's document production numbers SONDM000033217-20; SONDM000033221-24; SONDM000033225-27; SONDM000033228-30; SONDM000033258-64; SONDM000033265-67; SONDM000033268-70; SONDM000033271-73; SONDM000033274-78; SONDM000033279-80; SONDM000033281-83; SONDM000033284-341; SONDM000044582-85; SONDM000044612-13; SONDM000044387-89; SONDM000044440-41; SONDM000044464-65; SONDM000044486-87; SONDM000044522-23; SONDM000044532-33; SONDM000044649-52; SONDM000044668-69; SONDM000044614-16; SONDM000044600-603; SONDM000044575-78; SONDM000044383-84; SONDM000044337-38; SONDM000044493-94; SONDM000044621-24; SONDM000044625-28; SONDM000044629-32; SONDM000044666-67; SONDM000044586-90; SONDM000044353-54; SONDM000044595-99; SONDM000044415-16; SONDM000044484-85;

SONDM000044591-94; SONDM000044357-58; SONDM000044526-27; SONDM000044563-64; SONDM000044505-506; SONDM000044641-44; SONDM000044657-60; SONDM000044661-63; SONDM000044664-65; SONDM000044670-71; SONDM000044368-69; SONDM000044609-11; SONDM000044653-56; SONDM000044559-60; SONDM000044419-20; SONDM000044403-404; SONDM000044488-89; SONDM000044604-605; SONDM000033979-81; SONDM000033982; SONDM000033983-94; SONDM000033995-4000; SONDM000034001-4014; SONDM000034015-18; SONDM000034019-24; SONDM000034025-32; SONDM000034033-37; SONDM000034038-43; SONDM000034044-48; SONDM000034049-50; SONDM000034051-64; SONDM000034065-70; SONDM000034071-77; SONDM000034078-82; SONDM000034083-84; SONDM000034085; SONDM000034086-88; SONDM000034100-105; SONDM000034108-109; SONDM000034110-12; SONDM000034113-14; SONDM000034124-26; SONDM000034134-36; SONDM000034581-83; SONDM000034734-37; SONDM000034738-40; SONDM000034741-42; SONDM000034751-67; SONDM000034786-87; SONDM000034788; SONDM000034789; SONDM000034790; SONDM000034791; SONDM000034793-97; SONDM000034819-25; SONDM000034826-28; SONDM000034829-31; SONDM000045361-62; SONDM000045363-67; SONDM000045370-71; SONDM000045372-74; SONDM000045375-78; SONDM000045379-81; SONDM000045382-84; SONDM000045385-86; SONDM000045387-89; SONDM000045390-92; SONDM000045393-97; SONDM000045398-99; SONDM000045404-406; SONDM000045407-408; SONDM000045417-19; SONDM000045420-22; SONDM000045423-26; SONDM000045427; SONDM000045430-31; SONDM000045434-40; SONDM000045441-44; SONDM000045465-74; SONDM000045475-77; SONDM000045478-97; SONDM000045514-

41; SONDM000045542-48; SONDM000045549-53; SONDM000045554-55; SONDM000045556-60; SONDM000046108-137; SONDM000046138-206; SONDM000046207-349; SONDM000046350-466; SONDM000046467-95; SONDM000046496-530; SONDM000046531-33; SONDM000046534-605; SONDM000046606-41; SONDM000046642-88; SONDM000046723-818; SONDM000046819-68; SONDM000046869-99; SONDM000046900-30; SONDM000046931-45; SONDM000046946-52; SONDM000046953-87; SONDM000046988-7022; SONDM000047023-55; SONDM000047056-84; SONDM000047085-102; SONDM000047103-23; SONDM000047127-38; SONDM000047486-618; SONDM000047619-77; SONDM000047812-14; SONDM000047817-20; SONDM000047821-26; SONDM000047832-33; SONDM000047834-37; SONDM000047838-40; SONDM000047850-52; SONDM000047855-60; SONDM000047861-62; SONDM000047867-70; SONDM000047871-73; SONDM000047876-77; SONDM000047881-83; SONDM000047884-85; SONDM000047886-88; SONDM000047996-8007; SONDM000048052-85; SONDM000048086-153; SONDM000048154; SONDM000114132-34; SONDM000114135-40; SONDM000114141-45; SONDM000114146-48; SONDM000114149-55; SONDM000114156-59; SONDM000114160; SONDM000114161-67; SONDM000114168-70; SONDM000114171-72; SONDM000114173-80; SONDM000114181-201; SONDM000114202-208; SONDM000114209-213; SONDM000114214-15; SONDM000114216-22; SONDM000114223-24; SONDM000114235-46; SONDM000114247-58; SONDM000114274-79; SONDM000114280-88; SONDM000114289-305; SONDM000114306-309; SONDM000114310-12; SONDM000114313-17; SONDM000114345-50; SONDM000114375-79; SONDM000114380-82; SONDM000114383-86; SONDM000114387-97;

SONDM000114398-405; SONDM000114406-411; SONDM000114428-31; SONDM000114432-35; SONDM000114436-40; SONDM000114441-46; SONDM000114447-57; SONDM000114460-70; SONDM000114471-74; SONDM000114475-77; SONDM000114478-81; SONDM000114482-88; SONDM000114489-94; SONDM000114495-98; SONDM000114499-509; SONDM000114510-23; SONDM000114530-37; SONDM000114538-41; SONDM000114542; SONDM000114543; SONDM000114545-47; SONDM000114548; SONDM000114551; SONDM000114552-53; SONDM000114555-56; SONDM000114557-59; SONDM000114560; SONDM000114561; SONDM000114567; SONDM000114568-75; SONDM000114580; SONDM000114581-84; SONDM000114585; SONDM000114586; SONDM000114587; SONDM000114592-604; SONDM000114609-611; SONDM000114612; SONDM000114613; SONDM000114614-16; SONDM000114617-18; SONDM000114619; SONDM000114620-23; SONDM000114627-31; SONDM000114632; SONDM000114633-34; SONDM000114635-37; SONDM000114641-43; SONDM000114645; SONDM000114646; SONDM000114647-58; SONDM000114660; SONDM000114663-64; SONDM000114665*; SONDM000114666; SONDM000114667; SONDM000114668-69; SONDM000114670; SONDM000114671; SONDM000114672; SONDM000114674; SONDM000114675-79; SONDM000114681; SONDM000114682; SONDM000114683-85; SONDM000114692; SONDM000114693-95; SONDM000114696; SONDM000114697; SONDM000119104-07; SONDM000121307-21; SONDM000121339-2985; SONDM000122986-3020; SONDM000123021-830; SONDM000123831-5214 SONDM000132834-904; SONDM000132905-11; SONDM000135539-43; SONDM000135544-49; SONDM000135733-36; SONDM000147190-259; SONDM000151257-59.

LINKPLAY EXHIBIT 1004
Page 4525 of 4822

Sonos reserves the right to revise, correct, add to, supplement, or clarify its response to this Interrogatory as additional information is discovered and/or becomes available.

INTERROGATORY NO. 4:

For each product identified in response to Interrogatory No. 2 that allegedly practices or embodies (or has at any time allegedly practiced or embodied) any alleged invention claimed or described in the Patents-in-Suit, identify the unit sales, customers, revenues (net and gross), cost of goods sold, profit (net and gross), and allocated expenses, detailing what is included in each, for each product or service by month, and identify all documents in support thereof.

AMENDED RESPONSE TO INTERROGATORY NO. 4:

Sonos incorporates its objections and amended response to Interrogatory No. 2 herein by reference. Sonos also specifically objects to this Interrogatory as vague and ambiguous, as it is unclear what the phrases "detailing what is included in each" and "in support thereof" mean or refer to. Sonos also objects to this Interrogatory as overly broad, unduly burdensome, and/or calling for information that is neither relevant nor reasonably calculated to lead to the discovery of admissible evidence. For example, this Interrogatory seeks an identification of Sonos's "customers," which is not relevant to this litigation. As another example, this Interrogatory seeks "all documents in support," which is overly broad and unduly burdensome. As yet another example, this Interrogatory improperly seeks discovery from more than 6 years before the filing of the complaint, which is prohibited under the Court's Scheduling Order. Sonos further objects to this Interrogatory to the extent it seeks confidential, proprietary, and/or sensitive business information, prior to the entry of a Protective Order in this case. In addition, Sonos objects to this Interrogatory as premature to the extent it seeks expert discovery in advance of the date set forth in the Federal Rules of Civil Procedure and/or the Court's Scheduling Order.

Subject to the foregoing General Objections, General Statements, and specific objections, and pursuant to Fed. R. Civ. P. Rule 33(d), Sonos has produced or will produce documents from which information sought in this Interrogatory may be ascertained. *See, e.g.*, Sonos's document production numbers SONDM000048258; SONDM000048259-60; SONDM000048266-315; SONDM000048316-25; SONDM000048326-34; SONDM000048335; SONDM000051400-506; SONDM000051523-28; SONDM000052041; SONDM000052042; SONDM000052043; SONDM000052044; SONDM000052045; SONDM000125215-232; SONDM000135504; SONDM000135733-36; SONDM000147188; SONDM000147189; SONDM000147260-64; SONDM000147265; SONDM000151254-56; and SONDM000151260.

Sonos reserves the right to revise, correct, add to, supplement, or clarify its response to this Interrogatory as additional information is discovered and/or becomes available.

INTERROGATORY NO. 5:

Identify each product, if any, that has ever been marked with the patent number of the Patents-in-Suit, including the date when such marking was first made, the date on which such marking stopped (whether temporarily or permanently), and the patent numbers or numbers marked. A complete answer will include an identification of all documents or things that you contend provide evidence of such marking, and an identification of all Persons with knowledge concerning such facts (specifically identifying the Person or Persons most knowledgeable) to the extent not already specifically disclosed in Plaintiff's initial disclosures.

AMENDED RESPONSE TO INTERROGATORY NO. 5:

Sonos specifically objects to this Interrogatory as vague and ambiguous, as it seeks the identity of "patent numbers" on products "marked with the patent number." The reference to "patent numbers or numbers marked" in this Interrogatory is also objectionable as vague and ambiguous, as it is unclear what "numbers" are being referred to. Sonos also objects to this Interrogatory as overly broad, unduly burdensome, and/or calling for information that is neither

relevant nor reasonably calculated to lead to the discovery of admissible evidence. For example, this Interrogatory seeks an identification of "all documents or things," "all Persons with knowledge," and "the Person or Persons most knowledgeable." As another example, this Interrogatory requires an identification of "the date on which such marking stopped," which improperly requires a presumption to be made that Sonos stopped its patent marking. As yet another example, this Interrogatory improperly seeks discovery from more than 6 years before the filing of the complaint, which is prohibited under the Court's Scheduling Order. Sonos further objects to this Interrogatory to the extent it seeks information protected by the attorney-client privilege and/or work product immunity. Sonos also objects to this Interrogatory on the ground that it is a premature contention interrogatory that has been filed before a substantial amount of discovery has been conducted in this lawsuit. *See* Fed. R. Civ. P. 33(a)(2) ("[T]he court may order that [a contention] interrogatory need not be answered until after designated discovery has been completed . . . .").

Subject to, and without waiving, the foregoing Specific and General Objections, as stated in Paragraph 14 of its Third Amended Complaint, Sonos provides a link to its U.S. Patents and published U.S. Patent Applications, as well as a table that correlates Sonos's patents to its products, on Sonos's website at www.sonos.com/legal/terms#patents. *See* Ex. E to the Third Amended Complaint. In addition, Sonos encloses notices of its patents with its product inserts and manuals for its products, which provide that "[o]ur patent-to-product information can be found here: sonos.com/legal/patents." *See, e.g.*, Ex. F to the Third Amended Complaint.

Subject to the foregoing General Objections, General Statements, and specific objections, and pursuant to Fed. R. Civ. P. Rule 33(d), Sonos has produced or will produce documents from which information sought in this Interrogatory may be ascertained. *See, e.g.*, Sonos's document

production numbers SONDM000034916-78; SONDM000034979-024; SONDM000035025-154; SONDM000035424-25; SONDM000035426-27; SONDM000035428-29; SONDM000035432; SONDM000035433-654; SONDM000035655-56; SONDM000035657-58; SONDM000035659-60; SONDM000035661-959; SONDM000035960-6215; SONDM000036216-17; SONDM000036218-357; SONDM000036358-59; SONDM000036360-64; SONDM000036565-66; SONDM000036567-746; SONDM000036747-48; SONDM000036749-803; SONDM000037002-03; SONDM000037004-05; SONDM000037006-50; SONDM000037076-88; SONDM000037089-102; SONDM000037103-40; SONDM000037141-48; SONDM000037159-204; SONDM000037205-49; SONDM000037250-370; SONDM000037371-85; SONDM000037386-99; SONDM000037400-14; SONDM000037415-28; SONDM000037429-45; SONDM000037446-494; SONDM000037495-553; SONDM000037564-78; SONDM000037579-91; SONDM000037592-605; SONDM000037616-720; SONDM000037721-34; SONDM000037735-48; SONDM000037749-58; SONDM000037759-72; SONDM000037773-828; SONDM000037829-894; SONDM000037920-34; SONDM000037935-47; SONDM000037948-61; SONDM000037962-8003; SONDM000038014-62; SONDM000038063-108; SONDM000038109-233; SONDM000038234-38; SONDM000038239-56; SONDM000038257-71; SONDM000038272-86; SONDM000038287-301; SONDM000038302-15; SONDM000038316-323; SONDM000038324-56; SONDM000038357-69; SONDM000038370-413; SONDM000038414-461; SONDM000038504-518; SONDM000038519-36; SONDM000038537-53; SONDM000038554-87; SONDM000038598-638; SONDM000038639-80; SONDM000038681-742; SONDM000038743-57; SONDM000038758-74; SONDM000038775-89; SONDM000038790-808; SONDM000038809-23; SONDM000038824-40; SONDM000038841-

48; SONDM000038849-82; SONDM000038883-915; SONDM000038916-32; SONDM000038933-45; SONDM000038946-96; SONDM000038997-044; SONDM000039077-101; SONDM000039102-124; SONDM000039125-49; SONDM000039150-96; SONDM000039197-242; SONDM000039243-308; SONDM000039309-31; SONDM000039332-55; SONDM000039356-78; SONDM000039379-417; SONDM000039418-54; SONDM000039455-71; SONDM000039472-74; SONDM000044854-90; SONDM000045210-37; SONDM000045238-65; SONDM000148449-90; SONDM000148502-725.

Sonos reserves the right to revise, correct, add to, supplement, or clarify its response to this Interrogatory as additional information is discovered and/or becomes available.

INTERROGATORY NO. 6:

For each Asserted Claim of the Patents-in-Suit, on an element-by-element basis, identify the portion or portions of the specification that contain the written description of the alleged invention covered by the claim, and those portions of the specification that describe the manner and process of making and/or using the claim element, in such full, clear, concise, and exact terms as to enable any Person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and those portions of the specification that set forth the best mode contemplated by the inventor of carrying out the invention described in the claims.

AMENDED RESPONSE TO INTERROGATORY NO. 6:

Sonos specifically objects to this Interrogatory as overly broad, unduly burdensome, and/or calling for information that is neither relevant nor reasonably calculated to lead to the discovery of admissible evidence. For example, the "best mode contemplated by the inventor" is not relevant to this litigation because the "the failure to disclose the best mode shall not be a basis on which any claim of a patent may be canceled or held invalid or otherwise unenforceable." 35 U.S.C § 282(b)(3)(A). As another example, this Interrogatory impermissibly seeks validity contentions without any reference or connection to any invalidity contentions.

Sonos further objects to this Interrogatory to the extent it seeks information protected by the attorney-client privilege and/or work product immunity. In addition, Sonos objects to this Interrogatory as premature to the extent it seeks expert discovery in advance of the date set forth in the Federal Rules of Civil Procedure and/or the Court's Scheduling Order. Sonos further objects to this Interrogatory as premature to the extent it seeks information concerning the scope of any asserted claim that will be the subject of claim construction proceedings before the Court. In addition, Sonos objects to this Interrogatory on the ground that it is a premature contention interrogatory that has been filed before a substantial amount of discovery has been conducted in this lawsuit. *See* Fed. R. Civ. P. 33(a)(2) ("[T]he court may order that [a contention] interrogatory need not be answered until after designated discovery has been completed . . . .").

Subject to, and without waiving, the foregoing Specific and General Objections, Sonos states that under 35 U.S.C § 282, all the claims of the Patents-in-Suit are presumed to be valid, including with respect to the requirements of 35 U.S.C § 112. *See* 35 U.S.C § 282(a) and (b)(3)(A). This presumption of validity is also fully supported by the presumption of administrative correctness, as the Patents-in-Suit were all duly issued by the United States Patent & Trademark Office ("USPTO"), and the USPTO would not have issued the Patents-in-Suit if they failed to comply with the requirements of 35 U.S.C § 112. Moreover, under 35 U.S.C § 282, Defendants bear the burden of establishing (by clear and convincing evidence) any invalidity, including invalidity for failure to satisfy the requirements of 35 U.S.C § 112. *See* 35 U.S.C § 282(a) and (b)(3)(A). As the Supreme Court recently noted:

> Under the Patent Act, and the case law before its passage, a patent is presumed valid. That presumption takes away any need for a plaintiff to prove his patent is valid to bring a claim.

Commil USA, LLC v. Cisco Sys., Inc., 135 S. Ct. 1920, 1929 (2015) (internal citations and quotation marks omitted). Thus, Sonos is not required to prove validity, which this Interrogatory appears to seek.

Sonos's position is that all issued claims of the Patents-in-Suit are in full compliance with the requirements of 35 U.S.C § 112. To the extent that Defendants assert a specific invalidity challenge under 35 U.S.C § 112, Sonos will provide a rebuttal to such a challenge during the expert phase of this litigation.

Additionally, pursuant to Fed. R. Civ. P. Rule 33(d) and paragraph 2(b) of the Court's Scheduling Order, Sonos produced copies of the Patents-in-Suit and their file histories from which further information sought in this Interrogatory may be ascertained. These documents are located at SONDM000000001-25; SONDM000000151-164; SONDM000000179-193; SONDM000000194-206; SONDM000108929-55; SONDM000108956-93; SONDM000108994-9026; SONDM000109048-80; SONDM000109081-112; SONDM000109113-44; SONDM000109145-80; SONDM000014671-917; SONDM000000833-1107; SONDM000001921-5188; SONDM000019288-444; SONDM000052046-7731; SONDM000061498-7368; SONDM000067369-75093; SONDM000075094-600; SONDM000075601-82066; SONDM000082067-87675; SONDM000104015-7514; SONDM000135505-38.

Pursuant to Fed. R. Civ. P. Rule 33(d), Sonos may produce additional documents from which further information sought in this Interrogatory may be ascertained.

Sonos reserves the right to revise, correct, add to, supplement, or clarify its response to this Interrogatory as additional information is discovered and/or becomes available.

INTERROGATORY NO. 7:

For each Asserted Claim of the Patents-in-Suit that you contend meets the requirements of patentable subject matter under current law, describe the full factual and legal basis for your contention on a claim-by-claim basis.

AMENDED RESPONSE TO INTERROGATORY NO. 7:

Sonos specifically objects to this Interrogatory as vague and ambiguous, as it is unclear what "requirements of patentable subject matter under current law" are being referred to. Sonos also objects to this Interrogatory as vague and ambiguous to the extent that "patentable subject matter" refers to anything other than the patentable subject matter requirement of 35 U.S.C § 101. Moreover, Sonos objects to this Interrogatory as overly broad, unduly burdensome, and/or calling for information that is neither relevant nor reasonably calculated to lead to the discovery of admissible evidence. For example, this Interrogatory impermissibly seeks validity contentions without any reference or connection to any invalidity contentions. Sonos further objects to this Interrogatory to the extent it seeks information protected by the attorney-client privilege and/or work product immunity. In addition, Sonos objects to this Interrogatory as premature to the extent it seeks expert discovery in advance of the date set forth in the Federal Rules of Civil Procedure and/or the Court's Scheduling Order. Sonos further objects to this Interrogatory as premature to the extent it seeks information concerning the scope of any asserted claim that will be the subject of claim construction proceedings before the Court. In addition, Sonos objects to this Interrogatory on the ground that it is a premature contention interrogatory that has been filed before a substantial amount of discovery has been conducted in this lawsuit. *See* Fed. R. Civ. P. 33(a)(2) ("[T]he court may order that [a contention] interrogatory need not be answered until after designated discovery has been completed . . . .").

Subject to, and without waiving, the foregoing Specific and General Objections, Sonos states that under 35 U.S.C § 282, all the claims of the Patents-in-Suit are presumed to be valid. *See* 35 U.S.C § 282(a) and (b). This presumption of validity is also fully supported by the presumption of administrative correctness, as the Patents-in-Suit were all duly issued by the USPTO, and the USPTO would not have issued the Patents-in-Suit if they failed to comply with the requirements of 35 U.S.C § 101. Moreover, under 35 U.S.C § 282, Defendants bear the burden of establishing (by clear and convincing evidence) any invalidity, including invalidity for failure to satisfy the requirements of 35 U.S.C § 101. *See* 35 U.S.C § 282(a) and (b). As the Supreme Court recently noted:

> Under the Patent Act, and the case law before its passage, a patent is presumed valid. That presumption takes away any need for a plaintiff to prove his patent is valid to bring a claim.

Commil USA, LLC v. Cisco Sys., Inc., 135 S. Ct. 1920, 1929 (2015) (internal citations and quotation marks omitted). Thus, Sonos is not required to prove validity (or patentability), which this Interrogatory appears to seek.

Sonos's position is that all issued claims of the Patents-in-Suit are in full compliance with the requirements of 35 U.S.C § 101. To the extent that Defendants assert a specific invalidity challenge under 35 U.S.C § 101, Sonos will provide a rebuttal to such a challenge during the expert phase of this litigation.

Additionally, pursuant to Fed. R. Civ. P. Rule 33(d) and paragraph 2(b) of the Court's Scheduling Order, Sonos produced copies of the Patents-in-Suit and their file histories from which further information sought in this Interrogatory may be ascertained. These documents are located at SONDM000000001-25; SONDM000000151-164; SONDM000000179-193; SONDM000000194-206; SONDM000108929-55; SONDM000108956-93; SONDM000108994-

9026; SONDM000109048-80; SONDM000109081-112; SONDM000109113-44; SONDM000109145-80; SONDM000014671-917; SONDM000000833-1107; SONDM000001921-5188; SONDM000019288-444; SONDM000052046-7731; SONDM000061498-7368; SONDM000067369-75093; SONDM000075094-600; SONDM000075601-82066; SONDM000082067-87675; SONDM000104015-7514; SONDM000135505-38.

Pursuant to Fed. R. Civ. P. Rule 33(d), Sonos may produce additional documents from which further information sought in this Interrogatory may be ascertained.

Sonos reserves the right to revise, correct, add to, supplement, or clarify its response to this Interrogatory as additional information is discovered and/or becomes available.

INTERROGATORY NO. 8:

Describe in detail each instance in which any rights in the Patents-in-Suit have been licensed including, without limitation, in connection with the settlement of litigation, or in which there has been an offer or request to license. A complete answer will include a description of (a) all Persons involved, (b) the effective date(s) of the license and date(s) of termination, (c) all license agreements, (d) all terms of such license, including licensing fees and/or licensing rate, restrictions on the licensing terms, including field of use restrictions, (e) all monies received under each license, and provide all details concerning specific product sales or uses that were the purported bases for those monies, (f) whether the licensing agreement is currently in effect, and (g) whether the licensing agreement was ever in breach or terminated, and if so, by whom and for what.

AMENDED RESPONSE TO INTERROGATORY NO. 8:

Sonos specifically objects to this Interrogatory as overly broad, unduly burdensome, and/or calling for information that is neither relevant nor reasonably calculated to lead to the discovery of admissible evidence. For example, this Interrogatory seeks information about "an offer or request to license" the Patents-in-Suit without regard to the circumstances of such an offer or request. Sonos further objects to this Interrogatory to the extent it seeks information

protected by the attorney-client privilege and/or work product immunity. In addition, Sonos objects to this Interrogatory as premature to the extent it seeks expert discovery in advance of the date set forth in the Federal Rules of Civil Procedure and/or the Court's Scheduling Order.

Subject to, and without waiving, the foregoing Specific and General Objections, Sonos states that, to date, it has not licensed any of the Patents-in-Suit to anyone.

Sonos reserves the right to revise, correct, add to, supplement, or clarify its response to this Interrogatory as additional information is discovered and/or becomes available.

INTERROGATORY NO. 9:

Identify all facts supporting or negating your contention that Plaintiff has been damaged by Defendants' alleged infringement of the Patents-in-Suit, including, but not limited to a computation of each category of such damages and the basis and methodology therefore.

AMENDED RESPONSE TO INTERROGATORY NO. 9:

Sonos specifically objects to this Interrogatory as vague and ambiguous, as it is unclear what "methodology therefore" means. Sonos also objects to this Interrogatory to the extent it seeks information protected by the attorney-client privilege and/or work product immunity. Sonos also objects to this Interrogatory as premature to the extent it seeks expert discovery in advance of the date set forth in the Federal Rules of Civil Procedure and/or the Court's Scheduling Order. Sonos further objects to this Interrogatory on the ground that it is a premature contention interrogatory that has been filed before a substantial amount of discovery has been conducted in this lawsuit. *See* Fed. R. Civ. P. 33(a)(2) ("[T]he court may order that [a contention] interrogatory need not be answered until after designated discovery has been completed . . . .").

Subject to, and without waiving, the foregoing Specific and General Objections, Sonos states that as a result of Defendants' infringement of the Patents-in-Suit, Sonos has suffered damages including lost profits, reasonable royalties, and/or other business damages, as well as Defendants' total profits from the Accused HEOS Products. Moreover, much of the information necessary to establish Sonos's claims for damages is uniquely within the possession of Defendants, and Sonos will seasonably supplement its response to this Interrogatory upon obtaining such information.

Subject to the foregoing General Objections, General Statements, and specific objections, and pursuant to Fed. R. Civ. P. Rule 33(d), Sonos has produced or will produce documents from which information sought in this Interrogatory may be ascertained. *See, e.g.*, Sonos's document production numbers SONDM000048258; SONDM000048259-60; SONDM000048266-315; SONDM000048316-25; SONDM000048326-34; SONDM000048335; SONDM000051400-506; SONDM000051523-28; SONDM000052041; SONDM000052042; SONDM000052043; SONDM000052044; SONDM000052045; SONDM000048336-37; SONDM000051507-509; SONDM000051510-12; SONDM000051513-15; SONDM000051516-18; SONDM000051519-22; SONDM000051529-34; SONDM000045776-89; SONDM000046108-137; SONDM000046138-206; SONDM000046207-349; SONDM000046350-466; SONDM000046467-95; SONDM000046496-530; SONDM000046531-33; SONDM000046534-605; SONDM000046606-41; SONDM000046642-88; SONDM000046723-818; SONDM000046819-68; SONDM000046869-99; SONDM000046900-30; SONDM000046931-45; SONDM000046946-52; SONDM000046953-87; SONDM000046988-7022; SONDM000047023-55; SONDM000047056-84; SONDM000047085-102; SONDM000047103-23; SONDM000047127-38; SONDM000047486-618; SONDM000047619-77;

SONDM000047996-8007; SONDM000048052-85; SONDM000048086-153; SONDM000048154; SONDM000121339-2985; SONDM000122986-3020; SONDM000123021-830; SONDM000123831-5214; SONDM000125215-232; SONDM000135504; SONDM000135733-36; SONDM000147188; SONDM000147189; SONDM000147190-213; SONDM000147260-64; SONDM000147265; SONDM000151254-56; and SONDM000151260.

Sonos reserves the right to revise, correct, add to, supplement, or clarify its response to this Interrogatory as additional information is discovered and/or becomes available.

INTERROGATORY NO. 10:

Describe in detail every valuation of the Patents-in-Suit or any claims of the Patents-in-Suit, including, without limitation, the Person who made the valuation, the date and amount of the valuation, and all Documents describing or relating to such valuation.

AMENDED RESPONSE TO INTERROGATORY NO. 10:

Sonos specifically objects to this Interrogatory as vague and ambiguous, as it is unclear what "valuation" is being referred to. Sonos also objects to this Interrogatory as overly broad, unduly burdensome, and/or calling for information that is neither relevant nor reasonably calculated to lead to the discovery of admissible evidence. For example, not every "valuation" of the Patents-in-Suit is relevant to this litigation. As another example, this Interrogatory covers time periods that are not relevant to this lawsuit. Sonos further objects to this Interrogatory to the extent it seeks information protected by the attorney-client privilege and/or work product immunity. In addition, Sonos objects to this Interrogatory as premature to the extent it seeks expert discovery in advance of the date set forth in the Federal Rules of Civil Procedure and/or the Court's Scheduling Order. Sonos further objects to this Interrogatory as premature to the

extent it seeks information concerning the scope of any asserted claim that will be the subject of claim construction proceedings before the Court. Sonos also objects to this Interrogatory on the ground that it is a premature contention interrogatory that has been filed before a substantial amount of discovery has been conducted in this lawsuit. *See* Fed. R. Civ. P. 33(a)(2) ("[T]he court may order that [a contention] interrogatory need not be answered until after designated discovery has been completed . . . .").

Subject to, and without waiving, the foregoing Specific and General Objections, Sonos states that it is unaware of any valuation of the Patents-in-Suit that is not protected by the attorney-client privilege and/or work product immunity.

Sonos reserves the right to revise, correct, add to, supplement, or clarify its response to this Interrogatory as additional information is discovered and/or becomes available.

INTERROGATORY NO. 11:

For each of Defendants' products that Plaintiff alleges infringes any of the Patents-in-Suit, describe when and how Plaintiff became aware of the alleged infringement.

AMENDED RESPONSE TO INTERROGATORY NO. 11:

Sonos specifically objects to this Interrogatory to the extent it seeks information protected by the attorney-client privilege and/or work product immunity. Sonos further objects to this Interrogatory as premature to the extent that it requires Sonos to specifically identify the accused products or disclose its infringement contentions in this case prior to the deadlines set forth in the Court's Scheduling Order.

Subject to, and without waiving, the foregoing Specific and General Objections, Sonos states that in July 2014, Defendants' HEOS system first became available in the market, and that in September 2014, Sonos asked its outside counsel to analyze the HEOS system for possible

infringement. Sonos then engaged Delaware counsel on October 1, 2014, and filed the original Complaint for the present lawsuit on October 21, 2014. Between October 21, 2014 and December 17, 2014, Sonos and its outside counsel assessed whether the HEOS system infringed additional Sonos patents, which lead to the filing of the First Amended Complaint for this lawsuit on December 17, 2014. Likewise, between December 17, 2014 and February 27, 2015, Sonos and its outside counsel assessed whether the HEOS system infringed yet additional Sonos patents, which lead to the filing of the Second Amended Complaint for this lawsuit on February 27, 2015. Between February 27, 2015 and January 29, 2016, Sonos and its outside counsel assessed whether the HEOS system infringed additional Sonos patents, which lead to the filing of the Third Amended Complaint for this lawsuit on January 29, 2016.

Sonos reserves the right to revise, correct, add to, supplement, or clarify its response to this Interrogatory as additional information is discovered and/or becomes available.

AS TO OBJECTIONS:

POTTER ANDERSON & CORROON LLP

OF COUNSEL:

George I. Lee
Sean M. Sullivan
Rory P. Shea
J. Dan Smith
Michael P. Boyea
LEE SULLIVAN SHEA & SMITH LLP
224 N. Desplaines St, Suite 250
Chicago, IL 60661
(312) 754-9602

By: */s/ Philip A. Rovner*
Philip A. Rovner (#3215)
Jonathan A. Choa (#5319)
Hercules Plaza
P.O. Box 951
Wilmington, DE 19899
(302) 984-6000
provner@potteranderson.com
jchoa@potteranderson.com

Dated: October 10, 2016
1235545

Attorneys for Plaintiff Sonos, Inc.

CERTIFICATE OF SERVICE

I hereby certify that before 6:00 p.m. on October 10, 2016, I caused the foregoing to be served upon the following counsel for Plaintiffs as indicated below:

BY EMAIL

Jack B. Blumenfeld, Esq.
Michael J. Flynn, Esq.
Morris, Nichols, Arsht & Tunnell LLP
1201 N. Market Street
P.O. Box 1347
Wilmington, DE 19899
jblumenfeld@mnat.com
mflynn@mnat.com

Attorneys for Defendants D&M Holdings Inc. d/b/a The D +M Group, D&M Holdings U.S. Inc. and Denon Electronics (USA), LLC

John M. Jackson, Esq.
Nathaniel (Nate) St. Clair II, Esq.
Matthew C. Acosta, Esq.
Blake Dietrich, Esq.
Kurt A. Schwarz, Esq.
Jackson Walker, LLP
2323 Ross Avenue, Suite 600
Dallas, TX 75201
macosta@jw.com
bdietrich@jw.com
nstclair@jw.com
jjackson@jw.com
kschwarz@jw.com

David Folsom, Esq.
Jackson Walker L.L.P.
6002 Summerfield, Suite B
Texarkana, TX 75503
dfolsom@jw.com

Co-counsel for Defendants D&M Holdings Inc. d/b/a The D+M Group, D&M Holdings U.S. Inc. and Denon Electronics (USA), LLC

/s/ Philip A. Rovner

US009195258B2

(12) **United States Patent**
Millington

(10) **Patent No.: US 9,195,258 B2**
(45) **Date of Patent: Nov. 24, 2015**

(54) **SYSTEM AND METHOD FOR SYNCHRONIZING OPERATIONS AMONG A PLURALITY OF INDEPENDENTLY CLOCKED DIGITAL DATA PROCESSING DEVICES**

(71) Applicant: **Sonos, Inc.**, Santa Barbara, CA (US)

(72) Inventor: **Nicholas A. J. Millington**, Santa Barbara, CA (US)

(73) Assignee: **Sonos, Inc.**, Santa Barbara, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/184,935**

(22) Filed: **Feb. 20, 2014**

(65) **Prior Publication Data**

US 2014/0181173 A1 Jun. 26, 2014

Related U.S. Application Data

(63) Continuation of application No. 13/864,251, filed on Apr. 17, 2013, and a continuation-in-part of

(Continued)

(51) **Int. Cl.**
G06F 15/16 (2006.01)
G06F 1/00 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC ***G06F 1/00*** (2013.01); ***G05B 15/02*** (2013.01); ***G06F 3/048*** (2013.01); ***G06F 3/0482*** (2013.01);

(Continued)

(58) **Field of Classification Search**
CPC G06F 3/167; G06F 17/00; G06F 17/3074; G06F 3/048; G06F 3/0482; G06F 3/0484; G06F 3/126; G06F 3/16; H04L 65/60; H04L 12/2812
USPC 709/219, 231
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,296,278 A 10/1981 Cullison et al.
4,816,989 A 3/1989 Finn et al.

(Continued)

FOREIGN PATENT DOCUMENTS

EP 0251584 A2 1/1988
EP 0672985 A1 9/1995

(Continued)

OTHER PUBLICATIONS

PRISMIQ; Inc., "PRISMIQ Media Player User Guide", 2003, 44 pages.

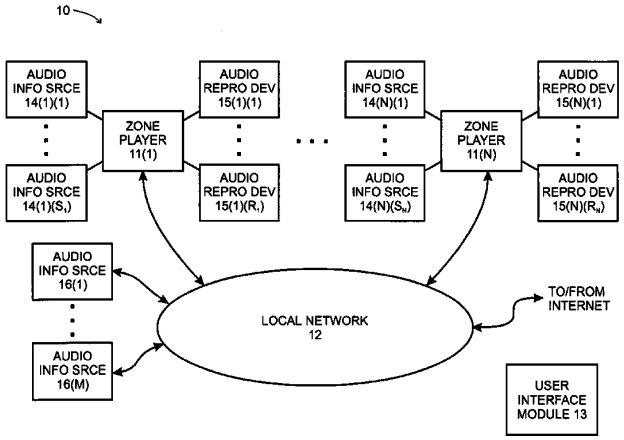
(Continued)

Primary Examiner — Oleg Survillo
(74) *Attorney, Agent, or Firm* — McDonnell Boehnen Hulbert & Berghoff LLP

(57) **ABSTRACT**

A system is described for maintaining synchrony of operations among a plurality of devices that have independent clocking arrangements. The system includes a task distribution device that distributes tasks to a synchrony group comprising a plurality of devices that are to perform the tasks distributed by the task distribution device in synchrony. The task distribution device distributes each task to the members of the synchrony group over a network. Each task is associated with a time stamp that indicates a time, relative to a clock maintained by the task distribution device, at which the members of the synchrony group are to execute the task. Each member of the synchrony group periodically obtains from the task distribution device an indication of the current time indicated by its clock, determines a time differential between the task distribution device's clock and its respective clock and determines therefrom a time at which, according to its respective clock, the time stamp indicates that it is to execute the task.

26 Claims, 5 Drawing Sheets



Related U.S. Application Data

application No. 13/297,000, filed on Nov. 15, 2011, and a continuation-in-part of application No. 10/816,217, filed on Apr. 1, 2004, now Pat. No. 8,234,395.

(60) Provisional application No. 60/490,768, filed on Jul. 28, 2003.

(51) **Int. Cl.**

H04J 3/06	(2006.01)
H04R 27/00	(2006.01)
G06F 17/00	(2006.01)
H03G 3/20	(2006.01)
H04L 29/06	(2006.01)
G06F 3/048	(2013.01)
G06F 3/16	(2006.01)
H04L 29/08	(2006.01)
G06F 3/0484	(2013.01)
H04R 3/12	(2006.01)
G06F 17/30	(2006.01)
G06F 3/0482	(2013.01)
H03G 3/00	(2006.01)
H04H 20/10	(2008.01)
H04H 20/26	(2008.01)
G05B 15/02	(2006.01)
G11B 20/10	(2006.01)
H04N 5/04	(2006.01)
H04N 9/79	(2006.01)
H04N 21/43	(2011.01)
H04N 21/436	(2011.01)

(52) **U.S. Cl.**

CPC ***G06F 3/0484*** (2013.01); ***G06F 3/16*** (2013.01); ***G06F 3/165*** (2013.01); ***G06F 3/167*** (2013.01); ***G06F 17/00*** (2013.01); ***G06F 17/3074*** (2013.01); ***G11B 20/10527*** (2013.01); ***H03G 3/00*** (2013.01); ***H03G 3/20*** (2013.01); ***H04H 20/103*** (2013.01); ***H04H 20/26*** (2013.01); ***H04J 3/0664*** (2013.01); ***H04L 65/60*** (2013.01); ***H04L 65/80*** (2013.01); ***H04L 67/1095*** (2013.01); ***H04L 67/26*** (2013.01); ***H04L 69/28*** (2013.01); ***H04N 5/04*** (2013.01); ***H04N 9/7904*** (2013.01); ***H04N 21/4307*** (2013.01); ***H04N 21/43615*** (2013.01); ***H04R 3/12*** (2013.01); ***H04R 27/00*** (2013.01); *G11B 2020/10592* (2013.01); *H04H 2201/20* (2013.01); *H04L 65/4076* (2013.01); *H04R 2227/003* (2013.01); *H04R 2227/005* (2013.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,153,579	A		10/1992	Fisch et al.
5,182,552	A		1/1993	Paynting
5,239,458	A		8/1993	Suzuki
5,299,266	A		3/1994	Lumsden
5,406,634	A		4/1995	Anderson et al.
5,440,644	A		8/1995	Farinelli et al.
5,467,342	A		11/1995	Logston et al.
5,491,839	A		2/1996	Schotz
5,553,222	A		9/1996	Milne et al.
5,602,992	A		2/1997	Danneels
5,668,884	A		9/1997	Clair, Jr. et al.
5,673,323	A		9/1997	Schotz et al.
5,696,896	A		12/1997	Badovinatz et al.
5,726,989	A	*	3/1998	Dokic 370/509
5,751,819	A		5/1998	Dorrough
5,761,320	A		6/1998	Farinelli et al.
5,787,249	A		7/1998	Badovinatz et al.
5,808,662	A		9/1998	Kinney et al.
5,815,689	A		9/1998	Shaw et al.
5,867,691	A		2/1999	Shiraishi
5,875,354	A		2/1999	Charlton et al.
5,887,143	A		3/1999	Saito et al.
5,923,869	A	*	7/1999	Kashiwagi et al. 713/501
5,923,902	A		7/1999	Inagaki
5,946,343	A		8/1999	Schotz et al.
5,956,088	A		9/1999	Shen et al.
6,009,457	A		12/1999	Moller
6,026,150	A		2/2000	Frank et al.
6,031,818	A		2/2000	Lo et al.
6,108,485	A	*	8/2000	Kim 386/201
6,108,686	A		8/2000	Williams, Jr.
6,122,668	A		9/2000	Teng et al.
6,128,318	A		10/2000	Sato
6,157,957	A		12/2000	Berthaud
6,175,872	B1		1/2001	Neumann et al.
6,185,737	B1		2/2001	Northcutt et al.
6,195,436	B1		2/2001	Scibora et al.
6,199,169	B1		3/2001	Voth
6,255,961	B1		7/2001	Van et al.
6,256,554	B1		7/2001	DiLorenzo
6,308,207	B1		10/2001	Tseng et al.
6,324,586	B1		11/2001	Johnson
6,332,147	B1		12/2001	Moran et al.
6,343,028	B1	*	1/2002	Kuwaoka 369/47.26
6,349,339	B1		2/2002	Williams
6,351,821	B1		2/2002	Voth
6,404,811	B1		6/2002	Cvetko et al.
6,430,353	B1		8/2002	Honda et al.
6,449,653	B2		9/2002	Klemets et al.
6,487,296	B1		11/2002	Allen et al.
6,522,886	B1		2/2003	Youngs et al.
6,526,325	B1	*	2/2003	Sussman et al. 700/94
6,535,121	B2		3/2003	Matheny et al.
6,587,127	B1		7/2003	Leeke et al.
6,598,172	B1		7/2003	VanDeusen et al.
6,611,537	B1		8/2003	Edens et al.
6,631,410	B1		10/2003	Kowalski et al.
6,674,803	B1		1/2004	Kesselring
6,687,664	B1	*	2/2004	Sussman et al. 704/201
6,757,517	B2		6/2004	Chang
6,778,493	B1		8/2004	Ishii
6,778,869	B2		8/2004	Champion
6,816,818	B2	*	11/2004	Wolf et al. 702/188
6,823,225	B1		11/2004	Sass
6,826,283	B1		11/2004	Wheeler et al.
6,836,788	B2		12/2004	Kim et al.
6,839,752	B1		1/2005	Miller et al.
6,898,642	B2		5/2005	Chafle et al.
6,907,458	B2		6/2005	Tomassetti et al.
6,912,610	B2		6/2005	Spencer
6,920,373	B2		7/2005	Xi et al.
6,934,766	B1		8/2005	Russell
6,970,482	B2		11/2005	Kim
6,985,694	B1		1/2006	De et al.
7,007,106	B1		2/2006	Flood et al.
7,020,791	B1		3/2006	Aweya et al.
7,043,651	B2		5/2006	Aweya et al.
7,047,308	B2		5/2006	Deshpande
7,068,596	B1		6/2006	Mou
7,113,999	B2		9/2006	Pestoni et al.
7,115,017	B1		10/2006	Laursen et al.
7,130,368	B1	*	10/2006	Aweya et al. 375/376
7,130,608	B2		10/2006	Hollstrom et al.
7,130,616	B2		10/2006	Janik
7,136,934	B2		11/2006	Carter et al.
7,143,141	B1		11/2006	Morgan et al.
7,143,939	B2		12/2006	Henzerling
7,162,315	B2		1/2007	Gilbert
7,185,090	B2		2/2007	Kowalski et al.
7,187,947	B1		3/2007	White et al.
7,206,367	B1		4/2007	Moore
7,206,967	B1		4/2007	Marti et al.
7,209,795	B2		4/2007	Sullivan et al.
7,218,708	B2		5/2007	Berezowski et al.
7,236,739	B2		6/2007	Chang

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,236,773	B2	6/2007	Thomas
7,293,060	B2	11/2007	Komsi
7,312,785	B2	12/2007	Tsuk et al.
7,313,593	B1	12/2007	Pulito et al.
7,324,857	B2	1/2008	Goddard
7,333,519	B2	2/2008	Sullivan et al.
7,372,846	B2	5/2008	Zwack
7,392,102	B2	6/2008	Sullivan et al.
7,412,499	B2	8/2008	Chang et al.
7,483,538	B2	1/2009	McCarty et al.
7,483,958	B1	1/2009	Elabbady et al.
7,519,667	B1	4/2009	Capps
7,571,014	B1	8/2009	Lambourne et al.
7,574,274	B2	8/2009	Holmes
7,599,685	B2	10/2009	Goldberg et al.
7,606,174	B2	10/2009	Ochi et al.
7,643,894	B2	1/2010	Braithwaite et al.
7,657,224	B2	2/2010	Goldberg et al.
7,657,644	B1	2/2010	Zheng
7,657,910	B1	2/2010	McAulay et al.
7,668,990	B2	2/2010	Krzyzanowski et al.
7,669,219	B2	2/2010	Scott, III
7,675,943	B2	3/2010	Mosig
7,676,142	B1	3/2010	Hung
7,702,279	B2	4/2010	Ko et al.
7,702,403	B1	4/2010	Gladwin et al.
7,711,774	B1	5/2010	Rothschild
7,720,096	B2	5/2010	Klemets
7,742,740	B2	6/2010	Goldberg et al.
7,743,009	B2	6/2010	Hangartner et al.
RE41,608	E	8/2010	Blair et al.
7,835,689	B2	11/2010	Goldberg et al.
7,853,341	B2	12/2010	McCarty et al.
7,865,137	B2	1/2011	Goldberg et al.
7,885,622	B2	2/2011	Krampf et al.
7,916,877	B2	3/2011	Goldberg et al.
7,917,082	B2	3/2011	Goldberg et al.
7,934,239	B1	4/2011	Dagman
7,996,588	B2	8/2011	Subbiah et al.
8,014,423	B2	9/2011	Thaler et al.
8,020,023	B2	9/2011	Millington et al.
8,023,663	B2	9/2011	Goldberg
8,028,038	B2	9/2011	Weel
8,028,323	B2	9/2011	Weel
8,045,952	B2	10/2011	Qureshey et al.
8,050,652	B2	11/2011	Qureshey et al.
8,074,253	B1	12/2011	Nathan
8,086,752	B2	12/2011	Millington et al.
8,103,009	B2	1/2012	McCarty et al.
8,112,032	B2	2/2012	Ko et al.
8,131,390	B2	3/2012	Braithwaite et al.
8,169,938	B2	5/2012	Duchscher et al.
8,214,873	B2	7/2012	Weel
8,230,099	B2	7/2012	Weel
8,234,395	B2	7/2012	Millington
8,290,603	B1	10/2012	Lambourne
8,315,555	B2	11/2012	Ko et al.
8,370,678	B2	2/2013	Millington et al.
8,423,659	B2	4/2013	Millington
8,473,844	B2	6/2013	Kreifeldt et al.
8,588,949	B2	11/2013	Lambourne et al.
9,042,556	B2	5/2015	Kallai et al.
2001/0009604	A1	7/2001	Ando et al.
2001/0022823	A1	9/2001	Renaud
2001/0027498	A1	10/2001	Van et al.
2001/0032188	A1	10/2001	Miyabe et al.
2001/0042107	A1	11/2001	Palm
2001/0046235	A1	11/2001	Trevitt et al.
2001/0047377	A1	11/2001	Sincaglia
2002/0002039	A1	1/2002	Qureshey et al.
2002/0002562	A1	1/2002	Moran et al.
2002/0002565	A1	1/2002	Ohyama
2002/0003548	A1	1/2002	Krusche et al.
2002/0022453	A1	2/2002	Balog et al.
2002/0026442	A1	2/2002	Lipscomb et al.
2002/0034374	A1	3/2002	Barton
2002/0042844	A1	4/2002	Chiazzese
2002/0049843	A1	4/2002	Barone et al.
2002/0062406	A1*	5/2002	Chang et al. 710/1
2002/0065926	A1	5/2002	Hackney et al.
2002/0072816	A1	6/2002	Shdema et al.
2002/0073228	A1	6/2002	Cognet et al.
2002/0080783	A1*	6/2002	Fujimori 370/384
2002/0090914	A1	7/2002	Kang et al.
2002/0093478	A1	7/2002	Yeh
2002/0095460	A1	7/2002	Benson
2002/0109710	A1	8/2002	Holtz et al.
2002/0112244	A1	8/2002	Liou et al.
2002/0114354	A1*	8/2002	Sinha et al. 370/503
2002/0114359	A1*	8/2002	Ibaraki et al. 370/535
2002/0124097	A1	9/2002	Isely et al.
2002/0129156	A1	9/2002	Yoshikawa
2002/0143998	A1	10/2002	Rajagopal et al.
2002/0159596	A1	10/2002	Durand
2002/0163361	A1	11/2002	Parkin
2002/0165721	A1	11/2002	Chang
2002/0165921	A1	11/2002	Sapieyevski
2002/0168938	A1	11/2002	Chang
2002/0173273	A1*	11/2002	Spurgat et al. 455/66
2002/0177411	A1	11/2002	Yajima et al.
2002/0184310	A1	12/2002	Traversat et al.
2002/0188762	A1	12/2002	Tomassetti et al.
2002/0194309	A1	12/2002	Carter et al.
2003/0002609	A1	1/2003	Faller et al.
2003/0018797	A1	1/2003	Dunning et al.
2003/0020763	A1	1/2003	Mayer et al.
2003/0023741	A1	1/2003	Tomassetti et al.
2003/0035072	A1	2/2003	Hagg
2003/0035444	A1	2/2003	Zwack
2003/0041173	A1	2/2003	Hoyle
2003/0041174	A1	2/2003	Wen et al.
2003/0043924	A1	3/2003	Haddad et al.
2003/0055892	A1	3/2003	Huitema et al.
2003/0061428	A1	3/2003	Garney et al.
2003/0066094	A1	4/2003	Van et al.
2003/0067437	A1	4/2003	McClintock et al.
2003/0073432	A1	4/2003	Meade
2003/0099212	A1	5/2003	Anjum et al.
2003/0099221	A1	5/2003	Rhee
2003/0110329	A1	6/2003	Higaki et al.
2003/0126211	A1	7/2003	Anttila et al.
2003/0157951	A1	8/2003	Hasty
2003/0195964	A1	10/2003	Mane
2003/0198254	A1*	10/2003	Sullivan et al. 370/503
2003/0198255	A1*	10/2003	Sullivan et al. 370/503
2003/0198257	A1*	10/2003	Sullivan et al. 370/516
2003/0200001	A1*	10/2003	Goddard 700/94
2003/0204273	A1	10/2003	Dinker et al.
2003/0204509	A1	10/2003	Dinker et al.
2003/0210796	A1	11/2003	McCarty et al.
2003/0219007	A1	11/2003	Barrack et al.
2003/0227478	A1	12/2003	Chatfield
2003/0231871	A1	12/2003	Ushimaru
2003/0235304	A1	12/2003	Evans et al.
2004/0001484	A1	1/2004	Ozguner
2004/0001591	A1	1/2004	Mani et al.
2004/0008852	A1	1/2004	Also et al.
2004/0010727	A1	1/2004	Fujinami
2004/0012620	A1	1/2004	Buhler
2004/0015252	A1	1/2004	Aiso et al.
2004/0019497	A1	1/2004	Volk et al.
2004/0024478	A1	2/2004	Hans et al.
2004/0024925	A1	2/2004	Cypher et al.
2004/0027166	A1	2/2004	Mangum et al.
2004/0032348	A1	2/2004	Lai et al.
2004/0041836	A1	3/2004	Zaner et al.
2004/0048569	A1	3/2004	Kawamura
2004/0066736	A1	4/2004	Kroeger
2004/0075767	A1	4/2004	Neuman et al.
2004/0078383	A1	4/2004	Mercer et al.
2004/0080671	A1	4/2004	Siemens et al.
2004/0093096	A1	5/2004	Huang et al.
2004/0098754	A1	5/2004	Vella et al.
2004/0131192	A1	7/2004	Metcalf

(56) **References Cited**

U.S. PATENT DOCUMENTS

2004/0133689	A1	7/2004	Vasisht	
2004/0143368	A1	7/2004	May et al.	
2004/0143852	A1	7/2004	Meyers	
2004/0148237	A1	7/2004	Bittmann et al.	
2004/0170383	A1	9/2004	Mazur	
2004/0203378	A1	10/2004	Powers	
2004/0208158	A1*	10/2004	Fellman et al.	370/345
2004/0213230	A1	10/2004	Douskalis et al.	
2004/0224638	A1	11/2004	Fadell	
2004/0228367	A1	11/2004	Mosig et al.	
2004/0248601	A1	12/2004	Chang	
2004/0249965	A1	12/2004	Huggins et al.	
2004/0249982	A1	12/2004	Arnold et al.	
2004/0252400	A1	12/2004	Blank et al.	
2005/0010691	A1	1/2005	Oyadomari et al.	
2005/0011388	A1	1/2005	Kouznetsov	
2005/0013394	A1	1/2005	Rausch et al.	
2005/0015551	A1	1/2005	Eames	
2005/0021590	A1	1/2005	Debique et al.	
2005/0027821	A1	2/2005	Alexander et al.	
2005/0047605	A1	3/2005	Lee et al.	
2005/0058149	A1	3/2005	Howe	
2005/0062637	A1*	3/2005	El Zabadani et al.	341/176
2005/0081213	A1	4/2005	Suzuoki et al.	
2005/0114538	A1	5/2005	Rose	
2005/0120128	A1	6/2005	Willes et al.	
2005/0125357	A1	6/2005	Saadat et al.	
2005/0131558	A1	6/2005	Braithwaite	
2005/0166135	A1	7/2005	Burke	
2005/0168630	A1	8/2005	Yamada et al.	
2005/0177643	A1	8/2005	Xu	
2005/0181348	A1	8/2005	Carey et al.	
2005/0195205	A1	9/2005	Abrams, Jr.	
2005/0195823	A1	9/2005	Chen et al.	
2005/0216556	A1	9/2005	Manion et al.	
2005/0281255	A1	12/2005	Davies et al.	
2005/0283820	A1	12/2005	Richards et al.	
2005/0288805	A1	12/2005	Moore et al.	
2005/0289224	A1	12/2005	Deslippe et al.	
2006/0095516	A1	5/2006	Wijeratne	
2006/0098936	A1*	5/2006	Ikeda et al.	386/46
2006/0119497	A1	6/2006	Miller et al.	
2006/0143236	A1	6/2006	Wu	
2006/0193454	A1	8/2006	Abou-chakra et al.	
2007/0038999	A1	2/2007	Millington et al.	
2007/0043847	A1	2/2007	Carter et al.	
2007/0047712	A1	3/2007	Gross et al.	
2007/0048713	A1	3/2007	Plastina et al.	
2007/0054680	A1	3/2007	Mo et al.	
2007/0142022	A1	6/2007	Madonna et al.	
2007/0142944	A1	6/2007	Goldberg et al.	
2007/0143493	A1	6/2007	Mullig et al.	
2007/0169115	A1	7/2007	Ko et al.	
2007/0180137	A1	8/2007	Rajapakse	
2007/0192156	A1	8/2007	Gauger	
2007/0249295	A1	10/2007	Ukita et al.	
2007/0271388	A1	11/2007	Bowra et al.	
2007/0299778	A1	12/2007	Haveson et al.	
2008/0022320	A1	1/2008	Ver	
2008/0091771	A1	4/2008	Allen et al.	
2008/0120429	A1	5/2008	Millington et al.	
2008/0126943	A1	5/2008	Parasnis et al.	
2008/0144861	A1	6/2008	Melanson et al.	
2009/0031336	A1	1/2009	Chavez et al.	
2009/0157905	A1	6/2009	Davis	
2009/0193345	A1	7/2009	Wensley et al.	
2009/0222115	A1	9/2009	Malcolm et al.	
2009/0228919	A1	9/2009	Zott et al.	
2010/0004983	A1	1/2010	Dickerson et al.	
2010/0049835	A1	2/2010	Ko et al.	
2010/0228740	A1	9/2010	Cannistraro et al.	
2010/0284389	A1	11/2010	Ramsay et al.	
2010/0299639	A1	11/2010	Ramsay et al.	
2011/0066943	A1	3/2011	Brillon et al.	
2012/0029671	A1	2/2012	Millington et al.	
2012/0030366	A1	2/2012	Collart et al.	
2012/0060046	A1	3/2012	Millington	
2012/0129446	A1	5/2012	Ko et al.	
2012/0290621	A1	11/2012	Heitz, III et al.	
2013/0018960	A1	1/2013	Knysz et al.	
2013/0080599	A1	3/2013	Ko et al.	
2013/0174100	A1	7/2013	Seymour et al.	
2013/0191454	A1	7/2013	Oliver et al.	
2013/0197682	A1	8/2013	Millington	
2014/0181569	A1	6/2014	Millington et al.	

FOREIGN PATENT DOCUMENTS

EP	1111527	A2	6/2001
EP	1122931	A2	8/2001
EP	2713281		4/2004
GB	2284327	A	5/1995
GB	2338374		12/1999
JP	07-210129		8/1995
JP	2003037585		2/2003
JP	2003101958		4/2003
JP	2005108427		4/2005
WO	9525313	A1	9/1995
WO	9961985	A1	12/1999
WO	0153994		7/2001
WO	02073851		9/2002
WO	03093950	A2	11/2003
WO	2005013047	A2	2/2005

OTHER PUBLICATIONS

Rothermel K., et al., "An Adaptive Stream Synchronization Protocol," 5th International Workshop on Network and Operating System Support for Digital Audio and Video, 1995.

Schulzrinne H., et al., "RTP: A Transport Protocol for Real-Time Applications, RFC 3550," Network Working Group, 2003, pp. 1-89.

The MPEG-2 Transport Stream. Retrieved from the Internet< URL: http://www.coolstf.com/mpeg/#ts>.

"UPnP; "Universal Plug and Play Device Architecture"; Jun. 8, 2000; version 1.0; Microsoft Corporation; pp. 1-54".

"Written Opinion of the International Searching Authority. issued by the International Searching Authority in connection with PCT Application No. PCT/US2013/046386, on Sep. 30, 2013, 6 pages.".

"Yamaha DME 32 manual: copyright 2001".

Akyildiz I.F., et al., "Multimedia Group Synchronization Protocols for Integrated Services Networks," IEEE Journal on Selected Areas in Communications, 1996, vol. 14 (1), pp. 162-173.

"AudioTron Quick Start Guide, Version 1.0", Voyetra Turtle Beach, Inc., Mar. 2001, 24 pages.

"AudioTron Reference Manual, Version 3.0", Voyetra Turtle Beach, Inc., May 2002, 70 pages.

"AudioTron Setup Guide, Version 3.0", Voyetra Turtle Beach, Inc., May 2002, 38 pages.

Benslimane A., "A Multimedia Synchronization Protocol for Multicast Groups," Proceedings of the 26th Euromicro Conference, 2000, vol. 1, pp. 456-463.

Biersack E., et al., "Intra- and Inter-Stream Synchronisation for Stored Multimedia Streams," IEEE International Conference on Multimedia Computing and Systems, 1996, pp. 372-381.

Blakowski G. et al., "A Media Synchronization Survey: Reference Model, Specification, and Case Studies", Jan. 1996, vol. 14, No. 1, 5-35.

Bretl W.E., et al., MPEG2 Tutorial [online], 2000 [retrieved on Jan. 13, 2009] Retrieved from the Internet:< http://www.bretl.com/mpeghtml/MPEGindex.htm>, pp. 1-23.

"European Extended Search Report for Application No. 13184747.7 mailed on Feb. 28, 2014, 8 pages".

Final Office Action mailed Jul. 13, 2009 for U.S. Appl. No. 10/816,217, filed Apr. 1, 2004.

"Final Office Action mailed Sep. 13, 2012 for U.S. Appl. No. 13/297,000", United States Patent and Trademark Office, Sep. 13, 2012, 17 pages.

Final Office Action mailed Oct. 21, 2011 for U.S. Appl. No. 10/816,217, filed Apr. 1, 2004.

(56) **References Cited**

OTHER PUBLICATIONS

Final Office Action mailed Jan. 28, 2011 for U.S. Appl. No. 10/816,217, filed Apr. 1, 2004.
"Final Office Action mailed Jul. 3, 2012 for U.S. Appl. No. 13/298,090, filed Nov. 16, 2011".
Final Office Action mailed Jun. 30, 2008 for U.S. Appl. No. 10/816,217, filed Apr. 1, 2004.
"Final Rejection mailed on Jan. 21, 2010 for U.S. Appl. No. 11/906,702, filed Oct. 2, 2007".
Huang C.M., et al., "A Synchronization Infrastructure for Multicast Multimedia at the Presentation Layer," IEEE Transactions on Consumer Electronics, 1997, vol. 43 (3), pp. 370-380.
"International Bureau,"Search Report" issued in connection with International Patent application No. PCT/US2013/046372, mailed Aug. 26, 2013, 3 pages.".
"International Bureau,"Written opinion" issued in connection with International Patent application No. PCT/US2013/046372, mailed Aug. 26, 2013, 4 pages.".
International Search Report for Application No. PCT/US04/23102, mailed on Aug. 1, 2008, 5 pages.
"International Search Report, issued by the International Searching Authority in connection with PCT Application No. PCT/US2013/046386, on Sep. 30, 2013, 3 pages.".
Ishibashi Y., "A Group Synchronization Mechanism for Live Media in Multicast Communications," IEEE Global Telecommunications Conference, 1997, vol. 2, pp. 746-752.
Ishibashi Y., "A Group Synchronization Mechanism for Stored Media in Multicast Communications," IEEE Information Revolution and Communications, 1997, vol. 2, pp. 692-700.
Jo J., et al., "Synchronized One-to-many Media Streaming with Adaptive Playout Control," Proceedings of SPIE, 2002, vol. 4861, pp. 71-82.
M. Nilsson., "ID3 Tag Version 2", Mar. 26, 1998, 28 Pages.
"Maniactools, "Identify Duplicate Files by Sound," Sep. 28, 2010, http://www.maniactools.com/soft/music-duplicate-remover/identify-duplicate-files-by-sound.shtml".
Mills D.L., "Network Time Protocol (Version 3) Specification, Implementation and Analysis," Network Working Group, Mar. 1992, <http://www.ietf.org/rfc/rfc1305.txt>.
Mills D.L., "Precision Synchronization of Computer Network Clocks," ACM SIGCOMM Computer Communication Review, 1994, vol. 24 (2), pp. 28-43.
Motorola., "Simplefi, Wireless Digital Audio Receiver, Installation and User Guide", Dec. 31, 2001.
"Non-final Office Action in connection with U.S. Appl. No. 13/619,237, mailed Apr. 10, 2013", United States Patent and Trademark Office, 10 pages.
"Non-Final Office Action mailed Dec. 5, 2013 for U.S. Appl. No. 13/827,653, filed Mar. 14, 2013".
Non-Final Office Action mailed Jan. 18, 2008 for U.S. Appl. No. 10/816,217, filed Apr. 1, 2004.
"Non-Final Office Action mailed Mar. 19, 2013 for U.S. Appl. No. 13/724,048, filed Dec. 21, 2012".
Non-Final Office Action mailed Jun. 21, 2011 for U.S. Appl. No. 10/816,217, filed Apr. 1, 2004.
Non-Final Office Action mailed Jan. 22, 2009 for U.S. Appl. No. 10/816,217, filed Apr. 1, 2004.
Non-Final Office Action mailed Jun. 25, 2010 for U.S. Appl. No. 10/816,217, filed Apr. 1, 2004.
"Non-Final Office Action mailed Nov. 25, 2013 for U.S. Appl. No. 13/533,105, filed Jun. 26, 2012.".
Non-Final Office Action mailed Feb. 29, 2012 for U.S. Appl. No. 13/297,000, filed Nov. 15, 2011.
"Non-Final Office Action mailed Apr. 30, 2012 for U.S. Appl. No. 13/204,511, filed Aug. 5, 2011".
"Non-Final Office Action mailed Jul. 30, 2013 for U.S. Appl. No. 13/724,048, filed Dec. 21, 2012".
"Non-Final Rejection mailed on Aug. 20, 2009 for U.S. Appl. No. 11/906,702, filed Oct. 2, 2007".
"Notice of Allowability in U.S. Appl. No. 13/619,237", Sep. 6, 2013, 4 pages.
Notice of Allowance Dec. 27, 2011 for U.S. Appl. No. 10/816,217, filed Apr. 1, 2004.
"Notice of Allowance mailed Mar. 6, 2014 for U.S. Appl. No. 13/827,653, filed Mar. 14, 2013".
"Notice of Allowance mailed Nov. 10, 2011 for U.S. Appl. No. 11/906,702, filed Oct. 2, 2007".
"Notice of Allowance mailed Nov. 13, 2013 for U.S. Appl. No. 13/724,048, filed Dec. 21, 2012".
"Notice of Allowance mailed Jan. 21, 2013 for U.S. Appl. No. 13/298,090, filed Nov. 16, 2011".
"Notice of Allowance mailed Oct. 5, 2012 for U.S. Appl. No. 13/204,511, filed Aug. 5, 2011".
Park S., et al., "Group Synchronization in MultiCast Media Communications," Proceedings of the 5th Research on Multicast Technology Workshop, 2003.
"Polycom Conference Composer manual: copyright 2001".
"Final Office Action mailed Mar. 27, 2014 for U.S. Appl. No. 13/533,105, filed Jun. 26, 2012.".
"Non-Final Office Action mailed May 1, 2014 for U.S. Appl. No. 14/184,522, filed Feb. 19, 2014".
"Non-Final Office Action mailed May 6, 2014 for U.S. Appl. No. 13/705,176, filed Dec. 5, 2012".
"Non-Final Office Action mailed May 12, 2014 for U.S. Appl. No. 14/184,528, filed Feb. 19, 2014".
"Non-Final Office Action mailed May 14, 2014 for U.S. Appl. No. 13/848,932, filed Mar. 22, 2013".
"Advisory Action mailed on Nov. 12, 2014, issued in connection with U.S. Appl. No. 13/907,666, filed May 31, 2013, 6 pages".
"Advisory Action mailed on Nov. 26, 2014, issued in connection with U.S. Appl. No. 14/186,850, filed Feb. 21, 2014, 9 pages".
"Advisory Action mailed on Jan. 8, 2015, issued in connection with U.S. Appl. No. 13/705,176, filed Dec. 5, 2012, 4 pages".
"Crown PIP Manual available for sale at least 2004, 68 pages".
"Final Office Action mailed on Dec. 17, 2014, issued in connection with U.S. Appl. No. 13/533,105, filed Jun. 26, 2012, 36 pages".
"Final Office Action mailed on Dec. 3, 2014, issued in connection with U.S. Appl. No. 14/184,528, filed Feb. 19, 2014, 12 pages".
"Final Office Action mailed on Jan. 7, 2015, issued in connection with U.S. Appl. No. 13/848,932, filed Mar. 22, 2013, 14 pages".
"Non-Final Office Action mailed on Dec. 1, 2014, issued in connection with U.S. Appl. No. 14/516,867, filed Oct. 17, 2014, 11 pages".
"Non-Final Office Action mailed on Nov. 17, 2014, issued in connection with U.S. Appl. No. 13/864,247, filed Apr. 17, 2013, 11 pages".
"Non-Final Office Action mailed on Nov. 18, 2014, issued in connection with U.S. Appl. No. 13/435,739, filed Mar. 30, 2012, 10 pages".
"Non-Final Office Action mailed on Nov. 19, 2014, issued in connection with U.S. Appl. No. 13/848,921, filed Mar. 22, 2013, 9 pages".
"Renkus Heinz Manual; available for sale at least 2004, 6 pages".
"Advisory Action mailed Sep. 18, 2008 for U.S. Appl. No. 10/816,217, filed Apr. 1, 2004, 8 pages".
"Advisory Action mailed Sep. 5, 2014 for U.S. Appl. No. 13/907,666, filed May 31, 2013, 3 pages".
"Bluetooth. "Specification of the Bluetooth System: The ad hoc SCATTERNET for affordable and highly functional wireless connectivity" Core, Version 1.0 A, Jul. 26, 1999, 1068 pages".
"Bluetooth. "Specification of the Bluetooth System: Wireless connections made easy" Core, Version 1.0 B, Dec. 1, 1999, 1076 pages".
"Dell, Inc. "Dell Digital Audio Receiver: Reference Guide" Jun. 2000, 70 pages".
"Dell, Inc. "Start Here" Jun. 2000, 2 pages".
"Final Office Action mailed Jun. 5, 2014 for U.S. Appl. No. 13/907,666, filed May 31, 2013".
"Final Office Action mailed on Oct. 22, 2014, issued in connection with U.S. Appl. No. 14/186,850, filed Feb. 21, 2014, 12 pages".
"Final Office Action mailed on Oct. 23, 2014, issued in conection with U.S. Appl. No. 13/705,176, filed Dec. 5, 2012, 23 pages".

(56) **References Cited**

OTHER PUBLICATIONS

"Japanese Intellectual Property Office, "Decision of Rejection," issued in connection with Japanese patent application No. 2012-178711, mailed on Jul. 4, 2014, 3 pages".
"Japanese Intellectual Property Office, "Office Action Summary," issued in connection with Japanese patent application No. 2012-178711, mailed on Nov. 19, 2013, 5 pages".
"Jones, Stephen. "Dell Digital Audio Receiver: Digital upgrade for your analog stereo" Analog Stereo. Jun. 24, 2000 <http://www.reviewsonline.com/articles/961906864.htm> retrieved Jun. 18, 2014, 2 pages".
"Louderback, Jim. "Affordable Audio Receiver Furnishes Homes With MP3" TechTV Vault. Jun. 28, 2000 <http://www.g4tv.com/articles/17923/affordable-audio-receiver-furnishes-homes-with-mp3/> retrieved Jul. 10, 2014, 2 pages".
"Non-Final Office Action mailed Jan. 5, 2012 for U.S. Appl. No. 13/298,090, filed Nov. 16, 2011, 40 pages".
"Non-Final Office Action mailed Jun. 17, 2014 for U.S. Appl. No. 14/176,808, filed Feb. 10, 2014".
"Non-Final Office Action mailed Dec. 18, 2013 for U.S. Appl. No. 13/907,666, filed May 31, 2013".
"Non-Final Office Action mailed Apr. 19, 2010 for U.S. Appl. No. 11/801,468, filed May 9, 2007, 16 pages".
"Non-Final Office Action mailed Jul. 25, 2014 for U.S. Appl. No. 14/184,526, filed Feb. 19, 2014".
"Non-Final Office Action mailed May 27, 2014 for U.S. Appl. No. 14/186,850, filed Feb. 21, 2014".
"Non-Final Office Action mailed Nov. 29, 2010 for U.S. Appl. No. 11/801,468, filed May 9, 2007, 17 pages".
"Non-Final Office Action mailed Jul. 31, 2014 for U.S. Appl. No. 13/533,105, filed Jun. 26, 2012".
"Non-Final Office Action mailed on Oct. 23, 2014, issued in connection with U.S. Appl. No. 13/848,904, filed Mar. 22, 2013, 11 pages".
"Non-Final Office Action mailed on Oct. 23, 2014, issued in connection with U.S. Appl. No. 13/864,251, filed Apr. 17, 2013, 11 pages".
"Non-Final Office Action mailed on Oct. 23, 2014, issued in connection with U.S. Appl. No. 13/888,203, filed May 6, 2013, 9 pages".
"Non-final Office Action mailed on Oct. 24, 2014, issued in connection with U.S. Appl. No. 13/435,776, filed Mar. 30, 2012, 14 pages".
"Notice of Allowance mailed May 6, 2011 for U.S. Appl. No. 11/801,468, filed May 9, 2007, 10 pages".
"Notice of Allowance mailed on Sep. 25, 2014, issued in connection with U.S. Appl. No. 14/176,808, filed Feb. 10, 2014, 5 pages".
"Palm, Inc. "Handbook for the Palm VII Handheld" May 2000, 311 pages".
""Welcome. You're watching Apple TV." Apple TV 1st Generation Setup Guide, Apr. 8, 2008 <http://manuals.info.apple.com/MANUALS/0/MA403/en_US/AppleTV_SetupGuide.pdf> Retrieved Oct. 14, 2014, 40 pages".
""Welcome. You're watching Apple TV." Apple TV 2nd Generation Setup Guide, Mar. 10, 2011 <http://manuals.info.apple.com/MANUALS/1000/MA1555/en_US/Apple_TV_2nd_gen_Setup_Guide.pdf> Retrieved Oct. 16, 2014, 35 pages".
""Welcome. You're watching Apple TV." Apple TV 3rd Generation Setup Guide, Mar. 16, 2012 <http://http://manuals.info.apple.com/MANUALS/1000/MA1607/en_US/apple_tv_3rd_gen_setup.pdf> Retrieved Oct. 16, 2014, 35 pages".
"Presentations at WinHEC 2000" May 2000, 138 pages.
"Yamaha DME Designer software manual: Copyright 2004, 482 pages".
"Advisory Action mailed on Apr. 15, 2015, issued in connection with U.S. Appl. No. 14/184,526, filed Feb. 19, 2014, 9 pages".
"Advisory Action mailed on Mar. 2, 2015, issued in connection with U.S. Appl. No. 13/848,932, filed Mar. 22, 2013, 3 pages.".
"Advisory Action mailed on Mar. 25, 2015, issued in connection with U.S. Appl. No. 13/533,105, filed Jun. 26, 2012, 5 pages.".
"Advisory Action mailed on Feb. 26, 2015, issued in connection with U.S. Appl. No. 14/184,528, filed Feb. 19, 2014, 3 pages.".
"European Extended Search Report for Application No. 14181454.1 mailed on Mar. 31, 2015, 9 pages.".
"Final Office Action mailed on Feb. 11, 2015, issued in connection with U.S. Appl. No. 14/184,526, filed Feb. 19, 2014, 13 pages".
"Final Office Action mailed on Feb. 12, 2015, issued in connection with U.S. Appl. No. 14/184,522, filed Feb. 19, 2014, 20 pages".
"Final Office Action mailed on Apr. 28, 2015, issued in connection with U.S. Appl. No. 14/186,850, filed Feb. 21, 2014, 20 pages".
"Final Office Action mailed on Mar. 3, 2015, issued in connection with U.S. Appl. No. 13/864,251, filed Apr. 17, 2013, 13 pages".
"Final Office Action mailed on Mar. 4, 2015, issued in connection with U.S. Appl. No. 13/848,904, filed Mar. 22, 2013, 16 pages.".
"Final Office Action mailed on Mar. 5, 2015, issued in connection with U.S. Appl. No. 13/888,203, filed May 6, 2013, 13 pages.".
"Final Office Action mailed on Mar. 9, 2015, issued in connection with U.S. Appl. No. 14/516,867, filed Oct. 17, 2014, 14 pages.".
"International Bureau,"International Preliminary Report on Patentability" issued in connection with International Patent application No. PCT/US2013/046372, mailed Dec. 31, 2014, 5 pages.".
"International Preliminary Report on Patentability and Written Opinion, issued by the International Searching Authority in connection with International Patent Application No. PCT/US2013/046386, mailed on Jan. 8, 2015, 8 pages".
"Non-Final Office Action mailed on Mar. 12, 2015, issued in connection with U.S. Appl. No. 13/705,174, filed Dec. 5, 2012, 13 pages.".
"Non-Final Office Action mailed on Mar. 13, 2015, issued in connection with U.S. Appl. No. 13/705,177, filed Dec. 5, 2012, 15 pages.".
"Non-Final Office Action mailed on Feb. 26, 2015, issued in connection with U.S. Appl. No. 14/186,850, filed Feb. 21, 2014, 25 pages.".
"Non-Final Office Action mailed on Mar. 26, 2015, issued in connection with U.S. Appl. No. 14/184,528, filed Feb. 19, 2014, 18 pages".
"Non-Final Office Action mailed on Mar. 27, 2015, issued in connection with U.S. Appl. No. 13/705,178, filed Dec. 5, 2012, 14 pages.".
"Non-Final Office Action mailed on Jan. 30, 2015, issued in connection with U.S. Appl. No. 14/504,812, filed Oct. 2, 2014, 13 pages".
"Non-Final Office Action mailed on Jan. 30, 2015, issued in connection with U.S. Appl. No. 14/290,493, filed May 29, 2014, 30 pages.".
"Non-Final Office Action mailed on Mar. 4, 2015, issued in connection with U.S. Appl. No. 13/435,776, filed Mar. 30, 2012, 16 pages.".
"Notice of Allowance mailed on May 19, 2015, issued in connection with U.S. Appl. No. 13/907,666, filed May 31, 2013, 7 pages".
"Pre-Interview First Office Action mailed on Mar. 10, 2015, issued in connection with U.S. Appl. No. 14/505,027, filed Oct. 2, 2014, 4 pages.".
"Re-Exam Non-Final Office Action mailed on Apr. 22, 2015, issued in connection with U.S. Appl. No. 90/013,423, filed Jan. 5, 2015, 16 pages.".
Advisory Action mailed on Jun. 1, 2015, issued in connection with U.S. Appl. No. 14/516,867, filed Oct. 17, 2014, 11 pages.
Baldwin, Roberto. "How-To: Setup iTunes DJ on Your Max and iPhone", available at http://www.maclife.com/article/howtos/howto_setup_itunes_dj_your_mac_and_iphone, archived on Mar. 17, 2009, 4 pages.
Final Office Action mailed on Jun. 15, 2015, issued in connection with U.S. Appl. No. 14/184,522, filed Feb. 19, 2014, 25 pages.
Non-Final Office Action mailed on Jun. 12, 2015, issued in connection with U.S. Appl. No. 13/848,932, filed Mar. 22, 2013, 16 pages.
Non-Final Office Action mailed on Jun. 19, 2015, issued in connection with U.S. Appl. No. 13/533,105, filed Jun. 26, 2012, 38 pages.
Non-Final Office Action mailed on Jun. 23, 2015, issued in connection with U.S. Appl. No. 13/705,176, filed Dec. 5, 2012, 30 pages.
Non-Final Office Action mailed on Jun. 3, 2015, issued in connection with U.S. Appl. No. 14/564,544, filed Dec. 9, 2014, 7 pages.
Non-Final Office Action mailed on Jun. 4, 2015, issued in connection with U.S. Appl. No. 13/871,795, filed Apr. 26, 2013, 16 pages.
Notice of Allowance mailed on Jul. 2, 2015, issued in connection with U.S. Appl. No. 13/848,904, filed Mar. 22, 2013, 17 pages.
Notice of Allowance mailed on Jul. 2, 2015, issued in connection with U.S. Appl. No. 13/888,203, filed May 6, 2013, 19 pages.
Notice of Allowance mailed on Jul. 6, 2015, issued in connection with U.S. Appl. No. 13/297,000, filed Nov. 15, 2011, 24 pages.

(56) **References Cited**

OTHER PUBLICATIONS

Advisory Action mailed on Jul. 28, 2015, issued in connection with U.S. Appl. No. 14/184,522, filed Feb. 19, 2014, 7 pages.
Baudisch et al., "Flat Volume Control: Improving Usability by Hiding the Volume Control Hierarchy in the User Interface", 2004, 8 pages.
Chakrabarti et al., "A Remotely Controlled Bluetooth Enabled Environment", IEEE, 2004, pp. 77-81.
Schmandt et al., "Impromptu: Managing Networked Audio Applications for Mobile Users", 2004, 11 pages.
Final Office Action mailed on Aug. 10, 2015, issued in connection with U.S. Appl. No. 14/290,493, filed on May 29, 2014, 26 pages.
Final Office Action mailed on Aug. 11, 2015, issued in connection with U.S. Appl. No. 13/864,247, filed on Apr. 17, 2013, 15 pages.
Final Office Action mailed Jul. 15, 2015, issued in connection with U.S. Appl. No. 14/504,812, filed on Oct. 2, 2014, 18 pages.
Final Office Action mailed on Aug. 3, 2015, issued in connection with U.S. Appl. No. 13/848,921, filed on Mar. 22, 2013, 13 pages.
Fulton et al., "The Network Audio System: Make Your Application Sing (As Well As Dance)!", The X Resource, 1994, 14 pages.
Hans et al., "Interacting with Audio Streams for Entertainment and Communication", 2003, 7 pages.
Levergood et al., "AudioFile: A Network-Transparent System for Distributed Audio Applications", Digital Equipment Corporation, 1993, 109 pages.
Notice of Allowance mailed on Aug. 10, 2015, issued in connection with U.S. Appl. No. 13/848,904, filed Mar. 22, 2013, 9 pages.
Notice of Allowance mailed on Aug. 12, 2015, issued in connection with U.S. Appl. No. 13/435,739, filed on Mar. 30, 2012, 27 pages.
Notice of Allowance mailed on Jul. 13, 2015, issued in connection with U.S. Appl. No. 14/184,526, filed on Feb. 19, 2014, 22 pages.
Notice of Allowance mailed on Jul. 15, 2015, issued in connection with U.S. Appl. No. 13/705,174, filed on Dec. 5, 2012, 18 pages.
Notice of Allowance mailed on Jul. 17, 2015, issued in connection with U.S. Appl. No. 13/864,251, filed on Apr. 17, 2013, 20 pages.
Notice of Allowance mailed on Jul. 29, 2015, issued in connection with U.S. Appl. No. 13/359,976, filed on Jan. 27, 2012, 28 pages.
Notice of Allowance mailed on Jul. 29, 2015, issued in connection with U.S. Appl. No. 14/186,850, filed on Feb. 21, 2014, 9 pages.
Notice of Allowance mailed on Jul. 30, 2015, issued in connection with U.S. Appl. No. 13/705,178, filed Dec. 5, 2012, 18 pages.
Notice of Allowance mailed on Aug. 4, 2015, issued in connection with U.S. Appl. No. 14/516,867, filed on Oct. 17, 2014, 13 pages.
Notice of Allowance mailed on Aug. 5, 2015, issued in connection with U.S. Appl. No. 13/435,776, filed on Mar. 30, 2012, 26 pages.
Nutzel et al., "Sharing Systems for Future HiFi Systems", IEEE, 2004, 9 pages.
Re-Exam Final Office Action mailed on Aug. 5, 2015, issued in connection with U.S. Appl. No. 90/013,423, filed on Jan. 5, 2015, 25 pages.

* cited by examiner

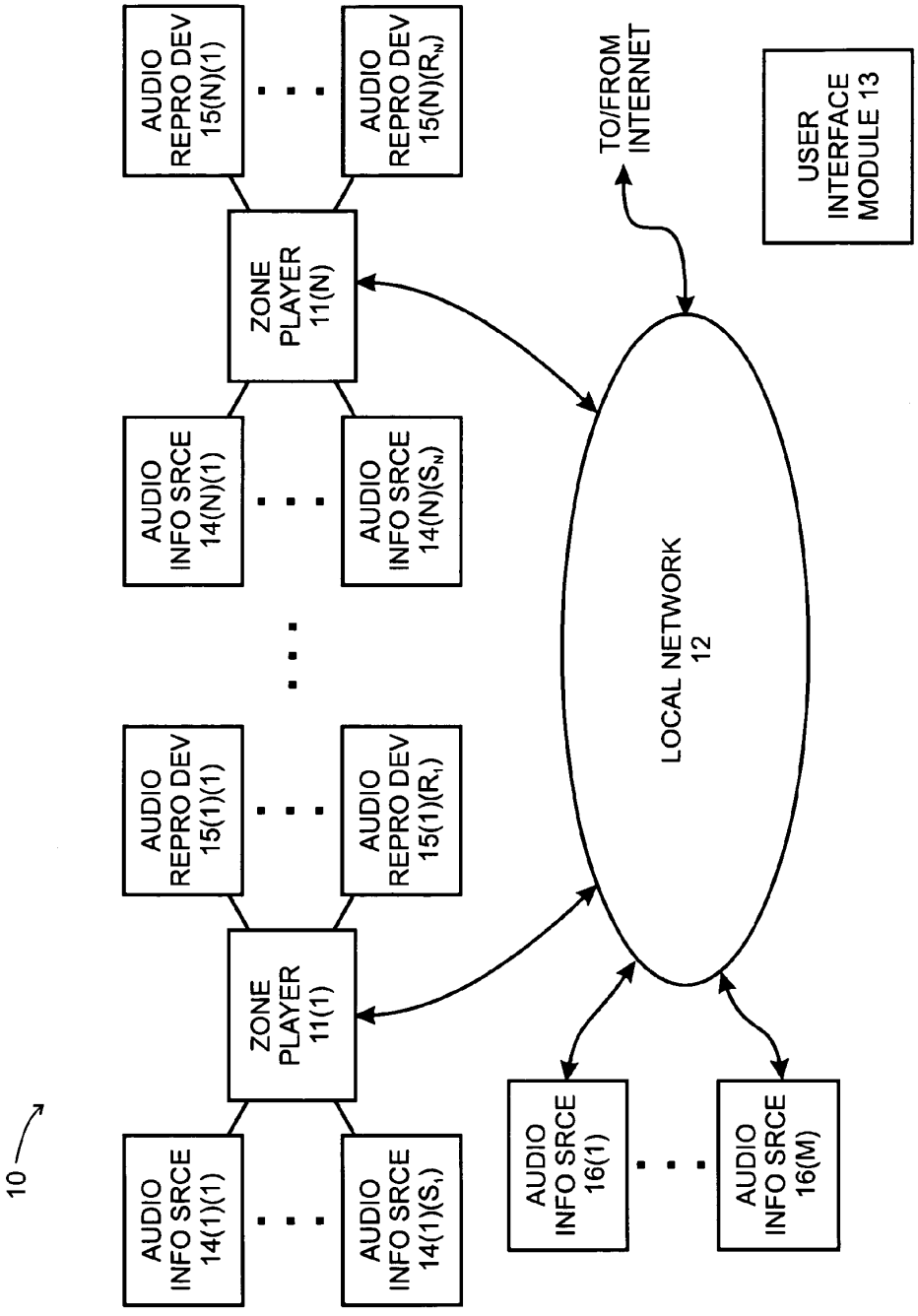

10
AUDIO INFO SRCE 14(1)(1)
AUDIO INFO SRCE 14(1)(S1)
AUDIO REPRO DEV 15(1)(1)
AUDIO REPRO DEV 15(1)(R1)
ZONE PLAYER 11(1)
AUDIO INFO SRCE 14(N)(1)
AUDIO INFO SRCE 14(N)(SN)
AUDIO REPRO DEV 15(N)(1)
AUDIO REPRO DEV 15(N)(RN)
ZONE PLAYER 11(N)
LOCAL NETWORK 12
TO/FROM INTERNET
USER INTERFACE MODULE 13
AUDIO INFO SRCE 16(1)
AUDIO INFO SRCE 16(M)

FIG. 1

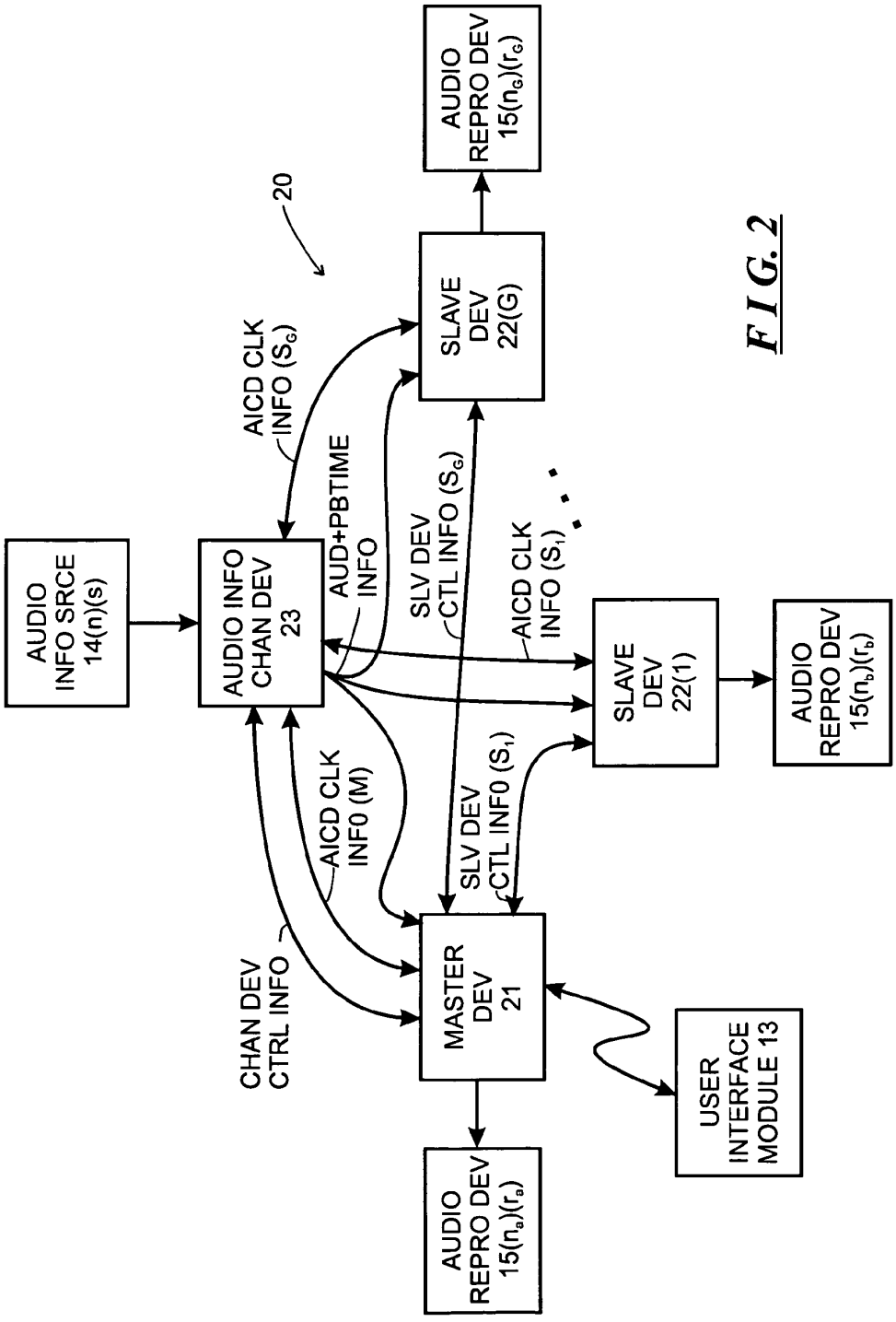

20
AUDIO INFO SRCE 14(n)(s)
AUDIO INFO CHAN DEV 23
AUD+PBTIME INFO
AICD CLK INFO (S_G)
SLV DEV CTL INFO (S_G)
AICD CLK INFO (S_1)
SLV DEV CTL INFO (S_1)
AICD CLK INFO (M)
CHAN DEV CTRL INFO
SLAVE DEV 22(G)
SLAVE DEV 22(1)
MASTER DEV 21
AUDIO REPRO DEV 15(n_G)(r_G)
AUDIO REPRO DEV 15(n_b)(r_b)
AUDIO REPRO DEV 15(n_a)(r_a)
USER INTERFACE MODULE 13

FIG. 2

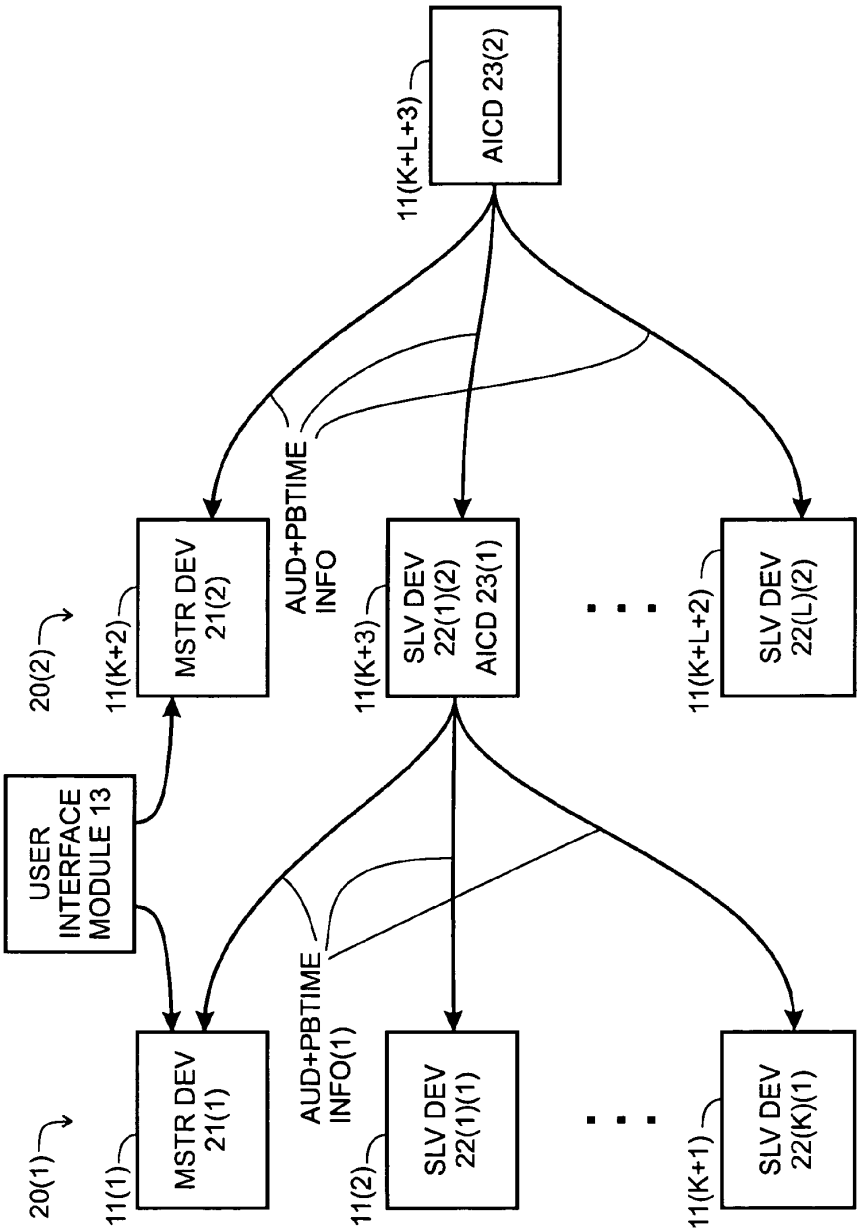

AICD 23(2)
11(K+L+3)
AUD+PBTIME INFO
20(2)
11(K+2)
MSTR DEV 21(2)
11(K+3)
SLV DEV 22(1)(2) AICD 23(1)
11(K+L+2)
SLV DEV 22(L)(2)
USER INTERFACE MODULE 13
AUD+PBTIME INFO(1)
20(1)
11(1)
MSTR DEV 21(1)
11(2)
SLV DEV 22(1)(1)
11(K+1)
SLV DEV 22(K)(1)

FIG. 2A

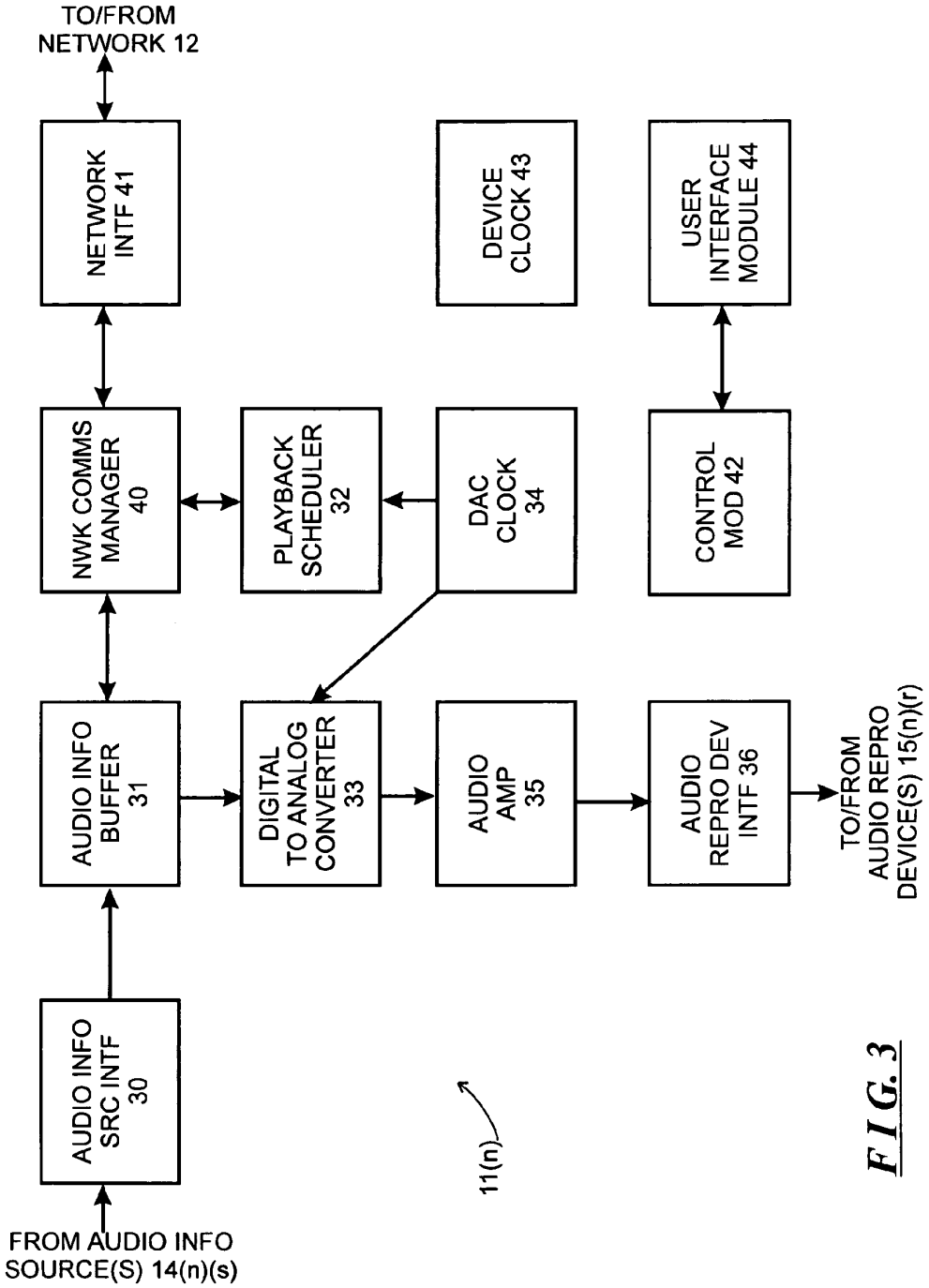

TO/FROM NETWORK 12
NETWORK INTF 41
DEVICE CLOCK 43
USER INTERFACE MODULE 44
NWK COMMS MANAGER 40
PLAYBACK SCHEDULER 32
DAC CLOCK 34
CONTROL MOD 42
AUDIO INFO BUFFER 31
DIGITAL TO ANALOG CONVERTER 33
AUDIO AMP 35
AUDIO REPRO DEV INTF 36
TO/FROM AUDIO REPRO DEVICE(S) 15(n)(r)
AUDIO INFO SRC INTF 30
11(n)
FROM AUDIO INFO SOURCE(S) 14(n)(s)

FIG. 3

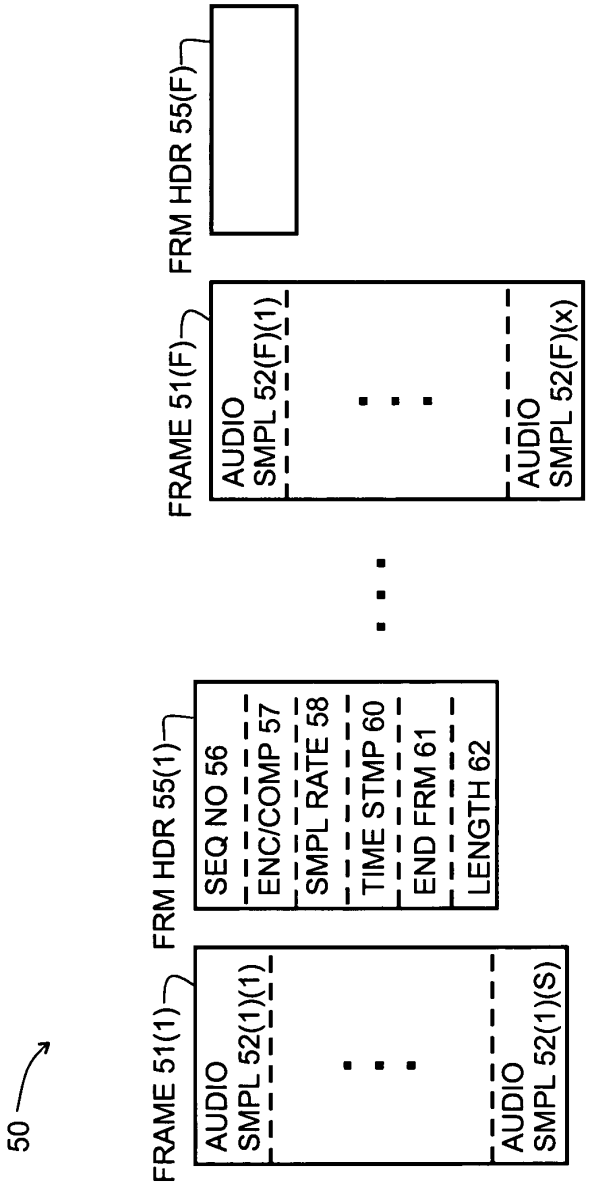

50
FRAME 51(1)
AUDIO SMPL 52(1)(1)
AUDIO SMPL 52(1)(S)
FRM HDR 55(1)
SEQ NO 56
ENC/COMP 57
SMPL RATE 58
TIME STMP 60
END FRM 61
LENGTH 62
FRAME 51(F)
AUDIO SMPL 52(F)(1)
AUDIO SMPL 52(F)(x)
FRM HDR 55(F)

FIG. 4

SYSTEM AND METHOD FOR SYNCHRONIZING OPERATIONS AMONG A PLURALITY OF INDEPENDENTLY CLOCKED DIGITAL DATA PROCESSING DEVICES

INCORPORATION BY REFERENCE

This application claims priority under 35 U.S.C. §120 to, and is a continuation of, U.S. Non-provisional patent application Ser. No. 13/864,251, filed Apr. 17, 2013, entitled "System and method for synchronizing operations among a plurality of independently clocked digital data processing devices," which claims priority under 35 U.S.C. §120 to, and is a continuation of, U.S. Non-provisional application Ser. No. 13/297,000, filed Nov. 15, 2011, entitled "Method for Synchronizing Audio Playback Between Multiple Networked Devices," which claims priority under 35 U.S.C. §120 to, and is a continuation of, U.S. Non-provisional application Ser. No. 10/816,217, now issued as U.S. Pat. No. 8,234,395, filed on Apr. 1, 2004, entitled "System and method for synchronizing operations among a plurality of independently clocked digital data processing devices," which claims priority under 35 U.S.C. §119 to U.S. Provisional Application Ser. No. 60/490,768, filed on Jul. 28, 2003, entitled "Method for Synchronizing Audio Playback Between Multiple Networked Devices," each of which are assigned to the assignee of the present application and are incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates generally to the field of digital data processing devices, and more particularly to systems and methods for synchronizing operations among a plurality of independently-clocked digital data processing devices. The invention is embodied in a system for synchronizing operations among a plurality of devices, in relation to information that is provided by a common source. One embodiment of the invention enables synchronizing of audio playback as among two or more audio playback devices that receive audio information from a common information source, or channel.

More generally, the invention relates to the field of arrangements that synchronize output generated by a number of output generators, including audio output, video output, combinations of audio and video, as well as other types of output as will be appreciated by those skilled in the art, provided by a common channel. Generally, the invention will find utility in connection with any type of information for which synchrony among independently-clocked devices is desired.

BACKGROUND OF THE INVENTION

There are a number of circumstances under which it is desirable to maintain synchrony of operations among a plurality of independently-clocked digital data processing devices in relation to, for example, information that is provided thereto by a common source. For example, systems are being developed in which one audio information source can distribute audio information in digital form to a number of audio playback devices for playback. The audio playback devices receive the digital information and convert it to analog form for playback. The audio playback devices may be located in the same room or they may be distributed in different rooms in a residence such as a house or an apartment, in different offices in an office building, or the like. For example, in a system installed in a residence, one audio playback device may be located in a living room, while another audio playback device is be located in a kitchen, and yet other audio playback devices may be located in various bedrooms of a house. In such an arrangement, the audio information that is distributed to various audio playback devices may relate to the same audio program, or the information may relate to different audio programs. If the audio information source provides audio information relating to the same audio program to two or more audio playback devices at the same time, the audio playback devices will generally contemporaneously play the same program. For example, if the audio information source provides audio information to audio playback devices located in the living room and kitchen in a house at the same time, they will generally contemporaneously play the same program.

One problem that can arise is to ensure that, if two or more audio playback devices are contemporaneously attempting to play back the same audio program, they do so simultaneously. Small differences in the audio playback devices' start times and/or playback speeds can be perceived by a listener as an echo effect, and larger differences can be very annoying. Differences can arise because for a number of reasons, including delays in the transfer of audio information over the network. Such delays can differ as among the various audio playback devices for a variety of reasons, including where they are connected into the network, message traffic and other reasons as will be apparent to those skilled in the art.

Another problem arises from the following. When an audio playback device converts the digital audio information from digital to analog form, it does so using a clock that provides timing information. Generally, the audio playback devices that are being developed have independent clocks, and, if they are not clocking at precisely the same rate, the audio playback provided by the various devices can get out of synchronization.

SUMMARY OF THE INVENTION

The invention provides a new and improved system and method for synchronizing operations among a number of digital data processing devices that are regulated by independent clocking devices. Generally, the invention will find utility in connection with any type of information for which synchrony among devices connected to a network is desired. The invention is described in connection with a plurality of audio playback devices that receive digital audio information that is to be played back in synchrony, but it will be appreciated that the invention can find usefulness in connection with any kind of information for which coordination among devices that have independent clocking devices would find utility.

In brief summary, the invention provides, in one aspect, a system for maintaining synchrony of operations among a plurality of devices that have independent clocking arrangements. The system includes a task distribution device that distributes tasks to a synchrony group comprising a plurality of devices that are to perform the tasks distributed by the task distribution device in synchrony. The task distribution device distributes each task to the members of the synchrony group over a network. Each task is associated with a time stamp that indicates a time, relative to a clock maintained by the task distribution device, at which the members of the synchrony group are to execute the task. Each member of the synchrony group periodically obtains from the task distribution device an indication of the current time indicated by its clock, determines a time differential between the task distribution

device's clock and its respective clock and determines therefrom a time at which, according to its respective clock, the time stamp indicates that it is to execute the task.

In one embodiment, the tasks that are distributed include audio information for an audio track that is to be played by all of the devices comprising the synchrony group synchronously. The audio track is divided into a series of frames, each of which is associated with a time stamp indicating the time, relative to the clock maintained by an audio information channel device, which, in that embodiment, serves as the task distribution device, at which the members of the synchrony group are to play the respective frame. Each member of the synchrony group, using a very accurate protocol, periodically obtains the time indicated by the audio information channel device, and determines a differential between the time as indicated by its local clock and the audio information channel device's clock. The member uses the differential and the time as indicated by the time stamp to determine the time, relative to its local clock, at which it is to play the respective frame. The members of the synchrony group do this for all of the frames, and accordingly are able to play the frames in synchrony.

BRIEF DESCRIPTION OF THE DRAWINGS

This invention is pointed out with particularity in the appended claims. The above and further advantages of this invention may be better understood by referring to the following description taken in conjunction with the accompanying drawings, in which:

FIG. **1** schematically depicts an illustrative networked audio system, constructed in accordance with the invention;

FIG. **2** schematically depicts a functional block diagram of a synchrony group utilizing a plurality of zone players formed within the networked audio system depicted in FIG. **1**;

FIG. **2**A schematically depicts two synchrony groups, illustrating how a member of one synchrony group can provide audio information to the members of another synchrony group;

FIG. **3** depicts an functional block diagram of a zone player for use in the networked audio system depicted in FIG. **1**; and

FIG. **4** is useful in understanding an digital audio information framing methodology useful in the network audio system depicted in FIG. **1**.

DETAILED DESCRIPTION OF AN ILLUSTRATIVE EMBODIMENT

FIG. **1** depicts an illustrative network audio system **10** constructed in accordance with the invention. With reference to FIG. **1**, the network audio system **10** includes a plurality of zone players **11**(**1**) through **11**(N) (generally identified by reference numeral **11**(*n*)) interconnected by a local network **12**, all of which operate under control of one or more user interface modules generally identified by reference numeral **13**. One or more of the zone players **11**(*n*) may also be connected to one or more audio information sources, which will generally be identified herein by reference numeral **14**(*n*)(*s*), and/or one or more audio reproduction devices, which will generally be identified by reference numeral **15**(*n*)(*r*). In the reference numeral **14**(*n*)(*s*), index "n" refers to the index "n" of the zone player **11**(*n*) to which the audio information source is connected, and the index "s" (s=1, . . . , S_n) refers to the "s-th" audio information source connected to that "n-th" zone player **11**(*n*). Thus, if, for example, a zone player **11**(*n*) is connected to four audio information sources **14**(*n*)(**1**) through **14**(*n*)(**4**), the audio information sources may be generally identified by reference numeral **14**(*n*)(*s*), with S_n=4. It will be appreciated that the number of audio information sources S_n may vary as among the various zone players **11**(*n*), and some zone players may not have any audio information sources connected thereto. Similarly, in the reference numeral **15**(*n*)(*r*), index "n" refers to the index "n" of the zone player **11**(*n*) to which the audio reproduction device is connected, and the index "r" (r=1, . . . , R_n) refers to the "r-th" audio information source connected to that "n-th" zone player **11**(*n*). In addition to the audio information sources **14**(*n*)(*s*), the network audio system **10** may include one or more audio information sources **16**(**1**) through **16**(M) connected through appropriate network interface devices (not separately shown) to the local network **12**. Furthermore, the local network may include one or more network interface devices (also not separately shown) that are configured to connect the local network **12** to other networks, including a wide area network such as the Internet, the public switched telephony network (PSTN) or other networks as will be apparent to those skilled in the art, over which connections to audio information sources may be established.

The zone players **11**(*n*) associated with system **10** may be distributed throughout an establishment such as residence, an office complex, a hotel, a conference hall, an amphitheater or auditorium, or other types of establishments as will be apparent to those skilled in the art or the like. For example, if the zone players **11**(*n*) and their associated audio information source(s) and/or audio reproduction device(s) are distributed throughout a residence, one, such as zone player **11**(**1**) and its associated audio information source(s) and audio reproduction device(s) may be located in a living room, another may be located in a kitchen, another may be located in a dining room, and yet others may be located in respective bedrooms, to selectively provide entertainment in those rooms. On the other hand, if the zone players **11**(*n*) and their associated audio information source(s) and/or audio reproduction device(s) are distributed throughout an office complex, one may, for example, be provided in each office to selectively provide entertainment to the employees in the respective offices. Similarly, if the zone players **11**(*n*) and associated audio information source(s) and/or audio reproduction device(s) are used in a hotel, they may be distributed throughout the rooms to provide entertainment to the guests. Similar arrangements may be used with zone players **11**(*n*) and associated audio information source(s) and/or audio reproduction device(s) used in an amphitheater or auditorium. Other arrangements in other types of environments will be apparent to those skilled in the art. In each case, the zone players **11**(*n*) can be used to selectively provide entertainment in the respective locations, as will be described below.

The audio information sources **14**(*n*)(*s*) and **16**(*m*) may be any of a number of types of conventional sources of audio information, including, for example, compact disc ("CD") players, AM and/or FM radio receivers, analog or digital tape cassette players, analog record turntables and the like. In addition, the audio information sources **14**(*n*)(*s*) and **16**(*m*) may comprise digital audio files stored locally on, for example, personal computers (PCs), personal digital assistants (PDAs), or similar devices capable of storing digital information in volatile or non-volatile form. As noted above, the local network **12** may also have an interface (not shown) to a wide area network, over which the network audio system **10** can obtain audio information. Moreover, one or more of the audio information sources **14**(*n*)(*s*) may also comprise an interface to a wide area network such as the Internet, the public switched telephony network (PSTN) or any other source of audio information. In addition, one or more of the

audio information sources **14**(*n*)(*s*) and **16**(*m*) may comprise interfaces to radio services delivered over, for example, satellite. Audio information obtained over the wide area network may comprise, for example, streaming digital audio information such as Internet radio, digital audio files stored on servers, and other types of audio information and sources as will be appreciated by those skilled in the art. Other arrangements and other types of audio information sources will be apparent to those skilled in the art.

Generally, the audio information sources **14**(*n*)(*s*) and **16**(*m*) provide audio information associated with audio programs to the zone players for playback. A zone player that receives audio information from an audio information source **14**(*n*)(*s*) that is connected thereto can provide playback and/or forward the audio information, along with playback timing information, over the local network **12** to other zone players for playback. Similarly, each audio information source **16**(*m*) that is not directly connected to a zone player can transmit audio information over the network **12** to any zone player **11**(*n*) for playback. In addition, as will be explained in detail below, the respective zone player **11**(*n*) can transmit the audio information that it receives either from an audio information source **14**(*n*)(*s*) connected thereto, or from an audio information source **16**(*m*), to selected ones of the other zone players **11**(*n'*), **11**(*n''*), . . . (n not equal to n', n'', . . .) for playback by those other zone players. The other zone players **11**(*n'*), **11**(*n''*), . . . to which the zone player **11**(*n*) transmits the audio information for playback may be selected by a user using the user interface module **13**. In that operation, the zone player **11**(*n*) will transmit the audio information to the selected zone players **11**(*n'*), **11**(*n''*), . . . over the network **12**. As will be described below in greater detail, the zone players **11**(*n*), **11**(*n'*), **11**(*n''*), . . . operate such that the zone players **11**(*n'*), **11**(*n''*), . . . synchronize their playback of the audio program with the playback by the zone player **11**(*n*), so that the zone players **11**(*n*), **11**(*n'*), **11**(*n''*) provide the same audio program at the same time.

Users, using user interface module **13**, may also enable different groupings or sets of zone players to provide audio playback of different audio programs synchronously. For example, a user, using a user interface module **13**, may enable zone players **11**(**1**) and **11**(**2**) to play one audio program, audio information for which may be provided by, for example, one audio information source **14**(**1**)(**1**). The same or a different user may, using the same or a different user interface module **13**, enable zone players **11**(**4**) and **11**(**5**) to contemporaneously play another audio program, audio information for which may be provided by a second audio information source, such as audio information source **14**(**5**)(**2**). Further, a user may enable zone player **11**(**3**) to contemporaneously play yet another audio program, audio information for which may be provided by yet another audio information source, such as audio information source **16**(**1**). As yet another possibility, a user may contemporaneously enable zone player **11**(**1**) to provide audio information from an audio information source connected thereto, such as audio information source **14**(**1**)(**2**), to another zone player, such as zone player **11**(**6**) for playback.

In the following, the term-"synchrony group" will be used to refer to a set of one or more zone players that are to play the same audio program synchronously. Thus, in the above example, zone players **11**(**1**) and **11**(**2**) comprise one synchrony group, zone player **11**(**3**) comprises a second synchrony group, zone players **11**(**4**) and **11**(**5**) comprise a third synchrony group, and zone player **11**(**6**) comprises yet a fourth synchrony group. Thus, while zone players **11**(**1**) and **11**(**2**) are playing the same audio program, they will play the audio program synchronously. Similarly, while zone players **11**(**4**) and **11**(**5**) are playing the same audio program, they will play the audio program synchronously. On the other hand, zone players that are playing different audio programs may do so with unrelated timings. That is, for example, the timing with which zone players **11**(**1**) and **11**(**2**) play their audio program may have no relationship to the timing with which zone player **11**(**3**), zone players **11**(**4**) and **11**(**5**), and zone player **11**(**6**) play their audio programs. It will be appreciated that, since "synchrony group" is used to refer to sets of zone players that are playing the same audio program synchronously, zone player **11**(**1**) will not be part of zone player **11**(**6**)'s synchrony group, even though zone player **11**(**1**) is providing the audio information for the audio program to zone player **11**(**6**).

In the network audio system **10**, the synchrony groups are not fixed. Users can enable them to be established and modified dynamically. Continuing with the above example, a user may enable the zone player **11**(**1**) to begin providing playback of the audio program provided thereto by audio information source **14**(**1**)(**1**), and subsequently enable zone player **11**(**2**) to join the synchrony group. Similarly, a user may enable the zone player **11**(**5**) to begin providing playback of the audio program provided thereto by audio information source **14**(**5**)(**2**), and subsequently enable zone player **11**(**4**) to join that synchrony group. In addition, a user may enable a zone player to leave a synchrony group and possibly join another synchrony group. For example, a user may enable the zone player **11**(**2**) to leave the synchrony group with zone player **11**(**1**), and join the synchrony group with zone player **11**(**6**). As another possibility, the user may enable the zone player **11**(**1**) to leave the synchrony group with zone player **11**(**2**) and join the synchrony group with zone player **11**(**6**). In connection with the last possibility, the zone player **11**(**1**) can continue providing audio information from the audio information source **14**(**1**)(**1**) to the zone player **11**(**2**) for playback thereby.

A user, using the user interface module **13**, can enable a zone player **11**(*n*) that is currently not a member of a synchrony group to join a synchrony group, after which it will be enabled to play the audio program that is currently being played by that synchrony group. Similarly, a user, also using the user interface module **13**, can enable a zone player **11**(*n*) that is currently a member of one synchrony group, to disengage from that synchrony group and join another synchrony group, after which that zone player will be playing the audio program associated with the other synchrony group. For example, if a zone player **11**(**6**) is currently not a member of any synchrony group, it, under control of the user interface module **13**, can become a member of a synchrony group, after which it will play the audio program being played by the other members of the synchrony group, in synchrony with the other members of the synchrony group. In becoming a member of the synchrony group, zone player **11**(**6**) can notify the zone player that is the master device for the synchrony group that it wishes to become a member of its synchrony group, after which that zone player will also transmit audio information associated with the audio program, as well as timing information, to the zone player **11**(**6**). As the zone player **11**(**6**) receives the audio information and the timing information from the master device, it will play the audio information with the timing indicated by the timing information, which will enable the zone player **11**(**6**) to play the audio program in synchrony with the other zone player(s) in the synchrony group.

Similarly, if a user, using the user interface module **13**, enables a zone player **11**(*n*) associated with a synchrony group to disengage from that synchrony group, and if the zone

player **11**(*n*) is not the master device of the synchrony group, the zone player **11**(*n*) can notify the master device, after which the master device can terminate transmission of the audio information and timing information to the zone player **11**(*n*). If the user also enables the zone player **11**(*n*) to begin playing another audio program using audio information from an audio information source **14**(*n*)(*s*) connected thereto, it will acquire the audio information from the audio information source **14**(*n*)(*s*) and initiate playback thereof. If the user enables another zone player **11**(*n'*) to join the synchrony group associated with zone player **11**(*n*), operations in connection therewith can proceed as described immediately above.

As yet another possibility, if a user, using the user interface module **13**, enables a zone player **11**(*n*) associated with a synchrony group to disengage from that synchrony group and join another synchrony group, and if the zone player is not the master device of the synchrony group from which it is disengaging, the zone player **11**(*n*) can notify the master device of the synchrony group from which it is disengaging, after which that zone player will terminate transmission of audio information and timing information to the zone player **11**(*n*) that is disengaging. Contemporaneously, the zone player **11**(*n*) can notify the master device of the synchrony group that it (that is, zone player **11**(*n*)) is joining, after which the master device can begin transmission of audio information and timing information to that zone player **11**(*n*). The zone player **11**(*n*) can thereafter begin playback of the audio program defined by the audio information, in accordance with the timing information so that the zone player **11**(*n*) will play the audio program in synchrony with the master device.

As yet another possibility, a user, using the user interface module **13**, may enable a zone player **11**(*n*) that is not associated with a synchrony group, to begin playing an audio program using audio information provided to it by an audio information source **14**(*n*)(*s*) connected thereto. In that case, the user, also using the user interface module **13** or a user interface device that is specific to the audio information source **14**(*n*)(*s*), can enable the audio information source **14**(*n*)(*s*) to provide audio information to the zone player **11**(*n*). After the zone player **11**(*n*) has begun playback, or contemporaneously therewith, the user, using the user interface module **13**, can enable other zone players **11**(*n'*), **11**(*n''*), . . . to join zone player **11**(*n*)'s synchrony group and enable that zone player **11**(*n*) to transmit audio information and timing information thereto as described above, to facilitate synchronous playback of the audio program by the other zone players **11**(*n'*), **11**(*n''*) . . . .

A user can use the user interface module **13** to control other aspects of the network audio system **10**, including but not limited to the selection of the audio information source **14**(*n*)(*s*) that a particular zone player **11**(*n*) is to utilize, the volume of the audio playback, and so forth. In addition, a user may use the user interface module **13** to turn audio information source(s) **14**(*n*)(*s*) on and off and to enable them to provide audio information to the respective zone players **11**(*n*).

Operations performed by the various devices associated with a synchrony group will be described in connection with FIG. **2**, which schematically depicts a functional block diagram of a synchrony group in the network audio system **10** described above in connection with FIG. **1**. With reference to FIG. **2**, a synchrony group **20** includes a master device **21** and zero or more slave devices **22**(**1**) through **22** (G) (generally identified by reference numeral **22**(*g*)), all of which synchronously play an audio program provided by an audio information channel device **23**. Each of the master device **21**, slave devices **22**(*g*) and audio information channel device **23** utilizes a zone player **11**(*n*) depicted in FIG. **1**, although it will be clear from the description below that a zone player may be utilized both for the audio information channel device for the synchrony group **20**, and the master device **21** or a slave device **22**(*g*) of the synchrony group **20**. As will be described below in more detail, the audio information channel device **23** obtains the audio information for the audio program from an audio information source, adds playback timing information, and transmits the combined audio and playback timing information to the master device **21** and slave devices **22**(*g*) over the network **12** for playback. The playback timing information that is provided with the audio information, together with clock timing information provided by the audio information channel device **23** to the various devices **21** and **22**(*g*) as will be described below, enables the master device **21** and slave devices **22**(*g*) of the synchrony group **20** to play the audio information simultaneously.

The master device **21** and the slave devices **22**(*g*) receive the audio and playback timing information, as well as the clock timing information, that are provided by the audio information channel device **23**, and play back the audio program defined by the audio information. The master device **21** is also the member of the synchrony group **20** that communicates with the user interface module **13** and that controls the operations of the slave devices **22**(*g*) in the synchrony group **20**. In addition, the master device **21** controls the operations of the audio information channel device **23** that provides the audio and playback timing information for the synchrony group **20**. Generally, the initial master device **21** for the synchrony group will be the first zone player **11**(*n*) that a user wishes to play an audio program. However, as will be described below, the zone player **11**(*n*) that operates as the master device **21** can be migrated from one zone player **11**(*n*) to another zone player **11**(*n'*), which preferably will be a zone player that is currently operating as a slave device **22**(*g*) in the synchrony group.

In addition, under certain circumstances, as will be described below, the zone player **11**(*n*) that operates as the audio information channel device **23** can be migrated from one zone player to another zone player, which also will preferably will be a zone player that is currently operating as a member of the synchrony group **20**. It will be appreciated that the zone player that operates as the master device **21** can be migrated to another zone player independently of the migration of the audio information channel device **23**. For example, if one zone player **11**(*n*) is operating as both the master device **21** and the audio information channel device **23** for a synchrony group **20**, the master device **21** can be migrated to another zone player **11**(*n'*) while the zone player **11**(*n*) is still operating as the audio information channel device **23**. Similarly, if one zone player **11**(*n*) is operating as both the master device **21** and the audio information channel device **23** for a synchrony group **20**, the audio information channel device **23** can be migrated to another zone player **11**(*n'*) while the zone player **11**(*n*) is still operating as the master device **21**. In addition, if one zone player **11**(*n*) is operating as both the master device **21** and the audio information channel device **23** for a synchrony group **20**, the master device **21** can be migrated to another zone player **11**(*n'*) and the audio information channel device can be migrated to a third zone player **11**(*n''*).

The master device **21** receives control information from the user interface module **13** for controlling the synchrony group **20** and provides status information indicating the operational status of the synchrony group to the user interface module **13**. Generally, the control information from the user interface

module **13** enables the master device **21** to, in turn, enable the audio information channel device **23** to provide audio and playback timing information to the synchrony group to enable the devices **21** and **22**(*g*) that are members of the synchrony group **20** to play the audio program synchronously. In addition, the control information from the user interface module **13** enables the master device **21** to, in turn, enable other zone players to join the synchrony group as slave devices **22**(*g*) and to enable slave devices **22**(*g*) to disengage from the synchrony group. Control information from the user interface module **13** can also enable the zone player **11**(*n*) that is currently operating as the master device **21** to disengage from the synchrony group, but prior to doing so that zone player will enable the master device **21** to transfer from that zone player **11**(*n*) to another zone player **11**(*n*'), preferably to a zone player **11**(*n*') that is currently a slave device **22**(*g*) in the synchrony group **20**. The control information from the user interface module **13** can also enable the master device **21** to adjust its playback volume and to enable individual ones of the various slave devices **22**(*g*) to adjust their playback volumes. In addition, the control information from the user interface module **13** can enable the synchrony group **20** to terminate playing of a current track of the audio program and skip to the next track, and to re-order tracks in a play list of tracks defining the audio program that is to be played by the synchrony group **20**.

The status information that the master device **21** may provide to the user interface module **13** can include such information as a name or other identifier for the track of the audio work that is currently being played, the names or other identifiers for upcoming tracks, the identifier of the zone player **11**(*n*) that is currently operating as the master device **21**, and identifiers of the zone players that are currently operating as slave devices **22**(*g*). In one embodiment, the user interface module **13** includes a display (not separately shown) that can display the status information to the user.

It will be appreciated that the zone player **11**(*n*) that is operating as the audio information channel device **23** for one synchrony group may also comprise the master device **21** or any of the slave devices **22**(*g*) in another synchrony group. This may occur if, for example, the audio information source that is to provide the audio information that is to be played by the one synchrony group is connected to a zone player also being utilized as the master device or a slave device for the other synchrony group. This will be schematically illustrated below in connection with FIG. **2**A. Since, as noted above, the zone player **11**(*n*) that is operating as the audio information channel device **23** for the synchrony group **20** may also be operating as a master device **21** or slave device **22**(*g*) for another synchrony group, it can also be connected to one or more audio reproduction devices **15**(*n*)(*r*), although that is not depicted in FIG. **2**. Since the master device **21** and slave devices **22**(*g*) are all to provide playback of the audio program, they will be connected to respective audio reproduction devices **15**(*n*)(*r*). Furthermore, it will be appreciated that one or more of the zone players **11**(*n*) that operate as the master device **21** and slave devices **22**(*g*) in synchrony group **20** may also operate as an audio information channel device for that synchrony group or for another synchrony group and so they may be connected to one or more audio information sources **14**(*n*)(*s*), although that is also not depicted in FIG. **2**. In addition, it will be appreciated that a zone player **11**(*n*) can also operate as a audio information channel device **23** for multiple synchrony groups.

If the audio information channel device **23** does not utilize the same zone player as the master device **21**, the master device **21** controls the audio information channel device by exchanging control information over the network **12** with the audio information channel device **23**. The control information is represented in FIG. **2** by the arrow labeled CHAN_DEV_CTRL_INFO. The control information that the master device **21** provides to the audio information channel device **23** will generally depend on the nature of the audio information source that is to provide the audio information for the audio program that is to be played and the operation to be enabled by the control information. If, for example, the audio information source is a conventional compact disc, tape, or record player, broadcast radio receiver, or the like, which is connected to a zone player **11**(*n*), the master device **21** may merely enable the zone player serving as the audio information channel device **23** to receive the audio information for the program from the audio information source. It will be appreciated that, if the audio information is not in digital form, the audio information channel device **23** will convert it to digital form and provide the digitized audio information, along with the playback timing information, to the master device **21** and slave devices **22**(*g*).

On the other hand, if the audio information source is, for example, a digital data storage device, such as may be on a personal computer or similar device, the master device **21** can provide a play list to the audio information channel device **23** that identifies one or more files containing the audio information for the audio program. In that case, the audio information channel device **23** can retrieve the files from the digital data storage device and provide them, along with the playback timing information, to the master device **21** and the slave devices **22**(*g*). It will be appreciated that, in this case, the audio information source may be directly connected to the audio information channel device **23**, as, for example, an audio information source **14**(*n*)(*s*), or it may comprise an audio information source **16**(*m*) connected to the network **12**. As a further alternative, if the audio information source is a source available over the wide area network, the master device **21** can provide a play list comprising a list of web addresses identifying the files containing the audio information for the audio program that is to be played, and in that connection the audio information channel device **23** can initiate a retrieval of the files over the wide area network. As yet another alternative, if the audio information source is a source of streaming audio received over the wide area network, the master device **21** can provide a network address from which the streaming audio can be received. Other arrangements by which the master device **21** can control the audio information channel device **23** will be apparent to those skilled in the art.

The master device **21** can also provide control information to the synchrony group's audio information channel device **23** to enable a migration from one zone player **11**(*n*) to another zone player **11**(*n*'). This may occur if, for example, the audio information source is one of audio information sources **16** or a source accessible over the wide area network via the network **12**. The master device **21** can enable migration of the audio information channel device **23** for several reasons, including, for example, to reduce the loading of the zone player **11**(*n*), to improve latency of message transmission in the network **12**, and other reasons as will be appreciated by those skilled in the art.

As noted above, the audio information channel device **23** provides audio and playback timing information for the synchrony group to enable the master device **21** and slave devices **22**(*g*) to play the audio program synchronously. Details of the audio and playback timing information will be described in detail below in connection with FIGS. **3** and **4**, but, in brief, the audio information channel device **23** transmits the audio and playback timing information in messages over the net-

work **12** using a multi-cast message transmission methodology. In that methodology, the audio information channel device **23** will transmit the audio and playback timing information in a series of messages, with each message being received by all of the zone players **11**(*n*) comprising the synchrony group **20**, that is, by the master device **21** and the slave devices **22**(*g*). Each of the messages includes a multi-cast address, which the master device **21** and slave devices **22**(*g*) will monitor and, when they detect a message with that address, they will receive and use the contents of the message. The audio and playback timing information is represented in FIG. **2** by the arrow labeled "AUD+PBTIME_INFO," which has a single tail, representing a source for the information at the audio information channel device **23**, and multiple arrowheads representing the destinations of the information, with one arrowhead extending to the master device **21** and other arrowheads extending to each of the slave devices **22**(*g*) in the synchrony group **20**. The audio information channel device **23** may make use of any convenient multi-cast message transmission methodology in transmitting the audio and playback timing information to the synchrony group **20**. As will be described in detail in connection with FIG. **4**, the audio and playback timing information is in the form of a series of frames, with each frame having a time stamp. The time stamp indicates a time, relative to the time indicated by a clock maintained by the audio information channel device **23**, at which the frame is to be played. Depending on the size or sizes of the messages used in the selected multi-cast message transmission methodology and the size or sizes of the frames, a message may contain one frame, or multiple frames, or, alternatively, a frame may extend across several messages.

The audio information channel device **23** also provides clock time information to the master device **21** and each of the slave devices **22**(*g*) individually over network **12** using a highly accurate clock time information transmission methodology. The distribution of the clock time information is represented in FIG. **2** by the arrows labeled "AICD_CLK_INF (M)" (in the case of the clock time information provided to the master device **21**) and "AICD_CLK_INF (S_1)" through "AICD_CLK_INF (S_G)" (in the case of audio information channel device clock information provided to the slave devices **22**(*g*)). In one embodiment, the master device **21** and slave devices **22**(*g*) make use of the well-known SNTP (Simple Network Time Protocol) to obtain current clock time information from the audio information channel device **23**. The SNTP makes use of a unicast message transfer methodology, in which one device, such as the audio information channel device **23**, provides clock time information to a specific other device, such as the master device **21** or a slave device **22**(*g*), using the other device's network, or unicast, address. Each of the master device **21** and slave devices **22**(*g*) will periodically initiate SNTP transactions with the audio information channel device **23** to obtain the clock time information from the audio information channel device **23**. As will be described below in more detail, the master device **21** and each slave device **22**(*g*) make use of the clock time information to determine the time differential between the time indicated by the audio information channel device's clock and the time indicated by its respective clock, and use that time differential value, along with the playback time information associated with the audio information and the respective device's local time as indicated by its clock to determine when the various frames are to be played. This enables the master device **21** and the slave devices **22**(*g*) in the synchrony group **20** to play the respective frames simultaneously.

As noted above, the control information provided by the user to the master device **21** through the user interface module **13** can also enable the master device **21** to, in turn, enable another zone player **11**(*n'*) to join the synchrony group as a new slave device **22**(*g*). In that operation, the user interface module **13** will provide control information, including the identification of the zone player **11**(*n'*) that is to join the synchrony group to the master device **21**. After it receives the identification of the zone player **11**(*n'*) that is to join the synchrony group, the master device **21** will exchange control information, which is represented in FIG. **2** by the arrows labeled SLV_DEV_CTRL_INF (S_1) through SLV_DEV_CTRL_INF (S_G) group slave control information, over the network **12** with the zone player **11**(*n'*) that is identified in the control information from the user interface module **13**. The control information that the master device **21** provides to the new zone player **11**(*n'*) includes the network address of the zone player **11**(*n*) that is operating as the audio information channel device **23** for the synchrony group, as well as the multi-cast address that the audio information channel device **23** is using to broadcast the audio and playback timing information over the network. The zone player that is to operate as the new slave device **22**(*g'*) uses the multi-cast address to begin receiving the multi-cast messages that contain the audio information for the audio program being played by the synchrony group.

It will be appreciated that, if the zone player **11**(*n*) that is operating as the master device **21** for the synchrony group **20** is also operating the audio information channel device **23**, and if there are no slave devices **22**(*g*) in the synchrony group **20**, the audio information channel device **23** may not be transmitting audio and playback timing information over the network. In that case, if the new slave device **22**(*g'*) is the first slave device in the synchrony group, the zone player **11**(*n*) that is operating as both the master device **21** and audio information channel device **23**, can begin transmitting the audio and playback timing information over the network **12** when the slave device **22**(*g'*) is added to the synchrony group **20**. The zone player **11**(*n*) can maintain a count of the number of slave devices **22**(*g*) in the synchrony group **20** as they join and disengage, and, if the number drops to zero, it can stop transmitting the audio and playback timing information over the network **12** to reduce the message traffic over the network **12**.

The new slave device **22**(*g'*) added to the synchrony group **20** uses the network address of the audio information channel device **23** for several purposes. In particular, the new slave device **22**(*g'*) will, like the master device **21** (assuming the zone player **11**(*n*) operating as the master device **21** is not also the audio information channel device **23**), engage in SNTP transactions with the audio information channel device **23** to obtain the clock timing information from the audio information channel device **23**. In addition, the new slave device **22**(*g'*) can notify the audio information channel device **23** that it is a new slave device **22**(*g'*) for the synchrony group **20** and provide the audio information channel device **23** with its network address. As will be described below, in one embodiment, particularly in connection with audio information obtained from a source, such as a digital data storage device, which can provide audio information at a rate that is faster than the rate at which it will be played, the audio information channel device **23** will buffer audio and timing information and broadcast it over the network **12** to the synchrony group **20** generally at a rate at which it is provided by the source. Accordingly, when a new slave device **22**(*g'*) joins the synchrony group **20**, the playback timing information may indicate that the audio information that is currently being broadcast by the audio information channel device **23** using the multi-cast methodology is to be played back some time in the

future. To reduce the delay with which the new slave device **22**(*g'*) will begin playback, the audio information channel device **23** can also retransmit previously transmitted audio and timing information that it had buffered to the new slave device **22**(*g'*) using the unicast network address of the slave device **22**(*g'*).

The master device **21** can also use the slave device control information exchanged with the slave devices **22**(*g*) for other purposes. For example, the master device **21** can use the slave device control information to initiate a migration of the master from its zone player **11**(*n*) to another zone player **11**(*n'*). This may occur for any of a number of reasons, including, for example, that the master device **21** is terminating playback by it of the audio program and is leaving the synchrony group **20**, but one or more of the other devices in the synchrony group is to continue playing the audio program. The master device **21** may also want to initiate a migration if it is overloaded, which can occur if, for example, the zone player **11**(*n*) that is the master device **21** for its synchrony group is also operating as an audio information channel device **23** for another synchrony group.

The user can also use the user interface module **13** to adjust playback volume by the individual zone players **11**(*n*) comprising the synchrony group. In that operation, the user interface module **13** provides information identifying the particular device whose volume is to be adjusted, and the level at which the volume is to be set to the master device **21**. If the device whose volume is to be adjusted is the master device **21**, the master device **21** can adjust its volume according to the information that it receives from the user interface module **13**. On the other hand, if the device whose volume is to be adjusted is a slave device **22**(*g*), the master device **21** can provide group slave control information to the respective slave device **22**(*g*), to enable it to adjust its volume.

The user can also use the user interface module **13** to enable a synchrony group **20** to cancel playing of the track in an audio program that is currently being played, and to proceed immediately to the next track. This may occur, for example, if the tracks for the program is in the form of a series of digital audio information files, and the user wishes to cancel playback of the track that is defined by one of the files. In that case, when the master device **21** receives the command to cancel playback of the current track, it will provide channel device control information to the audio information channel device **23** so indicating. In response, the audio information channel device **23** inserts control information into the audio and playback timing information, which will be referred to as a "resynchronize" command. In addition, the audio information channel device **23** will begin transmitting audio information for the next track, with timing information to enable it to be played immediately. The resynchronize command can also enable playback of a track to be cancelled before it has been played. Details of these operations will be described below.

As noted above, there may be multiple synchrony groups in the network audio system **10**, and further that, for example, a zone player **11**(*n*) may operate both as a master device **21** or a slave device **22**(*g*) in one synchrony group, and as the audio information channel device **23** providing audio and playback timing information and clock timing information for another synchrony group. An illustrative arrangement of this will be described in connection with FIG. **2**A. With reference to FIG. **2**A, that FIG. depicts elements of two synchrony groups, identified by reference numerals **20**(**1**) and **20**(**2**), respectively. For clarity, FIG. **2**A does not show a number of elements, the presence of which would be evident from FIGS. **1** and **2** as described above. For example, FIG. **2**A does not depict the audio information sources from which audio information is obtained for the synchrony groups or the audio reproduction devices that are used to produce sound for the master and slave devices, which are depicted in both FIGS. **1** and **2**. In addition, FIG. **2**A does not depict arrows that represent control information provided by the respective master devices to the slave devices in the respective synchrony groups, or to the audio information channel devices that provide audio and timing information for the respective synchrony groups, which are depicted in FIG. **2**. In addition, FIG. **2**A does not depict the arrows that represent the clock timing information provided by the audio information channel devices to the respective members of the respective synchrony groups, which are also depicted in FIG. **2**. As will be noted below, however, FIG. **2**A does depict arrows representing the audio and playback timing information provided by the respective audio information channel devices for the respective synchrony groups **20**(**1**), **20**(**2**), to the master and slave devices comprising the respective synchrony groups **20**(**1**), **20**(**2**).

Each synchrony group **20**(**1**), **20**(**2**) comprises elements of a number of zone players. A functional block diagram of a zone player will be described below in connection with FIG. **3**. Synchrony group **20**(**1**) includes a master device **21**(**1**) and "K" slave devices **22**(**1**)(**1**) through **22**(K)(**1**) (the index "1" in reference numeral **21**(**1**) and the last index in reference numeral **22**(**1**)(**1**) through **21**(K)(**1**) corresponds to the index of the synchrony group **20**(**1**) to which they belong) utilize zone players **11**(**1**) and **11**(K+1) respectively. Similarly, synchrony group **20**(**2**) includes a master device **21**(**2**) and "L" slave devices **22**(**1**)(**2**) through **22**(L)(**2**) that utilize zone players **11**(K+2) through **11**(K+L+2). In the illustrative arrangement depicted in FIG. **2**A, both synchrony groups **20**(**1**) and **20**(**2**) are controlled by the user interface module **13**, which can provide control information to, and receive status information from, the master devices **21**(**1**) and **21**(**2**) independently. It will be appreciated that separate user interface modules may be provided to provide control information to, and receive status information from, the respective master devices **21**(**1**), **21**(**2**).

As noted above, the slave device **22**(**1**)(**2**) in synchrony group **20**(**2**) utilizes zone player **11**(K+3). In the illustrative arrangement depicted in FIG. **2**A, the audio information channel device **23**(**1**) that provides audio and playback timing information to the master and slave devices **21**(**1**), **22**(**1**)(**1**), . . . , **22**(K)(**1**) of synchrony group **20**(**1**) also utilizes zone player **11**(K+3). As noted above, this may occur if, for example, the audio information source that is to provide audio information to be played by the synchrony group **20**(**1**) is connected to the zone player **11**(K+3). Thus, when the master device **21**(**1**) of synchrony group **20**(**1**) exchanges channel device control information with the audio information channel device **23**(**1**), it is effectively exchanging channel device control information with the zone player **11**(K+3). Similarly, when the master and slave devices **21**(**1**), **22**(**1**)(**1**), . . . , **22**(K)(**1**) of synchrony group **20**(**1**) receive audio and playback timing information, as well as clock timing information, from the audio information channel device **23**(**1**), they are effectively receiving the information from the zone player **11**(K+3). FIG. **2**A depicts a multi-headed arrow representing audio and playback timing information transmitted by the zone player **11**(K+3), as audio information channel device **23**(**1**), to the master and slave devices **21**(**1**), **22**(**1**)(**1**), . . . , **11**(K)(**1**) comprising synchrony group **20**(**1**).

On the other hand, in the illustrative arrangement depicted in FIG. **2**A, the synchrony group **20**(**2**) utilizes a zone player **11**(K+L+3) as its audio information channel device **23**(**2**). As with synchrony group **20**(**1**), when the master device **21**(**2**) of

synchrony group **20**(**2**) exchanges channel device control information with the audio information channel device **23**(**2**), it is effectively exchanging channel device control information with the zone player **11**(K+L+3). Similarly, when the master and slave devices **21**(**2**), **22**(**1**)(**2**), . . . , **22**(L)(**2**) of synchrony group **20**(**2**) receive audio and playback timing information, as well as clock timing information, from the audio information channel device **23**(**2**), they are effectively receiving the information from the zone player **11**(K+L+3). FIG. **2**A depicts a multi-headed arrow representing audio and playback timing information transmitted by the zone player **11**(K+3) as audio information channel device **23**(**2**) to the master and slave devices **21**(**2**), **22**(**1**)(**2**), . . . , **22**(L)(**2**) comprising synchrony group **20**(**2**).

In the illustrative arrangement depicted in FIG. **2**A, zone player **11**(K+L+3), which is the audio information channel device **23**(**2**) for synchrony group **20**(**2**), is not shown as being either a master or a slave device in another synchrony group. However, it will be appreciated that zone player **11**(K+L+3) could also be utilized as the master device or a slave device for another synchrony group. Indeed, it will be appreciated that the zone player that is utilized as the audio information channel device for synchrony group **20**(**2**) may also be a zone player that is utilized as the master device **21**(**1**) or a slave device **22**(**1**)(**1**), . . . , **22**(K)(**1**) in the synchrony group **20**(**1**).

A zone player **11**(*n*) that is utilized as a member of one synchrony group may also be utilized as the audio information channel device for another synchrony group if the audio information source that is to supply the audio information that is to be played by the other synchrony group is connected to that zone player **11**(*n*). A zone player **11**(*n*) may also be utilized as the audio information channel device for the other synchrony group if, for example, the audio information source is an audio information source **16**(*m*) (FIG. **1**) that is connected to the network **12** or an audio information source that is available over a wide area network such as the Internet. The latter may occur if, for example, the zone player **11**(*n*) has sufficient processing power to operate as the audio information channel device and it is in an optimal location in the network **12**, relative to the zone players comprising the other synchrony group (that is the synchrony group for which it is operating as audio information channel device) for providing the audio and playback timing information to the members of the other synchrony group. Other circumstances under which the zone player **11**(*n*) that is utilized as a member of one synchrony group may also be utilized as the audio information channel device for another synchrony group will be apparent to those skilled in the art.

As was noted above, the master device **21** for a synchrony group **20** may be migrated from one zone player **11**(*n*) to another zone player **11**(*n*'). As was further noted above, the audio information channel device **23** for a synchrony group **20** may be migrated from one zone player **11**(*n*) to another zone player **11**(*n*'). It will be appreciated that the latter may occur if, for example, the audio information source that provides the audio program for the synchrony group is not connected to the zone player **11**(*n*) that is operating as the audio information channel device **23**, but instead is one of the audio information sources **16**(*m*) connected to the network **12** or a source available over a wide area network such as the Internet. Operations performed during a migration of an audio information channel device **23** from one zone player **11**(*n*) to another zone player **11**(*n*') will generally depend on the nature of the audio information that is being channeled by the audio information channel device **23**. For example, if the audio information source provides streaming audio, the zone player **11**(*n*) that is currently operating as the audio information channel device **23** for the synchrony group **20**, can provide the following information to the other zone player **11**(*n*') that is to become the audio information channel device **23** for the synchrony group **20**:

(a) the identification of the source of the streaming audio information,

(b) the time stamp associated with the frame that the zone player **11**(*n*) is currently forming, and

(c) the identifications of the zone players that are operating as the master device **21** and slave devices **22**(*g*) comprising the synchrony group **20**.

After the zone player **11**(*n*') receives the information from the zone player **11**(*n*), it will begin receiving the streaming audio from the streaming audio information source identified by the zone player **11**(*n*), assemble the streaming audio information into frames, associate each frame with a time stamp, and transmit the resulting audio and playback timing information over the network **12**. The zone player **11**(*n*') will perform these operations in the same manner as described above, except that, instead of using the time indicated by its digital to analog converter clock **34** directly in generating the time stamps for the frames, the initial time stamp will be related to the value of the time stamp that is provided by the zone player **11**(*n*) (reference item (b) above), with the rate at which the time stamps are incremented corresponding to the rate at which its (that is, the zone player **11**(*n*')'s) clock increments. In addition, the zone player **11**(*n*') will notify the zone players that are operating as the master device **21** and slave devices **22**(*g*) of the synchrony group **20** that it is the new audio information channel device **23** for the synchrony group **20**, and provide the multi-cast address that it will be using to multi-cast the audio and playback timing information, as well as its unicast network address. After the members of the synchrony group **20** receive the notification from the zone player **11**(*n*') indicating that it is the new audio information channel device **23** for the synchrony group **20**, they will receive the audio and playback timing information from the zone player **11**(*n*') instead of the zone player **11**(*n*), using the multi-cast address provided by the zone player **11**(*n*'). In addition, they can utilize the zone player **11**(*n*')'s unicast network address to obtain current time information therefrom. It will be appreciated that the zone player **11**(*n*') will determine its current time in relation to the time stamp that is provided by the zone player **11**(*n*) (reference item (b) above) or the current time information that it received from the zone player **11**(*n*) using the SNTP protocol as described above.

Generally similar operations can be performed in connection with migrating the audio information channel device from one zone player **11**(*n*) to another zone player **11**(*n*') if the audio information is from one or more audio information files, such as may be the case if the audio information comprises MP3 or WAV files that are available from sources such as sources **16**(*m*) connected to the network **12** or over from sources available over a wide area network such as the Internet, except for differences to accommodate the fact that the audio information is in files. In that case, the zone player **11**(*n*) that is currently operating as the audio information channel device **23** for the synchrony group **20** can provide the following information to the zone player **11**(*n*') that is to become the audio information channel device **23** for the synchrony group **20**:

(d) a list of the audio information files containing the audio information that is to be played;

(e) the identification of the file for which the zone player **11**(*n*) is currently providing audio and playback timing information, along with the offset into the file for which the current

item of audio and playback timing information is being generated and the time stamp that the zone player **11**(*n*) is associating with that frame, and

(f) the identifications of the zone players that comprise the master device **21** and slave devices **22**(*g*) comprising the synchrony group **20**.

After the zone player **11**(*n'*) receives the information from the zone player **11**(*n*), it will begin retrieving audio information from the file identified in item (e), starting at the identified offset. In addition, the zone player **11**(*n'*) can assemble the retrieved audio information into frames, associate each frame with a time stamp and transmit the resulting audio and playback timing information over the network **12**. The zone player **11**(*n'*) will perform these operations in the same manner as described above, except that, instead of using the time indicated by its digital to analog converter clock **34** directly in generating the time stamps for the frames, the value of the initial time stamp will be related to the time stamp that is provided by the zone player **11**(*n*) (reference item (e) above), with the rate at which the time stamps are incremented corresponding to the rate at which its (that is, the zone player **11**(*n'*)'s) clock increments. In addition, the zone player **11**(*n'*) will notify the zone players that are operating as the master device **21** and slave devices **22**(*g*) of the synchrony group **20** that it is the new audio information channel device **23** for the synchrony group **20**, and provide the multi-cast address that it will be using to multi-cast the audio and playback timing information, as well as its unicast network address. After the members of the synchrony group **20** receive the notification from the zone player **11**(*n'*) indicating that it is the new audio information channel device **23** for the synchrony group **20**, they will receive the audio and playback timing information from the zone player **11**(*n'*) instead of the zone player **11**(*n*), using the multi-cast address provided by the zone player **11**(*n'*). In addition, they can utilize the zone player **11**(*n'*)'s unicast network address to obtain current time information therefrom. It will be appreciated that the zone player **11**(*n'*) will determine its current time in relation to the time stamp that is provided by the zone player **11**(*n*) (reference item (b) above) or the current time information that it received from the zone player **11**(*n*) using the SNTP protocol as described above. The zone player **11**(*n'*) will process successive audio information files in the list that it receives from the zone player **11**(*n*) (reference item (d)).

Operations performed by the zone players **11**(*n*) and **11**(*n'*) in connection with migration of the audio information channel device **23** for other types of audio information will be apparent to those skilled in the art. In any case, preferably, the zone player **11**(*n*) will continue operating as an audio information channel device **23** for the synchrony group **20** for at least a brief time after it notifies the zone player **11**(*n'*) that it is to become audio information channel device for the synchrony group, so that the zone player **11**(*n'*) will have time to notify the zone players in the synchrony group **20** that it is the new audio information channel device **23** for the synchrony group.

Before proceeding further in describing operations performed by the network audio system **10**, it would be helpful to provide a detailed description of a zone player **11**(*n*) constructed in accordance with the invention. FIG. **3** depicts a functional block diagram of a zone player **11**(*n*) constructed in accordance with the invention. All of the zone players in the network audio system **10** may have similar construction. With reference to FIG. **3**, the zone player **11**(*n*) includes an audio information source interface **30**, an audio information buffer **31**, a playback scheduler **32**, a digital to analog converter **33**, an audio amplifier **35**, an audio reproduction device interface **36**, a network communications manager **40**, and a network interface **41**, all of which operate under the control of a control module **42**. The zone player **11**(*n*) also has a device clock **43** that provides timing signals that control the general operations of the zone player **11**(*n*). In addition, the zone player **11**(*n*) includes a user interface module interface **44** that can receive control signals from the user interface module **13** (FIGS. **1** and **2**) for controlling operations of the zone player **11**(*n*), and provide status information to the user interface module **13**.

Generally, the audio information buffer **31** buffers audio information, in digital form, along with playback timing information. If the zone player **11**(*n*) is operating as the audio information channel device **23** (FIG. **2**) for a synchrony group **20**, the information that is buffered in the audio information buffer **31** will include the audio and playback timing information that will be provided to the devices **21** and **22**(*g*) in the synchrony group **20**. If the zone player **11**(*n*) is operating as the master device **21** or a slave device **22**(*g*) for a synchrony group, the information that is buffered in the audio information buffer **31** will include the audio and playback timing information that the zone player **11**(*n*) is to play.

The audio information buffer **31** can receive audio and playback timing information from two sources, namely, the audio information source interface **30** and the network communications manager **40**. In particular, if the zone player **11**(*n*) is operating as the audio information channel device **23** for a synchrony group **20**, and if the audio information source is a source **14**(*n*)(*s*) connected to the zone player **11**(*n*), the audio information buffer **31** will receive and buffer audio and playback timing information from the audio information source interface **30**. On the other hand, if the zone player **11**(*n*) is operating as the audio information channel device **23** for a synchrony group **20**, and if the audio information source is a source **16**(*m*) connected to the network **12**, or a source available over the wide area network, the audio information buffer **31** will receive and buffer audio and playback timing information from the network communications manager **40**. It will be appreciated that, if the zone player **11**(*n*) is not a member of the synchrony group, the zone player **11**(*n*) will not play this buffered audio and playback timing information.

On yet another hand, if the zone player **11**(*n*) is operating as the master device **21** or a slave device **22**(*g*) in a synchrony group, and if the zone player **11**(*n*) is not also the audio information channel device **23** providing audio and playback timing information for the synchrony group **20**, the audio information buffer **31** will receive and buffer audio and playback timing information from the network communications manager **40**.

The audio information source interface **30** connects to the audio information source(s) **14**(*n*)(*s*) associated with the zone player **11**(*n*). While the zone player **11**(*n*) is operating as audio information channel device **23** for a synchrony group **20**, and if the audio information is to be provided by a source **14**(*n*)(*s*) connected to the zone player **11**(*n*), the audio information source interface **30** will selectively receive audio information from one of the audio information source(s) **14**(*n*)(*s*) to which the zone player is connected and store the audio information in the audio information buffer **21**. If the audio information from the selected audio information source **14**(*n*)(*s*) is in analog form, the audio information source interface **30** will convert it to digital form. The selection of the audio information source **14**(*n*)(*s*) from which the audio information source interface **30** receives audio information is under control of the control module **42**, which, in turn, receives control information from the user interface module through the user interface module interface **44**. The audio

information source interface **30** adds playback timing information to the digital audio information and buffers the combined audio and playback timing information in the audio information buffer **21**.

More specifically, as noted above, the audio information source interface **30** receives audio information from an audio information source **14**(*n*)(*s*), converts it to digital form if necessary, and buffers it along with playback timing information in the audio information buffer **21**. In addition, the audio information source interface **30** will also provide formatting and scheduling information for the digital audio information, whether as received from the selected audio information source **14**(*n*)(*s*) or as converted from an analog audio information source. As will be made clear below, the formatting and scheduling information will control not only playback by the zone player **11**(*n*) itself, but will also enable other zone players **11**(*n'*), **11**(*n''*), . . . that may be in a synchrony group for which the zone player **11**(*n*) is the master device, to play the audio program associated with the audio information in synchrony with the zone player **11**(*n*).

In one particular embodiment, the audio information source interface **30** divides the audio information associated with an audio work into a series of frames, with each frame comprising digital audio information for a predetermined period of time. As used herein, an audio track may comprise any unit of audio information that is to be played without interruption. On the other hand, an audio program may comprise a series of one or more audio tracks that are to be played in succession. It will be appreciated that the tracks comprising the audio program may also be played without interruption, or alternatively playback between tracks may be interrupted by a selected time interval. FIG. **4** schematically depicts an illustrative framing strategy used in connection with one embodiment of the invention for a digital audio stream comprising an audio work. More specifically, FIG. **4** depicts a framed digital audio stream **50** comprising a sequence of frames **51**(**1**) through **51**(F) (generally identified by reference numeral **51**(*f*)). Each frame **51**(*f*), in turn, comprises a series of audio samples **52**(*f*)(**1**) through **52**(*f*)(S) (generally identified by reference numeral **52**(*f*)(*s*)) of the audio track. Preferably all of the frames will have the same number "S" of audio samples, although it will be appreciated from the following that that is primarily for convenience. On the other hand, it will be appreciated that, the number of audio samples may differ from "S"; this may particularly be the case if the frame **51**(*f*) contains the last audio samples for the digital audio stream for a particular audio work. In that case, the last frame **51**(F) will preferably contain samples **52**(F)(**1**) through **52**(F)(x), where "x" is less than "S." Generally, it is desirable that the number of samples be consistent among all frames **51**(*f*), and in that case padding, which will not be played, can be added to the last frame **51**(F).

Associated with each frame **51**(*f*) is a header **55**(*f*) that includes a number of fields for storing other information that is useful in controlling playback of the audio samples in the respective frame **51**(*f*). In particular, the header **55**(*f*) associated with a frame **51**(*f*) includes a frame sequence number field **56**, an encoding type field **57**, a sampling rate information field **58**, a time stamp field **60**, an end of track flag **61**, and a length flag field **62**. The header **55**(*f*) may also include fields (not shown) for storing other information that is useful in controlling playback. Generally, the frame sequence number field **56** receives a sequence number "f" that identifies the relative position of the frame **51**(*f*) in the sequence of frames **51**(**1**) . . . **51**(*f*) . . . **51**(F) containing the digital audio stream **50**. The encoding type field **57** receives a value that identifies the type of encoding and/or compression that has been used in generating the digital audio stream. Conventional encoding or compression schemes include, for example, the well-known MP3 and WAV encoding and/or compression schemes, although it will be appreciated that other schemes may be provided for as well. The sampling rate information field **58** receives sampling rate information that indicates the sampling rate for the audio samples **52**(*f*)(*s*). As will be apparent to those skilled in the art, the sampling rate determines the rate at which the zone player **11**(*n*) is to play the audio samples **52**(*f*)(*s*) in the frame, and, as will be described below, determines the period of the digital to analog converter clock **34**.

The condition of the end of work flag **61** indicates whether the frame **51**(*f*) contains the last digital audio samples for the audio track associated with the framed digital audio work **50**. If the frame **51**(*f*) does not contain the audio samples that are associated with the end of the digital audio stream **50** for a respective audio work, the end of work flag will be clear. On the other hand, if the frame **51**(*f*) does contain the audio samples that are associated with the end of the digital audio stream **50** for a respective audio work, the end of work flag **61** will be set. In addition, since the number of valid audio samples **52**(F)(s) in the frame **51**(F), that is, the samples that are not padding, may be less than "S," the default number of audio samples in a frame **51**(*f*), the length flag field **62** will contain a value that identifies the number of audio samples in **52**(F)(s) in the last frame **51**(F) of the audio work **50**. If, as noted above, the frames have a consistent number "S" of samples, the samples **52**(F)(x+1) through **52**(F)(S) will contain padding, which will not be played.

The time stamp field **60** stores a time stamp that identifies the time at which the zone player **11**(*n*) is to play the respective frame. More specifically, for each frame of a framed digital audio stream **50** that is buffered in the audio information buffer **21**, the audio information source interface **30**, using timing information from the digital to analog converter clock **34**, will determine a time at which the zone player **11**(*n*) is to play the respective frame, and stores a time stamp identifying the playback time in the time stamp field **60**. The time stamp associated with each frame will later be used by the playback scheduler **32** to determine when the portion of the digital audio stream stored in the frame is to be coupled to the digital to analog converter **33** to initiate play back. It will be appreciated that the time stamps that are associated with frames in sequential frames **51**(**1**), **51**(**2**), . . . , **51**(F), will be such that they will be played back in order, and without an interruption between the sequential frames comprising the digital audio stream **50**. It will further be appreciated that, after a time stamp has been determined for the first frame, stored in frame **51**(**1**), of a digital audio stream **50**, the audio information source interface **30** can determine time stamps for the subsequent frame **51**(**2**), **51**(**3**), . . . , **51**(F) in relation to the number of samples "S" in the respective frames and the sample rate. The time stamps will also preferably be such that frames will be played back after some slight time delay after they have been buffered in the audio information buffer **21**; the purpose for the time delay will be made clear below.

Returning to FIG. **3**, in addition to dividing the digital audio information into frames, the audio information source interface **30** also aggregates and/or divides the frames **51**(*f*) as necessary into packets, each of which will be of a length that would fit into a message for transmission over the network, and associates each packet with a packet sequence number. For example, if a packet will accommodate multiple frames **51**(*f*), **51**(*f*+1), . . . **51**(*f*+y−1), it will aggregate them into a packet and associate them with a packet number, for example p(x). If the entire frames **51**(*f*) and **51**(*f*+y−1) was accommo-

dated in packet p(x), where "x" is the sequence number, which will occur if the size of a packet is an exact multiple of the frame size, the next packet, p(x+1) will begin with frame **51**(*f*+y) and will include frames **51**(*f*+y), . . . , **51**(*f*+2y−1). Subsequent packets p(x+2), . . . will be formed in a similar manner. On the other hand, if the packet length will not accommodate an exact multiple of the frame size, the last frame in the packet will be continued at the beginning of the next packet.

If the audio information source interface **30** is aware of track boundaries, which may be the case if the tracks are divided into files, the packets will reflect the track boundaries, that is, the packets will not contain frames from two tracks. Thus, if the last frames associated with a track are insufficient to fill a packet, the packet will contain padding from the last frame associated with the track to the end of the packet, and the next packet will begin with the first frames associated with the next track.

In one embodiment, the audio information source interface **30** stores the packets in the audio information buffer **31** in a ring buffer. As is conventional, a ring buffer includes a series of storage locations in the buffer. Each entry will be sufficient to store one packet. Four pointers are used in connection with the ring buffer, a first pointer pointing to the beginning of the ring buffer, a second pointer pointing to the end of the ring buffer, an third "write" pointer pointing to the entry into which a packet will be written and a fourth "read" pointer pointing to the entry from which packet will be read for use in playback. When a packet is read from the ring buffer for playback, it will be read from the entry pointed to by the read pointer. After the packet has been read, the read pointer will be advanced. If the read pointer points beyond the end of the ring buffer, as indicated by the end pointer, it will be reset to point to the entry pointed to by the beginning pointer, and the operations can be repeated.

On the other hand, when the audio information source interface **30** stores a packet in the ring buffer, first determine whether the entry pointed to by the write pointer points to the same entry as the entry pointed to by the read pointer. If the write pointer points to the same entry as the entry pointed to by the read pointer, the entry contains at least a portion of a packet that has not yet been read for playback, and the audio information source interface **30** will delay storage of the packet until the entire packet has been read and the read pointer advanced. After the read pointer has been advanced, the audio information source interface **30** can store the packet in the entry pointed to by the write pointer. After the packet has been stored, the audio information source interface **30** will advance the write pointer. If the write pointer points beyond the end of the ring buffer, as indicated by the end pointer, it will be reset to point to the entry pointed to by the beginning pointer, and the operations can be repeated.

As noted above, the zone player **11**(*n*) can operate both as an audio information channel device **23** and a member of the synchrony group **20** of which it is a member. In that case, the audio information buffer **31** can contain one ring buffer. On the other hand, the zone player **11**(*n*) can operate as an audio information channel device **23** for one synchrony group **20**(**1**) (FIG. **2**A) and a member of another synchrony group **20**(**2**). In that case, the audio information buffer **31** would maintain two ring buffers, one for the audio and timing information associated with synchrony group **20**(**1**), and the other for the audio and timing information associated with synchrony group **20**(**2**). It will be appreciated that, in the latter case, the zone player **11**(*n*) will only use the audio and timing information that is associated with synchrony group **20**(**2**) for playback.

The playback scheduler **32** schedules playback of the audio information that is buffered in the audio information buffer **31** that is to be played by the zone player **11**(*n*). Accordingly, under control of the playback scheduler **32**, the digital audio information that is buffered in the audio information buffer **21** that is to be played by the zone player **11**(*n*) is transferred to the digital to analog converter **33** for playback. As noted above, if the zone player **11**(*n*) is operating as an audio information channel device **23** for a synchrony group **20** for which it is not a member, the playback scheduler **32** will not schedule the digital audio information that is to be played by that synchrony group **20** for playback. The playback scheduler **32** only schedules the digital audio information, if any, that is buffered in the audio information buffer **31** that is associated with a synchrony group for which the zone player **11**(*n*) is a member, whether as master device **21** or a slave device **22**(*g*).

Essentially, the playback scheduler **32** makes use of the read pointer associated with the circular buffer that contains the audio and playback timing information that is to be played by the zone player **11**(*n*). The playback scheduler **32** retrieves the packet information from the entry of the ring buffer pointed to by the read pointer, and then advances the ring pointer as described above. The playback scheduler **32** determines the boundaries of the frames in the packet and uses the time stamps in the time stamp fields **60** associated with the respective frame **51**(*f*), along with timing information provided by the zone player **11**(*n*)'s digital to analog converter clock **34**, to determine when the respective frame is to be transferred to the digital to analog converter **33**. Generally, when the time stamp associated with a buffered digital audio information frame corresponds to the current time as indicated by the digital to analog converter clock **34**, the playback scheduler **32** will enable the respective frame to be transferred to the digital to analog converter **33**.

The digital to analog converter **33**, also under control of the digital to analog converter clock **34**, converts the buffered digital audio information to analog form, and provides the analog audio information to the audio amplifier **35** for amplification. The amplified analog information, in turn, is provided to the audio reproduction devices **15**(*n*)(*r*) through the audio reproduction device interface **36**. The audio reproduction devices **15**(*n*)(*r*) transform the analog audio information signal to sound thereby to provide the audio program to a listener. The amount by which the audio amplifier **35** amplifies the analog signal is controlled by the control module **42**, in response to volume control information provided by the user through the user interface module **13**.

The network communications manager **40** controls network communications over the network **12**, and the network interface **41** transmits and receives message packets over the network **12**. The network communications manager **40** generates and receives messages to facilitate the transfer of the various types of information described above in connection with FIG. **2**, including the channel device control information, slave device control information, audio and playback timing information and the audio information channel device's clock timing information. In connection with the channel device control information and the slave device control information, the network communications manager **40** will generate messages for transfer over the network **12** in response to control information from the control module **42**. Similarly, when the network communications manager **40** receives messages containing channel device control information and slave device control information, the network communications manager will provide the information to the control module **42** for processing.

With regards to the audio information channel device's clock timing information, as noted above, the master device **21** and slave devices **22**(*g*) of the synchrony group **20** obtain the clock timing information from the audio information channel device **23** using the well-known SNTP. If the zone player **11**(*n*) is operating as the audio information channel device **23** for a synchrony group, during the SNTP operation, it will provide its current time, particularly a current time as indicated by its digital to analog converter clock **34**. On the other hand, if the zone player **11**(*n*) is operating as the master device **21** or slave device **22**(*g*) of a synchrony group **20**, it will receive the clock timing information from the audio information channel device **23**. After the respective device **21**, **22**(*g*) has obtained the audio information channel device's clock timing information, it will generate a differential time value ΔT representing the difference between the time T indicated by its digital to analog converter clock **34** and the current time information from the audio information channel device **23**. The differential time value will be used to update the time stamps for the frames of the digital audio stream **50** (FIG. **4**) that are received from the audio information channel device.

With regards to the audio and playback timing information, operations performed by the network communications manager **40** will depend on whether

(i) the audio and playback timing information has been buffered in the audio information buffer **31** for transmission, as audio information channel device **23**, over the network **12** to the master device **21** and/or slave devices **22**(*g*) of a synchrony group, or

(ii) the audio and playback timing information has been received from the network **12** to be played by the zone player **11**(*n*) as either the master device **21** for a synchrony group or a slave device in a synchrony group.

It will be appreciated that the network communications manager **40** may be engaged in both (i) and (ii) contemporaneously, since the zone player **11**(*n*) may operate both as the audio information channel device **23**(**1**) for a synchrony group **20**(**1**) (reference FIG. **2**A) of which it is not a member, and a member of another synchrony group **20**(**2**) for which another zone player **11**(*n'*) is the audio information channel device **23**(**2**). With reference to item (i) above, after a packet that is to be transmitted has been buffered in the respective ring buffer, the network communications manager **40** retrieves the packet, packages it into a message and enables the network interface **41** to transmit the message over the network **12**. If the control module **42** receives control information from the user interface module **13** (if the master device **21** is also the audio information channel device **23** for the synchrony group **20**) or from the master device (if the master device **21** is not the audio information channel device **23** for the synchrony group **20**) that would require the transmission of a "resynchronize" command as described above, the control module **42** of the audio information channel device **23** enables the network communications manager **40** to insert the command into a message containing the audio and playback timing information. Details of the operations performed in connection with the "resynchronize" command will be described below. As noted above, the "resynchronize" command is used if the user enables a synchrony group to terminate the playback of a track that is currently being played, or cancel playback of a track whose playback has not begun.

On the other hand, with reference to item (ii) above, if network interface **41** receives a message containing a packet containing frames of audio and playback timing information that the zone player **11**(*n*) is to play either as a master device **21** or a slave device for a synchrony group **20**, the network interface **41** provides the audio and playback timing information to the network communications manager **40**. The network communications manager **40** will determine whether the packet contains a resynchronize command and, if so, notify the control module **42**, which will enable operations to be performed as described below. In any case, the network communications manager **40** will normally buffer the various frames comprising the audio and playback timing information in the audio information buffer **31**, and in that operation will generally operate as described above in connection with the audio information source interface **30**. Before buffering them, however, the network communications manager **40** will update their time stamps using the time differential value described above. It will be appreciated that the network communications manager **40** will perform similar operations whether the messages that contain the packets were multicast messages or unicast messages as described above

The updating of the time stamps by the master device **21** and the slave devices **22**(*g*) in the synchrony group **20** will ensure that they all play the audio information synchronously. In particular, after the network communications manager **40** has received a frame **51**(*f*) from the network interface **41**, it will also obtain, from the digital to analog converter clock **34**, the zone player **11**(*n*)'s current time as indicated by its digital to analog converter clock **34**. The network communications manager **40** will determine a time differential value that is the difference between the slave device's current clock time, as indicated by its digital to analog converter **34**, and the audio information channel device's time as indicated by the audio information channel device's clock timing information. Accordingly, if the master or slave device's current time has a value T_S and the audio information channel device's current time, as indicated by the clock timing information, has a value T_C, the time differential value $\Delta T = T_S - T_C$. If the current time of the master or slave device in the synchrony group **20**, as indicated by its digital to analog converter clock **34**, is ahead of the audio information channel device's clock time as indicated by the clock timing information received during the SNTP operation, the time differential value will have a positive value. On the other hand, if the master or slave device's current time is behind the audio information channel device's clock time, the time differential value ΔT will have a negative value. If the zone player **11**(*n*) obtains clock timing information from the audio information channel device **23** periodically while it is a member of the synchrony group **20**, the network communications manager **40** can generate an updated value for the time differential value ΔT when it receives the clock timing information from the audio information channel device **23**, and will subsequently use the updated time differential value.

The network communications manager **40** uses the time differential value ΔT that it generates from the audio information channel device timing information and zone player **11**(*n*)'s current time to update the time stamps that will be associated with the digital audio information frames that the zone player **11**(*n*) receives from the audio information channel device. For each digital audio information frame that is received from the audio information channel device, instead of storing the time stamp that is associated with the frame as received in the message in the audio information buffer **21**, the network communications manager **40** will store the updated time stamp with the digital audio information frame. The updated time stamp is generated in a manner so that, when the zone player **11**(*n*), as a member of the synchrony group plays back the digital audio information frame, it will do so in synchrony with other devices in the synchrony group.

More specifically, after the zone player **11**(*n*)'s network interface **41** receives a message containing a packet that, in turn, contains one or more frames **51**(*f*), it will provide the packet to the network communications manager **40**. For each frame **51**(*f*) in the packet that the network communications manager **40** receives from the network interface **41**, the network communications manager **40** will add the time differential value ΔT to the frame's time stamp, to generate the updated time stamp for the frame **51**(*f*), and store the frame **51**(*f*), along with the header **55**(*f*) with the updated time stamp in the audio information buffer **31**. Thus, for example, if a frame's time stamp has a time value T_F, the network communications manager **40** will generate an updated time stamp T^U_F having a time value $T^U_F = T_F + \Delta T$. Since time value T^U_F according to the slave device's digital to analog converter clock **34** is simultaneous to the time value T_F according to the audio information channel device's digital to analog converter clock **34**, the zone player **11**(*n*) device will play the digital audio information frame at the time determined by the audio information channel device **23**. Since all of the members of the synchrony group **20** will perform the same operations, generating the updated time stamps T^U_F for the various frames **51**(*f*) in relation to their respective differential time values, all of the zone players **11**(*n*) in the synchrony group **20** will play them synchronously. The network communications manager **40** will generate updated time stamps T^U_F for all of the time stamps **60** in the packet, and then store the packet in the audio information buffer **31**.

It will be appreciated that, before storing a packet in the audio information buffer **21**, the network communications manager **40** can compare the updated time stamps T^U_F associated with the frames in the packet to the slave device's current time as indicated by its digital to analog converter clock **34**. If the network communications manager **40** determines the time indicated by the updated time stamps of frames **51**(*f*) in the packet are earlier than the zone player's current time, it can discard the packet instead of storing it in the audio information buffer **21**, since the zone player **11**(*n*) will not play them. That is, if the updated time stamp has a time value T^U_F that identifies a time that is earlier than the zone player's current time T_S as indicated by the zone player's digital to analog converter clock **34**, the network communications manager **40** can discard the packet.

If the zone player **11**(*n*) is operating as the master device **21** of a synchrony group **20**, when the user, through the user interface module **13**, notifies the zone player **11**(*n*) that another zone player **11**(*n'*) is to join the synchrony group **20** as a slave device **22**(*g*), the control module **42** of the zone player **11**(*n*) enables the network communications manager **40** to engage in an exchange of messages, described above in connection with FIG. **2**, to enable the other zone player **11**(*n'*) to join the synchrony group **20** as a slave device. As noted above, during the message exchange, the messages generated by the network communications manager **40** of the zone player **11**(*n*) will provide the network communications manager of the zone player **11**(*n'*) that is to join the synchrony group **20** with information such as the multi-cast address being used by the audio information channel device **23** that is providing the audio program to the synchrony group **20**, as well as a unicast network address for the audio information channel device **23**. After receiving that information, the network communications manager and network interface of the zone player **11**(*n'*) that is to join the synchrony group **20** can begin receiving the multi-cast messages containing the audio program for the synchrony group, engage in SNTP transactions with the audio information channel device **23** to obtain the latter's current time, and also enable the audio information channel device **23** to send the zone player **11**(*n'*) frames **51**(*f*) that it had previously broadcast using the unicast message transmission methodology as described above.

On the other hand, if the network communications manager **40** and network interface **41** of the zone player **11**(*n*) receive a message over the network **12** indicating that it is to become a slave device **22**(*g*) of a synchrony group for which another zone player **11**(*n'*) is the master device, the network communications manager **40** for zone player **11**(*n*) will provide a notification to the control module **42** of zone player **11**(*n*). Thereafter, the control module **42** of zone player **11**(*n*) can enable the network communications manager **40** of zone player **11**(*n*) to perform the operations described above to enable it to join the synchrony group **20**.

As noted above, the user, using user interface module **13**, can enable the synchrony group to terminate playback of a track of an audio program that is currently being played. After playback of a track that is currently being played has been terminated, playback will continue in a conventional manner with the next track that has been buffered in the audio information buffer **31**. It will be appreciated that that could be the next track that is on the original play list, or a previous track. In addition, the user can enable the synchrony group **20** to cancel playback of a track that it has not yet begun to play, but for which buffering of packets has begun in the synchrony group **20**. Both of these operations make use of the "resynchronize" command that the master device **21** of the synchrony group **20** can enable the audio information channel device **23** to include in the multi-cast message stream that it transmits to the synchrony group **20**. Generally, in response to receipt of the resynchronize command, the members of the synchrony group **20** flush the ring buffer containing the packets that they are to play in the future. In addition, if the members of the synchrony group provide separate buffers for their respective digital to analog converters **33**, the members will also flush those buffers as well. After the audio information channel device transmits a packet containing the resynchronize command:

(i) in the case of the use of the resynchronize command to terminate playing of a track that is currently being played, the audio information channel device **23** will begin multi-casting packets for the next track, to begin play immediately, and will continue through the play list in the manner described above; and

(ii) in the case of the use of the resynchronize command to cancel play of a track for which buffering has begun, but which is to be played in the future, the audio information channel device **23** will begin multi-casting packets for the track after the track that has been cancelled, to be played beginning at the time the cancelled track was to begin play, and will also continue through the play list in the manner described above.

It will be appreciated that,

(a) in the first case (item (i) directly above), the resynchronize command can enable the read pointer to be set to point to the entry in the circular buffer into which the first packet for the next track will be written, which will correspond to the entry to which the write pointer points, but

(b) in the second case (item (ii) directly above), the resynchronize command can enable the write pointer for the circular buffer to be set to point to the entry that contains the first packet for the track whose play is being cancelled.

It will further be appreciated that, if a track is cancelled for which buffering has not begun, the resynchronize command will generally not be necessary, since the audio information channel device **23** for the synchrony group **20** need only delete that track from the play list.

Operations performed in connection with use of the resynchronize command to cancel playback of a track that is currently being played will be described in connection with Packet Sequence A below, and operations performed in connection with the use of the resynchronize command to cancel playback of a track that is has not yet begun to play, but for which buffering of packets has begun, will be described in connection with Packet Sequence B below.

Packet Sequence A

(A1.0) [packet **57**]
(A1.1 [continuation of frame **99**]
(A1.2) [frame **100**, time=0:00:01, type=mp3 audio]
(A1.3) [frame **101**, time=0:00:02, type=mp3 audio]
(A1.4) [frame **102**, time=0:00:03, type=mp3 audio]
(A2.0) [packet **58**]
(A2.1) [continuation of frame **102**]
(A2.2) [frame **103**, time=0:00:04, type=mp3 audio]
(A2.3) [frame **104**, time=0:00:05, type=mp3 audio]
(A2.4) [frame **105**, time=0:00:06, type=mp3 audio]
(A3.0) [packet **59**]
(A3.1) [continuation of frame **105**]
(A3.2) [frame **106**, time=0:00:07, type=mp3 audio]
(A3.3) [frame **107**, time=0:00:08, type=mp3 audio]
(A3.4) [frame **108**, time=0:00:09, type=mp3 audio]
(A4.0) [packet **60**]
(A4.1) [continuation of frame **108**]
(A4.2) [frame **109**, time=0:00:10, type=mp3 audio]
(A4.3) [Resynchronize command]
(A4.4) [Padding, if necessary]
(A5.0) [packet **61**]
(A5.1) [frame **1**, time=0:00:07, type=mp3 audio]
(A5.2) [frame **2**, time=0:00:08, type=mp3 audio]
(A5.3) [frame **3**, time=0:00:09, type=mp3 audio]
(A5.4) [frame **4**, time=0.00.10, type=mp3 audio]
(A6.0) [packet **62**]
(A6.1) [continuation of frame **4**]
(A6.2) [frame **5**, time=0:00:11, type=mp3 audio]
(A6.3) [frame **6**, time=0:00:12, type=mp3 audio]
(A6.4) [frame **7**, time=0:00:13, type=mp3 audio]

Packet Sequence A comprises a sequence of six packets, identified by packet **57** through packet **62**, that the audio information channel device **23** multi-casts in respective messages to the members of a synchrony group **20**. It will be appreciated that the series of messages that the audio information channel device **23** may multi-cast to the synchrony group **20** may include a messages prior to the packet **57**, and may also include messages after packet **62**. Each packet comprises a packet header, which is symbolized by lines (A1.0), (A2.0), . . . (A6.0) in Packet Sequence A, and will generally also include information associated with at least a portion of a frame. In the packets represented in Packet Sequence A, each packet includes information associated with a plurality of frames. Depending on the lengths of the packets, each packet may contain information associated with a portion of a frame, an entire frame, or multiple frames. In the illustration represented by Packet Sequence A, it is assumed that each packet may contain information associated with multiple frames. In addition, it is assumed that a packet does not necessarily contain information associated with an integral number of frames; in that case, a packet may contain information associated with a portion of a frame, and the next packet will contain the information associated with the rest of a frame.

The frames and associated header playback timing information contained in the various packets are symbolized by lines (A1.1), (A1.2), . . . , (A1.4), (A2.1), . . . (A6.4) of Packet Sequence A. Thus, for example, line (A1.2) of packet **57** represents the one-hundredth frame, that is, frame **51**(**100**) (reference FIG. **4**), of the track whose audio information is being transmitted in the sequence of packets that includes packet **57**. The frame **51**(**100**) is to be played at an illustrative time, according to the audio information channel device's digital to analog converter clock, of "time=0:00:01," and the frame is encoded and/or compressed using the well-known MP3 encoding and compression methodology. In that case, the legend"time=0:00:01" represents the time stamp that would be included in field **60** (FIG. **4**) of the header associated with the frame **50**(**100**) as multi-cast by the audio information channel device for the synchrony group. It will be appreciated that the playback time and encoding/compression methodology will be referred in the header **55**(**100**) that is associated with the frame **51**(**100**). It will also be appreciated that the header may also contain additional information as described above.

Similarly, line (A1.3) of packet **57** represents the one-hundred and first frame, that is, frame **51**(**101**), of the track whose audio information is being transmitted in the sequence of packets that includes packet **57**. The frame **51**(**101**) is to be played at an illustrative time, according to the audio information channel device's digital to analog converter clock, of "0:00:02," and the frame is also encoded and/or compressed using the MP3 encoding and compression methodology. Line (A1.4) of packet **57** represents similar information, although it will be appreciated that, depending on the length of packet **57**, the line may not represent the information for an entire frame **51**(**102**) and/or its associated header. If the length of packet **57** is not sufficient to accommodate the information for the entire frame **51**(**102**) and/or associated header, the information will continue in packet **58**, as represented by line (A2.1) in Packet Sequence A. Similarly, if the length of packet **56** was not sufficient to contain the information for an entire frame **51**(**99**) preceding frame **51**(**100**), packet **57** (lines (A1.0) through 1.4) may contain any information from frame **51**(**99**) that packet **56** was unable to accommodate.

As noted above, when the master device **21** or a slave device **22**(*g*) in the synchrony group **20** receives the packet **57**, its respective network communications manager **40** will update the time stamps associated with the various frames **51**(*f*) as described above before buffering the respective frames in the respective audio information buffer **31**.

Packets **58** and **59** contain information that is organized along the lines described above in connection with packet **57**.

Packet **60** also contains, as represented by lines (A4.1) and (A4.2), information that is organized along the lines of the information represented by lines (Ax.1) and (Ax.2) ("x" equals an integer) described above in connection with packets **57** through **59**. On the other hand, packet **60** contains a resynchronize command, as represented by line (A4.3). Packet **60** also may contain padding, as represented by line 4.4, following the resynchronize command. As noted above, the master device **21** of a synchrony group **20** will enable the audio information channel device **23** that is providing audio information to the synchrony group **20** to multi-cast a message containing the resynchronize command when it receives notification from the user interface module **13** that the user wishes to cancel playback of a track that is currently being played. In the example depicted in Packet Sequence A, as will be described below, the audio information channel device **23** receives notification from the master device **21** that the user wishes to cancel playback of a track at a time corresponding to "time=0:00:07" according to its digital to analog converter clock **34**, and, in line (A4.3) of packet **60** it will provide the resynchronize command, followed by padding, if necessary.

As will be apparent from examining lines (A3.1) through (A3.4) of packet **59** and lines (A4.1) and (A4.2) of packet **60**, although the audio information channel device **23** has received the notification from the synchrony group's master device **21** to multi-cast the resynchronize command at a time corresponding to "time=0:00:07" according to the clock time indicated by its digital to analog converter clock **34**, it (that is, the audio information channel device **23**) has already multi-cast messages containing frames that are to be played at that time and subsequently. That is, the audio information channel device **23** has, multi-cast in packet **59**, frames **51**(**106**) through **51**(**108**) that contain time stamps "time=0:00:07," "time=0:00:08" and "time=0:00:09," respectively, and, in packet **60**, in addition to the continuation of frame **51**(**108**), frame **51**(**109**) that contains time stamp "time=0:00:10." (It will be appreciated that the times indicated by the illustrative time stamps are for illustration purposes only, and that in an actual embodiment the time stamps may have different values and differentials.)

As noted above, the audio information channel device **23** multi-casts a message containing a packet that, in turn, contains the resynchronize command when it receives the notification from the master device **21** to do so. In the example depicted in Packet Sequence A, the packet will be multi-cast when the audio information channel device's digital to analog converter clock time corresponds to "0:00:07." Subsequently, two things happen. In one, aspect, when the master device **21** and slave devices **22**(*g*) receive the packet that contains the resynchronize command, they will stop playing the audio program that they are playing.

In addition, the audio information channel device **23** will begin transmitting frames containing audio information for the next track, including therewith time stamps immediately following the digital to analog converter clock time at which the packet including the resynchronize command was transmitted. Accordingly, and with further reference to Packet Sequence A, the audio information channel device **23** will multi-cast a message containing packet **61**. As indicated above, packet **61** contains, as represented in lines (A5.1) through (A5.3), frames **51**(**1**) through **51**(**3**), which are the first three frames of the next track of the audio program that is to be played. It is also compressed and encoded using the MP3 encoding and compression scheme, and it is accompanied by time stamps "time=0:00:07," "time=0:00:08" and "time=0:00:10." As noted above, the time stamp "time=0:00:07" corresponds to the clock time at which the audio information channel device **23** multi-casts the resynchronize command, and, when the master device **21** and slave devices **22**(*g*) receive these frames, they would be expected to begin playing them very shortly, if not immediately after the audio information channel device **23** multi-casts the message containing the packet that, in turn, contains the resynchronize command. Packet **61** also includes at least a portion of the next frame, that is, frame **51**(**4**), for that track. In addition, Packet Sequence A depicted above further includes a subsequent packet, namely, packet **62**, that contains any necessary continuation of frame **51**(**4**), as well as three subsequent frames. If any additional packets are required for the track, as well as for subsequent tracks, they can be multi-cast in a similar manner.

As further noted above, the resynchronize command can also be used to cancel playing of one or more tracks for which playback has begun. This will be illustrated in connection with Packet Sequence B:

Packet Sequence B
(B1.0) [packet **157**]
(B1.1) [continuation of frame **99**]
(B1.2) [frame **100**, time=0:00:01, type=mp3 audio]
(B1.3) [frame **101**, time=0:00:02, type=mp3 audio]
(B1.4) [frame **102**, time=0:00:03, type=mp3 audio]
(B2.0) [packet **158**]
(B2.1) [continuation of frame **102**]
(B2.2) [frame **103**, time=0:00:04, type=mp3 audio]
(B2.3) [frame **104**, time=0:00:05, type=mp3 audio]
(B2.4) [frame **105**, time=0:00:06, type=mp3 audio]
(B3.0) [packet **159**]
(B3.1) [continuation of frame **105**]
(B3.2) [frame **106**, time=0:00:07, type=mp3 audio]
(B3.3) [track boundary notification]
(B3.4) [Padding, if necessary]
(B4.0) [packet **160**]
(B4.1) [frame **1**, time=0:00:08, type=mp3 audio]
(B4.2) [frame **2**, time=0:00:09, type=mp3 audio]
(B4.3) [frame **3**, time=0:00:10, type=mp3 audio]
(B5.0) [packet **161**]
(B5.1) [continuation of frame **3**]
(B5.2) [frame **4**, time=0:00:11, type=mp3 audio]
(B5.3) [Resynchronize, after packet **159**]
(B5.4) [Padding, if necessary]
(B6.0) [packet **162**]
(B6.1) [frame **1**, time=0:00:08, type=mp3 audio]
(B6.2) [frame **2**, time=0:00:09, type=mp3 audio]
(B6.3) [frame **3**, time=0:00:10, type=mp3 audio].
(B6.4) [frame **4**, time=0:00:11, type=mp3 audio]
(B7.0) [packet **163**]
(B7.1) [continuation of frame **4**]
(B7.2) [frame **5**, time=0:00:12, type=mp3 audio]
(B7.3) [frame **6**, time=0:00:13, type=mp3 audio]
(B7.4) [frame **7**, time=0:00:14, type=mp3 audio]

Packet Sequence B comprises a series of seven packets, identified by packet **157** through **163**, that the audio information channel device **23** multi-casts to the members of a synchrony group **20**. As with Packet Sequence A, it will be appreciated that the series of packets that the audio information channel device **23** may multi-cast to the synchrony group **20** may include packets prior to the packet **157**, and may also include packets after packet **162**. Each packet comprises a packet header, which is symbolized by lines (B1.0), (B2.0), . . . (B7.0) in Packet Sequence B. As in Packet Sequence A, each packet will also generally include information associated with at least a portion of a frame **51**(*f*) along with its associated frame **55**(*f*). As in the packets represented in Packet Sequence A, each packet includes information associated with a plurality of frames. Depending on the lengths of the packets, each packet may contain information associated with a portion of a frame, an entire frame, or multiple frames. Further, as with Packet Sequence A, it is assumed that each packet may contain information associated with multiple frames. In addition, it is assumed that a packet does not necessarily contain information associated with an integral number of frames; in that case, a packet may contain information associated with a portion of a frame, and the next packet will contain the information associated with the rest of a frame.

The structures of the packets represented by Packet Sequence B are similar to those described above in connection with Packet Sequence A, and will not be repeated here. Generally, Packet Sequence B illustratively contains a sequence of packets that represent at least portions of three tracks that may have been selected from, for example, a play list. In particular, packets **157** through **159** represent frames from a portion of one track, packets **160** and **161** represent frames from a second track and packets **162** and **163** represent frames from a third track. The play list indicated that the first,

second and third tracks were to be played in that order. With particular reference to Packet Sequence B, it should be noted that line (B3.3) indicates that packet **159** includes an indication that that packet contains the last frame for the track, and line (B3.4) provides for padding to the end of the packet. The first frame of the next track begins in packet **160**.

In connection with the use of the resynchronize command to cancel playback of a track, at least a portion of which the audio information channel device **23** has multi-cast to the members of the synchrony group, packet **161**, in line (B5.3) represents a resynchronize command that indicates that resynchronization is to occur after packet **159**, that is, immediately after the packet that contains the last frame of the first of the three tracks represented by the packets in Packet Sequence B. It should be noted that the resynchronize command is in the packet **161**, while the resynchronization is to occur at packet **160**, that is, the synchrony group is to not play the track starting with packet **160**, but instead is to begin playing the track frames for which begin with the next packet, that is, packet **162**. As with Packet Sequence A, in Packet Sequence B the audio information channel device **23**, in packet **162** and **163**, multi-casts frames whose time stamps indicate that they are to be played when the frames that were multi-cast in packets **160** and **161** were to be played. By use of the resynchronize command and specifying a packet in this manner, the audio information channel device can cancel playback of a track for which playback has not yet begun.

It will be appreciated that the resynchronize command is generally not necessary for cancelling play back of a track that the audio information channel device **23** has not started multi-casting to the synchrony group **20**, since the audio information channel device **23** itself can re-order the play list to accommodate the cancellation.

The invention provides a number of advantages. In particular, the invention provides a network audio system in which a number of devices share information can reproduce audio information synchronously, notwithstanding the fact that packets, which may contain digital audio information, transmitted over the network to the various zone players connected thereto may have differing delays and the zone players operate with independent clocks. Moreover, although the invention has been described in connection with audio information, it will be appreciated that the invention will find utility in connection with any type of isochronous information for which synchrony among devices is desired. The system is such that synchrony groups are created and destroyed dynamically, and in such a manner as to avoid requiring a dedicated device as the master device.

It will be appreciated that a number of changes and modifications may be made to the network audio system **10** as described above. For example, although the invention has been described as providing that the audio information channel device **23** provides digital audio information to the members synchrony group **20** that has been encoded using particular types of encoding and compression methodologies, it will be appreciated that the audio information channel device **23** can provide digital audio information to various members of the synchrony group **20** that have been encoded and compressed using different types of encoding and compression methodologies, and, moreover, for which different sampling rates have been used. For example, the audio information channel device **23** may provide digital audio information to the master device **21** and slave devices **22**(**1**) through **22**(g_1) using the MP3 methodology at a specified sampling rate, the digital audio information for the same program to slave devices **22**(g_1+1) through **22**(g_2) using the WAV methodology at one specified sampling rate, and to slave devices **22**(g_2+1) through **22**(G) using the WAV methodology at another specified sampling rate. In that case, the audio information channel device **23** can specify the particular encoding and compression methodology that has been used in the encoding type field **57** associated with each frame and the sampling rate in the sampling rate field **58**. Moreover, since the encoding and compression type and sampling rate are specified for each frame, the encoding and compression type and sampling rate can be changed from frame to frame. The audio information channel device **23** may use different multicast addresses for the different encoding and compression types and sampling rates, but it will be appreciated that that would not be required.

It will be appreciated that two advantages of providing that the encoding and compression methodology and the sampling rate is provided on a frame-by-frame basis, instead of on, for example, a track-by-track basis, is that that would facilitate a slave device joining the synchrony group **20** at a frame mid-track, without requiring, for example, the master device **21** or the audio information channel device **23** to notify it of the encoding and compression methodology or the sampling rate.

Another modification is that, instead of the network communications manager **40** of a member of a synchrony group **20** generating the updated time stamp T^{U}_{F} for a digital audio information frame by adding the time differential value ΔT to the time stamp T_F associated with a frame, the network communications manager **40** may instead generate the updated time stamp T^{U}_{F} by subtracting the differential time value ΔT from the member's current time T_S as indicated by the member's digital to analog converter clock **34** at the time at which the digital audio information is received. It will be appreciated, however, that there may be variable time delays in processing of messages by the slave device's network communications manager **40**, and so it may be preferable to generate the time differential value ΔT using the time stamp T_F provided by the audio information channel device **23**.

In addition, instead of the network communications manager **40** of a member of a synchrony group generating an updated time stamp to reflect the difference between the times indicated by the member's digital to analog converter clock and the audio information channel device's digital to analog converter clock, the network communications manager **40** can generate the time differential value ΔT and provide it to the member's playback scheduler **32**. In that case, the member's network communications manager **40** can store each digital audio information frame along with the time stamp T_F as received from the master device in the audio information buffer **21**. The playback scheduler **32** can utilize the time differential value ΔT, and the time stamps T_F associated with the digital audio information frames, to determine when the respective digital audio information frames are to be played. In determining when a digital audio information frame is to be played, the playback scheduler can add the time differential value to the time stamp T_F associated with the digital audio frame, and enable the digital audio frame to be coupled to the digital to analog converter **33** when the time indicated by the sum corresponds to the current time as indicated by the slave device's digital to analog converter clock **34**. Alternatively, when the member's digital to analog converter clock **34** updates its current time T_S, the playback scheduler can generate an updated current time T'_S by subtracting the differential time value ΔT from the current time T_S, and using the updated current time T'_S to determine when to play a digital audio information frame.

As described above, the members of a synchrony group **20** periodically obtain the audio information channel device's

current time value and uses the current time value that it receives from the audio information channel device to periodically update the time differential value ΔT that it uses in updating the time stamps associated with the various frames. It will be appreciated that, if the digital to analog converter clock(s) associated with the member(s) of a synchrony group **20** are ensured to have the same rate as the digital to analog converter clock, a member need only obtain the current time value from the audio information channel device once, at the beginning of playback.

As another alternative, if the zone players are provided with digital to analog converter clock **34** whose time and rate can be set by an element such as the network communications manager **40**, when a zone player **11**(*n*) is operating as a member of a synchrony group **20**, its network communications manager **40** can use the various types of timing information that it receives from the audio information channel device **23**, including the current time information and the playback timing information indicated by the time stamps that are associated with the various frames **51**(*f*) comprising the audio and playback timing information that it receives, to adjust the synchrony group member's digital to analog converter clock's time value and/or the clock rate that it uses for playback. If the clock's time value is to be adjusted, when the synchrony group member's network communications manager **40** initially receives the current time information from the audio information channel device **23** for the synchrony group **20**, the network communications manager **40** can set the synchrony group member's digital to analog converter clock **34** to the current time value as indicated by the audio information channel device's current time information. The network communications manager **40** can set the clock **34** to the current time value indicated by the audio information channel device's current time information once, or periodically as it receives the current time information.

Alternatively or in addition, the synchrony group member's network communications manager **40** can use one or both of the current time information and/or the playback timing information in the time stamps associated with the respective frames **51**(*f*) to adjust the clock rate of the clock **34** that it uses for playback. For example, when the synchrony group member's network communications manager **40** receives a frame **51**(f_X) having a time stamp having a time value T_{f_X}, it can generate the updated time value $T^U_{f_X}=T_{f_X}+\Delta T$ as described above, and store the frame with the time stamp with the updated time value in the audio information buffer **30**. In addition, since both the number of samples in a frame and the sampling rate, which determines the rate at which the frame is to be played, are known to the network communications manager **40**, it can use that information, along with the updated time value $T^U_{F_X}$ that is to be used for frame **51**(f_X) to generate an expected updated time value $T^E_{f_{X+1}}$ that is expected for the updated time stamp of the next frame **51**(f_{X+1}). After the synchrony group member's network communications manager **40** receives the next frame **51**(f_{X+1}), it can generate the updated time value $T^U_{f_{X+1}}$ and compare that value to the expected updated time value $T^E_{f_{X+1}}$. If the two time values do not correspond, or if the difference between them is above a selected threshold level, the clock that is used by the audio information channel device **23** to generate the time stamps is advancing at a different rate than the synchrony group member's digital to analog converter clock **34**, and so the network communications manager **40** can adjust the rate of the digital to analog converter clock **34** to approach that of the clock used by the audio information channel device **23** so that the differential time value ΔT is constant. On the other hand, if the two time values do correspond, then the time differential value ΔT is constant, or the difference is below a threshold level, and the network communications manager **40** need not change the clock rate of the digital to analog converter clock **34**. It will be appreciated that, if the clock rate is to be adjusted, the rate adjustment can be fixed, or it can vary based on, for example, the difference between the updated time value $T^U_{f_{X+1}}$ and the expected updated time value $T^E_{f_{X+1}}$.

It will also be appreciated that, if no rate adjustment is performed for one frame **51**(f_{X+1}), the synchrony group member's network communications manager **40** can generate an expected updated time value $T^E_{f_{X+2}}$ that is expected for the updated time stamp of the next frame **51**(f_{X+2}) using the updated time value $T^U_{F_X}$ determined for frame **51**(f_X), along with the number of samples in a frame and the sampling rate, and compare the expected updated time value $T^E_{f_{X+2}}$ to the updated time value $T^U_{f_{X+2}}$ that it generates when it receives frame **51**(f_{X+2}). At that point, if the network communications manager **41** determines that two time values do not correspond, or if the difference between them is above a selected threshold level, it can adjust the rate of the digital to analog converter clock **34**. Similar operations can be performed if no rate adjustment is performed for several successive frames **51**(f_{X+1}), **51**(f_{X+2}), ... This will accommodate the possibility that the rate differential between the clock **34** and the clock used by the audio information channel device **23** in generating the time stamps have rates that differ by an amount sufficiently small that it cannot be detected using time stamps of two or more successive frames.

Instead or in addition to adjusting the clock rate as described above, the synchrony group member's network communications manager **40** can perform similar operations in connection with adjusting the clock rate in connection with the current time information that it receives from the audio information channel device **23**.

Furthermore, although the network audio system **10** has been described such that the master device **21** of a synchrony group **20** can, in response to control information provided thereto by a user through the user interface module **13**, provide a notification to a zone player **11**(*n*) that it is to become a member of its synchrony group **20** as a slave device **22**(*g*), it will be appreciated that the user interface module **13** can provide the notification directly to the zone player **11**(*n*) that is to become a member of the synchrony group **20**. In that case, the zone player **11**(*n*) can notify the master device **21** that it is to become a slave device **22**(*g*) in the synchrony group **20**, after which the master device **21** can provide information regarding the synchrony group **20**, including the multi-cast and unicast addresses of the audio information channel device and other information as described above.

Similarly, although the network audio system **10** has been described such that the master device **21** of a synchrony group **20** can, in response to control information provided thereto by a user through the user interface module **13**, provide a command to a slave device **22**(*g*) to enable the slave device **22**(*g*) to adjust its volume, it will be appreciated that the user interface module **13** can provide control information directly to the slave device **22**(*g*) to enable the slave device **22**(*g*) to adjust its volume.

In addition, although the network audio system **10** has been described such that each frames **51**(*f*) is associated with a frame sequence number (reference field **56**, FIG. **4**), it will be appreciated that, if the packets described above in connection with Packet Sequence A and Packet Sequence B are provided with packet sequence numbers, the frame sequence numbers need not be provided, since the packet sequence numbers can suffice for defining the frame sequencing.

Furthermore, although the network audio system **10** has been described such that the zone players **11**(*n*) are provided with an audio amplifier **35** for amplifying the analog signal provided by the respective digital to analog converters **33**, it will be appreciated that a zone player may be provided that does not itself include an audio amplifier. In that case, the analog signal may be coupled to an external amplifier for amplification as necessary before being provided to the audio reproduction device(s) **15**(*n*)(*r*). It will be appreciated that a single zone player **11**(*n*) may be provided with multiple audio amplifiers and audio reproduction device interfaces, and, if necessary, multiple digital to analog converters **33**, to provide audio programs for corresponding numbers of synchrony groups.

Similarly, although the zone players **11**(*n*) have been described such that they may be connected to one or more audio information sources, it will be appreciated that an audio information source may form part of and be integrated into a zone player **11**(*n*). For example, a zone player may include a compact disk player, cassette tape player, broadcast radio receiver, or the like, that has been integrated into it. In addition, as noted above, an individual zone player **11**(*n*) may be connected to multiple audio information sources and may contemporaneously operate as the audio information channel device **23** for multiple synchrony groups.

In addition, although FIG. **1** shows the network audio system **10** as including one user interface module **13**, it will be appreciated that the system **10** may include a plurality of user interface modules. Each user interface module be useful for controlling all of the zone players as described above, or alternatively one or more of the user interface modules may be useful for controlling selected subsets of the zone players.

Moreover, it will be appreciated that, although the invention has been described in connection with audio information, it will be appreciated that the invention will find utility in connection with any type of information for which synchrony among devices connected to a network is desired.

As noted above, while a zone player **11**(*n*) is operating as audio information channel device **23** for a synchrony group **20**, when the zone player **11**(*n*)'s audio information source interface **30** or network communications manager **40** stores digital audio information frames based on audio information from an audio information source **14**(*n*)(*s*) in the audio information buffer **31**, it will provide time stamps for the respective frames to schedule them for playback after some time delay after they have been buffered in the audio information buffer **31**. The delay is provided so that, for other zone players **11**(*n*'), **11**(*n*"), . . . that are operating as members of a synchrony group, there will be sufficient time for the audio and playback timing information to be transferred over the network **12** to those other zone players **11**(*n*'), **11**(*n*"), . . . so that it can be processed and played by them at the appropriate time as described above. The time period that is selected for the time delay may be fixed or variable, and in either case may be based on a number of factors. If the time period selected for the time delay is fixed, it may be based on, for example, factors such as an estimate of the maximum latency in the network **12**, the estimated maximum loading of the various components comprising the zone players **11**(*n*), and other estimates as will be appreciated by those skilled in the art.

The time delay may be the same for audio information from all types of audio information sources, and may be constant over the entire period that the synchrony group **20** is playing an audio work. Alternatively, different time delays may be utilized based on various criteria. For example, if the audio information is to be played independently of information associated with other types of media, the time delay may be selected to be relatively long, on the order of a significant fraction of a second, or longer. On the other hand, if the audio information is to be played contemporaneously with, for example, video information, which may be supplied by, for example, a video disk, video tape cassette, over cable, satellite, or broadcast television, which may not be buffered or which may be displayed independently of the network audio system **10**, it may be undesirable to provide for such a lengthy delay, since the time delay of the audio playback, in relation to the video display, may be noticeable. In that case, the zone player **11**(*n*) may provide for a much shorter time delay. In one embodiment, the time delay provided for audio information to be played concurrently with video information is selected to be generally on the order of fifty milliseconds, which would barely, if at all, be perceptible to someone viewing the video. Other desirable time delays for information from other types of sources will be apparent to those skilled in the art.

As yet a further possibility, the zone player **11**(*n*), when operating as an audio information channel device **23** for a synchrony group **20**, can dynamically determine the time delay based on a number of conditions in the network audio system **10**, including, for example, the message transfer latency in network **12**, the loading of microprocessors or other components that are used in the various zone players **11**(*n*'), **11**(*n*"), . . . that may comprise a synchrony group **20**, as well as other factors. For example, if the audio information channel device **23** determines that the latency in the network **12** has increased beyond a selected threshold, the audio information channel device **23** can adjust the delay to increase the likelihood that the members of the synchrony group **20** will be able to receive the packets and process the frames so that they will be able to play them at the appropriate times. Similarly, if the audio information channel device **23** is notified that a member of the synchrony group **20** to which it provides audio information requires additional time to receive and process the frames that it transmits, the audio information channel device **23** can adjust the delay accordingly. It will be appreciated that, to reduce or minimize possible discontinuities in the audio playback by the members of the synchrony group, the audio information channel device **23** can, instead of adjusting the time delay during a particular audio track, adjust the time delay between tracks, during silent periods of a track or otherwise as will be appreciated by those skilled in the art. In addition, the audio information channel device **23** can use conventional audio compression methodologies to facilitate a speeding up and/or slowing down of playback of an audio track while it is in the process of providing additional time delay. Generally, the members of the synchrony group **20** can provide notifications to the audio information channel device **23** if they determine that they will need an additional time delay, and the audio information channel device **23** can adjust the time delay in accordance with the notifications from the members of the synchrony group **20**.

It will be appreciated that a system in accordance with the invention can be constructed in whole or in part from special purpose hardware or a general purpose computer system, or any combination thereof, any portion of which may be controlled by a suitable program. Any program may in whole or in part comprise part of or be stored on the system in a conventional manner, or it may in whole or in part be provided in to the system over a network or other mechanism for transferring information in a conventional manner. In addition, it will be appreciated that the system may be operated and/or otherwise controlled by means of information provided by an operator using operator input elements (not shown) which may be connected directly to the system or

which may transfer the information to the system over a network or other mechanism for transferring information in a conventional manner.

The foregoing description has been limited to a specific embodiment of this invention. It will be apparent, however, that various variations and modifications may be made to the invention, with the attainment of some or all of the advantages of the invention. It is the object of the appended claims to cover these and such other variations and modifications as come within the true spirit and scope of the invention.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. In a system comprising a plurality of controllers that are communicatively coupled via at least a local area network (LAN) with a plurality of zone players including a first zone player and a second zone player, a method comprising:

receiving, at the first zone player, control information from any one of the plurality of controllers via the LAN, wherein the received control information comprises a direction that instructs the first zone player to enter into a synchrony group with at least the second zone player;

in response to the direction, the first zone player entering into the synchrony group with the second zone player, wherein in the synchrony group, the first and second zone players are configured to play back audio in synchrony based at least in part on (i) audio content, (ii) playback timing information associated with the audio content that is generated by one of the first or second zone players, and (iii) clock time information for the one of the first or second zone players, and wherein the generated playback timing information and the clock time information are transmitted from the one of the first or second zone players to the other of the first or second zone players, wherein the first and second zone players remain independently clocked while playing back audio in synchrony; and

transmitting, by the first zone player to at least one of the plurality of controllers via the LAN, status information, wherein the status information comprises an indication of a status of the synchrony group.

2. The method of claim **1**, wherein the status information further comprises one or both of (a) an identification of a track currently being played by the synchrony group and (b) an identification of tracks scheduled to be played by the synchrony group.

3. The method of claim **2**, wherein the identification of a track currently being played by the synchrony group further comprises a name of the track currently being played by the synchrony group.

4. The method of claim **2**, wherein the identification of the tracks scheduled to be played by the synchrony group comprises a list of names of tracks scheduled to be played by the synchrony group.

5. The method of claim **1**, wherein the status information further comprises one or both of (a) an identification of a zone player that is operating as a master device of the synchrony group and (b) an identification of at least one zone player that is operating as a slave device of the synchrony group.

6. The method of claim **1**, wherein the first zone player comprises a master device of the synchrony group.

7. The method of claim **1**, further comprising:

the first zone player determining whether it is operating as a master device of the synchrony group, and

wherein transmitting status information to the at least one of the plurality of controllers comprises transmitting the status information to the at least one of the plurality of controllers only while the first zone player is operating as the master device of the synchrony group.

8. The method of claim **7**, further comprising:

receiving audio content via the network; and

while the first zone player is operating as the master device of the synchrony group, transmitting the received audio content to at least one zone player that is operating as a slave device of the synchrony group.

9. The method of claim **1**, wherein the first zone player comprises a device clock configured to generate clock time information for the first zone player, wherein the second zone player comprises a device clock configured to generate clock time information for the second zone player, and wherein the device clock of the first zone player operates independently of the device clock of the second zone player.

10. The method of claim **1**, wherein the first zone player is a master zone player of the synchrony group, wherein the audio content comprises a plurality of frames, wherein the playback timing information associated with the audio content comprises a playback time for each frame of the audio content, and wherein the first zone player is configured to play back audio in synchrony with the second zone player based at least in part on (i) the audio content, (ii) playback timing information associated with the audio content, wherein the playback timing information is generated by the first zone player, and (iii) clock time information for the first zone player, and wherein the generated playback timing information and the clock time information are transmitted from the first zone player to the second zone player; and

wherein the first zone player playing back audio in synchrony comprises, for each frame of the audio content, the first zone player playing back the frame when the device clock of the first zone player is the same as the playback time for the frame.

11. A system comprising:

a plurality of zone players that are communicatively coupled via at least a local area network (LAN) with a plurality of controllers, wherein:

each of the plurality of controllers is configured to provide control information to any one of the plurality of zone players via the LAN; and

each of the plurality of zone players is configured to (a) receive control information from any one of the plurality of controllers via the LAN, wherein the received control information comprises a direction for the zone player to enter into a synchrony group with at least one other zone player of the plurality of zone players, (b) in response to the direction, enter into the synchrony group with the at least one other zone player of the plurality of zone players, wherein in the synchrony group, the zone player and the at least one other zone player are configured to play back audio in synchrony based at least in part on (b-i) audio content, (b-ii) playback timing information associated with the audio content, wherein the playback timing information is generated by and transmitted from one of the zone player or the at least one other zone player to the other of the zone player or the at least one other zone player and (b-iii) clock time information for the one of the zone player or the at least one other zone player, wherein the clock time information is generated by and transmitted from the one of the zone player or the at least one other zone player to the other of the zone player or the at least one other zone player, wherein the zone players in the synchrony group remain independently clocked while playing back audio in synchrony, and (c) transmit status information to at least one of the

plurality of controllers via the LAN, wherein the status information comprises an indication of a status of the synchrony group.

12. The system of claim **11**, wherein each of the plurality of zone players is configured to transmit the status information while it is configured to operate as a master device of the synchrony group.

13. The system of claim **11**, wherein the status information further comprises one or both of (a) an identification of a track currently being played by the synchrony group and (b) an identification of tracks scheduled to be played by the synchrony group.

14. The system of claim **11**, wherein the status information further comprises one or both of (a) an identification of a zone player of the plurality of zone players that is operating as a master device of the synchrony group and (b) an identification of at least one zone player of the plurality of zone players that is operating as a slave device of the synchrony group.

15. The system of claim **11**, wherein a device clock of a first zone player is configured to generate clock time information for the first zone player, and wherein a device clock of a second zone player is configured to generate clock time information for the second zone player, and wherein the device clock of the first zone player operates independently from the device clock of the second zone player.

16. The system of claim **11**, wherein the plurality of zone players comprises a first zone player and a second zone player, wherein the first zone player is a master zone player of the synchrony group, wherein the audio content comprises a plurality of frames, wherein the playback timing information associated with the audio content comprises a playback time for each frame of the audio content, and wherein the first zone player is configured to play back audio in synchrony with the second zone player based at least in part on (i) the audio content, (ii) playback timing information associated with the audio content, wherein the playback timing information is generated by the first zone player, and (iii) clock time information for the first zone player generated by a device clock of the first zone player, and wherein the generated playback timing information and the clock time information are transmitted from the first zone player to the second zone player; and

wherein the first zone player playing back audio in synchrony comprises, for each frame of the audio content, the first zone player playing back the frame when the first zone player's device clock is the same as the playback time for the frame; and

wherein the second zone player comprises a device clock, and wherein the second zone player playing back audio in synchrony comprises determining a time differential between the first zone player's device clock and the second zone player's device clock, and for each frame of the audio content, (i) determining a playout time for the frame based on (i-a) the playback timing information received from the first zone player and (i-b) the determined time differential, and (ii) playing the frame at the determined playout time.

17. A first zone player comprising:

a network interface configured to interface the first zone player with at least a local area network (LAN);

a device clock configured to generate clock time information for the first zone player;

one or more processors; and

a tangible, non-transitory computer-readable memory having instructions stored thereon that, when executed by the one or more processors, cause the first zone player to:

receive control information from any one of a plurality of controllers over the LAN via the network interface, wherein the received control information comprises a direction for the first zone player to enter into a synchrony group with at least a second zone player;

in response to the direction, enter into the synchrony group with the second zone player, wherein in the synchrony group, the first and second zone players are configured to playback audio in synchrony based at least in part on (i) audio content, (ii) playback timing information associated with the audio content, wherein the playback timing information is generated by one of the first or second zone players, and (iii) clock time information for the one of the first or second zone players, and wherein the generated playback timing information and the clock time information are transmitted from the one of the first or second zone players to the other of the first or second zone players, wherein the first and second zone players remain independently clocked while playing back audio in synchrony; and

transmit status information to at least one of the plurality of controllers over the LAN via the network interface, wherein the status information comprises an indication of a status of the synchrony group.

18. The first zone player of claim **17**, wherein the status information further comprises one or both of (a) an identification of a track currently being played by the synchrony group and (b) an identification of tracks scheduled to be played by the synchrony group.

19. The first zone player of claim **18** wherein the identification of the track currently being played by the synchrony group comprises a name of the track currently being played by the synchrony group.

20. The first zone player of claim **18**, wherein the identification of the tracks scheduled to be played by the synchrony group comprises a list of names of tracks scheduled to be played by the synchrony group.

21. The first zone player of claim **17**, wherein the status information further comprises one or both of (a) an identification of a zone player that is operating as a master device of the synchrony group and (b) an identification of at least one zone player that is operating as a slave device of the synchrony group.

22. The first zone player of claim **17**, wherein the first zone player comprises a master device of the synchrony group.

23. The first zone player of claim **17**, wherein the tangible computer-readable memory further has instructions stored thereon that, when executed by the one or more processors, cause the first zone player to determine whether the first zone player is operating as a master device of the synchrony group, and wherein the instructions that cause the first zone player to transmit status information to the at least one of the plurality of controllers comprise instructions that cause the first zone player to transmit status information to the at least one of the plurality of controllers only while the first zone player is operating as the master device of the synchrony group.

24. The first zone player of claim **23**, wherein the tangible computer-readable memory further has instructions stored thereon that, when executed by the one or more processors, cause the first zone player to:

receive audio content via the network interface; and

while the first zone player is operating as the master device of the synchrony group, transmit the received audio content, via the network interface, to at least one zone player that is operating as a slave device of the synchrony group.

25. The first zone player of claim 17, wherein the device clock of the first zone player operates independently of a device clock of the second zone player.

26. The first zone player of claim 17, wherein the first zone player is a master zone player of the synchrony group, wherein the audio content comprises a plurality of frames, wherein the playback timing information associated with the audio content comprises a playback time for each frame of the audio content, and wherein the first zone player is configured to play back audio in synchrony with the second zone player based at least in part on (i) the audio content, (ii) playback timing information associated with the audio content, wherein the playback timing information is generated by the first zone player, and (iii) clock time information for the first zone player, and wherein the generated playback timing information and the clock time information are transmitted from the first zone player to the second zone player; and

wherein the first zone player playing back audio in synchrony comprises, for each frame of the audio content, the first zone player playing back the frame when the device clock of the first zone player is the same as the playback time for the frame.

* * * * *

US006611537B1

(12) **United States Patent**
Edens et al.

(10) **Patent No.: US 6,611,537 B1**
(45) **Date of Patent: Aug. 26, 2003**

(54) **SYNCHRONOUS NETWORK FOR DIGITAL MEDIA STREAMS**

(75) Inventors: **Glenn T. Edens**, Redwood City, CA (US); **Donald Robert Hoover**, Cupertino, CA (US); **Roger Charles Meike**, Redwood City, CA (US); **Timothy Andrew Ryan**, Menlo Park, CA (US)

(73) Assignee: **Centillium Communications, Inc.**, Fremont, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/079,914**

(22) Filed: **May 15, 1998**

Related U.S. Application Data

(60) Provisional application No. 60/050,933, filed on May 30, 1997.

(51) **Int. Cl.**[7] **H04J 3/16**; H04J 3/06

(52) **U.S. Cl.** **370/503**; 370/465

(58) **Field of Search** 370/258, 404, 370/465, 470, 503, 506, 509–510, 512

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,587,651	A	*	5/1986	Nelson et al.	370/88
4,991,172	A	*	2/1991	Cidon et al.	370/94.1
5,185,736	A	*	2/1993	Tyrrell et al.	370/55
5,206,857	A	*	4/1993	Farleigh	370/85.5
5,283,638	A	*	2/1994	Engberg et al.	348/14
5,307,459	A	*	4/1994	Petersen et al.	395/200
5,321,819	A	*	6/1994	Szczepanek	395/325
5,341,374	A		8/1994	Lewen et al.	370/85.4
5,541,957	A		7/1996	Lau	375/258
5,652,712	A	*	7/1997	Szczebak, Jr. et al.	364/571.01
5,668,811	A		9/1997	Worsley et al.	370/424
5,717,493	A	*	2/1998	Ozawa et al.	358/403
5,822,603	A	*	10/1998	Hansen et al.	395/800.01
5,872,784	A	*	2/1999	Rostoker et al.	370/395
5,907,685	A	*	5/1999	Douceur	395/200.78

FOREIGN PATENT DOCUMENTS

WO	PCT/US00/19979	7/2001	H04L/25/49

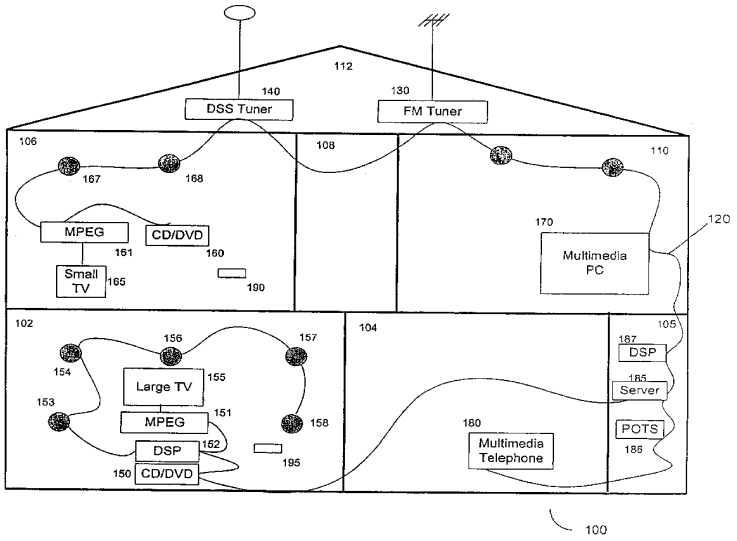
* cited by examiner

Primary Examiner—Alpus H. Hsu
Assistant Examiner—Toan Nguyen
(74) *Attorney, Agent, or Firm*—Fenwick & West LLP

(57) **ABSTRACT**

A network adapter for a synchronous logical ring network operates on existing physical twisted-pair telephone topologies. Information propagates around the logical ring, reaching every device on each revolution around the network. Network devices are full-duplex, transmitting and receiving information on every clock cycle. Network devices arbitrate to be elected the network clock device. By synchronizing all network devices to a single reference clock, and providing fixed frames of information propagating around the network at consistent time intervals, the logical ring network ensures that information propagates from one device to another at consistent time intervals. The fixed-length frames are divided into two independent streams: a data stream for the distribution of real-time continuous digital media streams; and a system command stream for the distribution of system commands.

28 Claims, 40 Drawing Sheets



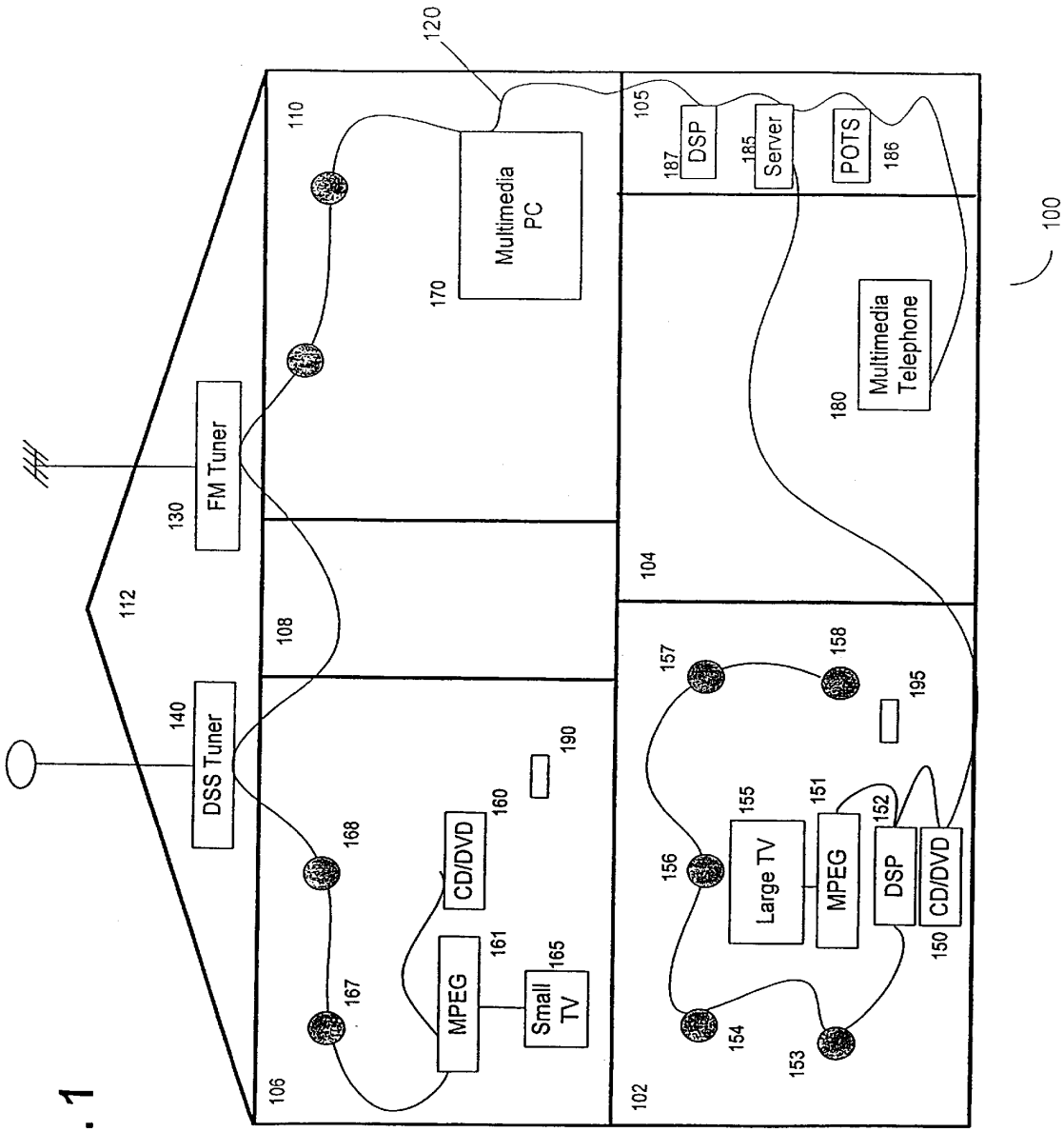

120
110
105
DSP
187
Server
185
POTS
186
Multimedia PC
170
100
FM Tuner
130
Multimedia Telephone
180
112
104
108
DSS Tuner
140
157
158
195
190
168
CD/DVD
160
155
151
152
156
Large TV
MPEG
DSP
CD/DVD
150
MPEG
161
Small TV
165
167
154
153
106
102

FIG. 1

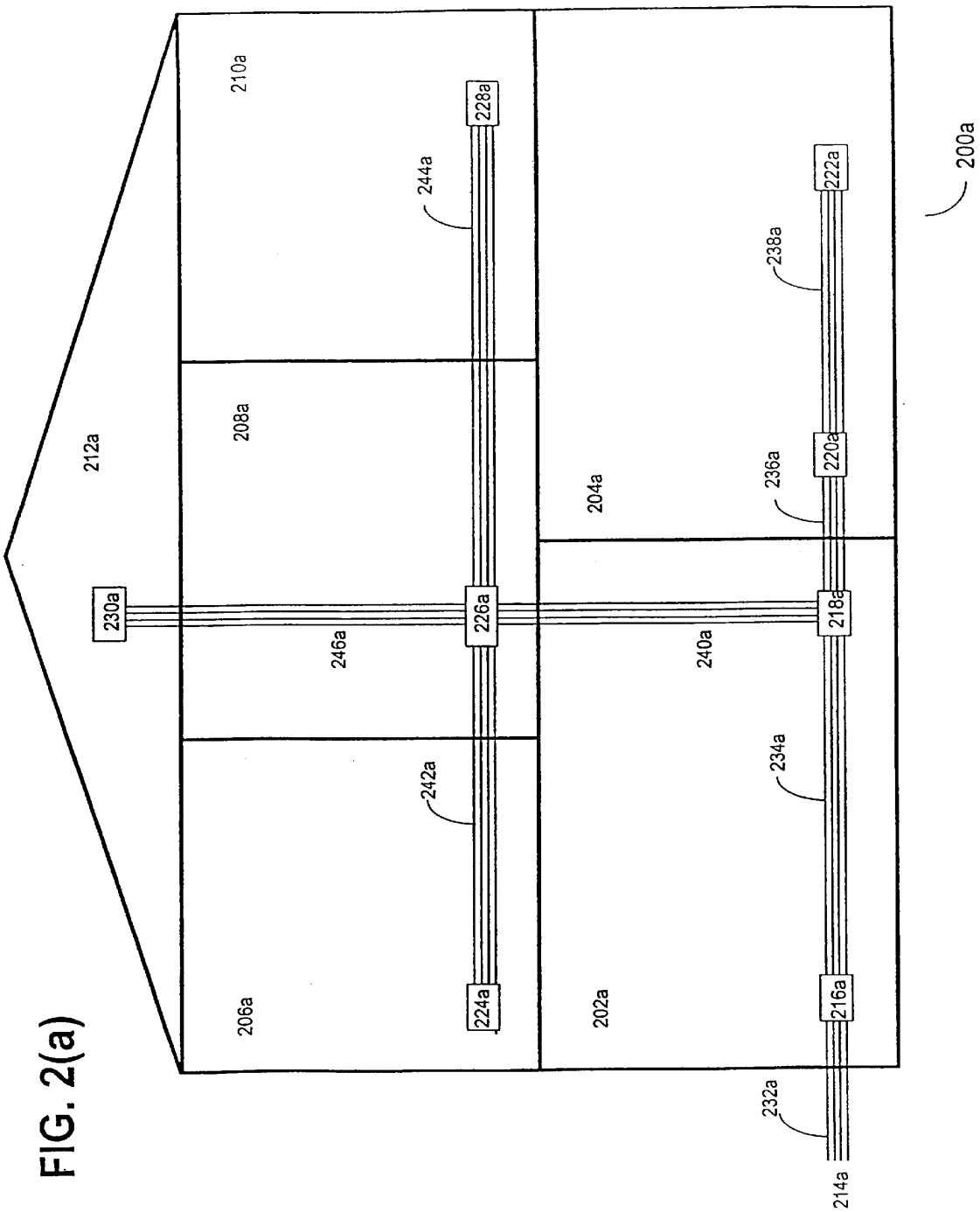

200a
210a
208a
212a
206a
204a
202a
228a
244a
222a
238a
220a
236a
230a
226a
218a
246a
240a
242a
234a
224a
216a
232a
214a

FIG. 2(a)

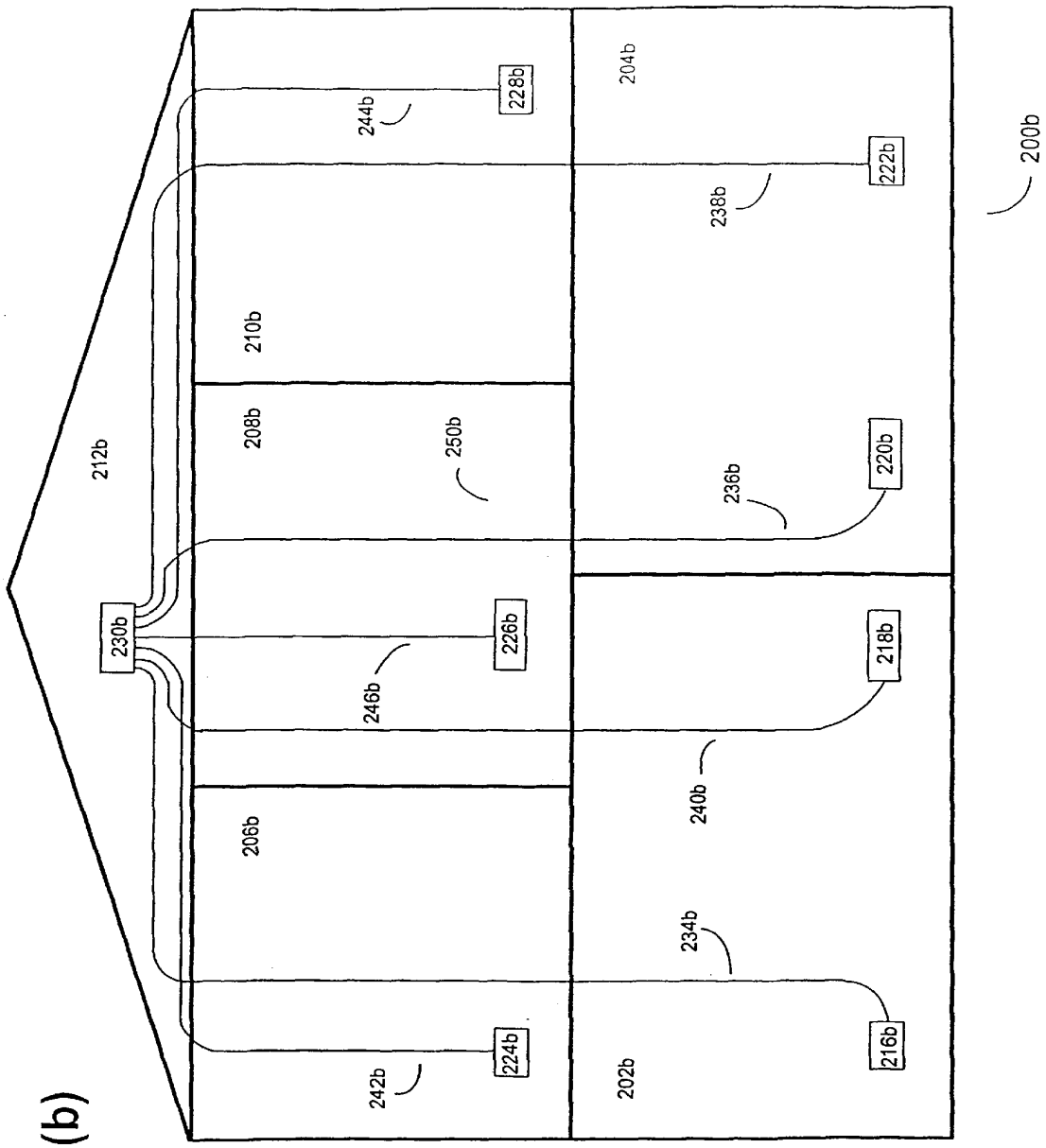

200b
202b
204b
206b
208b
210b
212b
216b
218b
220b
222b
224b
226b
228b
230b
234b
236b
238b
240b
242b
244b
246b
250b

FIG. 2(b)

FIG. 2(c)

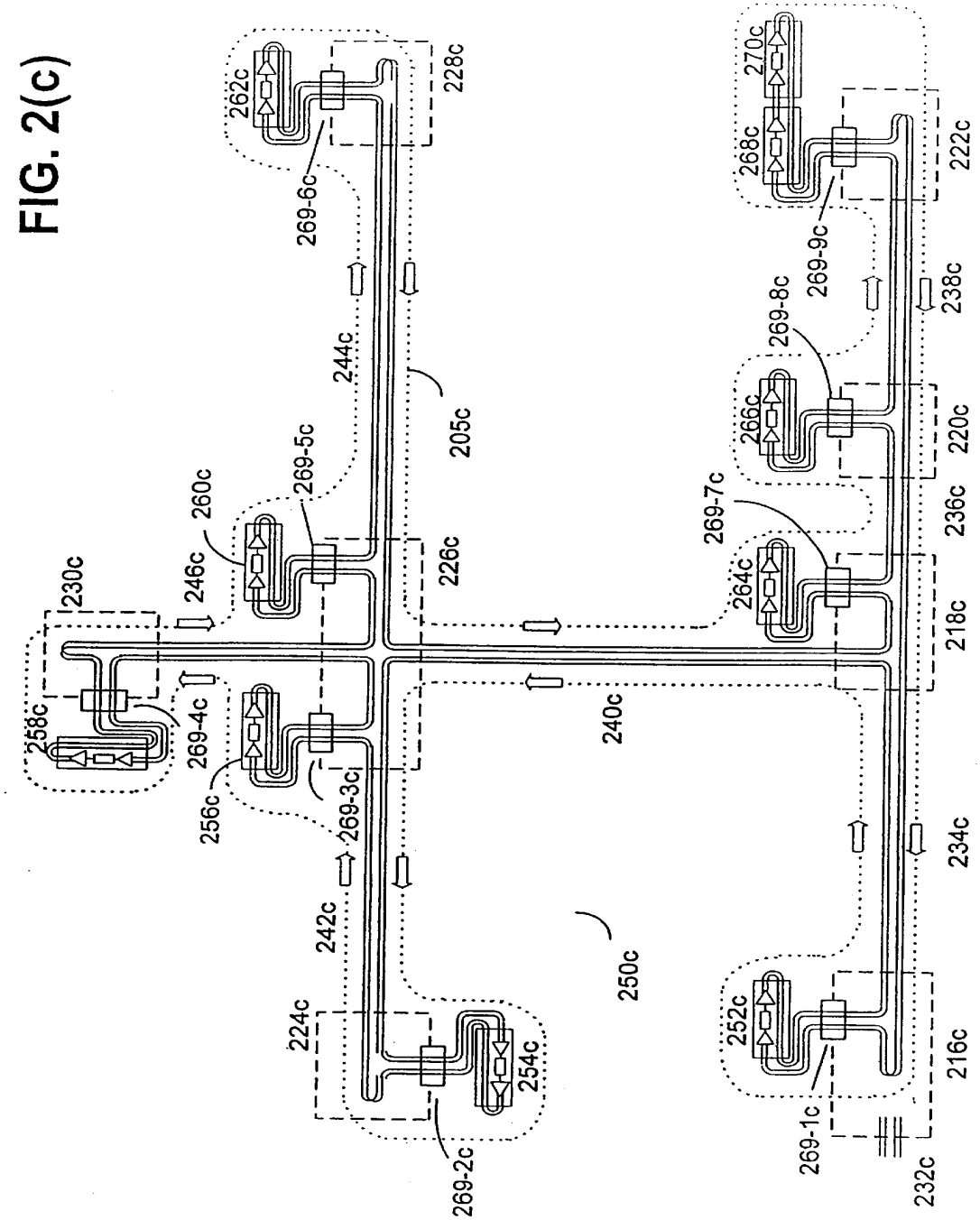

262c
228c
269-6c
244c
205c
260c
269-5c
246c
226c
230c
258c
269-4c
256c
269-3c
242c
224c
254c
269-2c
240c
250c
270c
268c
222c
269-9c
238c
269-8c
266c
220c
269-7c
236c
264c
218c
234c
252c
216c
269-1c
232c

FIG. 2(d)

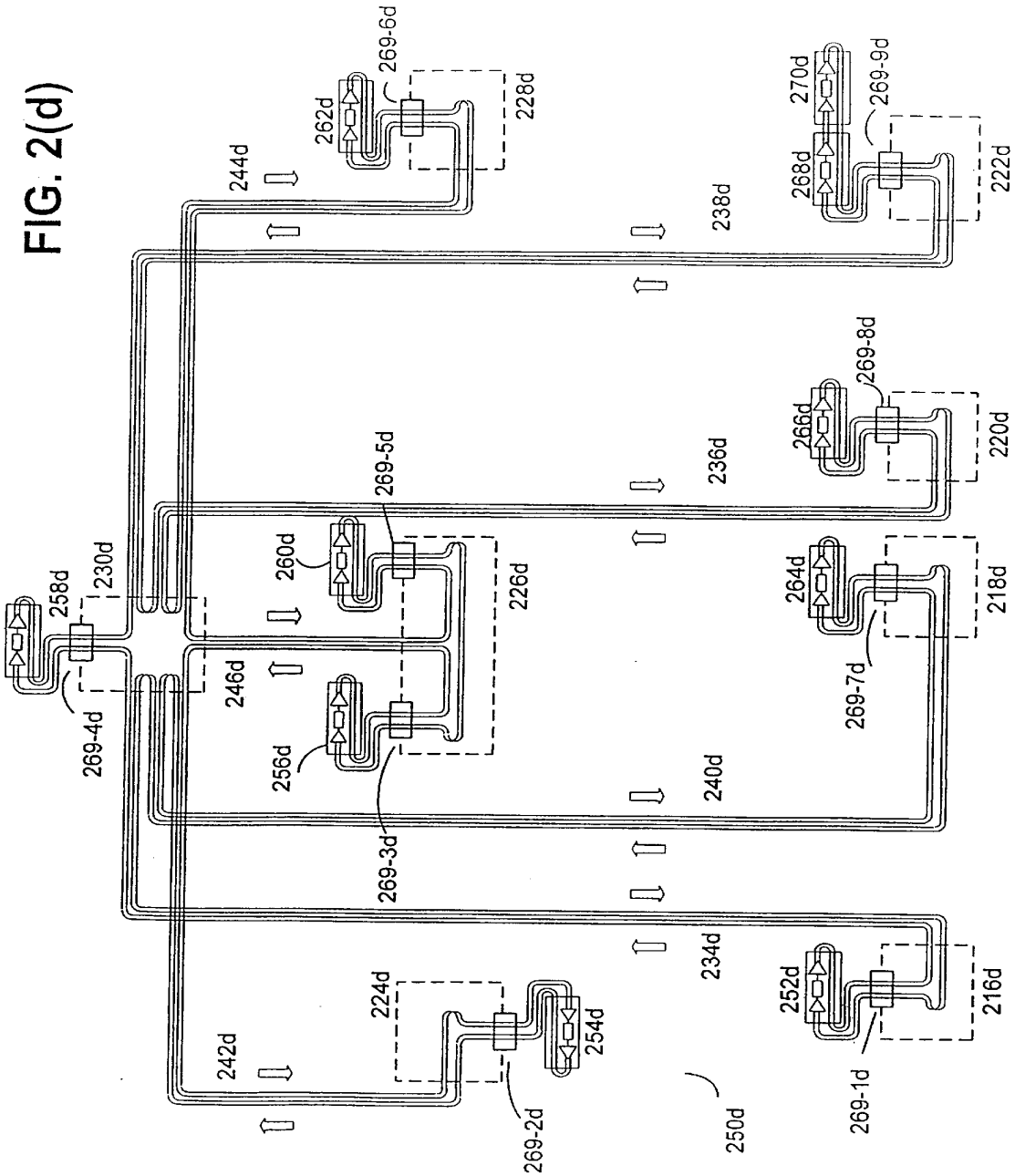

269-6d
262d
228d
244d
238d
270d
269-9d
268d
222d
269-8d
266d
220d
269-5d
260d
226d
236d
258d
230d
264d
218d
269-4d
246d
269-7d
256d
240d
269-3d
234d
224d
254d
252d
216d
242d
269-2d
250d
269-1d

FIG. 3

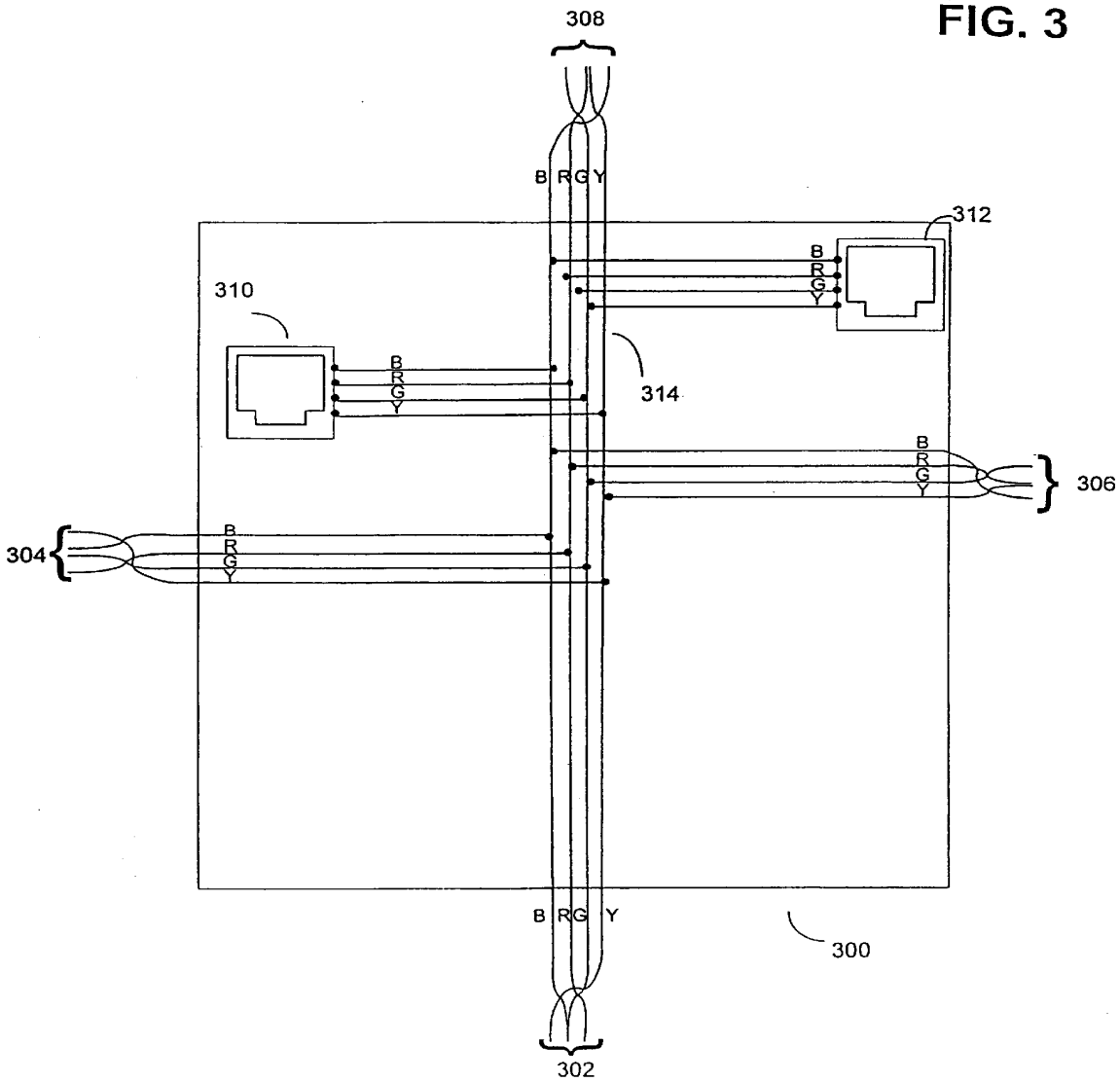


FIG. 4(a)

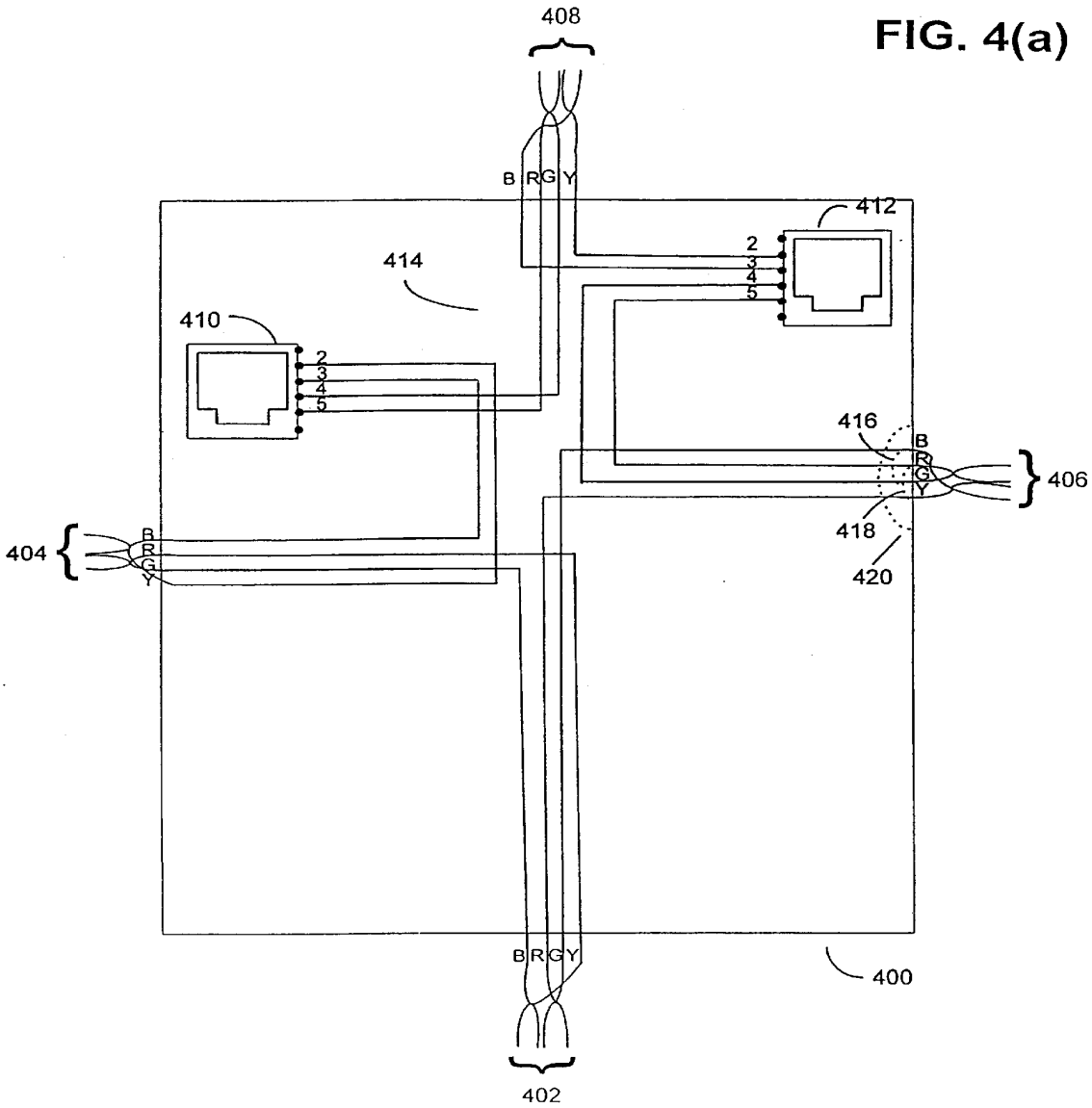
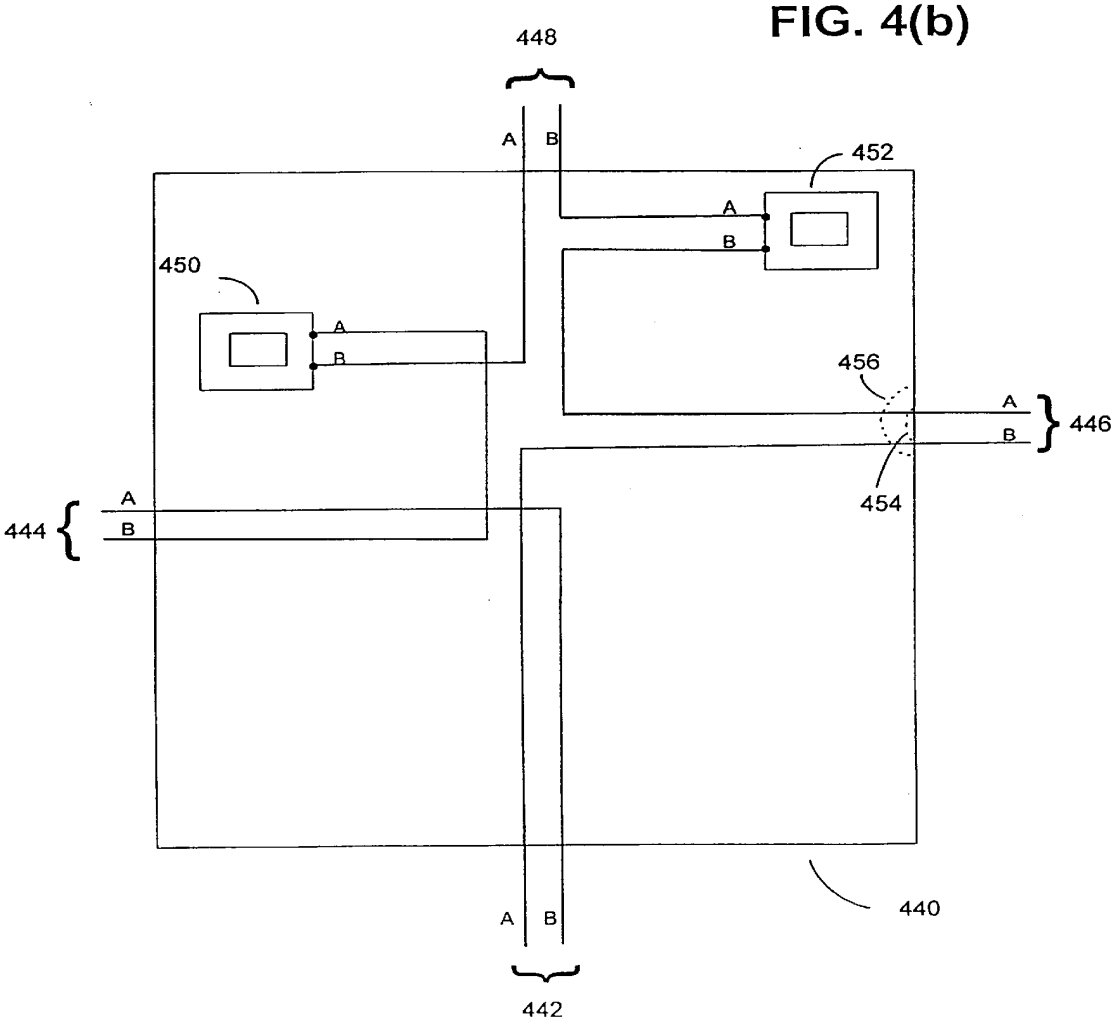

408
B R G Y
412
2
3
4
5
414
410
2
3
4
5
416
B
R
G
Y
406
418
420
404
B
R
G
Y
B R G Y
400
402

FIG. 4(b)



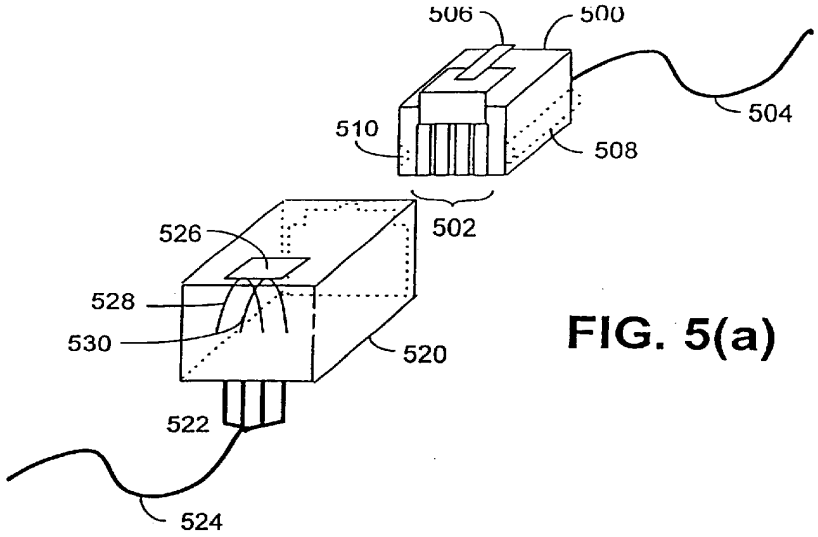


FIG. 5(a)

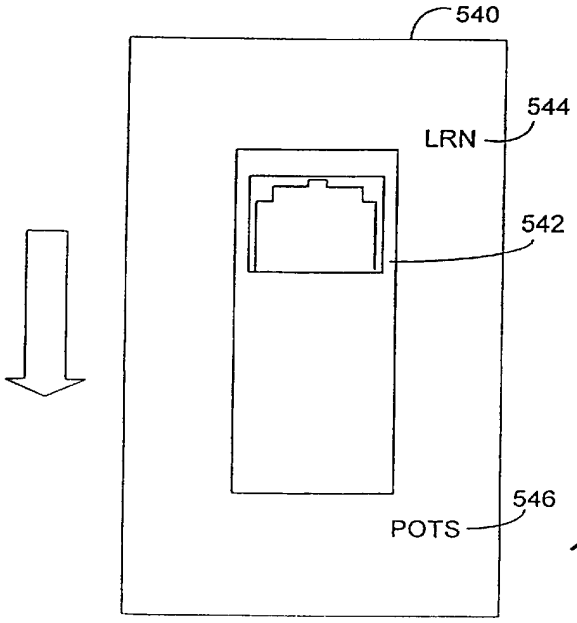


FIG. 5(b)

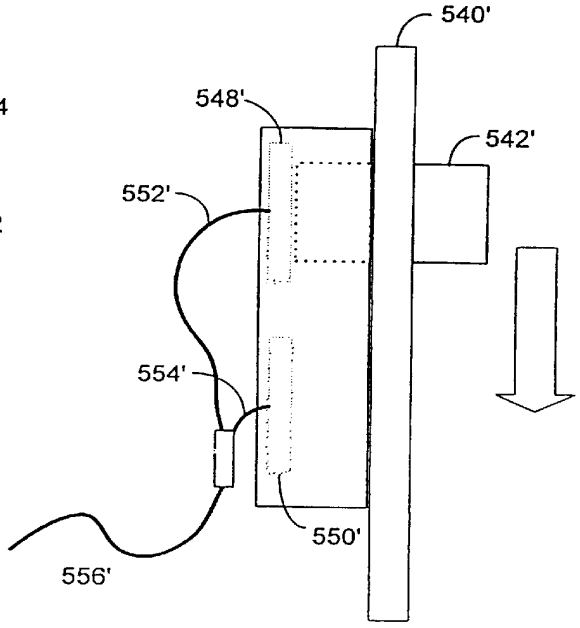


FIG. 5(c)

FIG. 6

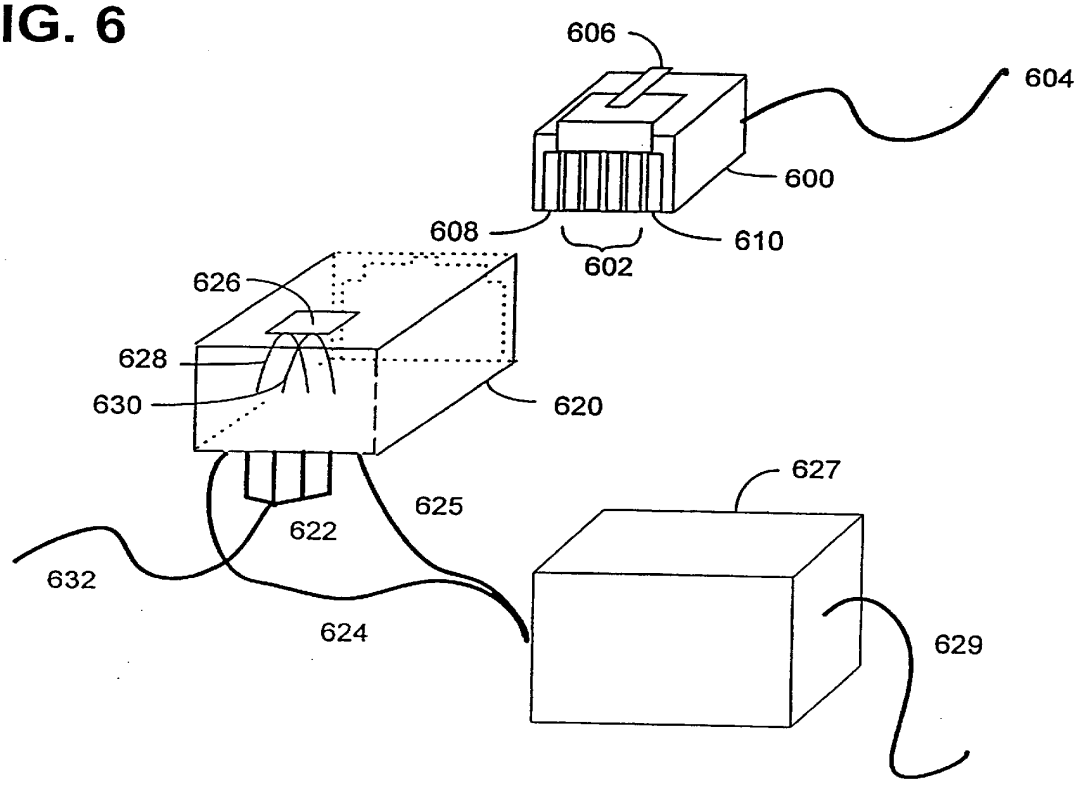
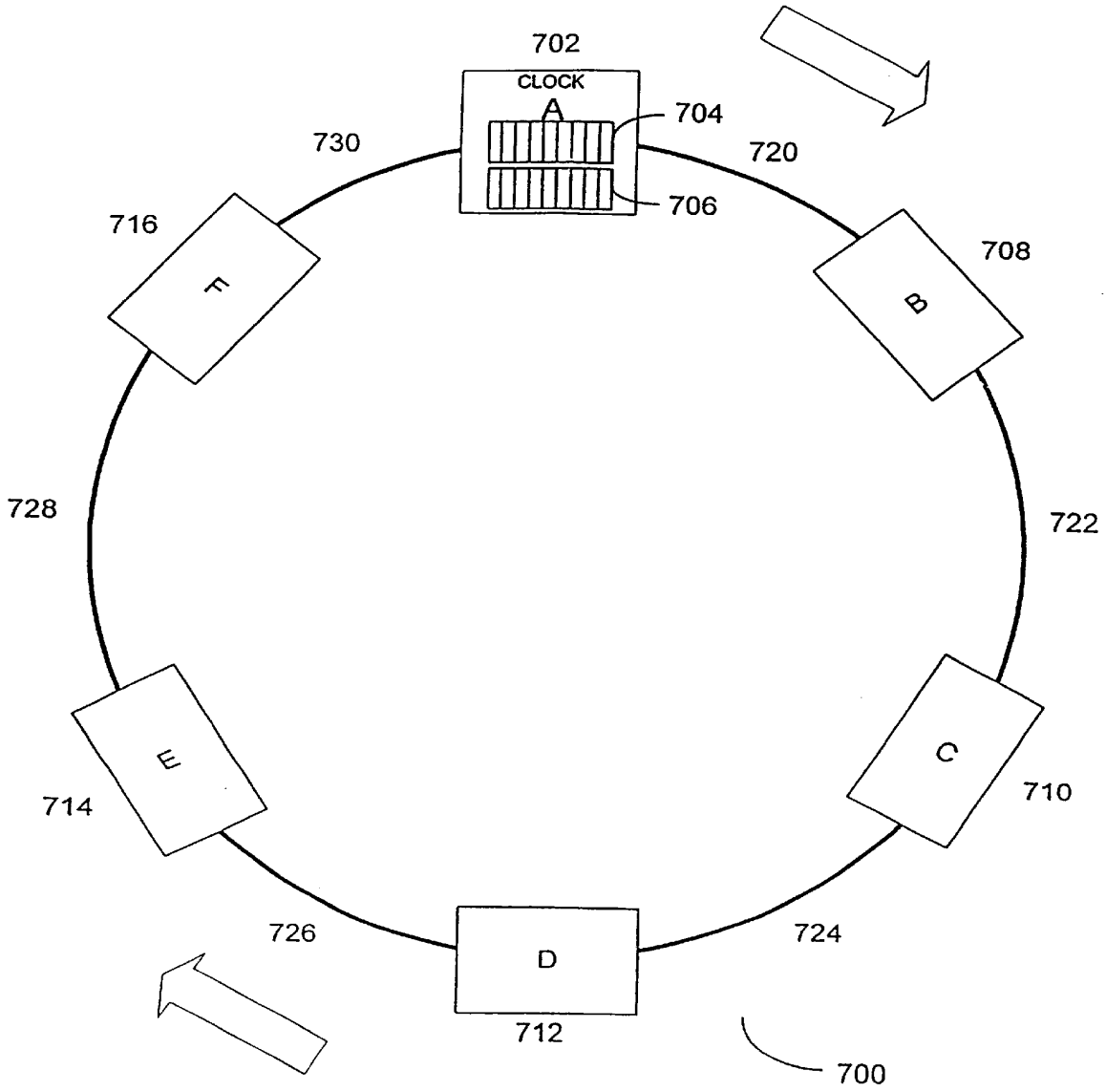


FIG. 7


702
CLOCK
A
704
706
720
730
716
F
708
B
728
722
E
714
C
710
726
724
D
712
700

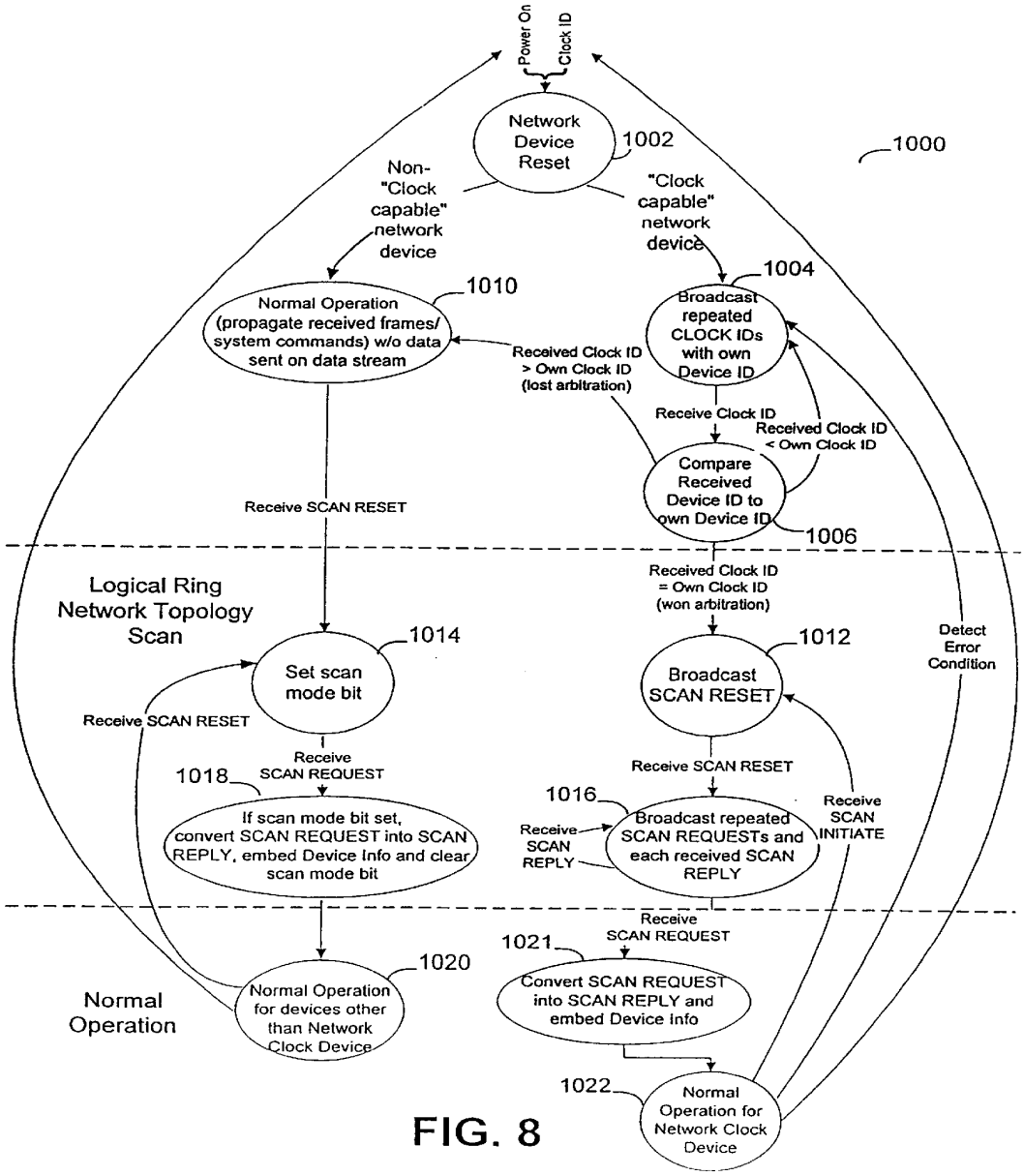

Power On
Clock ID
Network Device Reset
1002
1000
Non-"Clock capable" network device
"Clock capable" network device
1004
1010
Normal Operation (propagate received frames/ system commands) w/o data sent on data stream
Received Clock ID > Own Clock ID (lost arbitration)
Broadcast repeated CLOCK IDs with own Device ID
Receive Clock ID
Received Clock ID < Own Clock ID
Compare Received Device ID to own Device ID
1006
Receive SCAN RESET
Logical Ring Network Topology Scan
Received Clock ID = Own Clock ID (won arbitration)
1014
Set scan mode bit
1012
Broadcast SCAN RESET
Detect Error Condition
Receive SCAN RESET
Receive SCAN REQUEST
1018
If scan mode bit set, convert SCAN REQUEST into SCAN REPLY, embed Device Info and clear scan mode bit
1016
Receive SCAN REPLY
Broadcast repeated SCAN REQUESTs and each received SCAN REPLY
Receive SCAN INITIATE
Receive SCAN REQUEST
1021
Convert SCAN REQUEST into SCAN REPLY and embed Device Info
1020
Normal Operation
Normal Operation for devices other than Network Clock Device
1022
Normal Operation for Network Clock Device

FIG. 8

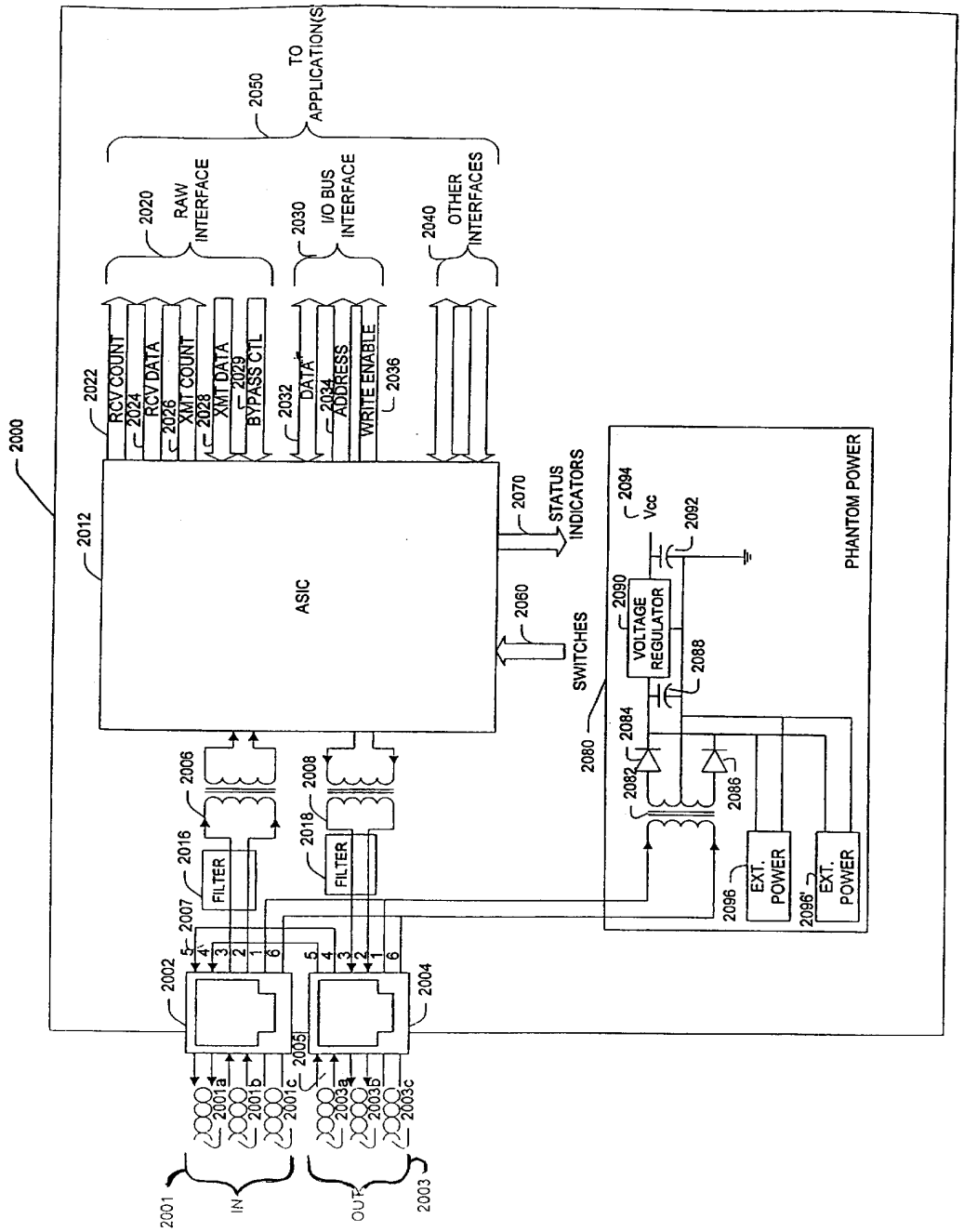

2000
2012
ASIC
2050
TO APPLICATION(S)
2020
RAW INTERFACE
2030
I/O BUS INTERFACE
2040
OTHER INTERFACES
2022
RCV COUNT
2024
RCV DATA
2026
XMT COUNT
2028
XMT DATA
2029
BYPASS CTL
2032
DATA
2034
ADDRESS
2036
WRITE ENABLE
2070
STATUS INDICATORS
2060
SWITCHES
2080
PHANTOM POWER
2084
Vcc
2092
2090
VOLTAGE REGULATOR
2088
2082
2086
2096
2096'
EXT. POWER
EXT. POWER
2006
2008
2016
2018
FILTER
FILTER
2007
2002
2004
2005
2001a
2001b
2001c
2003a
2003b
2003c
2001
IN
OUT
2003

FIG. 9

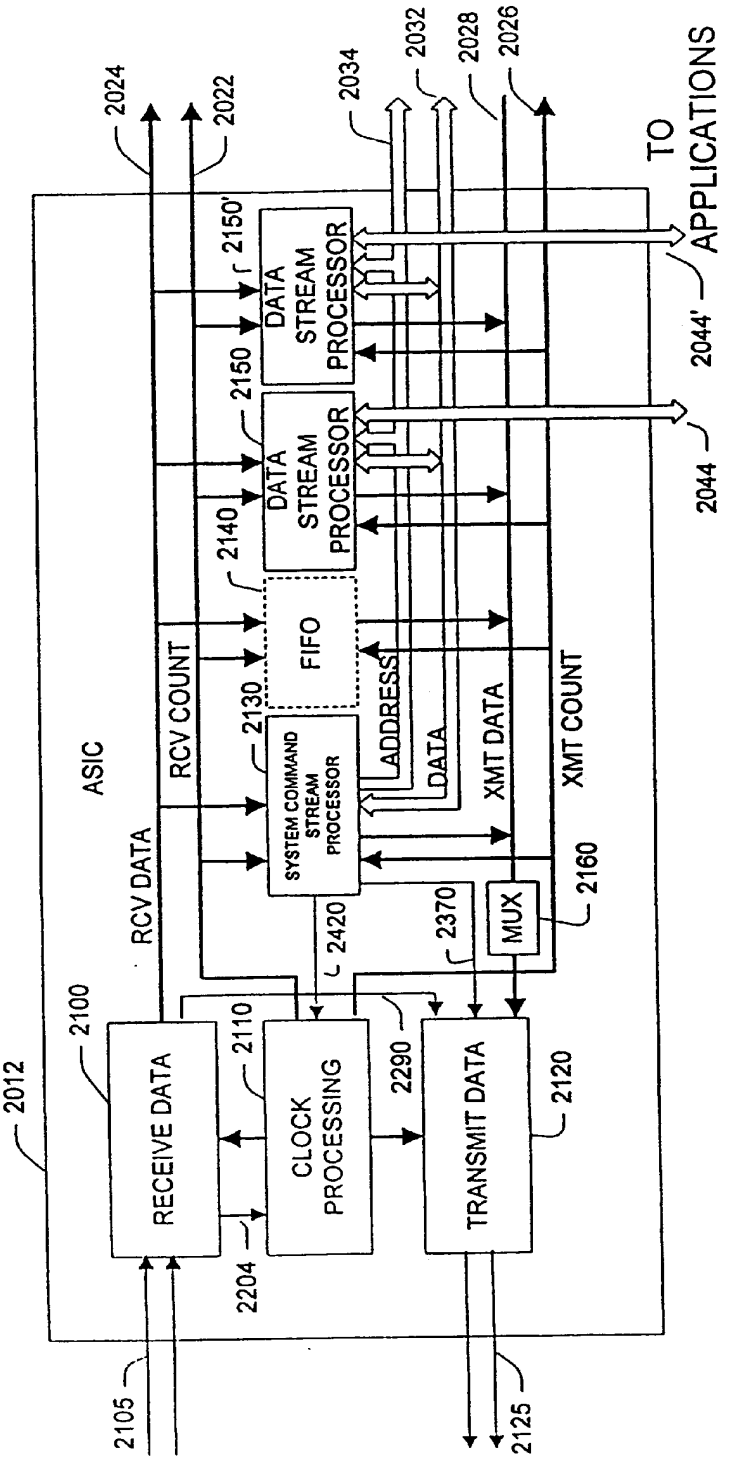

2012
ASIC
2100
RECEIVE DATA
2110
CLOCK PROCESSING
2120
TRANSMIT DATA
2130
SYSTEM COMMAND STREAM PROCESSOR
2140
FIFO
2150
DATA STREAM PROCESSOR
2150'
DATA STREAM PROCESSOR
2160
MUX
2022
2024
2026
2028
2032
2034
2044
2044'
2105
2125
2204
2290
2370
2420
RCV DATA
RCV COUNT
ADDRESS
DATA
XMT DATA
XMT COUNT
TO APPLICATIONS

FIG. 10

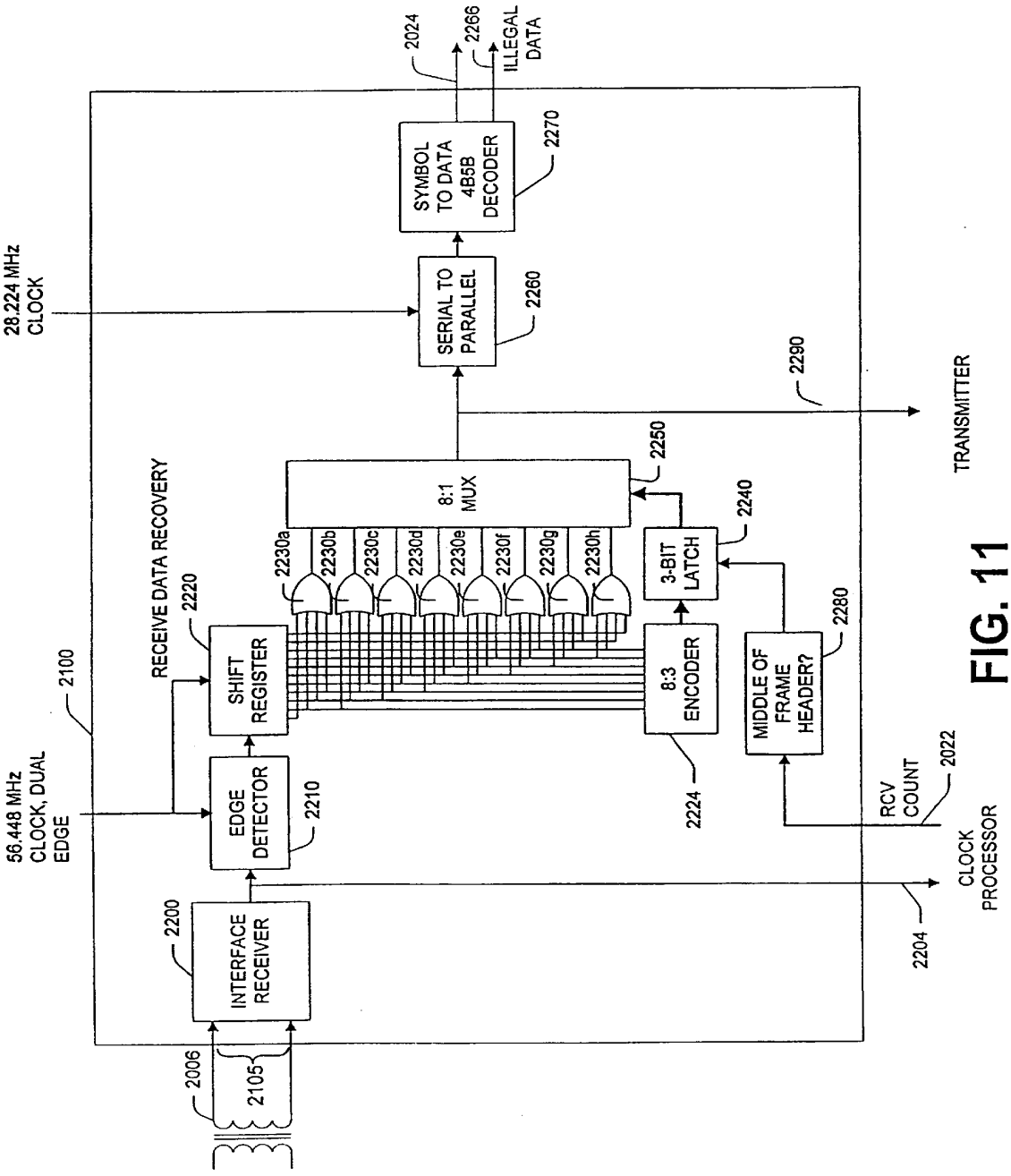

2024
2266
ILLEGAL DATA
SYMBOL TO DATA 4B5B DECODER
2270
28.224 MHz CLOCK
SERIAL TO PARALLEL
2260
2290
TRANSMITTER
2250
8:1 MUX
2230a
2230b
2230c
2230d
2230e
2230f
2230g
2230h
3-BIT LATCH
2240
RECEIVE DATA RECOVERY
2220
SHIFT REGISTER
2100
8:3 ENCODER
MIDDLE OF FRAME HEADER?
2280
56.448 MHz CLOCK, DUAL EDGE
EDGE DETECTOR
2210
2224
RCV COUNT
2022
CLOCK PROCESSOR
2200
INTERFACE RECEIVER
2204
2006
2105

FIG. 11

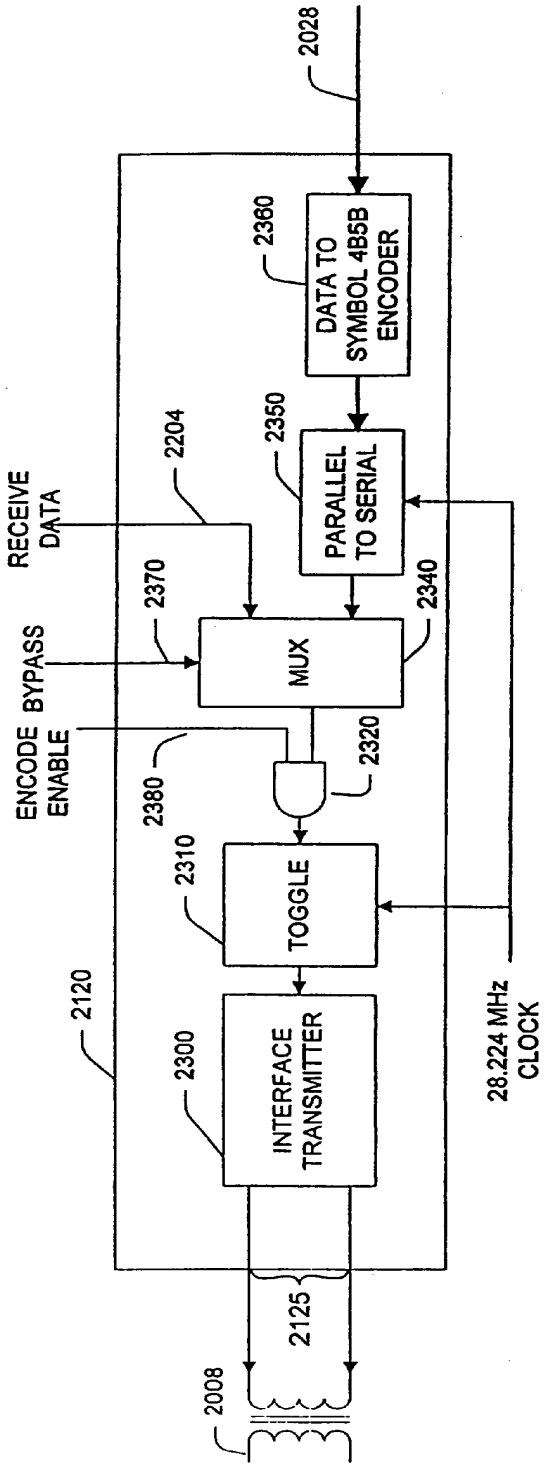

2028
2360
DATA TO SYMBOL 4B5B ENCODER
2350
PARALLEL TO SERIAL
2204
RECEIVE DATA
2370
BYPASS
2340
MUX
ENCODE ENABLE
2380
2320
2310
TOGGLE
2120
2300
INTERFACE TRANSMITTER
28.224 MHz CLOCK
2125
2008

FIG. 12

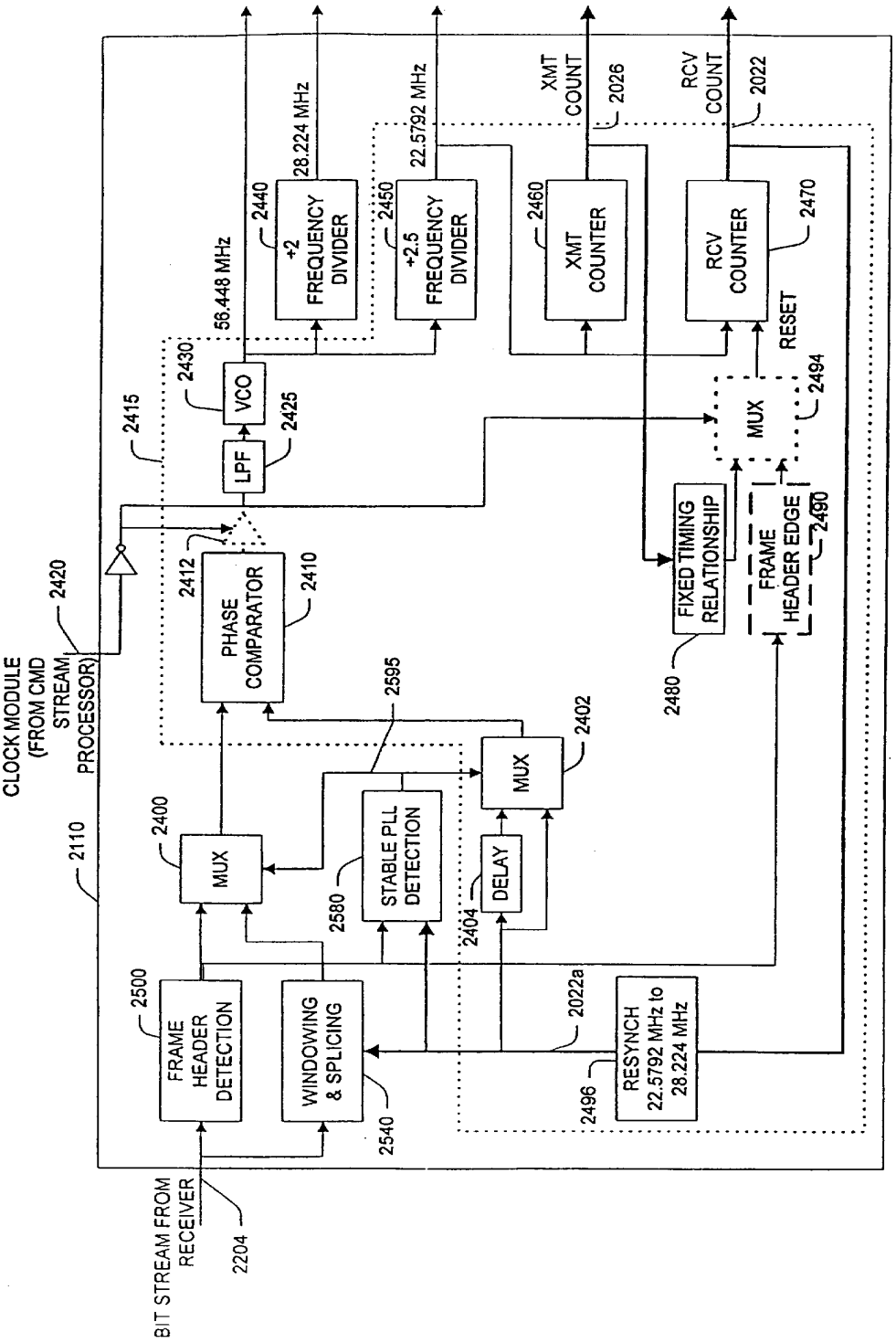

CLOCK MODULE (FROM CMD STREAM PROCESSOR)
2420
2110
2415
2412
PHASE COMPARATOR
2410
LPF
2425
VCO
2430
56.448 MHz
+2 FREQUENCY DIVIDER
2440
28.224 MHz
+2.5 FREQUENCY DIVIDER
2450
22.5792 MHz
XMT COUNTER
2460
XMT COUNT
2026
RCV COUNTER
2470
RCV COUNT
2022
RESET
MUX
2494
FIXED TIMING RELATIONSHIP
2480
FRAME HEADER EDGE
2490
2595
MUX
2402
MUX
2400
STABLE PLL DETECTION
2580
DELAY
2404
FRAME HEADER DETECTION
2500
WINDOWING & SPLICING
2540
2022a
RESYNCH 22.5792 MHz to 28.224 MHz
2496
BIT STREAM FROM RECEIVER
2204

FIG. 13(a)

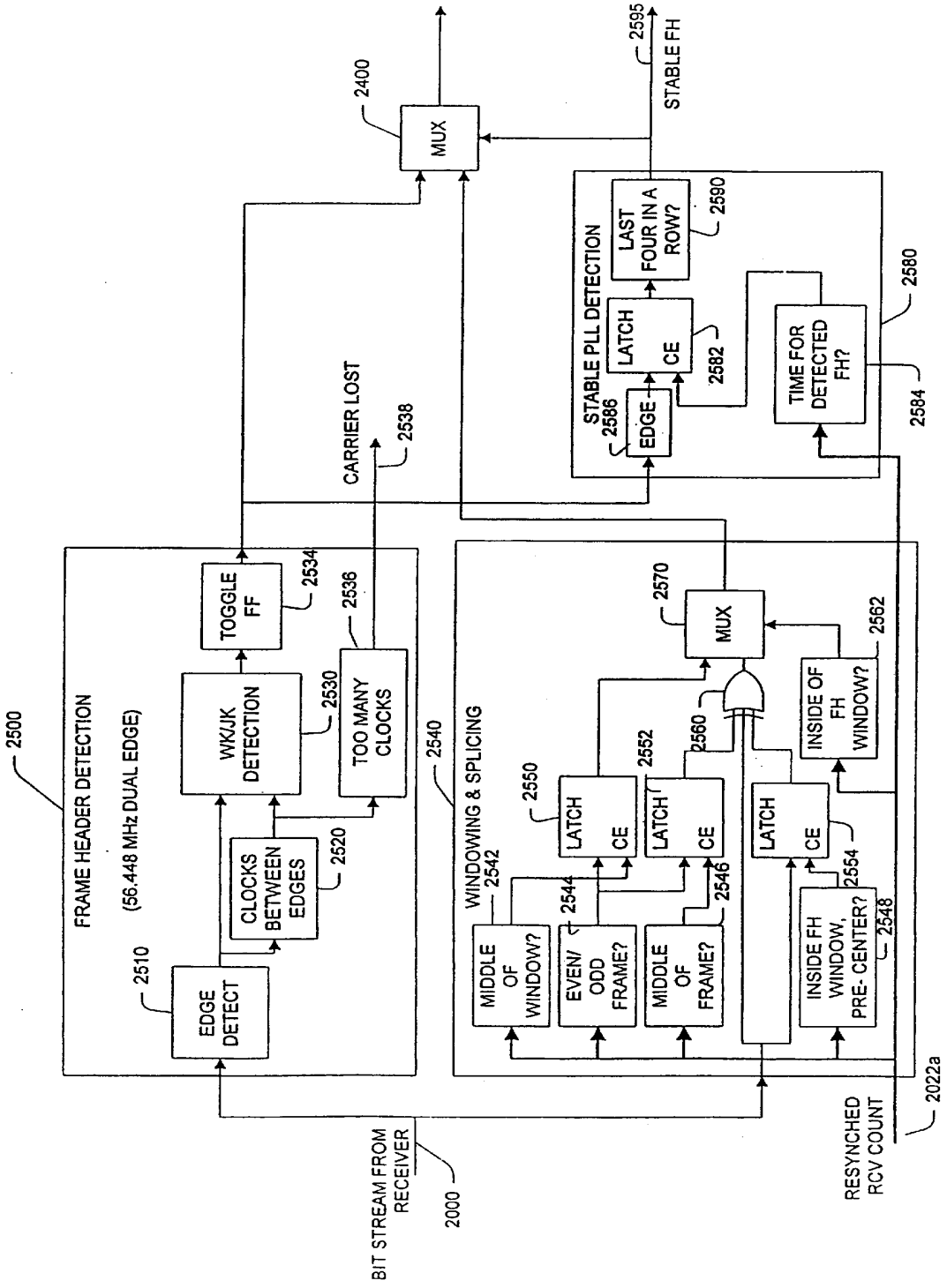

2500
FRAME HEADER DETECTION
(56.448 MHz DUAL EDGE)
2510
EDGE DETECT
CLOCKS BETWEEN EDGES
2520
WK/JK DETECTION
2530
TOO MANY CLOCKS
2536
TOGGLE FF
2534
CARRIER LOST
2538
2540
WINDOWING & SPLICING
2542
MIDDLE OF WINDOW?
2544
EVEN/ ODD FRAME?
2546
MIDDLE OF FRAME?
2548
INSIDE FH WINDOW, PRE- CENTER?
2554
LATCH
CE
2550
2552
2560
MUX
2570
INSIDE OF FH WINDOW?
2562
2400
MUX
2595
STABLE FH
STABLE PLL DETECTION
2586
EDGE
LATCH
CE
2582
LAST FOUR IN A ROW?
2590
TIME FOR DETECTED FH?
2584
2580
BIT STREAM FROM RECEIVER
2000
RESYNCHED RCV COUNT
2022a

FIG. 13(b)

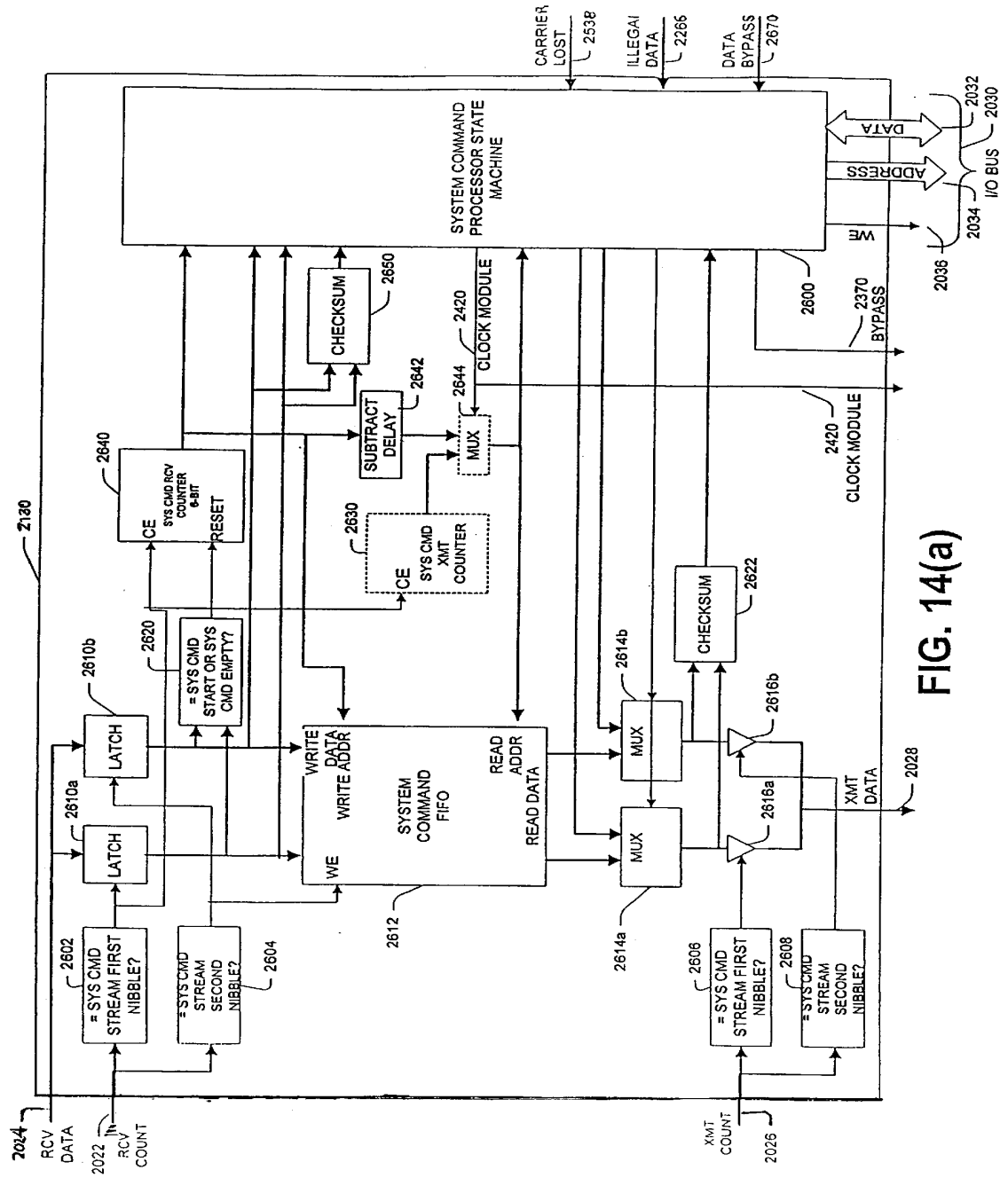
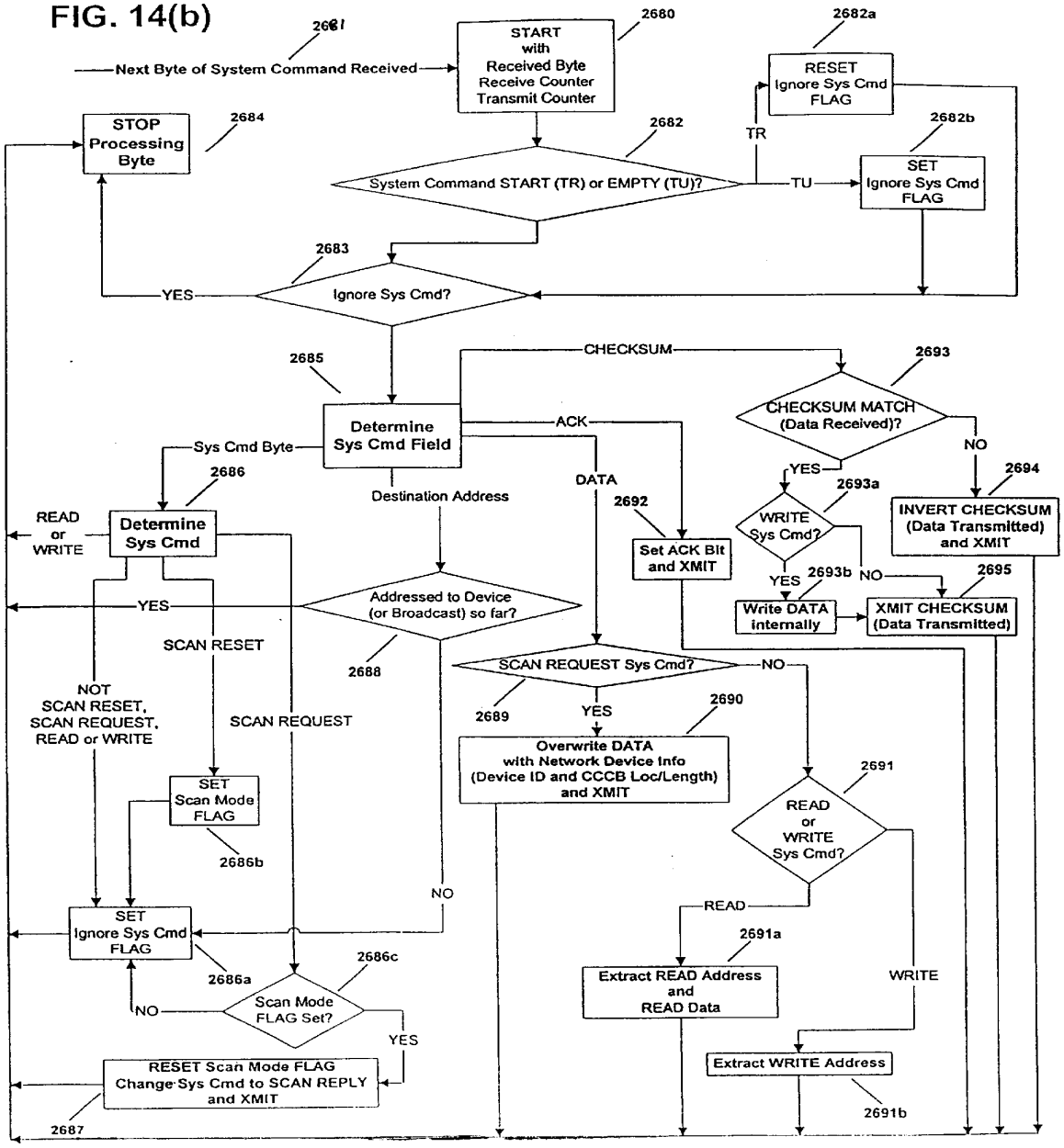

CARRIER LOST
2538
ILLEGAL DATA
2266
DATA BYPASS
2670
SYSTEM COMMAND PROCESSOR STATE MACHINE
DATA
ADDRESS
WE
I/O BUS
2032
2030
2034
2036
2600
2370 BYPASS
CHECKSUM
2650
2420 CLOCK MODULE
SUBTRACT DELAY
2642
2644
MUX
2640
SYS CMD RCV COUNTER 6-BIT
CE
RESET
2630
SYS CMD XMT COUNTER
CE
2620
= SYS CMD START OR SYS CMD EMPTY?
2130
2610b
LATCH
2610a
LATCH
WRITE DATA ADDR
WRITE
WE
SYSTEM COMMAND FIFO
READ ADDR
READ DATA
2612
2614b
MUX
2614a
MUX
CHECKSUM
2622
2616b
2616a
XMT DATA
2028
= SYS CMD STREAM FIRST NIBBLE?
2602
= SYS CMD STREAM SECOND NIBBLE?
2604
= SYS CMD STREAM FIRST NIBBLE?
2606
= SYS CMD STREAM SECOND NIBBLE?
2608
RCV DATA
2024
RCV COUNT
2022
XMT COUNT
2026

FIG. 14(a)

FIG. 14(b)


2681
Next Byte of System Command Received
START with Received Byte Receive Counter Transmit Counter
2680
RESET Ignore Sys Cmd FLAG
2682a
STOP Processing Byte
2684
System Command START (TR) or EMPTY (TU)?
2682
TR
TU
SET Ignore Sys Cmd FLAG
2682b
2683
Ignore Sys Cmd?
YES
CHECKSUM
2685
Determine Sys Cmd Field
ACK
Sys Cmd Byte
2686
Destination Address
DATA
2692
Set ACK Bit and XMIT
CHECKSUM MATCH (Data Received)?
2693
NO
YES
2694
INVERT CHECKSUM (Data Transmitted) and XMIT
WRITE Sys Cmd?
2693a
YES
NO
2693b
Write DATA internally
2695
XMIT CHECKSUM (Data Transmitted)
READ or WRITE
Determine Sys Cmd
Addressed to Device (or Broadcast) so far?
YES
2688
SCAN RESET
SCAN REQUEST Sys Cmd?
NO
2689
YES
2690
Overwrite DATA with Network Device Info (Device ID and CCCB Loc/Length) and XMIT
NOT SCAN RESET, SCAN REQUEST, READ or WRITE
SCAN REQUEST
SET Scan Mode FLAG
2686b
2691
READ or WRITE Sys Cmd?
READ
2691a
Extract READ Address and READ Data
WRITE
Extract WRITE Address
2691b
NO
SET Ignore Sys Cmd FLAG
2686a
2686c
Scan Mode FLAG Set?
NO
YES
RESET Scan Mode FLAG Change Sys Cmd to SCAN REPLY and XMIT
2687

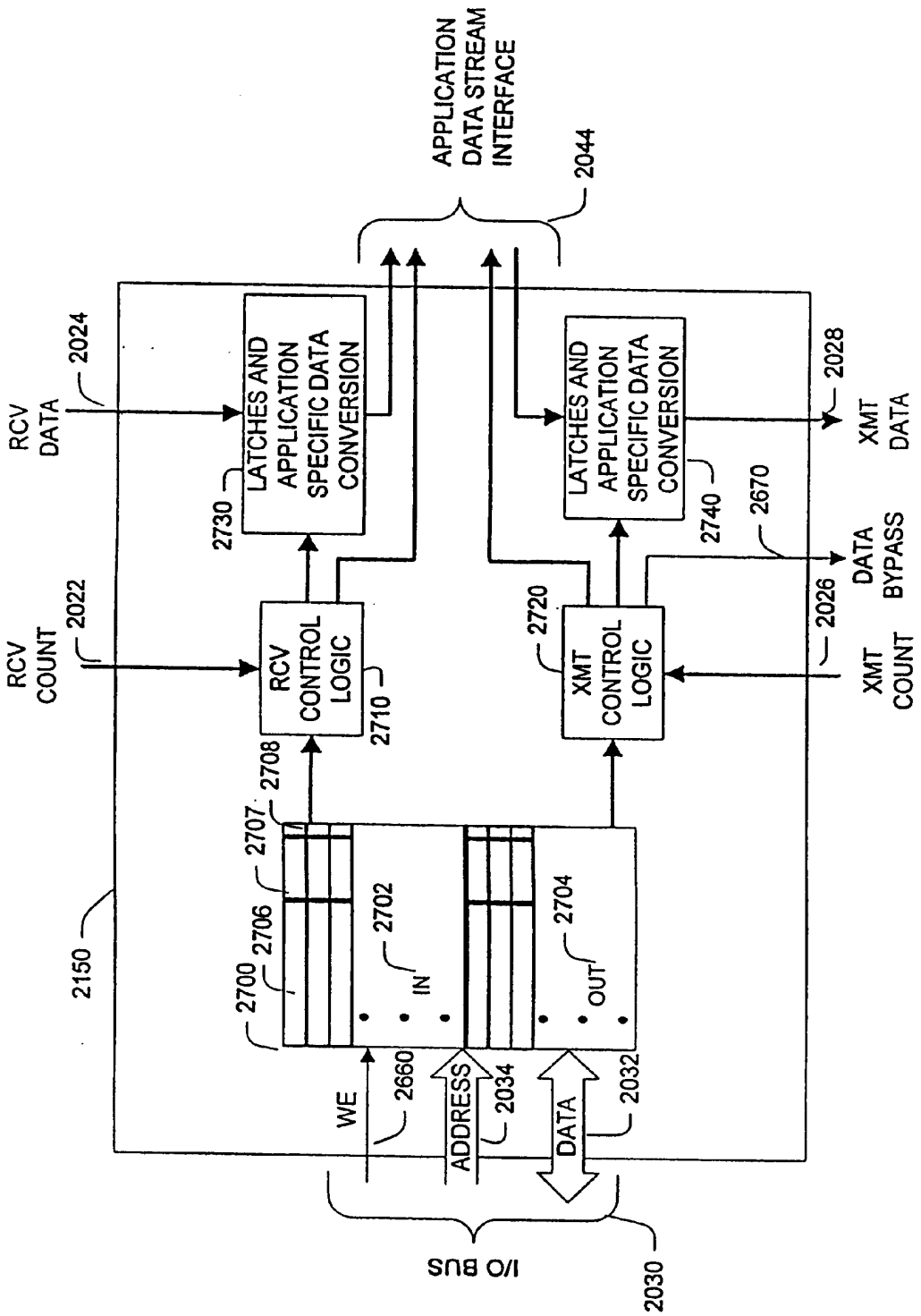

APPLICATION DATA STREAM INTERFACE
2044
RCV DATA
2024
LATCHES AND APPLICATION SPECIFIC DATA CONVERSION
2730
LATCHES AND APPLICATION SPECIFIC DATA CONVERSION
2740
2028
XMT DATA
2670
DATA BYPASS
2026
RCV COUNT
2022
RCV CONTROL LOGIC
2710
2720
XMT CONTROL LOGIC
XMT COUNT
2708
2707
2706
2700
2150
2702
IN
2704
OUT
WE
2660
ADDRESS
2034
DATA
2032
I/O BUS
2030

FIG. 15

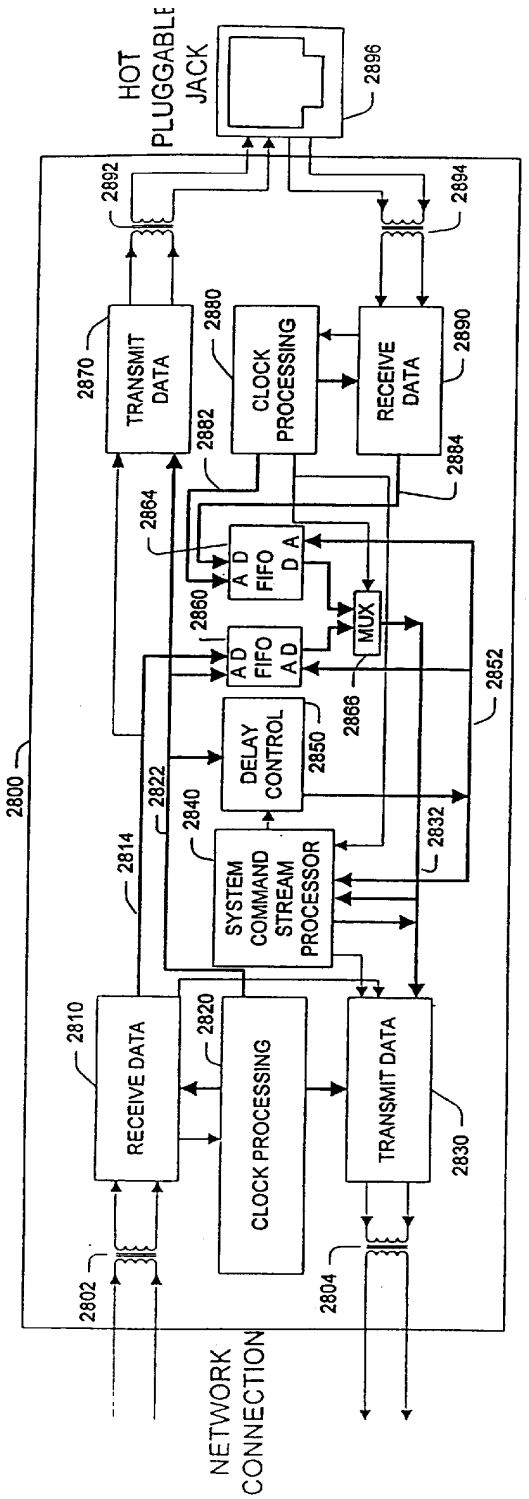

HOT PLUGGABLE JACK
2896
2892
2894
2870
TRANSMIT DATA
2880
CLOCK PROCESSING
2890
RECEIVE DATA
2882
2884
2864
A D FIFO D A
2860
MUX
A D FIFO A D
2852
2866
DELAY CONTROL
2850
2800
2822
2840
2814
SYSTEM COMMAND STREAM PROCESSOR
2832
2810
RECEIVE DATA
2820
CLOCK PROCESSING
TRANSMIT DATA
2830
2802
2804
NETWORK CONNECTION

FIG. 16

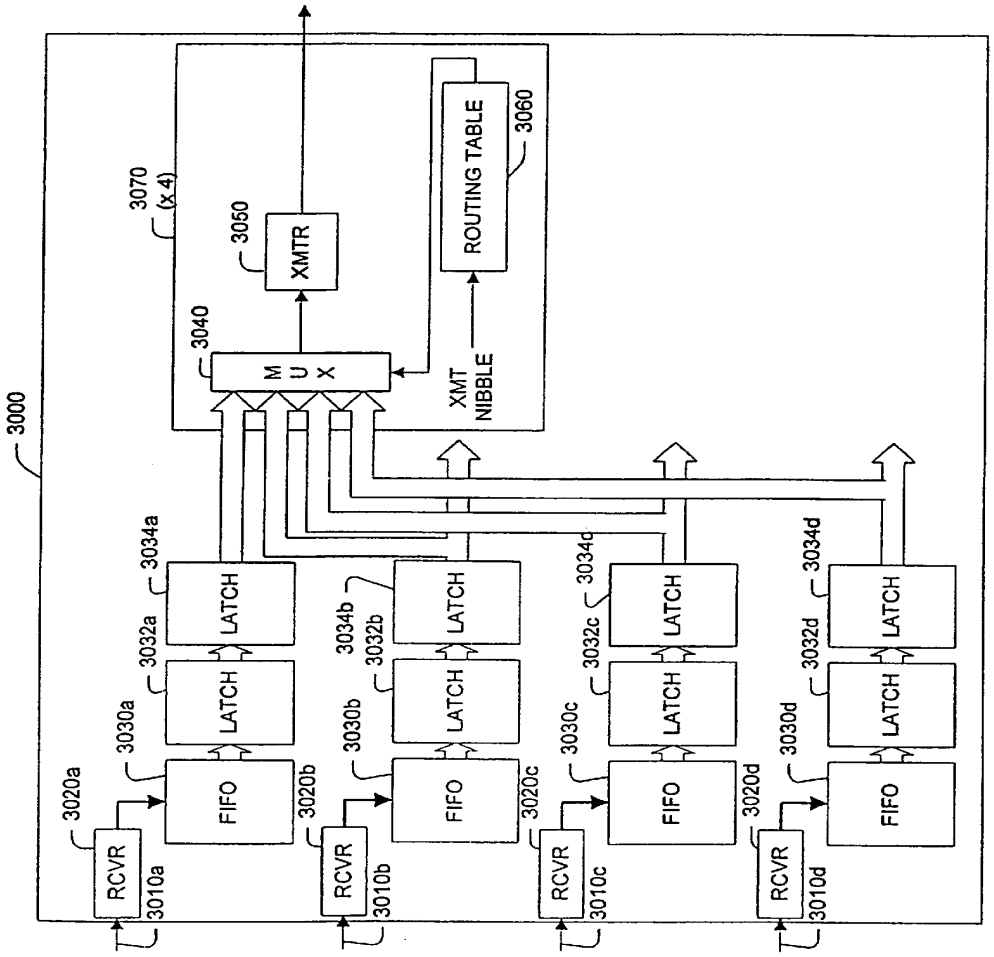

3000
3070
(x 4)
3060
XMTR
ROUTING TABLE
3040
MUX
XMT
NIBBLE
3034a
3034b
3034c
3034d
3032a
3032b
3032c
3032d
LATCH
3030a
3030b
3030c
3030d
3020a
3020b
3020c
3020d
FIFO
RCVR
3010a
3010b
3010c
3010d

FIG. 17

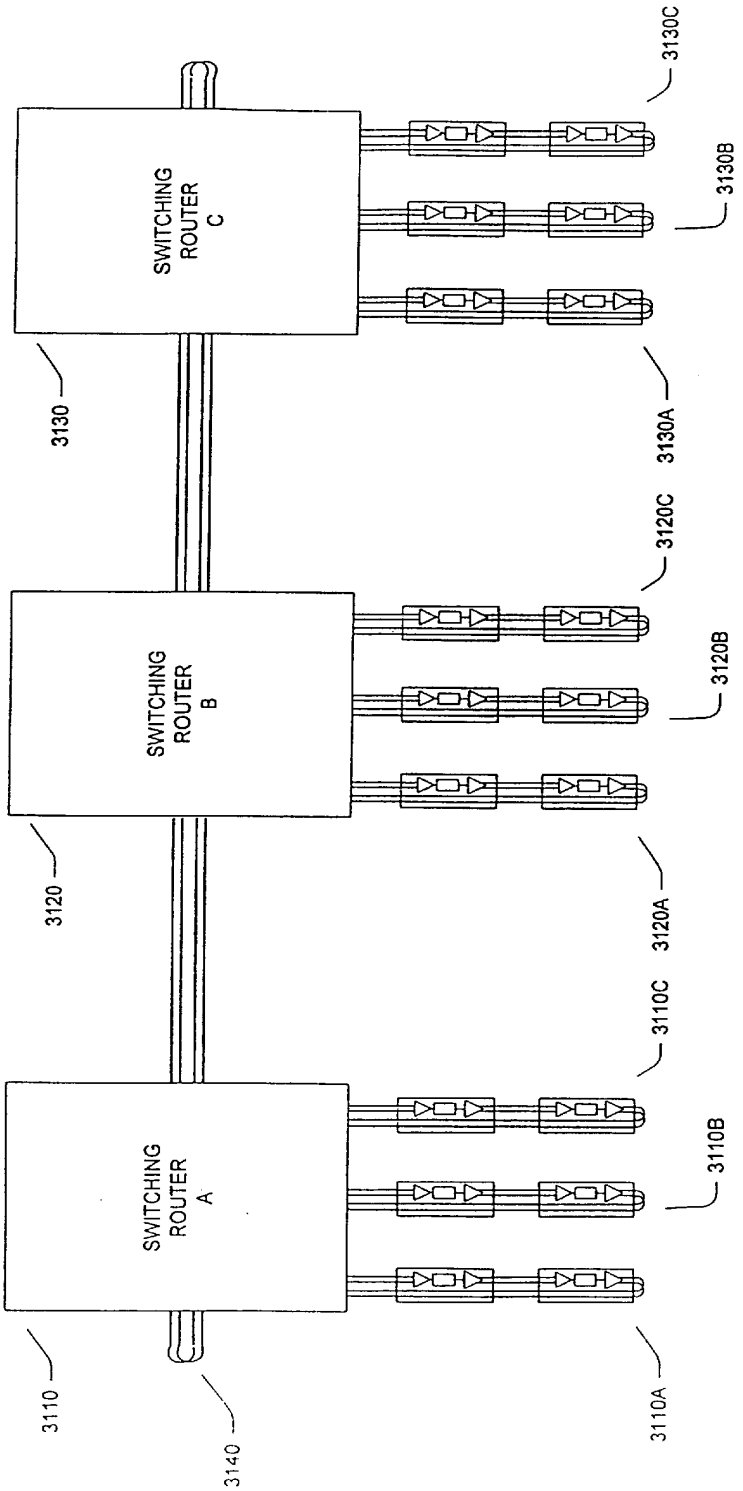

SWITCHING ROUTER C
SWITCHING ROUTER B
SWITCHING ROUTER A
3130C
3130B
3130A
3130
3120C
3120B
3120A
3120
3110C
3110B
3110A
3110
3140

FIG. 18

Fig. 19(a)

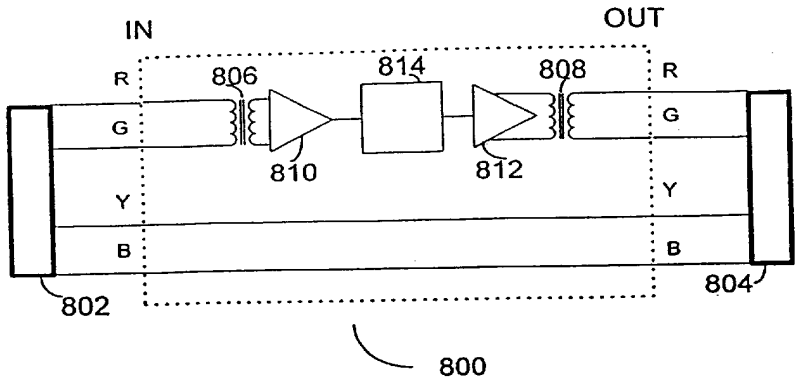


Fig. 19(b)

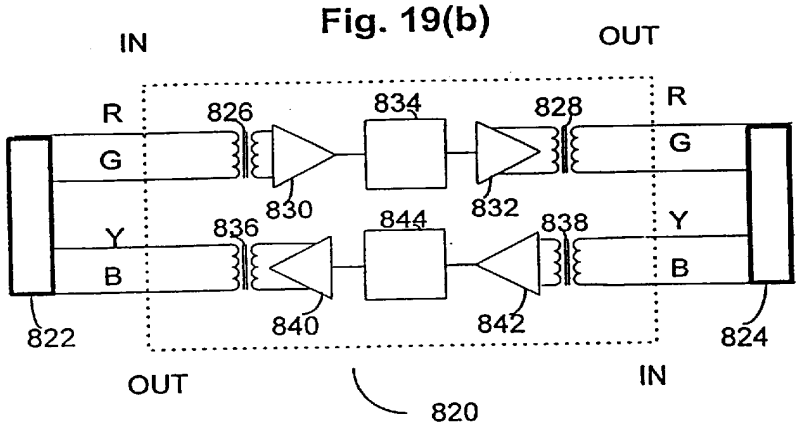


Fig. 19(c)

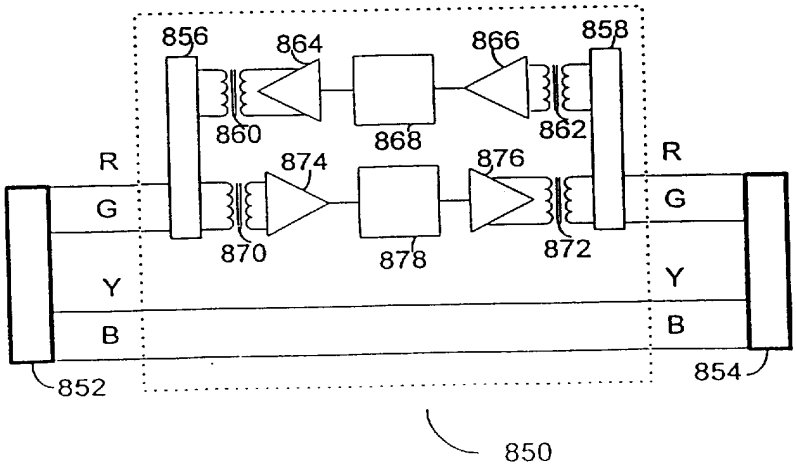


Fig. 19(d)

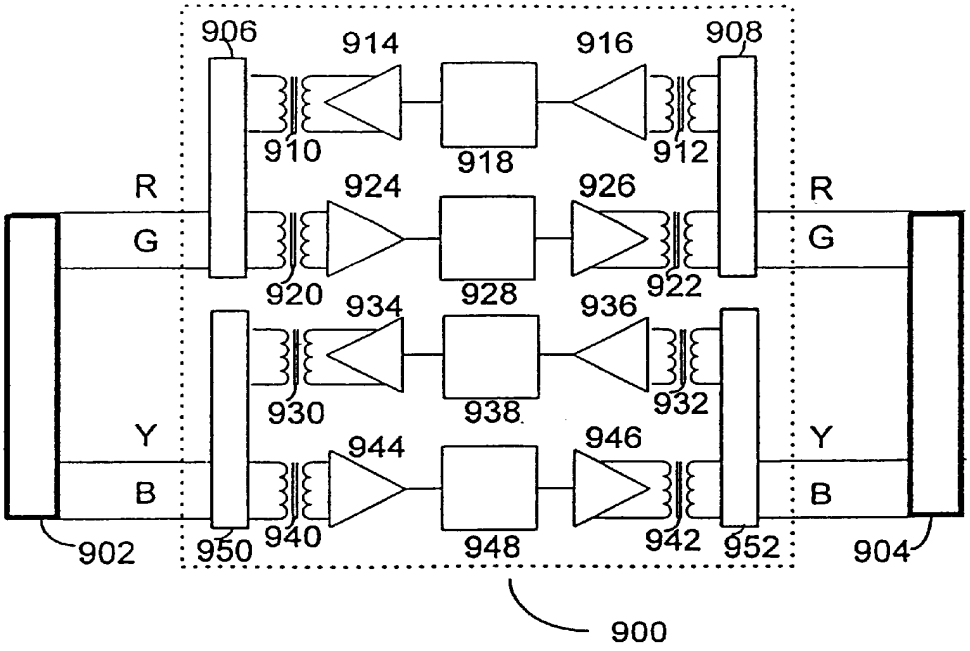


Fig. 19(e)

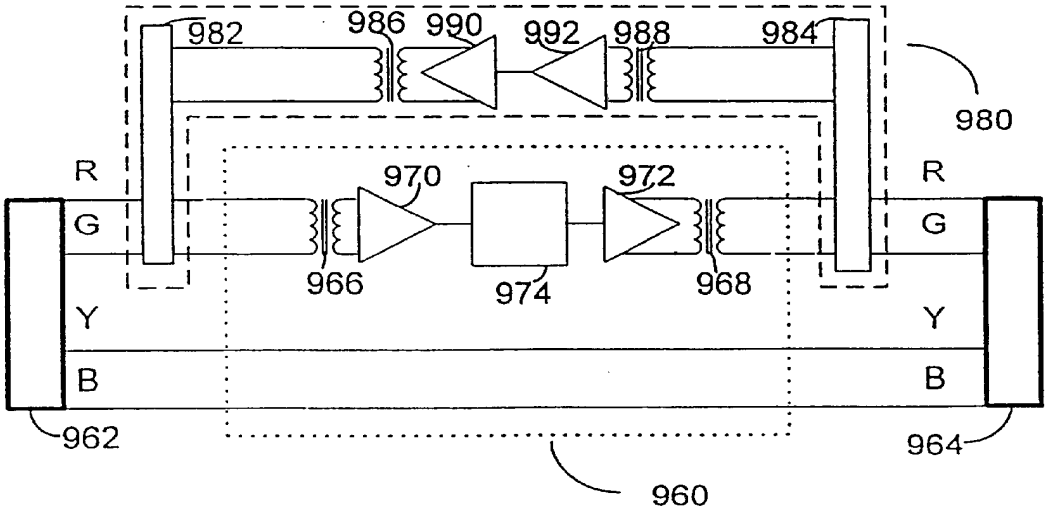


Fig. 20

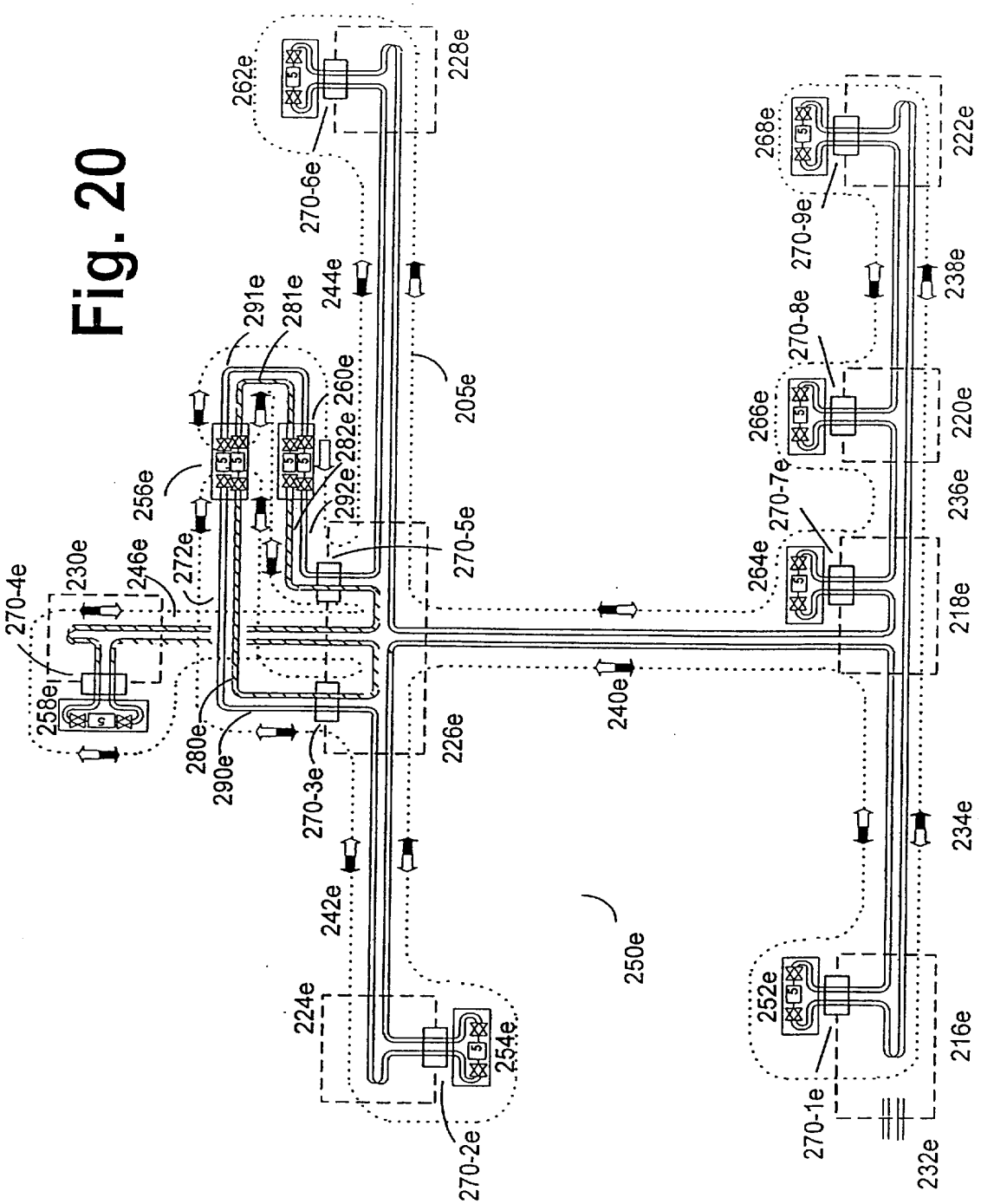

262e
228e
270-6e
291e
281e
244e
205e
260e
282e
292e
256e
272e
246e
230e
270-4e
258e
270-5e
280e
290e
270-3e
226e
240e
242e
224e
254e
270-2e
250e
268e
270-9e
222e
238e
270-8e
266e
220e
270-7e
236e
264e
218e
234e
252e
216e
270-1e
232e

FIG. 21(a)

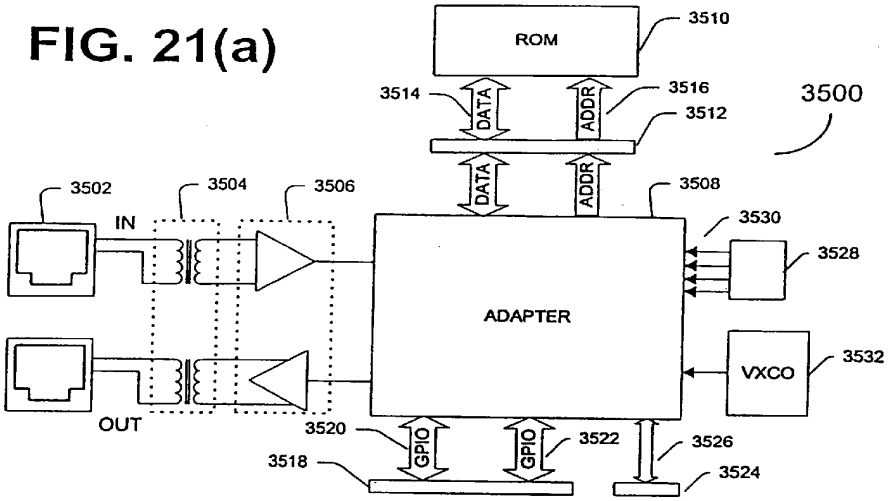


FIG. 21(b)

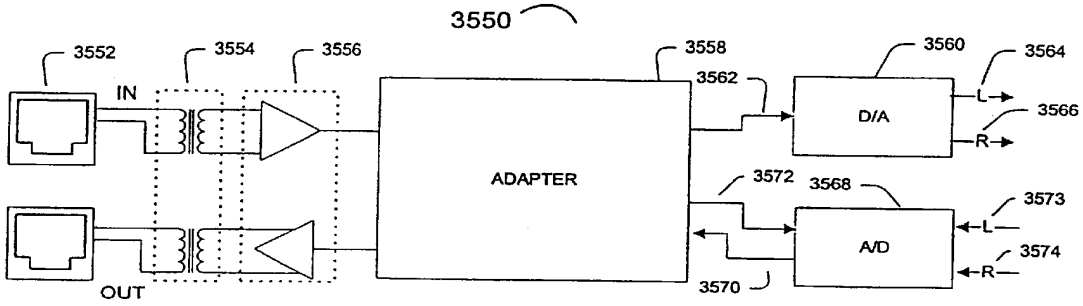


FIG. 21(c)

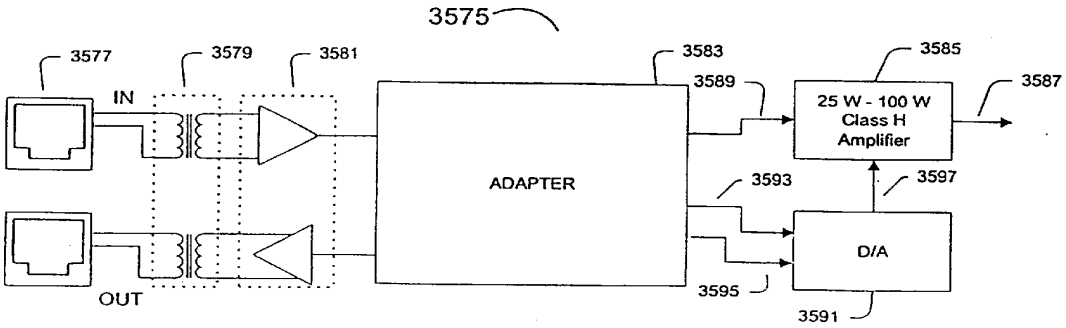


FIG. 21(d)

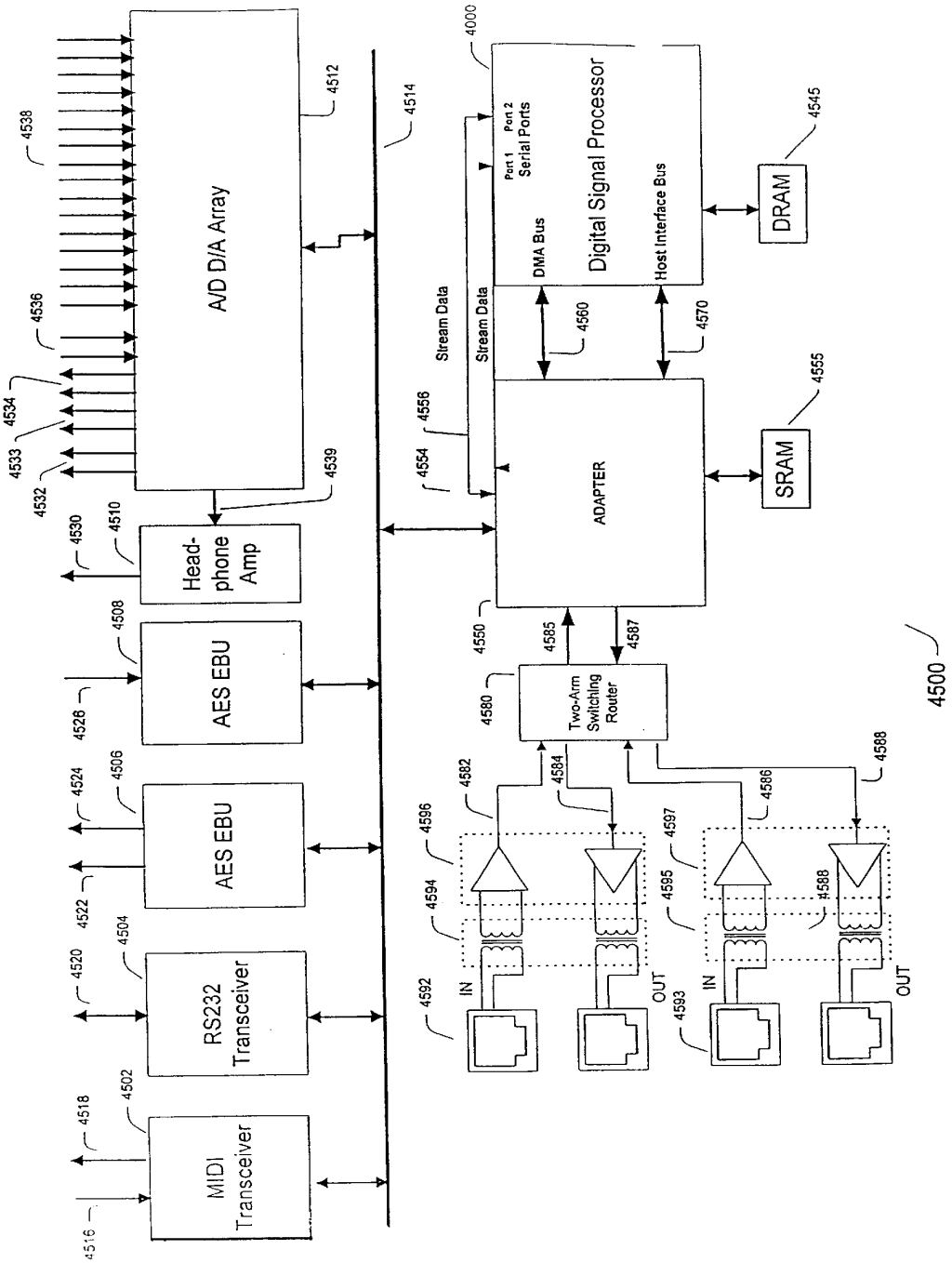
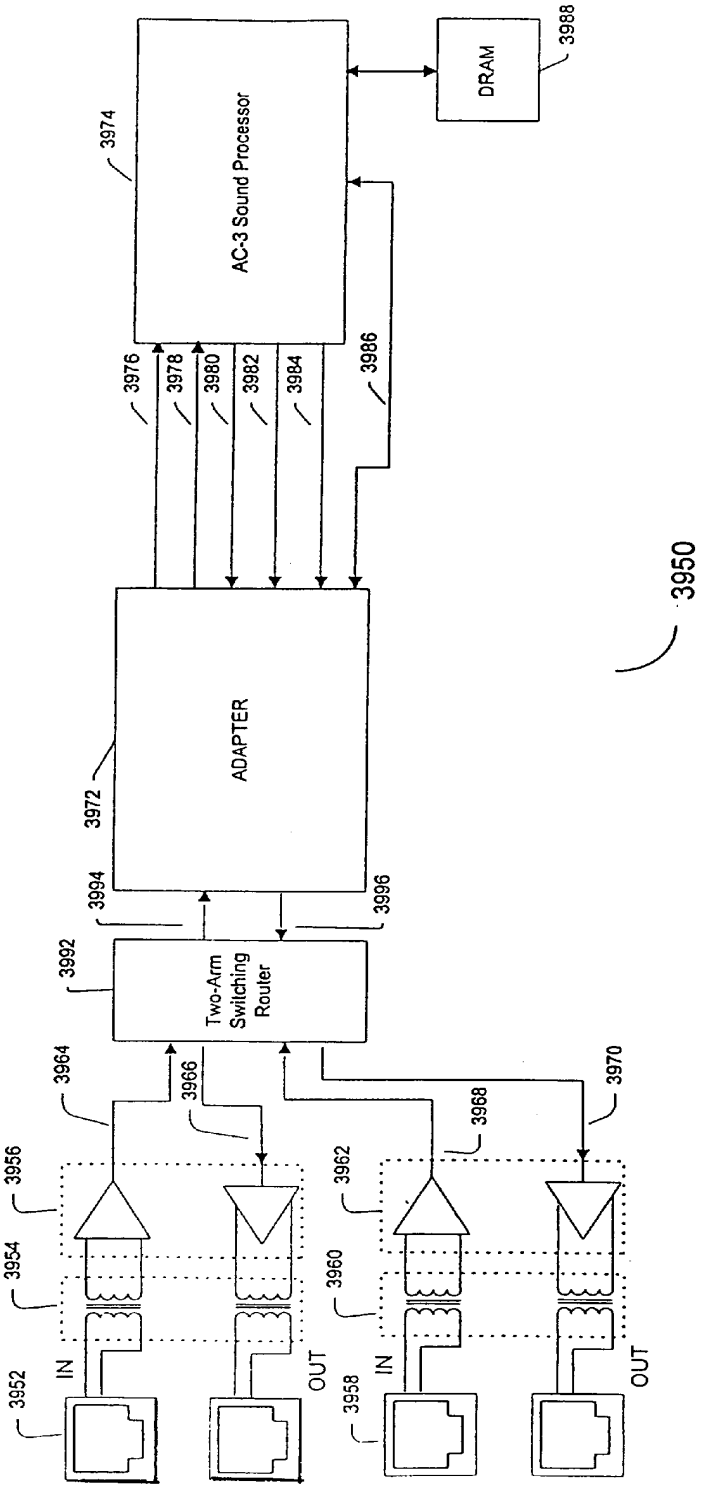

A/D D/A Array
Head-phone Amp
AES EBU
AES EBU
RS232 Transceiver
MIDI Transceiver
Digital Signal Processor
Port 1 Serial Ports
Port 2
DMA Bus
Host Interface Bus
DRAM
SRAM
ADAPTER
Stream Data
Stream Data
Two-Arm Switching Router
IN
OUT
IN
OUT
4000
4500
4502
4504
4506
4508
4510
4512
4514
4516
4518
4520
4522
4524
4526
4528
4530
4532
4533
4534
4536
4538
4539
4545
4550
4554
4555
4556
4560
4570
4580
4582
4584
4585
4586
4587
4588
4592
4593
4594
4595
4596
4597

FIG. 21(e)


3950
3974
AC-3 Sound Processor
3988
DRAM
3976
3978
3980
3982
3984
3986
3972
ADAPTER
3994
3996
3992
Two-Arm Switching Router
3964
3966
3968
3970
3956
3962
3954
3960
3952
IN
OUT
3958
IN
OUT

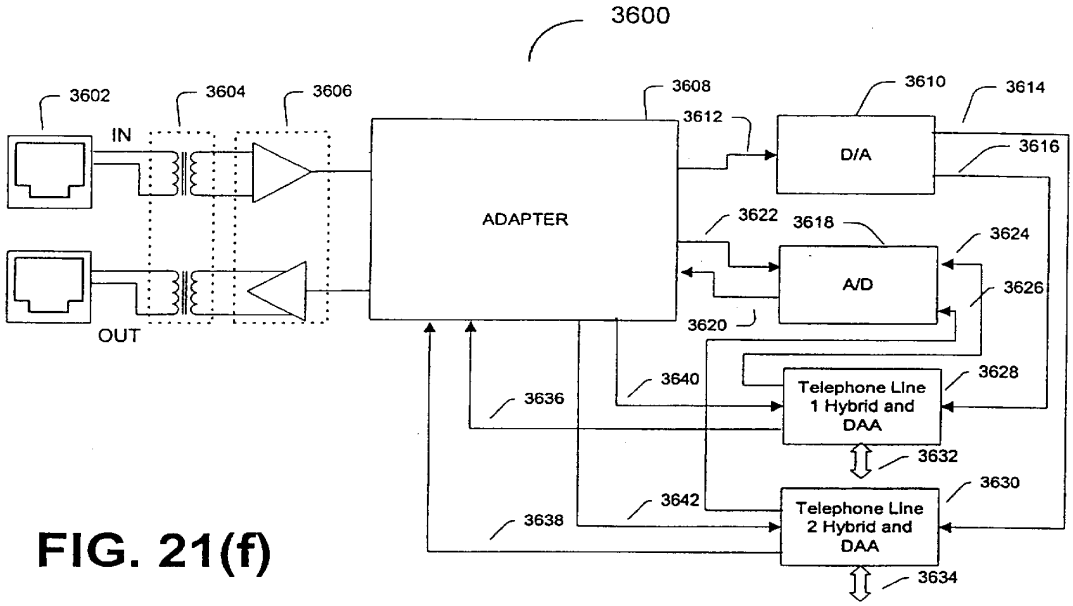


FIG. 21(f)

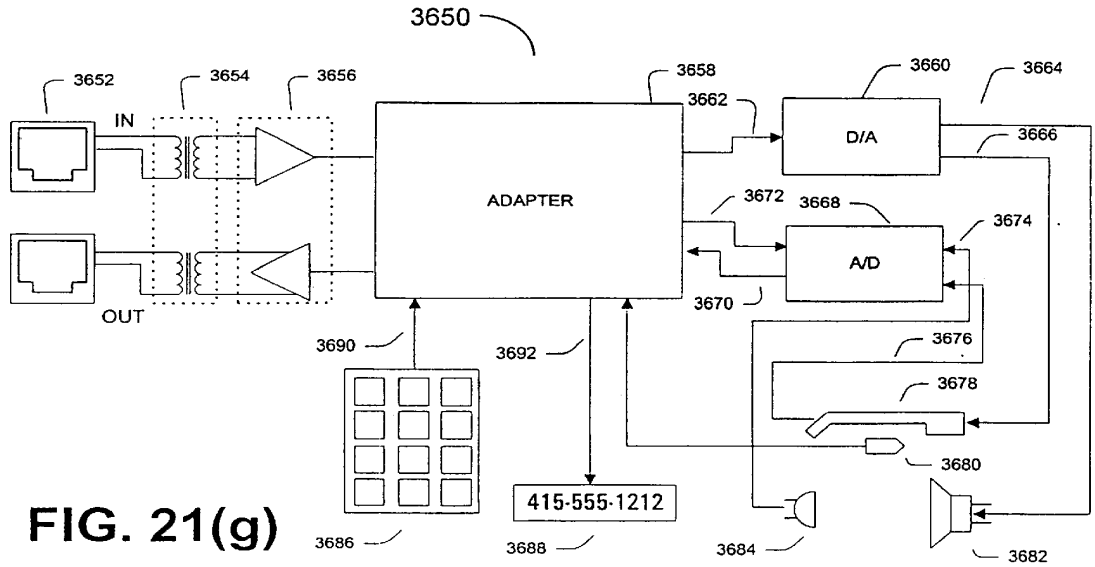


FIG. 21(g)

FIG. 21(h)

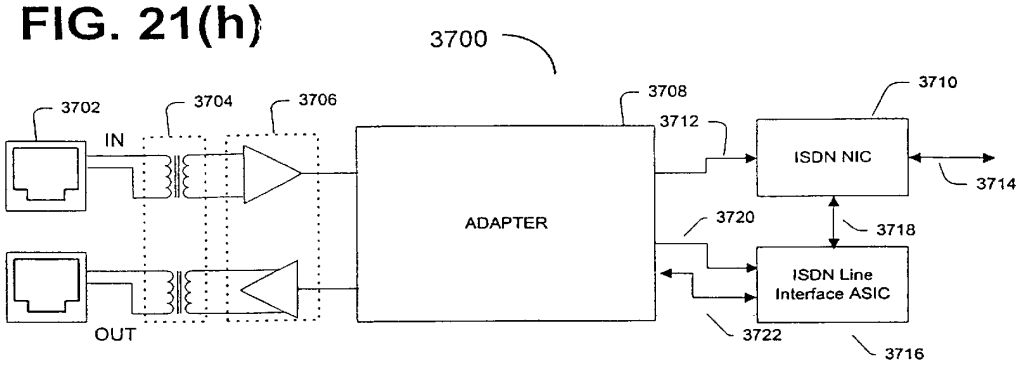


FIG. 21(i)

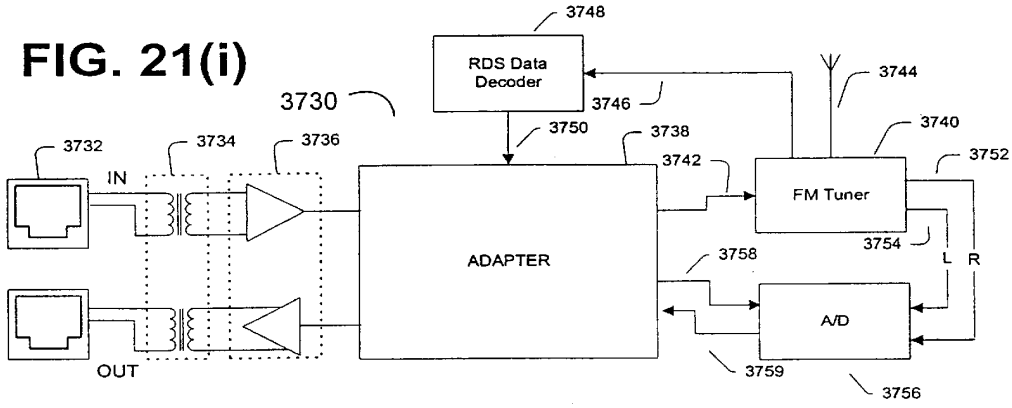
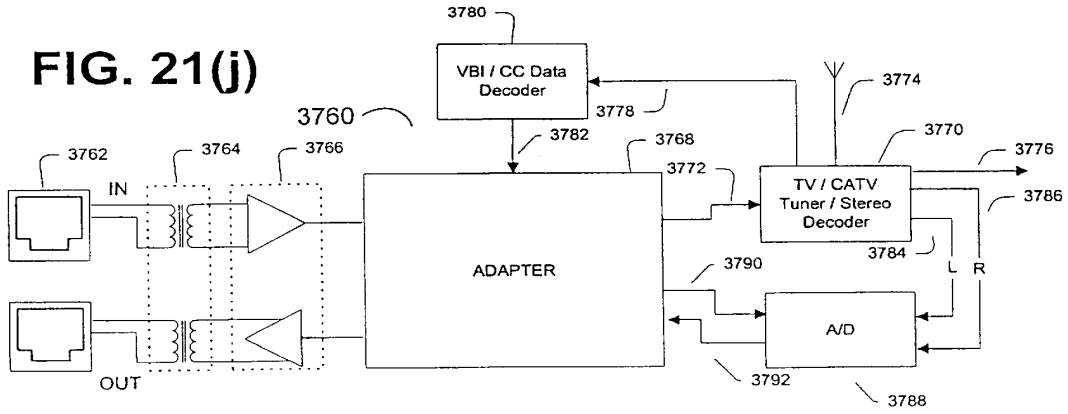


FIG. 21(j)



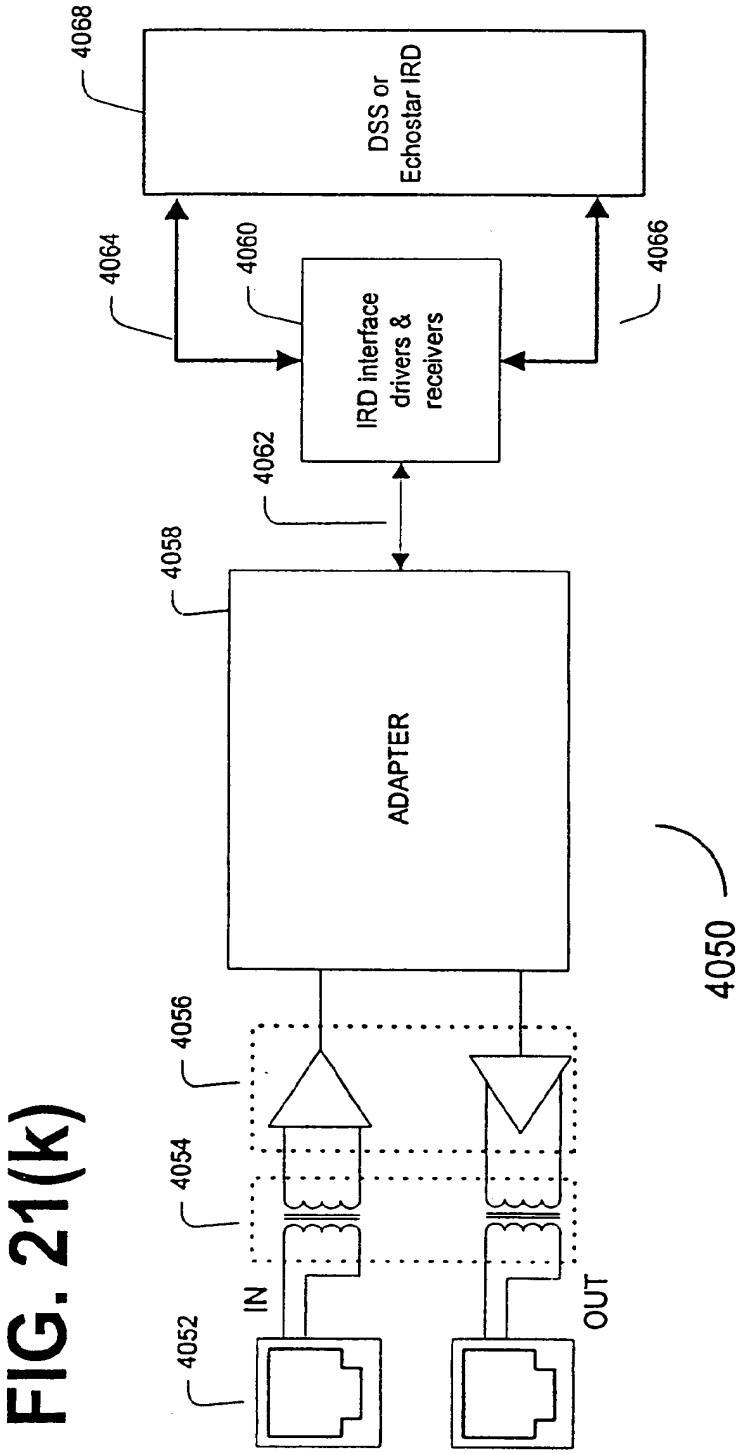

4068
DSS or Echostar IRD
4064
4060
4066
IRD interface drivers & receivers
4062
4058
ADAPTER
4050
4056
4054
IN
OUT
4052

FIG. 21(k)

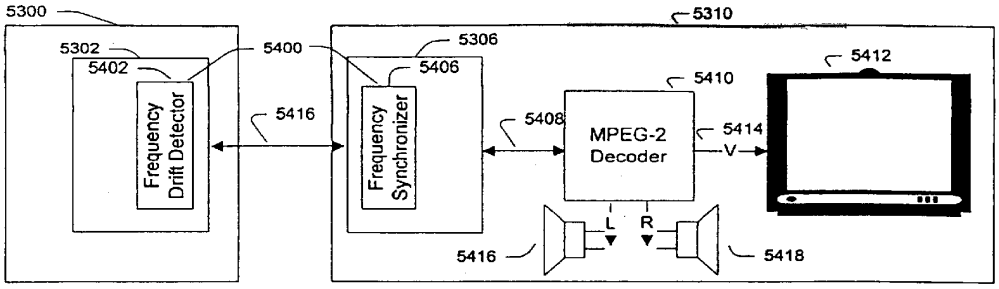


FIG. 21(l)

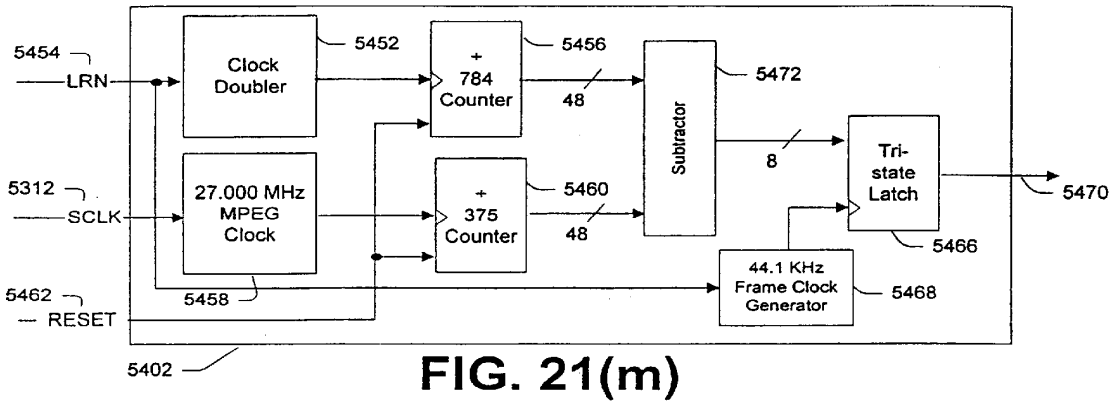


FIG. 21(m)

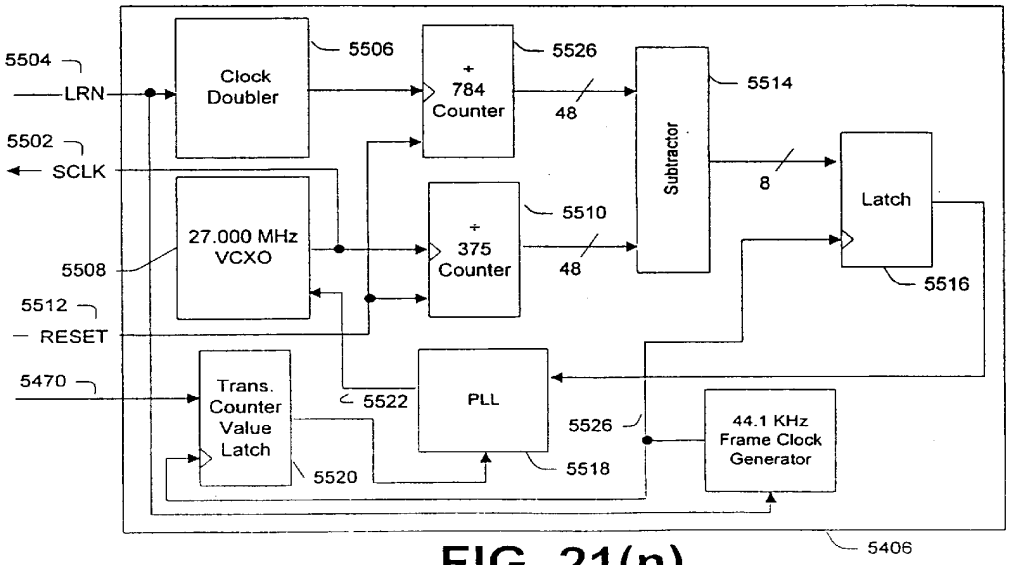


FIG. 21(n)

FIG. 21(o)

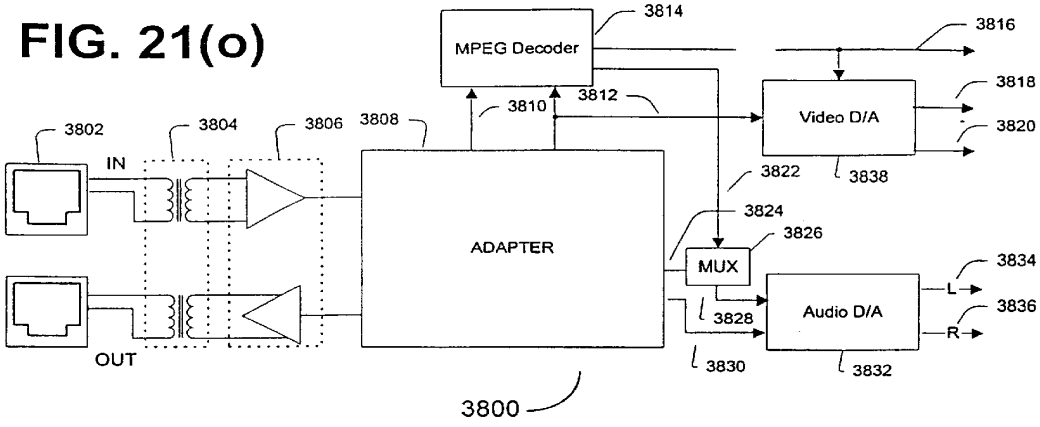


FIG. 21(p)

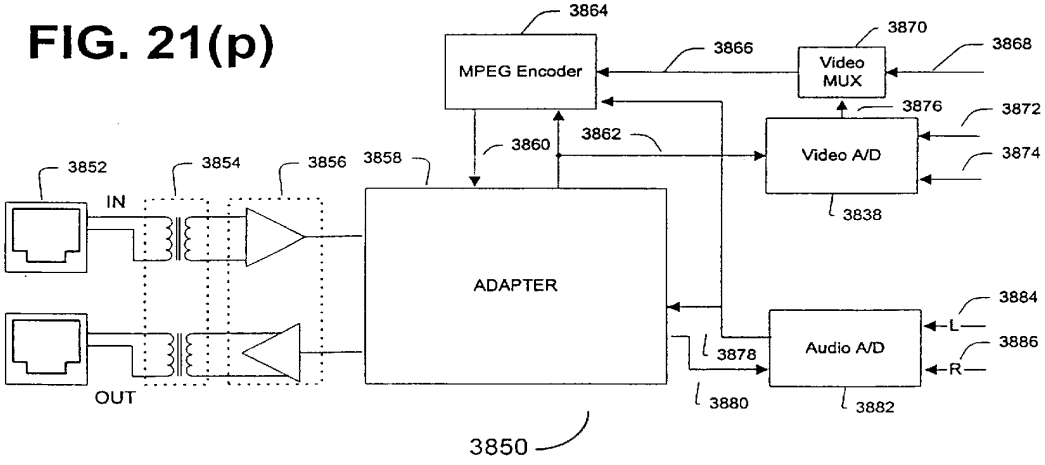


FIG. 21(q)

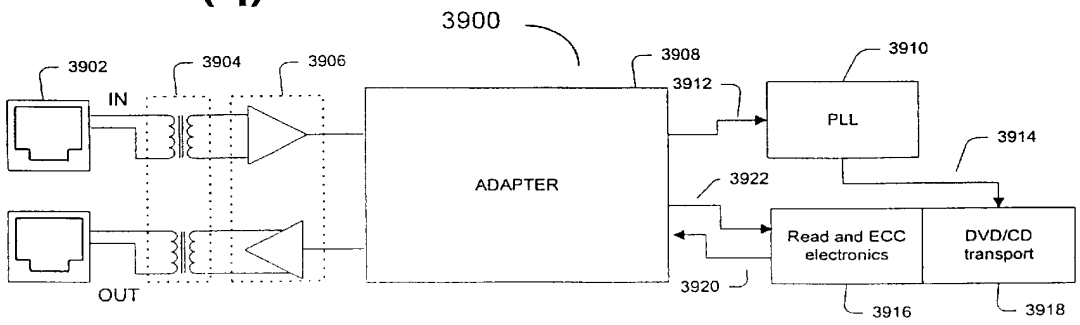


FIG. 21(r)

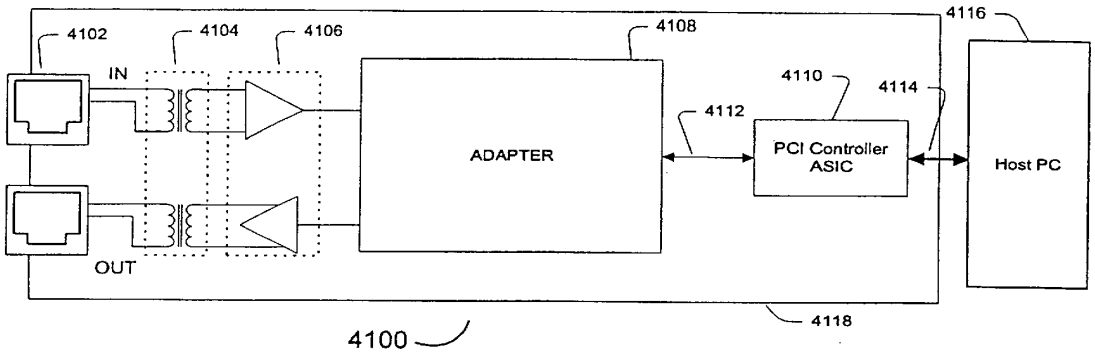


FIG. 21(s)

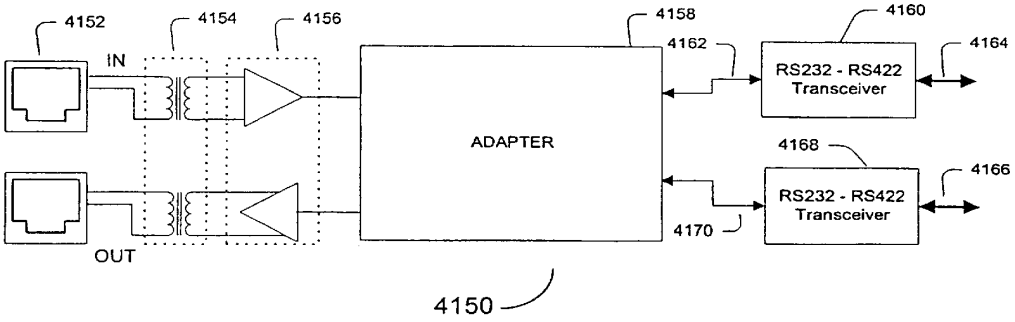


FIG. 21(t)

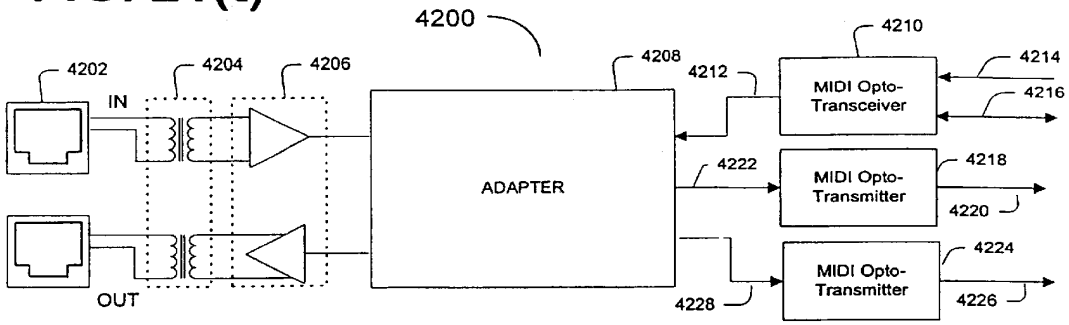


FIG. 21(u)

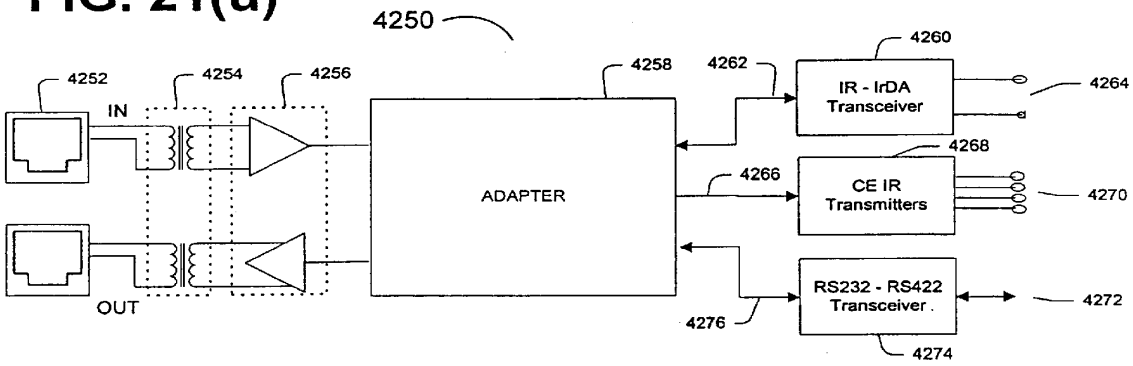


FIG. 21(v)

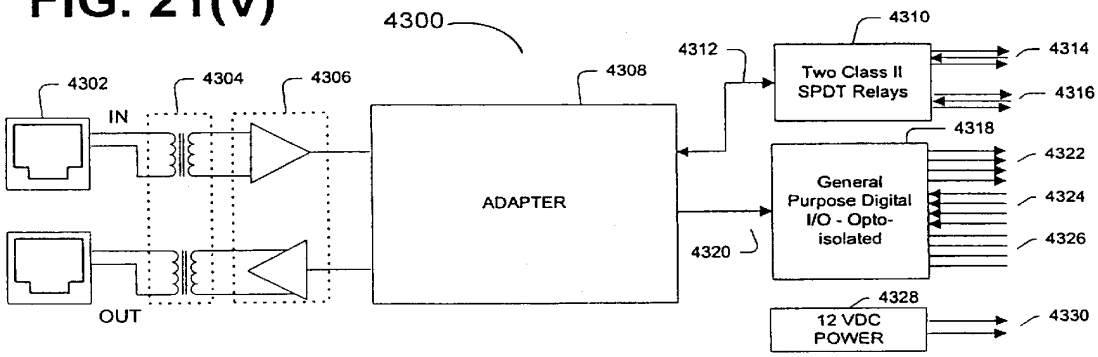


FIG. 21(w)

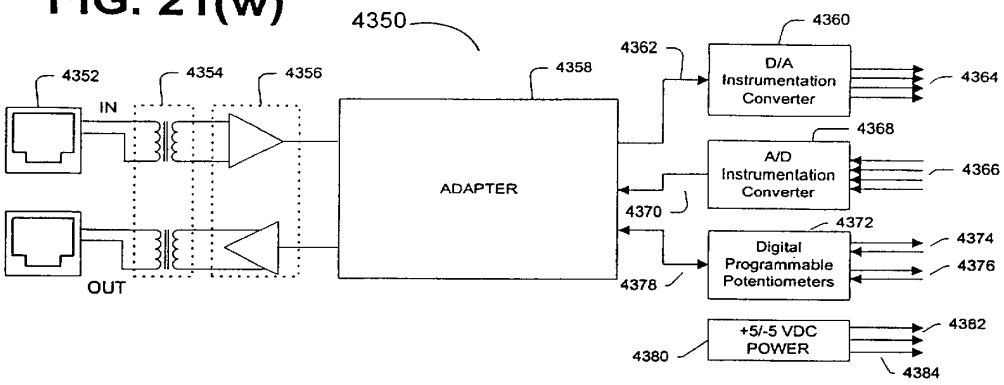


FIG. 21(x)

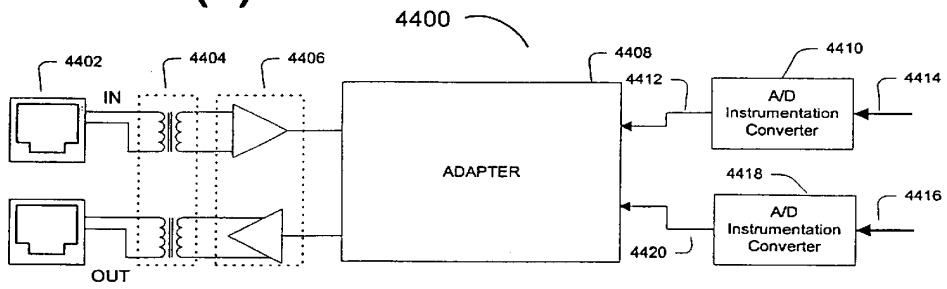
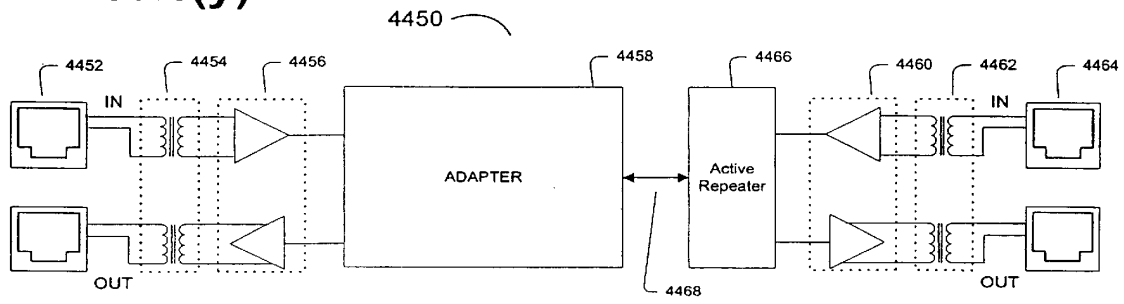


FIG. 21(y)



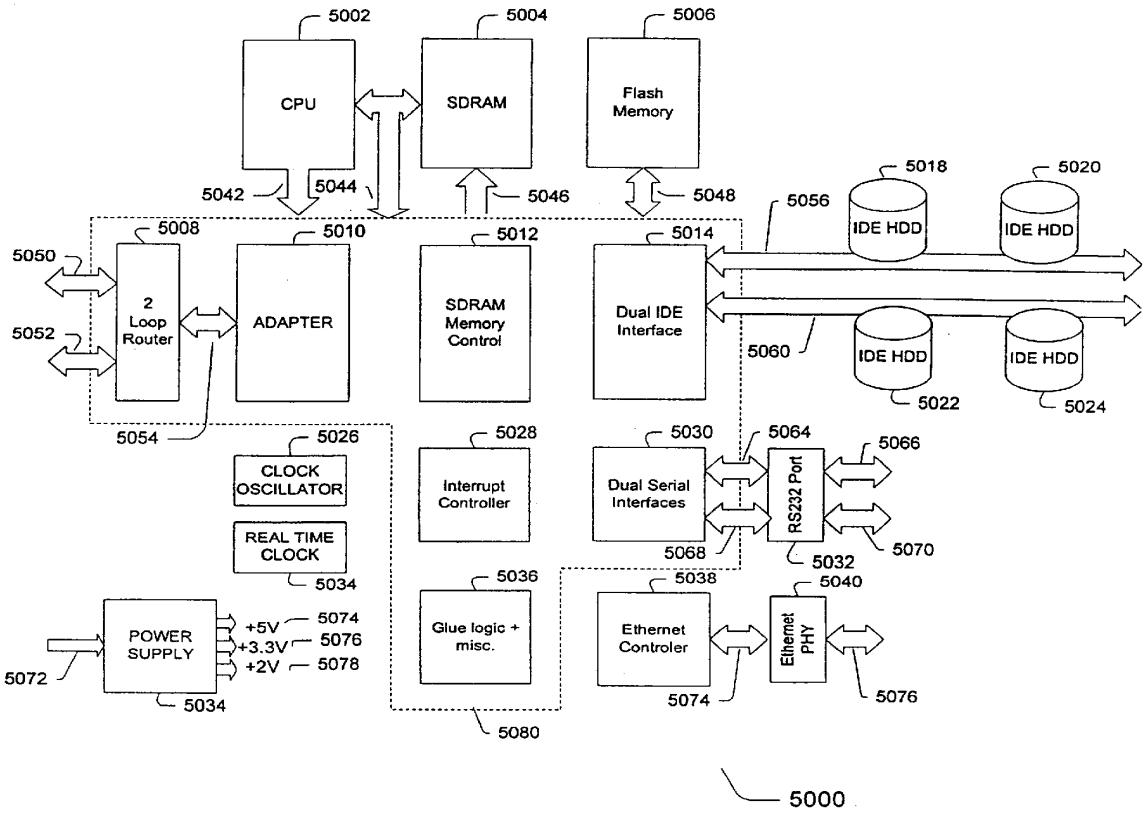

5002
CPU
5004
SDRAM
5006
Flash Memory
5042
5044
5046
5048
5018
IDE HDD
5020
IDE HDD
5056
5008
5010
5012
5014
5050
2 Loop Router
ADAPTER
SDRAM Memory Control
Dual IDE Interface
5052
5060
IDE HDD
IDE HDD
5022
5024
5054
5026
5028
5030
5064
5066
CLOCK OSCILLATOR
Interrupt Controller
Dual Serial Interfaces
RS232 Port
REAL TIME CLOCK
5034
5068
5032
5070
5036
5038
5040
POWER SUPPLY
+5V
+3.3V
+2V
5074
5076
5078
Glue logic + misc.
Ethernet Controler
Ethernet PHY
5072
5034
5074
5076
5080
5000

FIG. 22

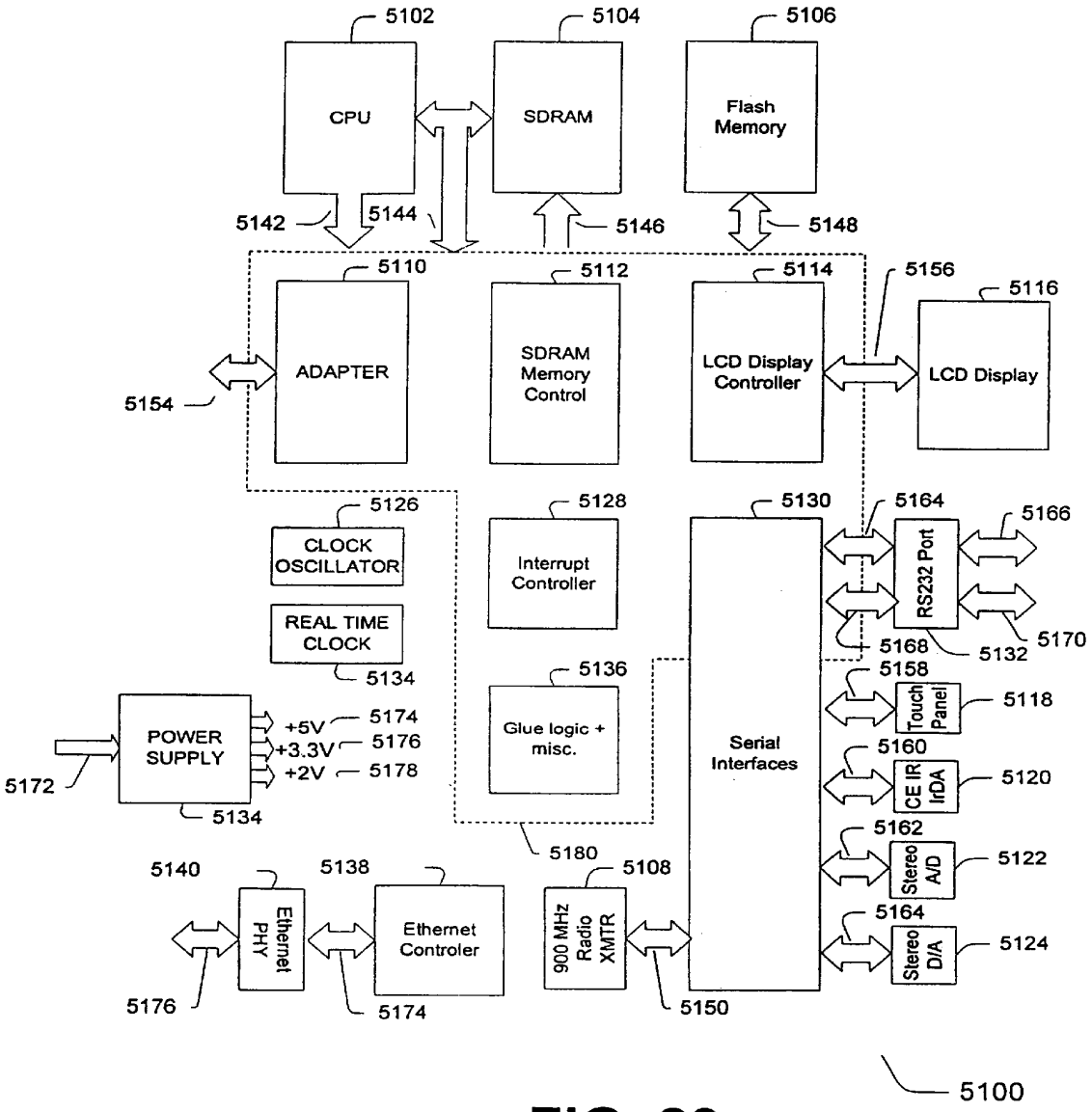

5102
CPU
5104
SDRAM
5106
Flash Memory
5142
5144
5146
5148
5110
ADAPTER
5112
SDRAM Memory Control
5114
LCD Display Controller
5156
5116
LCD Display
5154
5126
CLOCK OSCILLATOR
REAL TIME CLOCK
5134
5128
Interrupt Controller
5136
Glue logic + misc.
5130
Serial Interfaces
5164
5166
RS232 Port
5168
5132
5170
5158
Touch Panel
5118
5160
CE IR IrDA
5120
5162
Stereo A/D
5122
5164
Stereo D/A
5124
POWER SUPPLY
+5V
+3.3V
+2V
5174
5176
5178
5172
5134
5180
5140
Ethernet PHY
5138
Ethernet Controler
5108
900 MHz Radio XMTR
5176
5174
5150
5100

FIG. 23

SYNCHRONOUS NETWORK FOR DIGITAL MEDIA STREAMS

RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Application Ser. No. 60/050,933, filed on May 30, 1997, which is hereby incorporated by reference in its entirety.

I. BACKGROUND OF THE INVENTION

A. Field of the Invention

This invention relates generally to networks of consumer electronics devices, and in particular to synchronous networks optimized for digital media streams.

B. Nature of the Problem—Interconnecting Consumer Electronics Devices for Distribution of Audio, Video and other Media/Data, as well as Control Information, Throughout a Home or other Environment

The holy grail of the "smart home" has long been sought after, but networking of consumer electronics devices has yet to rise from hobbyist status. One of the fundamental obstacles to widespread acceptance of such networks is the difficulty and expense of interconnecting various types of consumer electronics and other devices within a single room, much less throughout an entire home or other environment, such as a hotel or apartment building, or a car, boat or recreational vehicle.

Moreover, even when such devices are interconnected, there remain problems of distributing control information, as well as audio, video and other types of media/data, in a sufficiently flexible manner to permit users to switch sources, record programs, schedule events and perform other advanced tasks without sacrificing the ease of use provided by a simple television and remote control.

Today's home theater systems, for example, quickly become unwieldy as devices are added (even apart from the "spaghetti" of cables interconnecting devices), in part because such devices typically do not all "speak the same language." Users are faced with fix unenviable task of having to "program" or configure their system to perform even relatively simple tasks, such as turning the system on and off. Anyone who has tried to explain to a spouse, friend or babysitter how to use the "universal" remote control (e.g., to watch or record a television program or videotape, laserdisc or satellite broadcast) understands the nature and complexity of this problem.

With the advent of digital media and services (e.g., audio CDs, DSS or DVB digital satellite broadcasts and DVD movies) comes an opportunity to address this problem from a more general-purpose system or network perspective. Such a network perspective can be contrasted with existing home theater and home automation systems which interconnect devices with dedicated media-specific cables (audio and video cables, speaker wire, etc.,), and provide a separate control topology (infrared remote controls, X10 control networks, etc.).

In a digital domain, all information (from audio, video and other digital media streams to custom commands and other control information, and even asynchronous network protocols) can be distributed, processed and controlled using the "same language"—i.e., the binary language spoken by virtually all of today's computer hardware and software, from dedicated hardware state machines to "smarter" controllers and general purpose CPU-based devices.

The opportunities provided by a network of devices distributing digital media and control information are enormous. It is far more difficult and expensive, for example, to distribute/route analog audio and video streams to devices throughout a home or other environment, much less process (e.g. record, mix and otherwise modify) particular information along the way, than it is to distribute such information in a digital environment. Moreover, by providing software control over individual "samples" of digital media, significant new functionality can be added to a system that simply was not feasible in an analog domain.

For example, users could decide to record a movie after watching the first 15 minutes, or record a song after hearing it in its entirety. Playing and recording digital media streams can be as simple as reading and writing a disk drive, as will be explained below. Moreover, with a software interface, users easily could select a variety of programs to be recorded (e.g., over the course of a week) without having to worry about switching tapes in the VCR. Additional telephone lines, or even complex PBX functionality, could be integrated into the system, all under software control for even greater flexibility. As will become apparent, the possibilities are virtually endless. The sheer flexibility afforded by digital media cannot be underestimated.

As discussed below, current systems for interconnecting consumer electronics and other devices suffer from a variety of problems, not the least of which is a lack of foresight with respect to the imminent digital revolution or "convergence." These problems include difficult and expensive cabling schemes, limited network topologies, complex and expensive devices, inadequate media synchronization and a general lack of integration between the means for distributing audio, video and other media, and the means for processing and controlling the information being distributed.

C. Description of Related Art

1. Home Entertainment Systems and Home Automation Networks

Current home entertainment systems and home automation networks illustrate many of the fundamental problems discussed above. Home theater systems, for example, effectively are limited to a single room in a house, primarily due to the difficulty and expense of interconnecting devices.

Each source device, such as a satellite receiver, VCR, laserdisc or DVD player, typically is connected, by relatively expensive audio and video cables, to a "central" preamplifier or other form of switching device, which is also connected to a main television/monitor as well as to one or more power amplifiers, which are in turn connected to various speakers throughout the room by dedicated (and also expensive) speaker cables.

Such a cabling scheme is both expensive and difficult to maintain. Removing a defective VCR from a rack of equipment, for example, often requires reconnecting cables in a new configuration just to enable the rest of the system to function while the VCR is being repaired. Moreover, flexibility is limited, even with relatively high-end preamplifiers. Only a limited number of source devices can be accommodated by any dedicated device interconnection scheme. It often is prohibitively expensive to replace a high-end preamplifier merely because it will not accommodate the latest source device added to the system. Users therefore still may suffer the inconvenience of connecting and disconnecting cables manually to switch sources.

Moreover, even when all devices can be accommodated, the functionality of such home theater systems still remains limited. Recording programs with a VCR, as noted above, remains a mysteriously unattainable objective. As more

source devices are added to a home theater system, the desire to record programs becomes greater, as does the difficulty of successfully recording a desired program.

Users frequently must change tapes, as well as figure out how to "program" a remote control to make the preamplifier, source device and VCR work together to record a program, particularly if someone is watching another program at the same time. Few systems even permit more than one program to be recorded simultaneously.

The difficulty of controlling consumer electronics devices and systems stems from the fact that most devices are not designed to interoperate with one another. User interfaces on universal remote controls are very limited. LCD screens, for example, rarely are used for more than listing a menu of commands. They rarely indicate any dynamic status information (such as which device is selected, which program is being recorded, etc.).

Moreover, universal remote control devices are extremely difficult to operate, and require extensive "programming" to perform even simple functions, such as turning the system on and off, which may require a "program" to send multiple commands—i.e., one to each device. Even switching from one source to another may require a multiple-command program—e.g., to switch video input sources on the television as well as switch the preamplifier source.

The result is an expensive system that is complex to set up, use and maintain, even in a single room. Multi-room systems are even more rare, due to the expense of dedicated cabling solutions, and the additional inconvenience of distributing control over devices across rooms. If VCRs, CD players and other source devices are physically located in different rooms of a house, the complexity of the "central" preamplifier, designed for dedicated cabling to all source and destination devices, becomes unwieldy.

As a result, users improvise by providing redundant functionality. Multiple preamplifiers, multiple VCRs, and multiple remote controls (often "programmed" uniquely for each room) are deployed, not necessarily because multiple devices are needed at any given time, but primarily because the alternative is too complex and expensive to be practical.

It is thus not surprising that such systems still are limited to hobbyists and high-end gadget-oriented users. Current attempts to address the multi-room problem—i.e., "home automation and multimedia networks" exhibit a number of fundamental design flaws. For example, virtually all current home automation standards (X10, CEBus, Echelon LONWorks, etc.) emphasize distribution of control information, as opposed to audio, video and other media.

In other words, such systems distribute analog media on one network or wiring infrastructure and digital control information on another separate network. Custom installation of dedicated audio, video and speaker cables throughout a home is required, and often is prohibitively expensive and results in relatively poor quality due to the degradation of analog signals propagating through multiple devices and extremely long cable runs. Home power lines (or infrared or radio frequency broadcast signals) typically are used to form a separate digital control network onto which remote control/sensor devices can be connected.

The quality of such home automation networks is far below audiophile and videophile standards. Analog audio and video signals simply cannot propagate for long distances, and through multiple A/D and D/A converters and other analog processing circuitry, without suffering significant degradation in quality. Transmitting multiple audio/video channels over coaxial cables, power lines or via radio frequency (RF) transmissions, degrades the signals significantly, and results in relatively low-quality audio and video output. transmissions, degrades the signals significantly, and results in relatively low-quality audio and video output.

Although some systems utilize existing unshielded twisted pair (UTP) telephone wiring to carry analog audio and video signals, the analog modulation of source audio and video signals over UTP cables also produces relatively low-quality audio and video output. Moreover, such systems still require custom installation of such UTP cabling, because the parallel nature of existing telephone wiring topologies (discussed in greater detail below) is not compatible with the dedicated cabling schemes discussed above.

As a result, the expense and complexity of such systems increases exponentially compared with single-room home theater systems. Although control over devices is improved (e.g., by a PC or other controller device, operating under software or firmware control), it is still limited, in essence, to the raw commands accepted by individual devices (e.g., by their remote controls).

Home automation networks, as a result of their separation of control and media distribution functionality, do not allow for sufficiently flexible control over streams of audio, video and other media, except at the most basic level of switching from one source to another. The result, as noted above, is a highly complex and expensive system that is difficult to set up, use and maintain.

Existing home automation networks simply are not poised to take advantage of the advent of digital media. Such media continues to be distributed in analog form over a separate network, distinct from the control network that is the primary focus of such home automation networks.

2. Local Area Networks and Ethernet

One potential solution to the problems rioted above is to implement a digital computer-based network of the type typically found in business environments for interconnecting personal computers, workstations, servers and printers. Although the recent increase in popularity of the home computer market has led to a great deal of discussion of home networks which merge general-purpose computing functionality with the consumer electronics devices found in home theaters, the solutions offered thus far do not seem to have advanced beyond the proposal stage.

Applying local area network technology (e.g., Ethernet and TCP/IP network protocols) to consumer electronics devices raises a number of problems. Although it appears advantageous to connect consumer electronics devices as generic nodes on a network, existing network protocols are far from optimized for real-time streams of digital audio and video.

Although current "solutions" are vague in nature, they typically fall into one of two categories. The first is analogous to the home automation networks discussed above, in which consumer electronics devices are connected via dedicated audio and video cables, and still transmit analog information along one network, while an Ethernet network, for example, enables home computers and other control devices to control the operation of the consumer electronics devices. The interface between the two networks is unclear, although the solutions offered by X10 and other home automation network standards appear to apply equally to this scenario.

The other alternative implementation is to distribute audio, video and other real-time media streams in digital

form. There are a number of obstacles to this scenario, however, not the least of which is the apparent absence of an existing physical and logical infrastructure to carry the digital media streams. Ethernet, for example, is not optimized to carry real-time continuous digital media streams. It is an asynchronous, packet-based protocol that would add significant overhead to digital audio and video samples, which require consistent and timely delivery, as opposed to the ability to "burst" packets of information at high speeds on demand.

The direction currently being followed by the computer industry appears to be focused on one high-speed bus protocol in particular, which was designed to enable personal computers to exchange information with peripherals such as disk drives, digital video camcorders and digital televisions. This bus protocol, known as "FireWire" (IEEE 1394), was designed more as an information-exchange protocol (to move data quickly between personal computers and peripherals) than as a network protocol optimized for distributing real-time continuous digital media streams among consumer electronics devices, along with control information, throughout a home.

Nevertheless, the momentum behind FireWire as an industry standard suggests that many home computers and consumer electronics devices soon will have built-in FireWire ports. What remains unclear is whether FireWire can solve the interconnection and control problems discussed above. Following is a brief discussion of FireWire, and of certain of its shortcomings in the context of a home network.

3. FireWire

FireWire devices are connected by a custom 6-wire cable, with two wires for power and two twisted-pairs for data. Devices can be daisy-chained to allow tree and other acyclic topologies (i.e., no "loops" are allowed). FireWire devices have limited "plug and play" and "hot-pluggable" functionality. In other words, devices can configure themselves automatically upon being powered on, and can be attached and removed from the network without turning off the entire system. Yet, doing so may interrupt (i.e., "reboot") the network, and thus interrupt existing digital media streams, as the network reinitializes and reconfigures devices.

On startup, the bus configures itself in three phases: bus initialization tree identification and self-identification. Whenever a new node is connected or disconnected, a signal sends all nodes into an initialization state, whereupon each node resets all topological information in a distributed manner. In other words, each node determines its own connections and passes this information along to its neighboring nodes, and so on throughout the network. One node is selected as the "root" node, and a unique physical ID is assigned to each node (though physical IDs are reassigned every time the bus is reconfigured).

FireWire employs two different processes, called "subactions," for distributing data packets among devices attached to the bus. One is asynchronous, while the other is isochronous. As is explained below. FireWire essentially is an asynchronous bus protocol, in that audio, video and other data packets are not distributed among devices at fixed intervals in accordance with a master clock.

Asynchronous subactions begin with an arbitration period to determine which requesting device is granted control of the bus (because only one device can transmit at a time). The winning node transmits certain transaction and other codes (for speed, format, etc.), along with its address and that of destination nodes, and variable-length data. If the packet is not a broadcast packet, there is a brief gap, followed by an acknowledgment from the destination node. Asynchronous subactions are followed by "subaction gaps," which are required due to propagation delays.

Isochronous subactions are similar, but have a simpler arbitration process, a short channel identifier instead of source and destination addresses, no acknowledgment, and shorter gaps between subactions. FireWire uses a relatively slow 8 kHz clock for isochronous transmissions. After all desired isochronous packets have been sent, the bus resumes asynchronous subactions.

FireWire devices are half-duplex. Thus, devices connected to two or more nodes cannot propagate incoming data while transmitting their own data. FireWire devices employ a "data-strobe encoding" scheme (invented by engineers at Inmos, Ltd.—see U.S. Pat. No. 5,341,371), which involves transmitting data on one twisted-pair wire and a strobe signal on the other pair. The strobe signal transitions whenever two consecutive data bits are the same. This technique was believed to result in increased skew tolerance compared to a standard clocked format (such as 4B/5B or 8B/10B and clocked NRZ coding, as explained below in the context of the present invention).

From the above summary of the characteristics of FireWire, it is apparent that there are a number of obstacles to applying FireWire to real-time distribution of digital media streams among consumer electronics devices, particularly in light of its essentially asynchronous and half-duplex nature.

The installation cost of a FireWire network of consumer electronics devices is likely to be quite high. Custom installation of FireWire cables is likely to he required throughout a house, despite the use of twisted-pair cables. No mechanism for compatibility with existing UTP telephone wiring topologies is included in the FireWire specification.

In addition to the high cost of installing FireWire, the cost of FireWire devices themselves is likely to be quite high, due primarily to the asynchronous nature of FireWire. Because data packets are transmitted asynchronously, devices must be able to buffer incoming packets and generate timing information internally (i.e., "timestamps" associated with the data packets), which must be communicated to other devices. Moreover, almost double the audio data is required due to this buffering/timestamping process, resulting in a significant loss of bandwidth. This results in complex and expensive devices, due to the memory, buffers, counters and associated circuitry required to perform such functions. Even a simple FireWire device requires at least a simple processor (CPU) and memory to implement the FireWire protocol stack.

The 8 kHz isochronous cycle simply is too slow for applications requiring CD-quality (44.1 kHz) audio. Were FireWire to increase its isochronous cycle frequency to 44.1 kHz, some of these obstacles might be overcome.

The lack of asynchronous time base also results insignificant clock jitter. The start time of an isochronous packet may be delayed by an asynchronous packet (due to their variable length). To account for this possibility, a delay is encoded in the "cycle start" signal, resulting in clock jitter. Moreover, additional jitter results from the variable amount of time between the "cycle start" and the actual start of a specific device's subactions, requiring each device to maintain its own timing register to account for this source of jitter.

There are solutions to these timestamp and clock jitter problems. Yet, they add significant cost and complexity to

every device attached to a FireWire bus. As a result, FireWire devices need CPUs just to manage these bus protocol issues. This could be a significant obstacle to acceptance of FireWire for anything beyond relatively high-end computer peripherals and the most expensive consumer electronics devices, such as HDTV or digital camcorders.

For applications requiring real-time delivery of continuous digital media streams, FireWire has additional problems. One significant limitation to FireWire is the total length of the connecting cable, which is limited in the current specification to 4.5 meters (unless extremely expensive fiber optic or other alternative cables are used). This short length is a significant limitation even within a single room used for a typical home theater system; and is prohibitive in the context of a house-wide application, such as a home telephone PBX or multi-room digital audio and video distribution system.

Even if repeaters could be accommodated, such devices would be relatively expensive, and would contribute to FireWire's 64-device limitation. An asynchronous FireWire router might well become necessary to accommodate additional devices beyond this limit. Such a route would be extremely complex, requiring knowledge of data types to reassemble packets, buffering of variable-length packets, etc. In addition to being expensive, such a router would impose variable-length delays, making it extremely difficult, for example, to synchronize two speakers receiving information from a source device via the router. Each speaker would have to receive and handle timestamps (due to variable delays from other devices, as well as the router), and reassemble data packets, just in order to play 44.1 kHz digital audio samples.

Another problem with FireWire devices in the context of a network of consumer electronics devices is that no mechanism exists to enable such devices to be truly hot-pluggable. The FireWire bus will reset whenever a device is added or removed, resulting in an interruption (however short) to all existing data streams. The FireWire specification contains no provision for a router or other device to isolate a particular device or chain of devices from the rest of the network, such that the FireWire bus need not reset, and thus disrupt, the entire network when a device is added to or removed from this isolated network segment or zone.

The lack of static device IDs also creates problems. Each device must update its topology table whenever the bus is reinitialized e.g., whenever a new device is added or removed, or a device malfunctions. No device therefore can rely on these device IDs remaining constant.

As will become apparent below, certain of the techniques employed in the present invention could be adapted to FireWire buses and associated FireWire peripherals. For example, FireWire peripherals could be adapted for use as a node on a network of the present invention. Moreover, certain of the disadvantages of FireWire noted above could be overcome to some extent by adopting and/or combining with particular aspects of FireWire certain of the techniques discussed below.

For example, static device IDs could be employed to simplify device identification and addressing, as well as the self-configuration process—because a device's presence could be detected via its static ID. Static IDs also would facilitate the implementation of copy protection, fraud detection and other features that rely on the identification of particular devices. In addition, device-specific information could be stored along with the device ID, such as pointers to external device drivers (as discussed below).

Nevertheless, FireWire remains essentially an asynchronous bus protocol. It simply is not optimized for distributing real-time continuous digital media streams among consumer electronics devices in a network environment. It was designed as a computer peripheral bus, for exchanging data (asynchronously) between computers and peripherals, such as disk drives and digital camcorders.

4. Synchronous Networks and Ring Networks

Unlike FireWire, a truly synchronous network could overcome many of the limitations discussed above. Yet, synchronous network protocols (as discussed below) have not been optimized or adapted for use with consumer electronics devices to enable the distribution of digital media streams in a manner that overcomes the limitations noted above.

TDMA networks, for example, utilize time-division multiplexing, and synchronize all devices to a master clock. Yet, the bandwidth on a TDMA network typically is divided equally among the devices on the network. In other words, if 10 devices are on the network, each device gets 1/10th the network bandwidth, and thus can transmit information only during that channel or "time slice" (e.g., during unit 1 of every 10 units of time).

In the context of transmitting digital media streams, however, certain data streams require more bandwidth than others. Video data, for example, requires more data than audio, though it is sampled less frequently. Yet, TDMA networks assign each device a single channel in which to transmit all of its data. These channels are based simply on the number of devices on the network, and bear no relationship to the bandwidth requirements of the type of data being transmitted. This problem is exacerbated when asynchronously distributed variable bit-rate data, such as MPEG2 compressed video, must also be accommodated. TDMA network technology provides no solution to either of these problems. TDMA devices are left with a single fixed-width channel which is not well suited for accommodating either multiple real-time continuous data types having differing bandwidth requirements, or an asynchronous data type having bandwidth requirements that vary over time.

Even in the context of a ring network, in which data propagates from one device to another around a loop oaring (and is overwritten when a device desires to insert its own data), a device on a TDMA network could transmit information (such as a digital audio sample) anytime during its assigned time slice. Moreover, that time slice might charge whenever a new device is added to or removed from the network. Thus, a device cannot guarantee consistent delivery of particular data, despite the synchronous nature of TDMA.

Ring networks, however, appear to be good candidates for consistently delivering particular data (e.g., a digital audio stream) from one device to another (e.g., from a CD player to a speaker), assuming that such information propagates around the ring at a consistent rate (e.g., synchronously, based upon a master clock). Yet, existing ring networks suffer from many of the same deficiencies discussed above.

Token Ring networks, for example, are asynchronous in nature. Each device transmits data only when it receives the "token," which does not occur at fixed intervals of time. Thus, such networks cannot guarantee consistent delivery of real-time continuous digital media streams.

FDDI networks on the surface appear to be synchronous ring networks; yet, they transmit information synchronously only in a point-to-point manner. In other words, the transmitter on one device is synchronized to the receiver on the next device on the ring. Yet, the transmitter and receiver

within a device are not synchronized to each other. Information therefore will not always propagate through a device at a consistent rate, due to the difference between the transmit and receive oscillators within a device, among other factors.

FDDI devices compensate for this difference with an "elasticity buffer" which avoids losing data, but does not guarantee consistent delivery of data. For example, if a device receives data "late," it will transmit that data late. If it receives data "early," it will place that data in its elasticity buffer, and transmit such data in a FIFO fashion.

Thus, FDDI devices also cannot guarantee consistent delivery of data such as real-time continuous digital media streams. They are optimized for high throughput, but not for consistent, synchronous delivery of data.

D. Resolving the Problem

The above description of home theater systems and home automation networks, and of various existing asynchronous and synchronous network protocols, illustrates many of the obstacles to interconnecting consumer electronics devices for distribution of audio, video and other media (including both real-time continuous digital media streams and asynchronous data), as well as control information, throughout a home or other environment. It also serves to explain why the "smart home" has remained such an elusive goal.

Problems such as those discussed above must be resolved before home networks can achieve widespread acceptance. What is needed is a low-cost physical network topology, preferably one that is compatible with the existing physical cabling infrastructure in a home, to avoid the significant barrier to entry of having to rewire an entire home merely to set up a simple network consisting of a few devices. Such a topology should enable devices to be interconnected with relative ease, as contrasted with the difficulty and expense of interconnecting audio and video and other consumer electronics devices within and across rooms of a home using available technologies.

Such a network also should be compatible with existing consumer electronics devices, again to avoid the significant barrier to entry of having to replace all existing devices merely to set up a simple network consisting of a few devices. Moreover, such adapters and other devices preferably should be relatively inexpensive (at least no more expensive than comparable existing devices) in order to encourage consumers to adopt this new technology.

The network should accommodate real-time continuous digital media streams, as well as asynchronous data (and digitize existing analog audio and video) in order to provide the significant benefits and flexibility noted above. To do so, the network must deliver such digital media streams reliably, in order to provide the same level of synchronization as is currently provided by existing analog delivery mechanisms.

II. SUMMARY OF THE INVENTION

To achieve these objectives, one embodiment of the present invention provides a protocol and architecture for a synchronous logical ring network which operates on the existing physical twisted-pair telephone topologies found in most homes today (forming a "logical" ring without requiring in-wall wiring modifications). The logical ring network can even replace the existing analog telephone network in the home. It can accommodate daisy-chained network devices which, because they need not be connected to a junction box in the wall, require neither in-wall nor junction-box wiring modifications. Moreover, virtually any physical topology (star, loop, tree, etc.) throughout a home, office or other environment can be converted, with minor junction-box wiring modifications, into a logical ring network of the present invention.

Information can propagate around this logical ring, reaching every device on each revolution around the network. Network devices are full-duplex, transmitting and receiving information simultaneously.

An arbitration process occurs automatically upon network initialization, and one of the competing devices is elected the network clock device to which all other devices are then synchronized. By synchronizing all network devices to a single reference clock, and providing fixed frames of information propagating around the network at consistent time intervals (44.1 kHz "frame rates" in one embodiment, to enable device synchronization to the CD audio sample rate), the logical ring network ensures that information always will propagate from one device to another at consistent time intervals. In other words, information will propagate consistently around the logical ring network at the frame rate; and the time required for information to propagate between any two particular devices will remain fixed.

Following network initialization (and whenever devices are added or removed), an auto-configuration process configures each network device and determines the network topology. The entire network topology is discerned and made available to interested devices, even though individual devices need not be capable of interpreting such information. Devices can be added and removed in true "plug and play" fashion, and will be hot-pluggable if connected anywhere on a chain of devices attached to a "hot-pluggable smart jack" device.

Most network devices are relatively "dumb" and inexpensive, in that they require only simple hardware state machines to accommodate the basic network protocol, and to transmit and/or receive digital media streams. Network devices have unique static device IDs, which simplify device identification and addressing, as well as network initialization, and form the basis for encryption to provide network security, authentication and/or copy protection functionality. Devices also can contain other device-specific information, including device drivers (or pointers to external device drivers) that can be executed on their behalf by "smart" CPU-based controllers.

In addition to accommodating adapters that connect existing consumer electronics devices to a logical ring network of the present invention, the network architecture accommodates new "restructured" digital-ready devices that redistribute existing device functionality across the network. For example, by removing MPEG2 decoders from DVD players, the compressed digital information can be distributed/processed throughout the logical ring network before reaching its ultimate destination (e.g., a television attached to or incorporating an MPEG2 decoder).

Information propagates along the logical ring network in fixed-length frames which, in one embodiment, comprise 640 bits of encoded data, transmitted at a raw bit rate of 28.224 MHz. In addition to "frame header" markers that synchronize devices to a master clock, these frames contain two independent streams—a "data stream" for the distribution of real-time continuous digital media streams, as well as asynchronous data, and a "system command stream" for the distribution of "system commands," which are used primarily for network initialization and auto-configuration of network devices, as well as basic switching of digital media streams. The system command stream propagates along a "default network path" that reaches every network device.

The data stream, however, can propagate along any available path, to provide for greater overall network bandwidth (e.g., by adding a switching router device to the network to create alternative data stream paths).

The data stream is divided into distinct "channels" (the size of each channel being tailored to the bandwidth and sample-rate requirements of a particular media type) which operate by default, and can be reallocated dynamically (in some cases even occupying discontiguous portions of the data stream). In this manner, devices can reliably guarantee consistent delivery of data (e.g., audio samples at the standard CD audio 44.1 kHz rate) having particular bandwidth requirements. Thus, two speakers on the network will receive left and right channel digital audio, respectively, at the "same time" (i.e., within one sample time of accuracy), and thus be synchronized to each other (i.e., phase coherent), even if the source device is physically located in another room and/or zone of the network). Phase coherency is a critical factor in high-quality stereo audio systems, as well as multi-channel surround sound systems, such as Dolby AC-3.

The data stream also can contain embedded control information and other asynchronous data, including compressed MPFEG2 video and other variable hit-rate data, as well as asynchronous network protocols, such as I^2C, RS232 serial protocols and TCP/IP. Such information is delivered synchronously, however, thereby avoiding collisions. Network devices also can utilize channels of the data stream to send custom commands to one another, including control information, pursuant to virtually any protocol known to such devices.

III. BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objectives, aspects, and advantages will be better understood from the following detailed description of embodiments of the present invention with reference to the following drawings:

FIG. **1** is a system diagram illustrating a typical configuration of consumer electronics devices connected to a logical ring network of the present invention.

FIG. **2**(*a*) is a system diagram illustrating a standard physical topology for an analog telephone network in a typical home environment.

FIG. **2**(*b*) is a system diagram illustrating a standard physical star topology for a data and/or voice network in a typical home environment.

FIG. **2**(*c*) is a system diagram illustrating the transformation of a standard physical topology for an analog telephone network into a logical ring network of the present invention.

FIG. **2**(*d*) is a system diagram illustrating the transformation of a standard physical star topology for a data and/or voice network into a logical ring network of the present invention.

FIG. **3** is a wiring diagram illustrating standard unshielded twisted-pair telephone cables connected in parallel at a junction box in a typical home environment.

FIG. **4**(*a*) is a wiring diagram illustrating a replacement junction box converting arbitrary physical topologies of standard unshielded twisted-pair telephone cables into a logical ring network of the present invention.

FIG. **4**(*b*) is a wiring diagram illustrating generic wiring of a replacement junction box for converting arbitrary physical topologies into a logical ring network of the present invention.

FIG. **5**(*a*) is a diagram illustrating the interconnection of a standard telephone connector and a jack of a replacement junction box on a logical ring network of the present invention.

FIGS. **5**(*b*) and **5**(*c*) are diagrams illustrating a switchable replacement junction box with jacks for both a standard analog telephone network and a logical ring network of the present invention.

FIG. **6** is a diagram illustrating the integration of phantom power from a standard internal transformer into a jack of a replacement junction box on a logical ring network of the present invention.

FIG. **7** is a system diagram illustrating the default network path of a logical ring network of the present invention.

FIG. **8** is a state diagram illustrating network initialization and auto-configuration of a synchronous logical ring network of the present invention.

FIG. **9** is a block diagram illustrating various interfaces to an ASIC embodiment of a core network adapter for connecting devices to a synchronous logical ring network of the present invention.

FIG. **10** is a block diagram illustrating major functional components of a core network adapter for connecting devices to a synchronous logical ring network of the present invention.

FIG. **11** is a block diagram of a receiver component of a transceiver in a core network adapter for connecting devices to a synchronous logical ring network of the present invention.

FIG. **12** is a block diagram of a transmitter component of a transceiver in a core network adapter for connecting devices to a synchronous logical ring network of the present invention.

FIG. **13**(*a*) is a block diagram of a clock processing and synchronization component of a transceiver in a core network adapter for connecting devices to a synchronous logical ring network of the present invention.

FIG. **13**(*b*) is a detailed block diagram of particular synchronization portions of a clock processing and synchronization component of a transceiver in a core network adapter for connecting devices to a synchronous logical ring network of the present invention.

FIG. **14**(*a*) is a block diagram illustrating a system command stream processing component in a core network adapter for connecting devices to a synchronous logical ring network of the present invention.

FIG. **14**(*b*) is a flowchart illustrating the operation of a basic system command processor state machine of a core network adapter for connecting devices to a synchronous logical ring network of the present invention.

FIG. **15** is a block diagram illustrating a data stream processing component in a core network adapter for connecting devices to a synchronous logical ring network of the present invention.

FIG. **16** is a black diagram of a hot-pluggable smart jack device into which other network devices can be connected and disconnected without requiring complete reinitialization of a synchronous logical ring network of the present invention.

FIG. **17** is a block diagram illustrating a multi-zone router for connecting distinct arms of a synchronous logical ring network of the present invention.

FIG. **18** is a system diagram illustrating the interconnection of multiple multi-zone routers for connecting distinct arms of a synchronous logical ring network of the present invention.

FIGS. **19**(*q*)–(*d*) are schematic diagrams illustrating single, dual, bidirectional and dual-bidirectional transmis-

sion and receive drivers, respectively, of devices on a logical ring network of the present invention.

FIG. **19**(*e*) is a schematic diagram of a device adapter for enabling devices having only unidirectional transmission and receive drivers to coexist with devices having bidirectional transmission and receive drivers on a logical ring network of the present invention.

FIG. **20** is a system diagram illustrating the interconnection of devices having 5-level, dual and bidirectional transmission and receive drivers on a logical ring network of the present invention.

FIGS. **21**(*a*)–**21**(*y*) are block diagrams illustrating key components of various network devices on a synchronous logical ring network of the present invention.

FIG. **22** is a block diagram illustrating a mass storage server device on a synchronous logical ring network of the present invention.

FIG. **23** is a block diagram illustrating a remote control/monitor human interface device on a synchronous logical ring network of the present invention.

IV. DETAILED DESCRIPTION

A. High-Level System Configuration

Illustrated in FIG. **1** is atypical system-level configuration of consumer electronics devices connected to a logical ring network **120** of the present invention throughout a typical home **100**, having family room **102**, kitchen **104**, utility room **105**, bedroom **106**, hallway **108**, den **110** and attic **112**.

It should be noted that the present invention can be implemented with devices other than consumer electronics devices (e.g., business, industrial, professional and other devices) and in environments other than a home (e.g., office, hotel, apartment building, car, boat, recreational vehicle, etc.). The particular environment or application may result in a significantly different configuration than that illustrated in FIG. **1**. The advantages of the present invention described below with reference to a network of consumer electronics devices in a home also apply to these other environments and applications.

It should be further noted that a logical ring network can be formed merely by connecting two network devices together with a standard RJ-11 telephone cable (as well as with standard or slightly modified RJ-11, RJ-12, RJ-45 or other connectors in other embodiments, as discussed below). More devices can be added to the network by daisy-chaining them directly to one of these two devices, or connecting them to a junction box (for distribution throughout home **100**), as will be discussed in greater detail below. All devices and/or components illustrated in FIG. **1** are shown attached to logical ring network **120** in a daisy-chain fashion (either within a room or behind the walls via a junction box of house **100**). The actual physical topology of logical ring network **120**, and the manner in which devices are interconnected, will be discussed in greater detail below.

Broadcast FM audio is received by FM Tuner **130**, where it is digitized and transmitted onto logical ring network **120**. Broadcast MPEG2 audio/video information is received by DSS Tuner **140**. Because such MPEG2 information already is in digital form and compressed, it can be transmitted directly onto logical ring network **120**. As will be explained below for one embodiment, the MPEG2 decoding will occur only after such information leaves logical ring network **120** (e.g., it a television where the information will be decoded and decompressed for viewing).

In addition to these two broadcast audio/video sources, other source devices include CD/DVD players **150** (in room **102**) and **160** (in room **106**), as well as Multimedia PC **170** (in room **110**) and Multimedia Telephone **180** (in room **104**). Information transmitted by these source devices propagates around logical ring network **120** and can be received by any appropriate destination device, as will be described in greater detail below.

For example, an MPEG2 movie, received by DSS Tuner **140** or played at CD/DVD player **150** or **160**, could be displayed on small television **165** and/or large television **155** (after being decoded by MPEG2 decoders **161** and **151**, respectively). The audio extracted by MPEG2 decoder **161** could be transmitted back onto logical ring network **120** and played by left **167** and right **168** amplifier/speakers. The audio extracted by MPEG2 decoder **151** could be transmitted back onto logical ring network **120**, processed by DSP (e.g., AC-3 surround sound decoder) **152**, and then transmitted back onto logical ring network **120** and played by surround sound amplifier/speakers **153**, **154**, **156**, **157** and **158**. The systems in rooms **106** and **102** could be controlled by respective remote control/interface/monitor devices **190** and **195** (which could range from simple remote controls to complex controllers with large LCD screens capable of viewing computer graphics images, MPEG2 video, etc.).

As will be discussed below, virtually any information obtained or generated by one network device can be distributed "simultaneously" (i.e., within the same digital sample, appropriate to the media type) to any other network device, merely because such devices are connected to logical ring network **120**. For example, server **185** in utility room **105** might be recording various digital audio/video programs/channels previously selected by a family member. Upon request, such information could be transmitted along logical ring network **120** for immediate viewing, or saved for later viewing (e.g., to avoid being overwritten as new programs are recorded). Targeted information, e.g., local advertisements, could even be added to such saved programs (perhaps replacing national advertisements), as could material tailored to any particular "target group" (e.g., middle-class suburban homeowners), or even an individual viewer or family.

Multimedia PC **170** could be used to control devices on logical ring network **120**, as well as to transmit and receive digital media to/from other network devices. For example, a family member in room **102** might use control device **195** to control/display PC graphics on the screen of device **195**. Multimedia telephone **180** could be a digital telephone, capable of accessing the legacy analog telephone network via POTS adapter **186**. Such devices could have built-in PBX functionality, or could provide such functionality via general-purpose DSP device **187**.

As can be seen from this relatively simple example, logical ring network **120** provides a great deal of flexibility. Not only can any network device distribute real-time continuous digital media streams (and possibly asynchronous data) to any other network device, but such devices (including legacy devices connected via an adapter, as well as new "digital-ready" devices) can exhibit functionality not feasible with existing technologies, such as recording programs already in progress in their entirety.

It is significant to note that network devices need not be complex or expensive to perform basic functions such as communicating with the network and transmitting and receiving digital media streams. Yet, by adding devices of greater complexity, particularly CPU-based devices controlled by software or firmware, the possibilities are virtually endless (as will be discussed below).

B. Synchronous Logical Ring Network

1. Transforming Arbitrary Physical Topologies into a Logical Ring Network

a) Creating a Default Network Path on a Logical Ring Network

With reference now to FIG. **2**(*a*), a typical house plan **200***a* is presented, with rooms **202***a*, **204***a*, **206***x*, **208***a*, **210***a* and **212***a*. Standard unshielded twisted pair telephone wiring segments **232***a*, **234***a*, **236***a*, **238***a*, **240***a*, **242***s*, **244***a*, and **246***a* interconnect the telephone network **214***a* and junction boxes **216***a* and **218***a* in room **202***a*, **220***a* and **222***a* in room **204***a*, **224***a* in room **206***a*, **226***a* in room **208***a*, **228***a* in room **210***a*, and **230***a* in room **212**(*a*). The wiring forms a three-pronged star or T-junction node at junction box **218***a*, a four-pronged star or node at junction box **226***a*, as well as terminator or end nodes at junction boxes **222***a*, **224***a*, **228***a* and **230***a* (and at junction box **216***a* once the network is formed), and a "middle" node at junction box **220***a*.

Because standard residential telephone infrastructure requires junction boxes to be connected in parallel via only a single pair of unshielded twisted pair wiring, the actual physical topology in typical homes may well include many of these multiple-pronged junction boxes. This technique simplifies the task of wiring junction boxes together, One need merely run one pair from a given junction box to another nearby junction box. Typically, however (as a historical by-product of the advent of lighted "Princess" telephones), most homes have at least two pairs run in tandem to each junction box.

As will be illustrated below, a logical ring network can be formed using existing "in-wall" telephone wiring segments **234***a*, **236***a*, **238***a*, **240***a*, **242***a*, **244***a*, and **246***a*. This logical ring network can be formed from the arbitrary physical topologies found in standard telephone networks merely by modifying the wiring connections at the junction boxes, as will be discussed below. In typical homes, it will not be necessary to incur the potentially significant additional expense of running pairs among junction boxes behind the walls.

Newer homes, or homes that have been retrofitted via custom "in-wall" wiring, may well have an even more flexible physical topology such as the "star" configuration shown in FIG. **2**(*b*). Each junction box **216***b*, **218***b*, **220***b*, **222***b*, **224***b*, **226***b*, and **228***b* is wired as a "home run" back to a central location, i.e., junction box **230***b*. As will be discussed in greater detail below, this physical star topology greatly simplifies the subsequent addition of a switching router device to the logical ring network to increase overall network bandwidth by segmenting the logical ring network into multiple zones or network "arms."

Moreover, the wires themselves may be of a different type from standard residential unshielded telephone wiring. Category 3 or Category 5 unshielded twisted pair wiring, or even coaxial or fiber optic cable, may be installed in order to support higher-speed signal propagation, and thus provide increased cable lengths and/or network bandwidth. As will become apparent, the logical ring network of the present invention can support virtually any transmission media, including wireless configurations.

It also should be noted that, in many star topologies, 4 twisted pairs are used (instead of 2 pairs) for Ethernet and similar networks. Ethernet, for example, uses only 2 of those 4 pairs, leaving the remaining 2 pairs free. One could, for example, dedicate 2 of those pairs to an existing Ethernet network, and utilize the remaining 2 pairs for the logical ring network of the present invention. As will be discussed below, one also can utilize the logical ring network of the present invention to support higher-level protocols, including TCP/IP, RS232, etc. Other variations are possible, of course, depending upon the number of pairs available. A logical ring network can even be formed using a single pair of wires, in a particular configuration discussed below. For simplicity, however, the following discussion of modifications to physical star topologies will reference the more typical 2-pair embodiment of a logical ring network, recognizing that additional pairs could be utilized for other purposes.

A logical ring network also can be formed from this physical star topology by modifying the wiring connections among "in-wall" wiring segments **234***b*, **236***b*, **238***b*, **240***b*, **242***b*, **244***b*, and **246***b* (each multiple-pair wiring segment represented by a single line) at junction boxes **216***b*, **218***b*, **220***b*, **222***b*, **224***b*, **226***b*, **228***b* and **230***b*.

As will be illustrated below, regardless of the network's physical topology, a single path can be created, referred to herein as the "default network path," which traverses each network device in a consistent order on the logical ring. Although signals travelling along this default network path may encounter a junction box and/or device multiple times per "revolution," network devices typically will be connected such that they process signals exactly once per "revolution," as is illustrated in FIG. **2**(*c*), for example, by junction box **226***c* and device **268***c* (at junction box **222***c*).

As will be explained in greater detail below, network devices on a logical ring network of the present invention are synchronized to one another; and each imposes a constant amount of delay (differing from device to device) to process signals. Given that signals travelling along the default network path encounter each network device exactly once per "revolution" around the entire logical ring network, the signal propagation time around the logical ring network along this default network path (and between any two particular devices along the way) remains constant. As a result, network devices are afforded a fixed amount of total network bandwidth for sending and receiving information along this default network path. Various means of increasing network bandwidth will be discussed in greater detail below.

b) Connecting Network Devices to a Logical Ring Network

FIG. **2**(*c*) illustrates how network devices are connected at the junction boxes of logical ring network **250***c*. Devices **252***c*, **254***c*, **256***c*, **258***c*, **260***c*, **262***c*, **264***c*, **266***c* and **268***c* are connected, respectively, to junction boxes **216***c*, **224***c*, **226***c*, **230***c*, **226***c* (again), **228***c*, **218***c*, **220***c* and **222***c*, via jacks **269-1***c*, **269-2***c*, **269-3***c*, **269-4***c*, **269-5***c*, **269-6***c*, **269-7***c*, **269-8***c*, and **269-9***c*. In addition, device **270***c* is "daisy-chained" to device **268***c*.

Each device receives information on one "incoming" pair of wires and transmits information on one "outgoing" pair of wires. Typically, devices will have at least two jacks (not shown) to enable them to be daisy-chained together, e.g., within a room of a house. In such cases, as is illustrated by devices **268***c* and **270***c*, the two jacks can be wired together such that information traveling through junction box **269–9***c* may be received by device 268*c* via a first of its two jacks, processed by device **268***c* and transmitted via its other jack to daisy-chained device **270***c*, where it eventually will "loop" back to device **268***c* via that other jack after being processed by device **270***c*, and finally "loop" back to junction box **269-9***c* via the first jack of device **268***c*.

As noted above, one can create a logical ring network (as well as extend an existing logical ring network) merely by

daisy-chaining devices to one another, without connecting any devices to a junction box, and thus obviating the need to perform any wiring modifications. To extend the logical ring network to another room of a house, for example, one could daisy-chain RJ-11 cables between the rooms. Even if this were not practical, one would only need to modify the wiring at a single junction box in each room to connect the rooms. Thus, a logical ring network can be extended gradually throughout a house to add new devices as the need arises.

In the embodiment illustrated in FIG. **2**(*c*), network devices each contain only a single unidirectional transceiver (shown as a single pair of receiver/transmitter triangles pointing in the same direction). As a result, each network device is capable of transmitting and receiving information only along a single path. Thus, signals propagate only along the default network path **205***c* (discussed in greater detail below).

Starting, for example, at device **252***c*, information would be transmitted along one pair of wiring segments **234***c*, **240***c* and **242***c* to device **254***c*, and then along the other pair of segment **242***c* to device **256***c*, along one pair of segment **246***c* to device **258***c*, and then along the other pair of segment **246***c* to device **260***c*, along one pair of segment **244***c* to device **262***c*, and then along the other pair of segments **244***c* and **240***c* to device **264***c*, then along one pair of segment **236***c* to device **266***c*, then along one pair of segment **238***c* to device **268***c*, and then to daisy-chained device **270***c* where it would pass back through device **268***c* and finally return to device **252***c* along the other pair of segments **238***c*, **236***c* and **234***c*.

It should be noted that, in another embodiment, any wiring segment between two devices could be replaced with a unidirectional and/or bidirectional wireless link (RF, infrared, etc.). For example, by employing wireless transceivers at the two endpoints of a chain of devices having unidirectional transceivers, a logical ring network could be constructed with only a single pair of wires, with the wireless link serving as the "return path" to complete the default network path.

Contemplating that logical ring network **250***c* would be created from an existing plain old telephone system ("POTS") network, it can be seen that the connection with the outside telephone network through line **232***c* is severed. As will be discussed below, this connection could be reestablished (now with a logical ring network instead of a POTS network) via an analog telephone adapter device having the necessary circuitry to interface to both a POTS network and a logical ring network.

Alternatively, as is discussed below, one could configure the entire network with the capability of switching between the analog telephone network and the logical ring network, or simply use one pair for the analog telephone network and the other pair for the logical ring network. In such a configuration, however (as explained below), in order to complete the default network path of the logical ring network along that single pair, either that single pair would have to form a physical loop, or the devices would require bidirectional transceivers (also discussed below). Other combinations are possible, particularly if additional pairs are made available (as can be understood by one of ordinary skill in the art).

FIG. **2** (*d*) illustrates the analogous connectivity of devices to a logical ring network **250***d* having a physical star topology (showing the two pairs used by the logical ring network). Devices **252***d*, **254***d*, **256***d*, **258***d*, **260***d*, **262***d*, **264***d*, **266***d* and **268***d* are connected, respectively, to junction boxes **216***d*, **224***d*, **226***d*, **230***d*, **226***d* (again), **228***d*, **218***d*, **220***d* and **222***d*, via jacks **269-1***d*, **269-2***d*, **269-3***d*, **269-4***d*, **269-5***d*, **269-6***d*, **269-7***d*, **269-8***d*, and **269-9***d*. In addition, device **270***d* is daisy-chained to device **268***d*.

In this embodiment, as in FIG. **2**(*c*), network devices **252***d*, **254***d*, **256***d*, **258***d*, **260***d*, **262***d*, **264***d*, **266***d*, **268***d* and **270***d* each contain only a single unidirectional transceiver. Thus, information propagates only along the default network path (not separately identified, but described below).

Starting, for example, at device **258***d*, connected at junction box **230***d*, information would be transmitted along one pair of wiring segment **238***d* to device **268***d* and daisy-chained device **270***d* (via junction box **222***d*), and back "home" (to junction box **230***d*) along the other pair of segment **238***d*, and next along one pair of wiring segment **236***d* to device **266***d* (via junction box **220***d*) and back "home" (to junction box **230***d*) along the other pair of segment **236***d*, and next along one pair of wiring segment **244***d* to device **262***d* (via junction box **228***d*) and back "home" (to junction box **230***d*) along the other pair of segment **244***d*, and next along one pair of wiring segment **246***d* to devices **260***d* and **256***d* (via junction box **226***d*) and back "home" (to junction box **230***d*) along the other pair of segment **246***d*, and next along one pair of wiring segment **242***d* to device **254***d* (via junction box **224***d*) and back "home" (to junction box **230***d*) along the other pair of segment **242***d*, and next along one pair of wiring segment **240***d* to device **264***d* (via junction box **218***d*) and back "home" (to junction box **230***d*) along the other pair of segment **240***d*, and finally along one pair of wiring segment **234***d* to device **252***d* (via junction box **216***d*) and back "home" (to junction box **230***d*) along the other pair of segment **234***d*, where it completes the default network path and returns to original device **258***d*.

It should be noted that, using standard unshielded twisted pair wiring, whether in a star or other physical topology, the total distance between network devices along the default network path may have a practical limitation due to signal attenuation. This limitation will depend on the quality of the wire. Standard "silver satin" wire, for example, may be limited to approximately **100** feet, whereas Category 5 wire may perform reliably with runs in excess of 300 feet. Should this problem arise, devices that act as repeaters, to amplify the signal, can be added to the logical ring network.

c) Modifying Physical Parallel Wiring Connections to Form a Physical Loop via Replacement Junction Boxes

As noted above, unless one limits a logical ring network to devices that are directly daisy-chained to one another, certain physical wiring modifications may well be required at the junction boxes (including jacks) at which network devices will be connected. Such wiring modifications in essence transform arbitrary physical topologies of existing residential telephone networks into a logical ring network of the present invention.

Unlike the physical parallel bus topology of a standard residential telephone network, illustrated in FIG. **3**, a logical ring network requires the creation of a physical loop—i.e., a closed physical path. This physical loop can be created by daisy-chaining the two-pair wiring segments, including jacks, connected at a junction box (i.e., connecting one pair of each segment to a pair of another segment) until a physical loop is formed, as is illustrated in FIG. **4**(*a*) discussed below.

Although this physical loop (and thus a logical ring network) can be formed using a single pair of wires, such a

configuration requires that devices remain connected together directly to maintain this physical loop. If one device is removed from the physical loop, for example, the two devices to which it is connected must be connected to each other directly to reestablish the physical loop. This one-pair configuration therefore does not afford the same level of flexibility discussed below with respect to a two-pair configuration, in which virtually any physical network topology can be converted into a logical ring network via minor junction-box wiring modifications which create a physical loop. Moreover, as will be discussed below, "jumper wires" connecting the two pairs of wires within the jacks (at junction boxes and within devices themselves) of such a logical ring network maintain this physical loop regardless of whether other devices are inserted into these jacks.

The more flexible star configuration illustrated in FIG. **2**(*b*) also requires similar wiring modifications. "Hub" junction box **230***b*, where many multiple-pair "in-wall" wiring segments come together, will of course have many more wiring connections than the remaining "spoke" junction boxes, each of which is connected only to one multiple-pair "in-wall" wiring segment. These wiring modifications are illustrated in FIGS. **4**(*a*), **4**(*b*) and **5**(*a*) below.

To better illustrate these wiring modifications, consider typical junction box wiring for the physical parallel bus topology of a standard residential telephone network. This junction box wiring is illustrated in FIG. **3** by means of a typical junction box **300** having four sets of twisted pair wires **302**, **304**, **306**, and **308**, as well as two telephone jacks **310** and **312** (e.g., standard RJ-11 jacks). Each set of twisted pair wires **302**, **304**, **306** and **308**, consists of two twisted pairs (the "B-Y" or black-yellow pair, and the "R-G" or red-green pair) made up of four wire segments, B, R, G and Y, in accordance with standard wiring practice. As noted above, standard telephone wiring is connected in parallel, with each red wire segment connected with each other red wire segment, each green with each other green, and so on. Thus, the wiring forms a parallel bus structure **314** as shown.

As illustrated in FIG. **4**(*a*), replacement junction box **400** interconnects multiple external twisted pair wire sets **402**, **404**,**406** and **408** to two jacks **410** and **412**. In one embodiment, each individual external wire segment (e.g., the red wire segment) of each of the external twisted pair wire sets **402**, **404**, **406** and **408** is attached to replacement junction box **400** via standard junction box screw terminals (not shown) or one of a variety of interface terminals or other means of connecting two wire segments. Replacement junction box **400** could be manufactured with its interface terminals already interconnected by internal interface wire segments **414**, such that one could effectively interconnect external twisted pair wire sets **402**, **404**, **406** and **408** to one another merely by connecting their individual external wire segments to the interface terminals of junction box **400**.

Internal interface wire segments **414** in junction box **400** support four external twisted pair wire sets and two jacks, which should be sufficient for most residential wiring configurations. In the event a junction box has more than four external twisted pair wire set "junctions" (e.g., "hub" junction box **230***d* in FIG. **2**(*d*)), multiple of these replacement junction boxes could be used, with each such junction box handling up to four of these "junctions." Of course, extended replacement junction boxes supporting more than four external twisted pair wire sets (and/or more than two jacks) also could be utilized.

By convention in this embodiment, the B-Y pair of one external twisted pair were set is connected, respectively, to the R-G pair (via interface terminals, not shown, and interfaces wire segments **414**, as noted above) of another external twisted pair wire set and/or jack. This "B-Y to R-G" connection pattern involves connecting the "outgoing" (e.g., B-Y) pair of one external twisted pair wire set or jack to the "incoming" (e.g., R-G) pair of another external twisted pair wire set or jack until a physical loop is formed.

In this embodiment, jacks **410** and **412** of replacement junction box **400** (as well as the jacks of network adapters connecting devices to a logical ring network, discussed below) utilize adjacent wire segments to connect the B-Y and the R-G pairs. For example, for a standard 6-wire RJ-12 jack, wires **2** and **3** would be connected to the B-Y pair of another external wire segment or jack, while wires **4** and **5** would be connected to the R-G pair of yet another external wire segment or jack (with wires **1** and **6**, not shown, optionally used for phantom power as discussed below).

Thus, twisted pair set **402** connects to twisted pair set **404**, which connects the jack **410**, which connects to twisted pair set **408**, which connects to jack **412**, which connects to twisted pair set **406**, which completes the physical loop by connecting back to twisted pair set **402**. These connections mirror the connections shown in FIG. **2**(*c*) inside junction box **226***c*, with segments **240***c*, **242***c*, **244***c* and **246***c* of FIG. **2**(*c*) respectively associated with twisted pair sets **402**, **404**, **406** and **408**, and jacks **269-3***c* and **269-5***c* respectively associated with jacks **410** and **412**.

Also by convention, as will be discussed in greater detail below, devices with two jacks typically process information received on their "incoming" pair (wires **2** and **3**) via one jack, and transmit it to another device via their "outgoing" pair (also wires **2** and **3**) via the other jack. Eventually, information will return to the device on the other pair (wires **4** and **5**) of that other jack and pass (unchanged) directly through the device and out the other pair (wires **4** and **5**) of the first jack back to its original source. If one jack of the device is not connected to another device, then information will be transferred (as shown below) from that jack's "outgoing" pair (wires **2** and **3**) to the jack's other pair (wires **4** and **5**), as if the information had returned from another device, and back out of the device via the other pair (wires **4** and **5**) of the other jack.

Although homeowners could hire a cabling technician to disconnect the "in-wall" external wire segments from existing junction boxes, and reconnect them to the interface terminals of replacement junction boxes, many homeowners may elect to perform these wiring modifications themselves, particularly if the replacement junction boxes are designed to greatly simplify the task and reduce the probability of "user error." In this regard, replacement junction box **400** can include removable jumpers (e.g., 420, shown in ghost) at the interface terminals (and an analogous device inside each jack, as will be discussed below in the context of FIG. **5**(*a*)) to maintain the physical loop in the event that set goes unused.

Removable jumper **420** connects the B-Y pair to the R-G pair, through cross-wires **416** (e.g., connecting the "red" and "yellow" interface wire segments) and **418** (e.g., connecting the "green" and "black" interface terminals), respectively, which continues the physical loop in the absence of a connection with twisted pair set **406**. The homeowner would remove the jumper only from those interface terminals that are to be connected to external twisted pair wire sets.

Thus, replacement junction box **400** could be used to replace virtually any standard residential telephone junction box. To replace "end" junction box **224***c* in FIG. **2**(*c*), for

example, only one jumper (e.g., **420**) need be removed to connect twisted pair set **406** in FIG. **4**(*a*) to wiring segment **242***c* in FIG. **2**(*c*). To replace "4-way" junction box **226**(*c*) in FIG. **2**(*c*), however, jumpers from all four twisted pair wiring sets (**402**, **404**, **406**, and **408**) would need to be removed to connect them to wiring segments **240***c*, **242***c*, **244***c* and **246***c* of FIG. **2**(*c*), as discussed above. In the unusual event that a junction box and more than four twisted pair wire "junctions," multiple or extended replacement junction boxes could be used as noted above.

FIG. **4**(*b*) illustrates a logical representation of a replacement junction box **440**, independent of the precise transmission medium. Each set of wires **442**, **444**, **446** (with removable jumper cross-wires **454** and **456**) and **448**, as well as connections to jacks (or other connectors) **450** and **452**, is shown as two lines ("A" and "B"), each of which could represent a twisted pair cable, a coaxial cable or other transmission medium. The connections among the lines and jacks are analogous with those shown in FIG. **4**(*a*).

d) Replacement Jacks and Connectors

Replacement junction box **400** illustrated in FIG. **4**(*a*) includes jacks **410** and **412** to connect network devices to the logical ring network of the present invention. In this typical embodiment in which twisted pair wiring is present, standard RJ-11 or RJ-12 jacks and connectors could be utilized, as illustrated in FIG. **5**(*a*).

Jack **520**, which would be part of a replacement junction box, includes a mechanism to interconnect the two pairs of twisted pair wiring set **522** to complete the physical loop in the event that no network device is connected to jack **520**. Yet, this mechanism must be disabled when a network device is connected—i.e., when a connector, such as connector **500**, is inserted into jack **520**.

One embodiment of such a mechanism is protruding tab **526** (shown retracted) with attached wires **528** and **530** to interconnect wires **522** (e.g., R to Y and G to B) when connector **500** is not inserted, but to be pushed out of the way (breaking circuit) upon insertion of connector **500**. This mechanism will ensure that the physical loop is completed regardless of whether a network device is inserted into jack **520**. It is readily apparent to one of ordinary skill in the art that other mechanisms are available to solve this problem of interconnecting a jack's two pairs until a network device is connected to that jack (e.g., a spring-loaded mechanism, an electrical switch, etc.).

In all other respects, jack **520** can be a standard RJ-11 jack, with standard B, R, G and Y wires **522** (or a standard 6-wire RJ-12 jack) connected to twisted pair cable **524**. Moreover, connector **500** can be a standard RJ-11 connector, with standard B, R, G and Y wires **502**(or a standard 6-wire RJ-12 connector), twisted pair cable **504** and locking clip **506**. Certain advantages, however, may be obtained by deviating further from standard RJ-11 and RJ-12 jacks and connectors.

For example, it may be desirable to make the jacks and connectors non-standard so that a user cannot mistakenly connect a conventional device, such as a POTS phone, into a jack on a replacement junction box. Thus, the addition of a protruding rib **508** (shown in ghost) along with a complementary notch **510** (also shown in ghost) on connector **500**, and a similarly configured jack (not shown), could prevent such accidental connections. It should be evident to one of ordinary skill in the art that there are many other such "lock out" mechanisms that could be devised. In addition, the jack could include a light (or other indicator) indicating whether a device and/or appropriate connector is connected to that jack.

Moreover, as will be discussed in greater detail below, it may be desirable to create a "smart jack" which not only closes the physical loop regardless of whether a network device is connected, but also maintains a fixed amount of network delay. Such a mechanism enables one to connect and disconnect network devices (daisy-chained to the smart jack) without disrupting the transmission of information (e.g., an audio or video stream) among other devices on the logical ring network. As will be discussed below, this "hot pluggable smart jack" is itself a network device into which a chain of other network devices can be connected, but which adjusts its delay (and causes the logical ring network to be reconfigured) to account for the insertion or removal of any of such other network devices without disrupting the transmission of information among the remaining network devices (including information passing through the hot pluggable smart jack itself).

In yet another embodiment, it may be desirable to enable a homeowner to switch between the conventional POTS analog telephone network and the logical ring network of the present invention, merely by toggling a switch at the junction box. As illustrated in FIG. **5**(*b*), a front view, a wall plate **540** has a vertically slidable jack **542**, which locks in either of two positions, "LRN" **544** and "POTS" **546**, for logical ring network and conventional analog telephone network operation, respectively, in the side view of FIG. **5**(*c*), the jack **542'** can be seen protruding on either side of wall plate **540'**. In the upper (LRN) position, jack **542'** abuts plate **548'**, and in the lower (POTS) position, abuts plate **548'**. Plates **548'** and **550'** are connected in the "in-wall" wiring **556'** through cables **552'** and **554'**, respectively.

In one embodiment, plates **548'** and **550'** could be printed circuit boards such that plate **550'** implements POTS circuitry (analogous to that shown in FIG. **3**), while plate **548'** implements logical ring network circuitry (analogous to that shown in FIG. **4**(*a*)). It should be evident to one of ordinary skill in the art that there are many mechanisms for switching the wiring infrastructure from a POTS network to the logical ring network configuration of the present invention, including removable modules/printed circuit boards, reversible boards, relays, etc. As will be discussed below, it is even possible for a POTS network to coexist (i.e., to share a pair of wires) with a logical ring network.

e) Phantom Power

In one embodiment of the invention, it may be desirable to route power to devices (including hot pluggable smart jacks) via the same jack used to connect such devices to the logical ring network. In other words, instead of requiring the device to obtain power externally (e.g., from a battery or by plugging the device into a standard power outlet), the jack can include an additional pair of wires to (optionally) route power from a standard power junction box through a power supply to a network device. In this manner, the homeowner merely need plug in a single standard RJ-12 (6-wire) cable, and obtain both "phantom" power and a connection to a logical ring network. No separate power cable would be necessary.

As will be illustrated in one embodiment below, such "phantom" power could be transformer isolated to supply approximately 25 watts of power to network devices (including hot pluggable smart jacks). Such power would be sufficient for many network devices (such as telephones and satellite speakers), while others (such as powered subwoofers) might still require external power. Critical components (e.g., last one telephone in a house) could also be connected to a "battery back-up" device such as a

standard UPS, so that they would continue to function in the event of a power outage.

FIG. **6** shows a standard six-pin RJ-12 connector **600**, with locking tab **606** and twisted pair cable **604**, which can be inserted into the corresponding six-pin jack **620** with twisted pair cable **632**. This arrangement includes the conventional two pairs of wires **602** and **622** on the connector **600** and jack **620**, respectively, as well as the protruding tab **626** on jack **620** with attached wires **628** and **630** to ensure completion of the physical loop. The remaining two wires of a standard 6-wire RJ-12 jack, however, are used for "phantom" power lines **608** and **610** on connector **600**, and corresponding lines **624** and **625** on jack **620**. These power lines may be supplied from the house current **629** via power supply **627** (or from any other "in-wall" power source), which in one embodiment supplies high-frequency AC 24V power synchronized to the 44.1 kHz "frame rate" described below. Note also that an RJ-11 connector could be inserted into jack **620** to connect a device to the logical ring network, though no phantom power would be supplied to that device.

As noted above, a hot pluggable smart jack (not shown here, but discussed in greater detail below) would itself be a network device. In the embodiment described below, this device would include two jacks. One jack would be of the type illustrated in FIG. **6**, and would provide "in-wall" phantom power needed to power the hot pluggable smart jack itself. The other jack would be the hot pluggable smart jack into which another network device would be inserted and removed. This jack preferably would be of the type illustrated in FIG. **6**, so that it could provide optional phantom power to any network device inserted therein. A more standard jack, however, such as the one illustrated in FIG. **5**(*a*), would be sufficient.

f) Physical Media Hybridization

It should also be noted that, instead of providing a separate pair of wires for phantom power, or for a POTS network, either or both of these functions can share the same pair of wires with each other, as well as with a logical ring network. Because each of the pairs of a logical ring network is a balanced transformer-isolated transmission line, each wire of a given pair is doing the exact complement/opposite of its partner. Thus, the resulting electromagnetic field emanating from each pair of wires will be zero. This reduces the radio emissions of the network and provides noise isolation for these signals.

Signals that are common-mode, or which have the same potential on both of the wires of a pair, will radiate as if such signals were transmitted only on one wire. Such signals will thus be completely independent from the different signal between the wires. In other words, in the ideal case, there should be no interaction between the two transmission modes.

Because the data on a logical network is transmitted differentially in one embodiment discussed below, it is possible to use the common mode of each of the pairs as virtual wires to transmit other information and/or power. This information could be analog voice over a POTS line equivalent, or some other transmission system. Power can be transmitted simultaneously by utilizing a high pass filter to isolate the audio/phone signaling from the ultransonic AC power signal.

These signals could be injected onto the wires by the equivalent of connecting these signals to the center-tap of the transmission and reception transformers. This has to be done very carefully so as not to misbalance the differential signal, which could result in less than complete cancellation of the differential signal, which in turn could create interferences.

Alternatively, a single pair of wires can support both a logical ring network (with bidirectional drivers) and a POTS network, as well as power. This can be accomplished by using high-pass, low-pass and band-pass filters, respectively, at each wiring junction to isolate each of these three types of signals from one another. All such filters could be "high-frequency balanced" to prevent the high-frequency network signal from becoming misbalanced, and thereby creating radio interference.

In one embodiment, all three types of signals could share the same pair of wires, which could be unshielded twisted pair, coaxial or other conductive media. If another pair of wires were available, it could be dedicated to a logical ring network and/or power, leaving the POTS network untouched on its own existing pair of wires, thereby preventing any interference between the phone system and the power lines or a logical ring network. Alternatively, one pair of wires could be dedicated to the bidirectional logical ring network, with the other pairs supporting the POTS network and/or power. This embodiment would greatly simplify the required hybrid circuitry. For example, relatively simple analog low-pass and high-pass filters could be employed to isolate these two types of signals, because no high-frequency network signal would need to be accommodated.

g) Logical Ring Network

Having illustrated the modifications to the physical network topology, one can now appreciate the advantages of a logical ring network independent of its underlying physical topology. The wiring at the junction boxes (including jacks and possibly connectors) may have been modified via replacement junction boxes as illustrated in FIGS. **3**–**6** to transform arbitrary physical topologies into a logical ring network. Devices have been connected to the logical ring network, either at those replacement junction boxes and/or directly to one another in a daisy-chained fashion, as illustrated in FIGS. **2**(*c*) and **2**(*d*) above. In either case, as noted above, a single physical loop, and thus a single default network path, has been formed.

Although information propagating along this default network path physically may reach the same device multiple times per "revolution" (e.g., as illustrated by device **268***c* in FIG. **2**(*c*)), such information is processed only once by each device, thereby forming a logical ring network. In other embodiments discussed below, however, alternative paths to the default network path are utilized to increase overall network bandwith.

FIG. **7** illustrates the default network path of a logical ring network **700** having network devices "A" **702** (acting as the network "clock" as explained below), "B" **708**, "C" **710**, "D" **712**, "E" **714** and "F" **716**, respectively connected by logical cable segments **720**, **722**, **724**, **726**, **728** and **730**. By convention, information is transmitted in a clockwise direction from network clock device A **702** to device B **708**, to device C **710**, to device D **712**, to device E **714**, to device F **716**, back to network clock device A **702**, and so on.

As noted above, and as will be explained in greater detail below, network devices on a logical ring network of the present invention are synchronized to one another. This synchronization occurs upon initialization of the logical ring network, during which each device capable of acting as a "clock" device arbitrates for election as the "network clock" device. The network clock device sends a synchronization marker at constant intervals along the default network path to which all other devices synchronize. As will be explained below, this low-level device synchronization greatly facilitates the synchronization of audio and video sources, audio

sources received by multiple speakers, and many other media synchronization requirements.

Because network devices with single unidirectional drivers can transmit signals only in one direction along the default network path, and because (as noted above) the time for any given stream of data to propagate around this default network path remains constant, a logical ring network affords devices a fixed amount of total network bandwidth. As will be discussed below, this total network bandwidth can be allocated (by default, and later reallocated dynamically) into fixed-length channels, the size of which can be determined by the requirements of each particular media stream.

At some point, however, reallocation of existing network bandwidth may be insufficient, and additional network bandwidth may be desired. For example, if every member of a large family had his own television, and each wanted to watch a different program at the same time, total network bandwidth might be insufficient to accommodate such a situation.

Moreover, as more network devices are added to the logical ring network, the total delay around the logical ring network along this default network path may exceed the maximum delay necessary to ensure phase coherency between any two devices. For example, two or more 44.1 kHz audio samples sent by CD player device might reach a left speaker device before the first such sample reaches a right speaker device, resulting in and undesirable lack of phase coherency between the two speakers that would diminish the listening experience.

There are a variety of ways of increasing network bandwidth to accommodate such situations, which will be discussed in greater detail below. Logical ring network bandwidth can be increased, for example, by providing (i) better physical media supporting a higher data transmission rate; (ii) more efficient modulation techniques (i.e., compressing information); and/or (iii) alternate paths between devices for the transmission of data (e.g., by adding to the logical ring network a switching router device, or simply adding devices with multiple and/or bidirectional transceivers). The precise means by which network bandwidth can be increased will be better understood following an explanation of the manner in which devices transfer data and "system commands" to one another on a logical ring network.

2. Synchronous Logical Ring Network Architecture

a) Overview

As noted above, a logical ring network of the present invention is a synchronous network. All devices transmit and receive information at periodic intervals determined by a "network clock" device (as described below). In one embodiment, during each clock cycle, each device simultaneously transmits information to the next device along the default network path.

In the case of switching routers and other devices with multiple and/or bidirectional transceivers, alternate, "shortcut" paths (as compared with the default network path) may be available as a means of increasing network bandwidth, as will be discussed in greater detail below. To the extent all network devices have only one unidirectional transceiver, however, all information is transmitted from device to device in a consistent order along the default network path.

As noted above, each device imposes a constant amount of delay to process information—i.e., to receive information and then transmit either the same information, or modified information, to the next device on the logical ring network (including signal propagation delays, which increase with the length of the physical wire between devices). This "device delay time," though constant, differs from device to device. Thus, as information propagates from device to device along the default network path, the delay from one device to the next may vary. Yet, the propagation time for a complete "revolution" around the logical ring network remains constant.

For example, if there are three devices on the logical ring network, it may take five clock cycles for information to propagate from the first device to the second device, but only four clock cycles to propagate to the third device and six clock cycles to propagate back to the first device. Yet, it will always take fifteen clock cycles for information to propagate from any device around the network along the default network path and back to that device. As will be explained below, this cumulative propagation time actually will be "rounded up" by the network clock device to an amount sufficient to accommodate fixed-length "frames" of information.

As a result of this fixed cumulative propagation time for information to travel around the logical ring network along this default network path, network devices are afforded a fixed amount of total network bandwidth for sending and receiving information along the default network path. As will be discussed below, however, the total network bandwidth is not simply divided equally among devices. Each device is allocated a fixed amount of bandwidth (appropriate for the particular type(s) of data which that device transmits and/or receives) which differs from device to device and can be altered dynamically.

b) Network Clock Synchronization and Information Framework

In one embodiment, at least one device on a logical ring network must be capable of acting as the network clock device, typically in addition to performing its "normal" function (e.g., CD player). During network initialization, a clock arbitration process determines which device (among those capable of acting as the network clock device) will be deemed the network clock device. In other embodiments, the network clock device could be predetermined—e.g., via a user-settable switch.

Once the network clock device has been selected, all other devices are synchronized to the network clock device. The precise details of the network initialization process, and the manner in which devices are synchronized to the network clock device, are discussed in greater detail below.

In one embodiment, all network devices, including the network clock device, transmit raw bits of information, referred to as "symbol bits"(described below), at a rate of 28.224 MHz. This rate was selected to facilitate compliance with current FCC regulations relating to radio frequency interference ("RFI") for information transmitted over standard unshielded twisted pair cables. Overall network bandwidth may be increased, for example (as discussed below), by utilizing better physical media supporting a higher data transmission rate.

These symbols bits are encoded, using a 4B/5B encoding scheme (also described below), to distinguish normal "data bits" (representing information such as digital audio or video streams, or embedded asynchronous data) from special markers used for various purposes such as identifying and delimiting frames, "system commands," null data, etc. Thus, the network "data bit rate" is 22.5792 MHz, or 4/5 of the network "symbol bit rate" of 28.224 MHz. Every 5-bit "symbol" represents either one nibble (4 bits) of data or all/part of a special marker.

One of these special markers, the "frame header" (which actually comprises **2** symbols), is used to synchronize all other devices to the network clock device at a rate useful for synchronizing digital media streams, such as CD audio or MPEG video. Because audio, with its high sample rate, is particularly susceptible to distortion owing to timing discrepancies (compared to video, for example, which typically is sampled no more than 60 times per second), the network clock device generates frame headers at a "frame rate" of 44.1 kHz, the standard CD audio sample rate. In essence, by sending out a periodic frame header, the network clock device not only sends out a 44.1 kHz synchronization marker, but also creates the header for a fixed-length "frame" of information.

This fixed-length frame, which will be discussed in greater detail below, is comprised (in one embodiment) of 640 symbol bits or, equivalently, 512 data bits. One can derive this frame size by dividing the symbol bit rate (or data bit rate) by the frame rate of 44.1 kHz. The network clock device creates these fixed-length frames, which then propagate from device to device on the logical ring network. As will be discussed below, in one embodiment, the network clock device periodically (e.g., once per minute) sends out a "Time Sync" frame header ("WK" in Table I below) to mark a particular "time of day" in lieu of the far more frequently used "Clock Sync" frame header ("JK" in Table I below).

To maintain a consistent frame rate and avoid corruption of data, the network clock device in one embodiment buffers received data to ensure that an integral number of frames are present on the logical ring network at any given time. In other words, the network clock device imposes an artificial delay (using a mechanism described in greater detail below) to "round up" the sum of the individual device delay times to the next highest multiple of 22.676 μs (1/44.1 kHz), resulting in a "cumulative frame propagation delay" of 22.676 μs or an integral multiple thereof.

If this cumulative frame propagation delay equals exactly 22.676 μs, rather than a higher multiple thereof, information is guaranteed to propagate from any device to any other device within one CD audio sample time, thereby ensuring phase coherency among devices. For example, left and right speakers are guaranteed to be "synchronized" to the same audio sample time while playing stereo audio generated by a CD player.

Assuming a typical device delay time of approximately 6 of the 640 available 28.224 MHz clock cycles per "revolution" of a frame, a logical ring network will continue to guarantee this "one audio sample" level of phase coherency until over 100 such devices are added to the network. Even at the point at which the delay exceeds 22.676 μs, and the network clock device "rounds up" the cumulative frame propagation delay (e.g., to 45.332 μs, or 1/22.05 kHz), the logical ring network will continue to function, through with greater potential delay between devices.

For example, although the frame rate would continue to be 44.1 kHz, two full frames (instead of one) would be present in the logical ring network at any given time. Thus, information might require up to 45.352 μs (i.e., two audio sample times) to propagate from one device to another along the default network path.

Yet, as noted above, a logical ring network could be segmented into multiple physical loops or network "arms," and a switching router could be added, such that the frame propagation delay around each network arm would again equal (or be rounded up to) 22.676 μs. As will be discussed in greater detail below, the default network path would still traverse every device on the logical ring network (not just those on an individual network arm). Thus, information propagating along this path would still have a cumulative frame propagation delay exceeding the 22.676 μs delay present on each network arm. However, this path might be used only for "system commands" (at a much slower system command rate of approximately 1.1 kHz, as explained below), as opposed to streams of "normal" data which could follow a shorter path by switching, via the switching router, from one network arm (containing the source device sending the data) directly to another (containing the destination device receiving the data).

c) Data Encoding

As noted above, all information transmitted in one embodiment of a logical ring network is encoded using a 4B/5B coding system. Each 5-bit symbol represents either one of 16 possible data values (0–15) or all/part of a special marker, discussed below, used for various purposes such as frame headers, "system command" delimiters, error detection or null data.

A 4B/5B encoding of information transmitted at 28.224 MHz is employed so as to avoid a large DC offset and to ensure a sufficient number of voltage transitions over time to enable each network device to synchronize to the incoming data and receive the information accurately (as will be explained in greater detail below with respect to the synchronization hardware inside a logical ring network adapter for each network device).

At the physical layer, in one embodiment, network devices utilize an "NRZ" (non-return to zero) bi-level coding scheme. They transmit a "1" symbol bit by transitioning from a low-to-high (or high-to-low) voltage, and a "0" symbol bit by maintaining the current voltage level. To ensure a sufficient number of transitions, the 4B/5B logical encoding values are selected such that a valid sequence of symbols never includes more than 3 consecutive "0" symbol bits. Thus, only about 2/3 of the 32 possible 5-bit combinations are used.

In the embodiment illustrated in Table I (and discussed in greater detail below) a transmitting device can encode 4B data nibbles and special markers into 5B symbols in the following manner. The device encodes data and special markers as 5-bit quantities (shown as "Translated Values" in Table I) by appending a "0" onto the MSB of 4B data nibbles, and appending a "1" onto the MSB of 4-bit representations of each special marker. The device then translates these 5-bit quantities into the 5B symbols which it physically transmits to the next device on the logical ring network. Receiving devices then decode these 5B symbols by translating them back into the 5-bit Translated Values shown in Table I and interpreting them (based on the MSB of the symbol's Translated Value) either as 4-bit data nibbles or as special markers.

TABLE I

4B/5B ENCODING				
SYMBOL BIT VALUES 4 3 2 1 0	TRANSLATED VALUES 4 3 2 1 0	EQUIVALENT DATA 3 2 1 0	NAME	FUNCTION
1 1 1 1 0	0 0 0 0 0	0 0 0 0	0	Data
0 1 0 0 1	0 0 0 0 1	0 0 0 1	1	
1 0 1 0 0	0 0 0 1 0	0 0 1 0	2	

TABLE I-continued

4B/5B ENCODING				
SYMBOL BIT VALUES 4 3 2 1 0	TRANS-LATED VALUES 4 3 2 1 0	EQUIVALENT DATA 3 2 1 0	NAME	FUNCTION
1 0 1 0 1	0 0 0 1 1	1 0 1 1	3	
0 1 0 1 0	0 0 1 0 0	0 1 0 0	4	
0 1 0 1 1	0 0 1 0 1	0 1 0 1	5	
0 1 1 1 0	0 0 1 1 0	0 1 1 0	6	
0 1 1 1 1	0 0 1 1 1	0 1 1 1	7	
1 0 0 1 0	0 1 0 0 0	1 0 0 0	8	
1 0 0 1 1	0 1 0 0 1	1 0 0 1	9	
1 0 1 1 0	0 1 0 1 0	1 0 1 0	A	
1 0 1 1 1	0 1 0 1 1	1 0 1 1	B	
1 1 0 1 0	0 1 1 0 0	1 1 0 0	C	
1 1 0 1 1	0 1 1 0 1	1 1 0 1	D	
1 1 1 0 0	0 1 1 1 0	1 1 1 0	E	
1 1 1 0 1	0 1 1 1 1	1 1 1 1	F	
1 1 1 1 1	1 0 0 0 0	SPECIAL	I	Idle
1 1 0 0 0	1 0 0 0 1	MARKERS	J	First symbol of Clock Sync Frame Header marker
0 1 0 0 0	1 1 1 0 0		W	First symbol of Time Sync Frame Header marker
1 0 0 0 1	1 0 0 1 0		K	Second symbol of Clock Sync and Time Sync Frame Header markers
0 1 1 0 1	1 0 1 0 0		T	First symbol of System Command Start/Empty markers
0 0 1 1 1	1 0 1 0 1		R	Second symbol of System Command Start marker
0 0 1 0 1	1 0 1 1 0		U	Second symbol of System Command Empty marker
0 0 0 0 0	1 0 1 1 1	INVALID	V	Invalid Code
0 0 0 0 1	1 1 0 0 0		V	NOT USED
0 0 0 1 0	1 1 0 0 1		V	
0 0 0 1 1	1 0 0 1 1		V	
0 0 1 0 0	1 1 1 0 1		V	
0 0 1 1 0	1 1 0 1 1		V	
0 1 1 0 0	1 1 1 0 1		V	
1 0 0 0 0	1 1 1 1 0		V	
1 1 0 0 1	1 1 1 1 1		V	

d) Fixed-Length Frame Format

As noted above, in one embodiment of a logical network, the fundamental frame rate is 44,100 fixed length frames per second (44.1 kHz). In this embodiment, the length of each frame is 640 symbol bits or, equivalently, 512 data bits. As is illustrated below, a frame is divided into 128 "nibbles," encoded as 5B symbols for transmission, and representing, when decoded, mostly 4-bit data nibbles along with certain special markers, as shown in Table I above.

The size of this fixed-length frame could be expanded beyond 128 nibbles, in another embodiment, to accommodate more data and thus increase total network bandwidth. For example, better physical media could be used to support a higher data bit rate beyond 22.5792 MHz. Moreover, a more efficient modulation technique, such as 5-level, coding, could be used in the transceivers of each device's network adapter, enabling each device to transmit two data bits (instead of one) during each 22.5792 MHz clock cycle.

In any event, after a logical ring network is initialized (as discussed in greater detail below), each frame is created in the first instance by the network clock device, which fills the frame with a frame header, a "system command" (also described below) and, where no data is supplied, "idle" ("I") markers which other devices may overwrite with actual data. The network clock device also may itself embed actual data (e.g., a CD audio stream) into a frame.

As each frame propagates from device to device on the logical ring network, each device processes the information in the frame and either passes it along to the next device unmodified or overwrites certain information. As will be explained in greater detail below, devices typically pass along most of the frame unmodified.

For example, a CD player might "insert" samples of a CD audio recording into left and right stereo audio channels of the frame—e.g., by overwriting nibbles **2–7** of the frame with a digital sample of left-channel audio, and nibbles **66–71** of the frame with a digital sample of right-channel audio. Yet, the CD player would ignore most of the other nibbles, because they relate to other digital media streams (e.g., video, telephone, or embedded asynchronous data) which do not concern the CD player.

In one embodiment illustrated in Table II below, the frame header occupies the first two nibbles (**0** and **1**) of the 128 nibbles in each frame. Of the remaining 126 nibbles, 124 nibbles are allocated to the "data stream" which includes the audio, video, telephone and other streams or "channels" of digital media disturbed among the devices on the logical ring network. This data stream, discussed in greater detail below, is divided into two 62-nibble blocks in the frame (nibbles **2-63** and **66-127**), separated by a one-byte (nibbles **64–65**) "system command stream."

The system command stream, also explained in greater detail below, is used primarily for initializing and reconfiguring devices on a logical ring network. In one embodiment, this system command stream is comprised of fixed-length 40-byte "system commands" that occupy 40 consecutive frames (but only 2 nibbles per frame). Because system commands are processed by every network device, they are sent along the default network path.

Thus, fixed-length frames propagate from device to device on the logical ring network (transmitted as nibble **0**, nibble **1** . . . nibble **128**, with each nibble transmitted from MSB to LSB), and include, in addition to a frame header, two distinct information streams—the data stream and the system command stream. As will be discussed below, these two information streams operate independently from one another.

For example, as noted above, if alternate paths are made available to increase total network bandwidth (e.g., by using a switching router to route information from one network arm to another), these alternate paths are used by the data stream. The system command stream always propagates along the default network path (which will include every network arm) to ensure that it reaches every network device. Moreover, as explained in greater detail below, the network can be reconfigured (e.g., when a network device is added to or removed from a hot-pluggable smart jack) via the system command stream without interrupting the propagation of data among network devices via the data stream.

In one embodiment, illustrated in FIG. **7**, network clock device **702** is responsible for buffering frames, via frame FIFO **706**, to ensure that an integral number of frames are present on the logical ring network at any given time. Thus, network clock device **702** would finish transmitting the entirety of a frame before transmitting the frame header for the next frame. This prevents frames from overlapping one another and becoming corrupted.

Moreover, as noted above, each network device impose some delay (typically equal to about six 28.224 MHz symbol

bit times in this embodiment, or 6×0.03543 μs=0.2126 μs) in order to receive/process/transmit each bit of a frame. Network clock device **702** artificially delays (i.e., buffers) each symbol bit it receives in order to "round up" the total of these device delay times to a cumulative frame propagation delay time equal to the next highest integral number of 44.1 kHz frames (i.e., an integral multiple of 22.676 μs).

Once this cumulative frame propagation delay equals 22.676 μs (i.e., frames propagate at 44.1 kHz, and exactly one 44.1 kHz frame is present on the logical ring network), then all network devices are guaranteed to receive any given 44.1 kHz audio sample before any network device receives the next such sample. If the logical ring network is segmented into multiple network arms, then a switching router can buffer frames (as explained in greater detail below) to ensure that exactly one frame is present on each network arm. As a result, data sent from one network arm to another may be delayed by a few audio sample times; though devices on the same network arm (e.g., left and right speakers) would receive such data at the "same time"—i.e., during the same audio sample time.

Although this buffering mechanism enables devices on the same network arm, such as left and right speakers, to remain "in phase," there are certain situations in which it is desirable to alter the effective phase relationships among devices (whether on the same or on different network arms). For example, rather than require speakers to be physically positioned at precise locations within a room to obtain a desired listening experience, one could simulate this physical positioning of speakers by programming a specified delay into one or more devices. This could be accomplished, for example, by employing a FIFO or analogous buffering mechanism within particular devices to delay the processing or retransmission of data by such devices. Such FIFOs could be programmed, for example, by a "smart" CPU-based controller device on the network.

In one embodiment, a DSP device, upon decoding a surround sound audio stream, might utilize an on-board FIFO to delay particular decoded audio streams before transmitting them over the logical ring network to one or more speaker devices—i.e., simulating the effect of physically moving those speakers. In this embodiment, each speaker still would play its audio team stream "immediately" upon receiving it via the logical ring network. In another embodiment, this buffering mechanism could be located within one or more speaker devices (perhaps in addition to the DSP device), such that a particular speaker would delay the playing of its audio stream for a special period of time after receiving it via the logical ring network, still achieving the same effect of simulating physical movement of the speakers.

Network clock device **702**, in addition to buffering frames in this embodiment also is responsible for buffering system commands, via system command FIFO **704**, to ensure that an integral number of system commands are present on the logical ring network at any given time. As is done for frames, network clock device **702** would finish transmitting the entirety of a fixed-length (40-byte) system command before transmitting the "system command leader" (explained below) for the next system command. This prevents system commands from overlapping one another and becoming corrupted. Network clock device **702** also performs certain system command maintenance functions which will be explained in greater detail below.

It should be noted that, in this embodiment, each network device buffers system commands for at least one frame (which includes one byte of a system command), to allow the device sufficient time to modify each byte of a system command, if necessary. Network clock device **702**, however, performs additional buffering, as noted above to "round up" the cumulative delay (for system commands to traverse the default network path) to an integral multiple of 40 frame times. This "cumulative system command propagation delay" (an integral multiple of 40 frames) is the time required for a system command to propagate around the entire default network path. It should be distinguished from the cumulative frame propagation delay (an integral multiple of one frame), which is the time required for a frame to propagate around an arm of the logical ring network (which would be the entire default network path in the case of a network that is not segmented into multiple network arms).

TABLE II

FIXED-LENGTH FRAME FORMAT

NIBBLES	DESCRIPTION
0–1	Frame Header (Clock Sync or Time Sync)
2–63	First Block of Data Stream Channels
64–65	System Command Stream
66–127	Second Block of Data Stream Channels

e) Data Streams

The vast majority of the total network bandwidth is utilized by network devices sending and receiving digital media streams, such as audio, video, phone, asynchronous and other data. As noted above, in one embodiment, 124 of the 128 nibbles in each frame are allocated to the data stream. A single byte (2 nibbles) is allocated to the frame header, and another byte (2 nibbles) to the system command stream.

In this embodiment, the data stream is allocated by default into various fixed-width channels as illustrated in Table III below. These channel assignments can be modified dynamically, as is discussed in greater detail below. These channels may be associated with a particular type of media (e.g., digital audio) and may occupy a number of 4-bit data nibbles (varying from channel to channel) corresponding to the network bandwidth required by such media.

For example, in the default data stream channel allocation illustrated in Table III, "Audio Left Channel 0" occupies nibbles **2–7** of a frame, and represents the left channel of a stereo digital audio stream. In order to achieve CD-quality audio for that left channel, 4 nibbles (16 bits) are required to represent the range of audio intensity levels for each audio sample. The remaining 2 nibbles can be used for additional information, such as more phone lines or "surround sound" (e.g., Dolby ProLogic), which is encoded into stereo audio recordings.

Note that the 44.1 kHz frame rate in this embodiment guarantees that these audio samples will reach a playback device (e.g., a left speaker) at precise 22.676 μs (1/44.1 kHz) intervals. Moreover, each of these same audio samples will reach the corresponding right speaker, for example, within the same 22.676 μs (1/44.1 kHz) interval, thereby maintaining phase coherence (within the same audio sample time) between the left and right speakers.

As noted above, this same level of phase coherence is achieved even if the source device (e.g., a CD player) is physically located on another arm of the logical ring network, and requires multiple audio sample times to transmit each audio sample to the speakers. In other words, the speakers (assuming, as is likely to be the case, that they are

both in the same room and on the same network arm) remain phase coherent, and thus receive the digital audio stream at the "same time" (i.e., same audio sample time) relative to each other, even though they both receive it delayed by a few audio samples from the time it was transmitted by the CD player.

It should be further noted that this 44.1 kHz level of "synchronization accuracy" (which could be modified if desired) is sufficient to enable other media types (e.g., digital video) to be synchronized to audio as well as to one another. Digital video frame rates, for example, require only 30–60 samples per second, compared to 44,100 audio samples per second. Where necessary, synchronization of the logical ring network to external clock rates (e.g., MPEG1 and MPEG2 clock rates) also can be achieved, via a general-purpose mechanism discussed below in the context of particular MPEG-related devices.

The default data stream channel assignments illustrated in Table III allocate the 22.5792 Mbit total network bandwidth (based on the 22.5792 MHz data bit rate) to allow for the following simultaneous digital media streams: (i) 4-CD-quality digital stereo audio streams; (ii) 2 MPEG2 compressed digital audio/video streams; (iii) 8 digital phone streams; (iv) 32 embedded asynchronous data streams, each "sample" occupying a nibble every eight frame; and (v) 2 miscellaneous data streams, each the size of an MPEG2 compressed digital audio/video stream.

As will be discussed in greater detail below, network devices can utilize these default channels in one embodiment via switches located on each device set to one or more particular default channels. For example, a CD player might have its switches set for "Audio Channel 0" by default, though a user could set these switches to "Audio Channel 1" accommodate other audio sources (e.g., the audio from a laserdisc player).

Moreover, in this embodiment, network devices also have on-board memory (e.g., registers), the contents of which can be set dynamically (e.g., by another network device) to override the channel(s) indicated by the switches. The manner in which this dynamic data stream channel allocation is performed is discussed in greater detail below.

As noted above (and discussed in greater detail below), certain users may require additional bandwidth beyond that provided by the default data stream channel assignments. For example, a user may desire a third simultaneous MPEG2 channel, so that three people in the house can watch different video programs simultaneously.

Dynamic data stream channel allocation may be sufficient to solve such a problem, e.g., adding a third simultaneous MPEG2 channel by utilizing one of the unused miscellaneous channels. If more simultaneous channels were required than could be obtained via dynamic reallocation of channels, then a switching router could be added to segment the logical ring network into distinct arms, each of which has a delay (in this embodiment) of exactly 22.676 μs (1/44.1 kHz). Alternatively, network devices with transceivers using 5-level coding or other modulation techniques also could be added to the logical ring network to increase bandwidth, e.g., doubling the size of a frame by sending two data bits (instead of one) during each clock period.

Moreover, the addition of a switching router might also be desirable in the unlikely event that the number of network devices (e.g., more than about 100) creates a cumulative frame propagation delay exceeding 22.676 μs (1/44.1 kHz). These and other solutions to the need for increased network bandwidth are discussed in greater detail below.

In addition to typical real-time continuous data streams, such as digital audio and video streams, one also can embed synchronous data (e.g., serial data, TCP/IP packets, compressed MPEG1 or MPEG2 video, etc.) into data stream channels, as will be explained in greater detail below. Such asynchronous data, though distributed among network devices synchronously (and thus without network collisions), can be processed by those devices on the logical ring network that are capable of interpreting such data types. Other network devices merely "pass on" such data, as they would other digital media streams in which they were not interest. As will be explained below, such data may not even occupy an entire nibble every frame (due to lesser bandwidth requirements), and may therefore be interleaved with other data (or "null" data), e.g., every nth frame.

Thus, the data stream provides multiple channels for network devices to transmit to one another a variety of different data types having differing bandwidth requirements. These channels enable network devices to utilize precisely the amount of network bandwidth required by a particular data type, with the ability to reallocate channels dynamically (as will be discussed below) as these requirements change (e.g., as a user selects different source devices, turns devices on or off, or adds/removes devices from the logical ring network).

TABLE III

DEFAULT DATA STREAM CHANNEL ASSIGNMENTS

NIBBLE(S)	MEDIA TYPE	CHANNEL	DESCRIPTION	SIZE
0–1	Frame Header	—	—	1 byte/2 symbols
2–7	Audio	0	Left/ LeftX	16 bits/4 nibbles 24-bit extension byte/ 6 nibbles total
8	Phone	0	—	1 nibble
9	Phone	1	—	1 nibble
10–15	Audio	1	Left/ LeftX	16 bits/4 nibbles 24-bit extension byte/ 6 nibbles total
16	Phone	2	—	1 nibble
17	Phone	3	—	1 nibble
18–23	Audio	2	Left/ LeftX	16 bits/4 nibbles 24-bit extension byte/ 6 nibbles total
24	Asynch Net	0–7	—	1 nibble
25	Asynch Net	8–15	—	1 nibble
26–31	Audio	3	Left/ LeftX	16 bits/4 nibbles 24-bit extension byte/ 6 nibbles total
32–47	Video	0	—	8 bytes/16 nibbles
48–63	Miscellaneous	0	—	8 bytes/16 nibbles
64–65	System Command Byte	—	—	1 byte/2 symbols
66–71	Audio	0	Right/ RightX	16 bits/4 nibbles 24-bit extension byte/ 6 nibbles total
72	Phone	4	—	1 nibble
73	Phone	5	—	1 nibble
74–79	Audio	1	Right/ RightX	16 bits/4 nibbles 24-bit extension byte/ 6 nibbles total
80	Phone	6	—	1 nibble
81	Phone	7	—	1 nibble
82–87	Audio	2	Right/ RightX	16 bits/4 nibbles 24-bit extension byte/ 6 nibbles total
88	Asynch Net	16–23	—	nibble
89	Asynch Net	24–31	—	1 nibble
90–95	Audio	3	Right/ RightX	16 bits/4 nibbles 24-bit extension byte/ 6 nibbles total
96–111	Video	1	—	8 bytes/16 nibbles

TABLE III-continued

DEFAULT DATA STREAM CHANNEL ASSIGNMENTS

NIBBLE(S)	MEDIA TYPE	CHANNEL	DESCRIPTION	SIZE
112–127	Miscellaneous	1	—	8 bytes/16 nibbles

f) System Command Stream

As noted above, the system command stream is used primarily for initialization and configuration of devices on a logical ring network. By propagating along the default network path, the system command stream reaches every network device. In one embodiment, the system command stream consists of fixed-length 40-byte system commands (formatted as illustrated in Table IV below), distributed over 40 frames, and thus occupying two nibbles (1 byte) per frame.

In this embodiment, the first 2 nibbles of a system command are interpreted as special "system command header" markers, and the remaining 78 nibbles (39 bytes) are interpreted as data. As shown in Table I above, the MSB of the 5-bit "Translated Value" of each symbol determines whether that symbol represents a special marker (MSB=1) or data (MSB=0).

The system command header delimits system commands within the system command stream and indicates whether the current system command already is "in use" (i.e., contains a system command already propagating along the default network path) or is "empty" (i.e. free to be overwritten by the receiving network device). The two-symbol "system command start" marker ("TR") indicates that the system command is in use, while the two-symbol "system command empty" marker ("TU") indicates an empty system command.

If a network device desires to initiate a system command, it waits for, and then overwrites, a system command empty marker (TU) with a system command start marker (TR). It then overwrites the subsequent 39 bytes in the system command stream (i.e., 1 byte per frame) with the appropriate data, as discussed below, filling unused portions of fields with numeric "0"s. Network devices have sufficient time to overwrite portions of a system command because, as noted above, each network device imposes at least a one-frame delay to process system commands. Thus, network devices can modify system commands initiated by other network devices, as well as initiate their own system commands (although, as will become apparent below, there is no requirement in this embodiment that network devices be capable of initiating system commands).

Following the system command header is a one-byte system command identifier. Like an opcode, this field distinguishes the various types of system commands described below. The seven LSBs of this 8-bit field are used to identify up to 127 different types of system commands ("0x00–0x7E"), with the "0x7F" value reserved for future extensibility via "extended" system commands which could be defined, for example, using part of the 20-byte "system command data" field described below. The MSB of the system command identifier ("age bit") is used to mark or "age" system commands so that they can be "removed" from the logical ring network and their bandwidth reclaimed (as is discussed in greater detail below).

Following the system command identifier field is an 8-byte network device "destination address" field. As will be explained below, each network device is identified in this embodiment by a unique 64-bit address. The destination address field indicates the intended target of the system command. A destination address of all "0" s indicates a "broadcast" destination address intended for all network devices. Although system commands propagate to every network device on the default network path, devices other than the intended target need not process or perform the system command. They merely "pass it on" to the next device on the default network path.

Following the destination address field is an 8-byte network device "source address" field which identifies the network device that initiated the system command. This enables network devices to communicate "privately" with one another—e.g., responding to a system command by placing the source address from the original system command in the destination address field of the responsive system command.

Following the source address field is a 20-byte "system command data" field which contains information specific to each particular type of system command (as will be discussed below). As noted above, this field could also include extended system command identifiers.

The next to last byte of a system command is the "status" byte. Network devices set the LSB or "acknowledge" bit of this byte in a received system command to acknowledge receipt of the system command. Because system commands propagate back to the network device that initiated them before being removed, the initiating network device can inspect the acknowledge bit and know whether the target device received the system command. The "next-to-LSB" (i.e., bit 1) of the status byte is undefined in this embodiment. As will be discussed below, most system commands that are addressed directly to a network device (i.e., not broadcast) require an acknowledgement.

The 6 MSBs of the status byte can be used by a network device as a "sequence number" to track system commands it initiates. This sequence number can be particularly useful if a network device transmits a sequence of system commands and the cumulative system command propagation delay exceeds 40 frames (e.g., 80 or 120 frames). Rather than having to "remember" (i.e., buffer) the entire sequence or system commands it has initiated in order to detect an error (e.g., a system command that is garbled during transmission), the device can detect such an error merely by detecting a gap in the order of the sequence numbers as it receives its own system commands (e.g. 1, 2, 3, 5, 6-indicating that the 4^{th} system command it initiated was somehow corrupted while propagating along the default network path). In addition, sequence numbers can be used by both the sender and recipient to distinguish otherwise identical system commands.

The final byte of a system command is the "checksum" byte, which contains an error detection checksum reflecting the other 39 bytes of the system command. Upon receiving a system command (even an empty system command), a network device can regenerate the checksum from the first 39 bytes of that system command, and compare that generated checksum to the received checksum byte (as shown below) to detect certain errors, such as an accidentally "flipped bit" during transmission.

In one embodiment, the network device only performs the system command after receiving it in its entirety and verifying it via its checksum byte. If the checksum byte does not match the generated checksum, then the device does not perform the system command. By that time, however, the

device already may have passed on (and perhaps modified) many bytes of the system command.

In this embodiment, if the network device does not modify any portion of the system command, then it merely passes the entire system command (including the checksum byte, "matching" or not) onto the next network device on the logical ring network. That next device will thus generate the same matching or non-matching checksum, and act in a similar manner.

If, however, the network device modifies any portion of the system command (e.g., to initiate its own system command, acknowledge a system command initiated by another network device, etc.), then the device computes and transmits its own checksum byte, reflecting the other 39 (somewhat modified) bytes of the system command transmitted to the next device on the logical ring network. Yet, if the checksum byte of the received system command does not match the checksum generated from the other 39 bytes as received, then the device instead transmits the "one's complement" (i.e., logical complement of each bit) of that computed checksum byte. This virtually guarantees that the next device will receive a bad (non-matching) checksum and ignore the modified system command. Following is one embodiment of such a checksum algorithm.

To verify a received system command, a network device first concatenates each pair of 4-bit data nibbles it receives (after checking and stripping off the MSB of the 5-bit Translated Values of the received symbols as shown in Table I), with the first nibble received being the most significant nibble. For special markers such as the "System Command Start" and "System Command Empty" markers, the device checks and strips off the MSBs of the 5-bit Translated Values of each received symbol to create 4-bit values before concatenating them together.

The device uses these 8-bit values to regenerate a checksum to compare to the received checksum byte, by performing a cumulative "bytewise" addition (8-bit addition with no carry beyond the MSB) of the first 39 of these 8-bit values of the system command received, beginning with the system command header. It then extracts the received checksum byte as data—i.e., by stripping off the MSB ("0") from the 5-bit Translated Values of each of the 2 received nibbles of the received checksum byte, and concatenating them together into an 8-bit extracted checksum with the first nibble received being the most significant nibble. Finally, the device compares the 8-bit regenerated checksum to this 8-bit extracted checksum. Only an exact match constitutes a validly received system command.

To compute a checksum byte to transmit as part of a modified system command, the device concatenates pairs of 4-bit data nibbles (or the least significant 4 bits of the 5-bit Translated Value of each special marker symbol) derived from the (somewhat modified) data/markers, prior to further encoding/translating them into 5-bit symbols for transmission to the next device on the logical ring network. The device computes a checksum, as above, by performing a cumulative "bytewise" addition (8-bit addition with no carry beyond the MSB) of the first 39 of these 8-bit values of the system command to be transmitted, again beginning with the system command header.

As noted above, however, if the received system command was not valid (due to a non-matching received checksum byte), the device logically complements this computed checksum byte (i.e., inverts all 8 bits) for the purpose of propagating a "bad" checksum to the next device on the logical ring network, indicating that the system command cannot be trusted.

At this point, whether or not the received system command was valid, the device transforms this 8-bit computed (and possibly inverted) checksum into two distinct 5-bit Translated Values by prepending a "0" to the MSB of the most significant 4-bit nibble of the 8-bit computed checksum (to form the first 5-bit Translated Value of the new checksum byte), and prepending a "0" to the MSB of the least significant 4-bit nibble of the 8-bit computed checksum (to form the second 5-bit Translated Value of the new checksum byte). Finally, the device transmits this new checksum byte by encoding these two distinct 5-bit Translated Values into symbols for transmission to the next device on the logical ring network.

TABLE IV

SYSTEM COMMAND FORMAT

FIELD	SIZE	DESCRIPTION
S	1 byte/2 symbols	System Command Header "System Command Start" (TR) and "System Command Empty" (TU) markers
CMD	1 byte/2 nibbles	System Command identifier (MSB is the age bit)
Destination ID	8 bytes/16 nibbles	Destination address
Source ID	8 bytes/16 nibbles	Source address
System Command Data	20 bytes/40 nibbles	System Command-specific information
Status	1 byte/2 nibbles	Sequence Number, Acknowledge, etc.
Checksum	1 byte/2 nibbles	Error detection checksum

Table V below illustrates one embodiment of a set of system commands. Assuming a 44.1 kHz frame rate along the default network path, the system command stream includes approximately 1100 of these 40-byte system commands per second. By supporting over 1000 system commands per second, the logical ring network can be reintialized and/or reconfigured in less than a second, as will be discussed below, even as the number of network devices increases substantially and devices such as switching routers are added to increase network bandwith for the data stream. If network devices need to send custom commands to one another, or simply need additional command bandwidth, they can embed such commands in the data stream, as discussed below.

It should be noted that, because every network device receives these system commands, the NRZ bi-level coding scheme is used for transmission of the system command stream. For example (as discussed in greater detail below), certain network devices might utilize 5-level coding or other advanced modulation techniques to increase network bandwidth for the data stream. Such portions of the data stream might propagate along an alternate "shortcut" path instead of the default network path, and might encounter only network devices capable of interpreting data transmitted via these advanced modulation techniques. The system command stream, however, propagates to every network device, and thus is transmitted via NRZ bi-level coding—the "lowest common denominator" modulation technique.

In one embodiment, the network clock device initiates a stream (over the course of 40 frames) of 40-byte empty system commands which propagate along the default network path. Following the system command empty marker, the network clock device transmits 38 bytes of numeric "0"s and a correct checksum byte (as described above).

As noted above, another device receiving one of these empty system commands can initiate a system command by modifying the system command header—i.e., overwriting the system command empty marker with a system command start marker. Because each device delays the system command stream by buffering system commands (typically for at least a few 44.1 kHz frame times), the network clock device must, as noted above, "round up" the cumulative system command propagation delay to an integral multiple of 40 of these 44.1 kHz frame times to prevent system commands from overlapping one another and becoming corrupted.

The network clock device also is responsible in this embodiment for "aging" and removing system commands, as noted above. Upon receiving a non-empty system command, the network clock device can set its age bit (the MSB of the system command identifier) and wait for that system command to propagate around the default network path of the logical ring network. Upon receiving any system command with its age bit set, the network clock device can remove that system command (which every network device, including the device that initiated the system command, has had an opportunity to process) by changing its system command start marker to a system command empty marker, and thereby creating another empty system command which other network devices can then overwrite to initiate their own system command.

The network clock device also ages and removes system commands with a bad (non-matching) checksum byte. The network clock device does not age empty system commands; though it does recreate them to avoid retaining any transmission errors.

The network clock device also does not need to age system commands which it initiates. Instead of setting the age bit, it may simply recognize its own system command (by its source address) after it propagates around the default network path of the logical ring network, and then remove that system command as described above. Other network devices also can remove their own system commands in this manner, thereby promoting "fairness" in that empty system commands will not be so readily available only to devices closely following the network clock device along the default network path. In addition, overall system command throughput is increased because system commands are removed from the network more quickly; and replaced with empty system commands.

In order to remove its own system commands, however, devices must buffer some portion of each received system command to determine whether it should be removed, thereby increasing system command latency. In one embodiment, 20 bytes are buffered, so that the device can identify its own system command via the Source ID field. The system command also will be removed, upon detecting a bad checksum byte, even if the Source ID field match was due to a transmission error.

As a result, system commands are delayed for 20 (44.1 kHz) frames when propagating through such devices (and even longer for the network clock device, which buffers an entire 40-byte system command and rounds up the cumulative system command propagation delay to an integral multiple of 40 frames).

In any event, a system command initiated by a network device will return to that network device before being removed (by the device itself or by the network clock device). That network device thus has an opportunity to recover data (e.g., an acknowledge bit or the location of device-specific data) which was "embedded" into the system command by the target/destination device to which the system command was addressed. Network devices embed such data by overwriting the relevant field(s) of the system command, padding any unused data nibbles of such fields (or entire unused fields) with numeric "0"s, and generating a new checksum.

In this manner, most network devices can be relatively "dumb"—i.e., capable only of responding to system commands (important for significant purposes, such as network initialization and/or device configuration), but not necessarily capable of initiating system commands or handling complex communications protocols. As smarter "system controllers" with CPUs are added to the network, these "smart" devices can reconfigure "dumb" devices by reading/executing their device drivers (stored, for example, in on-board memory) and reading/writing their on-board registers, as discussed below.

Illustrated in Table V below is one embodiment of a set of system commands. As noted above, these system commands are used primarily for initialization and/or configuration of network devices. Each of these system commands is explained in greater detail below in the context of the operation of the logical ring network.

Briefly, the MASTER RESET, CLOCK ID, SCAN RESET, SCAN REQUEST, SCAN REPLY and SCAN INITIATE system commands are used to reset and initialize network devices. Network devices (if capable) can communicate with one another, and read/write one another's device-specific information via the MESSAGE, READ, WRITE, SET and GET system commands. Data stream channels can be reallocated and controlled via the TALK ASSIGN, TALK QUERY, LISTEN ASSIGN, LISTEN QUERY, START STREAMS, STOP STREAMS, and QUERY STREAMS system commands. Network devices can utilize the PLL LOCK system command to synchronize to external information transmitted at reference frequencies that differ from the logical ring network frequency (e.g., data bit rate). The network clock device transmits the "time of day" periodically via the TIME MARK system command and WK Time Sync frame header marker. Finally, this set of system commands can be extended with additional system commands via the EXTENDED system command field identifier.

TABLE V

SYSTEM COMMANDS

SYSTEM COMMAND	CONTENTS	PURPOSE
MASTER RESET	1 TR 2 0x01 3–10 Destination ID* 11–18 Source ID 19–39 Zeros 40 CHECKSUM	Used to perform a reset of individual or all network devices. Upon being reset, devices return to their "default"state, without the need for a subsequent network clock device arbitration and logical ring network topology scan.
CLOCK ID	1 TR 2 0x02 3–10 Broadcast ID 11–18 CLK Device ID 19–39 Zeros 40 CHECKSUM	Upon being reset (in response to power up, detection of an error condition or a MASTER RESET system command), "clock-capable" network devices repeatedly broadcast CLOCK ID system commands with their own Device ID source address (ignoring received CLOCK ID system

TABLE V-continued

SYSTEM COMMANDS

SYSTEM COMMAND		CONTENTS	PURPOSE
			commands having a lower Device ID) until they receive a CLOCK ID system command having a higher Device ID (indicating they will not become the network clock device) or a CLOCK ID system command with their own Device ID (indicating they will become the network clock device).
SCAN RESET	1	TR	Upon becoming the network clock device (or subsequently receiving a SCAN INITIATE system command), the network clock device performs a "soft"reset (scan) of network devices by broadcasting a SCAN RESET system command to notify every network device that it should respond to the next SCAN REQUEST system command it receives
	2	0x03	
	3–10	Broadcast ID	
	11–18	CLK Device ID	
	19–39	Zeros	
	40	CHECKSUM	
SCAN REQUEST	1	TR	After sending a SCAN RESET system command, the network clock device repeatedly sends SCAN REQUEST system commands (listing itself as the "destination") until it receives one of these system commands unmodified (indicating that all network devices have received/modified one of these system commands). Each network device overwrites the first (and only the first) SCAN REQUEST system command it receives by changing the SCAN REQUEST system command identifier field to a SCAN REPLY (now destined for the network clock device), embedding in the system command data field its Device ID and the location and length of its device-specific configuration and code control block (stored in its local memory address space), and setting the acknowledge bit of the status byte.
	2	0x04	
	3–10	CLK Device ID	
	11–18	CLK Device ID	
	19–22	Zeros	
	23–36	Returned Data Stream	
	37–38	Zeros	
	39	ACK	
	40	CHECKSUM	
SCAN REPLY	1	TR	Created when each network device modifies a SCAN REQUEST system command, and then modified by the network clock device which broadcasts each of these modified SCAN REPLY system commands so that interested network devices can discern the logical ring network topology.
	2	0x05	
	3–10	CLK Device ID/ Broadcast ID	
	11–18	CLK Device ID	
	19–22	Zeros	
	23–36	Returned Data Stream	
	37–38	Zeros	
	39	ACK	
	40	CHECKSUM	
SCAN INITIATE	1	TR	Used by a network device (e.g., a hot pluggable smart jack upon insertion or removal of a network device) to cause network clock device to initiate a "soft" reset (scan) of network devices to enable interested network devices to discern the logical ring network topology.
	2	0x06	
	3–10	Broadcast ID	
	11–18	Source ID	
	19–38	Zeros	
	39	ACK	
	40	CHECKSUM	

TABLE V-continued

SYSTEM COMMANDS

SYSTEM COMMAND		CONTENTS	PURPOSE
MESSAGE	1	TR	Used to send events and other information (in a predefined "message data" format) to which interested devices can respond. The Timestamp indicates, for example, when an event occurred or will/should occur.
	2	0x07	
	3–10	Destination ID*	
	11–18	Source ID	
	19–32	Message Data	
	33–38	Timestamp**	
	39	ACK	
	40	CHECKSUM	
SET	1	TR	Used to write values (up to single-byte registers in one embodiment) in the local I/O address space of a network device. The locations and functions of these "registers" are documented in the configuration and code control block in the local memory address space of each network device, and can be read via a READ system command. The Timestamp, if supported by a destination network device, can be used to queue the actual write until the designated time.
	2	0x08	
	3–10	Destination ID	
	11–18	Source ID	
	19–21	I/O Address	
	22	Length	
	23–32	Sent Data	
	33–38	Timestamp**	
	39	ACK	
	40	CHECKSUM	
GET	1	TR	Used to read values (up to 16 single-byte registers in one embodiment) from the local I/O address space of a network device. The locations and functions of these "registers" are documented in the configuration and code control block in the local memory address space of each network device, and can be read via a READ system command.
	2	0x09	
	3–10	Destination ID	
	11–18	Source ID	
	19–21	I/O Address	
	22	Length	
	23–38	Returned Data	
	39	ACK	
	40	CHECKSUM	
WRITE	1	TR	Used to write values to the local memory address space of a network device. The local memory address space of a device can address on-board ROM (which of course cannot be written), RAM or peripheral registers, and can contain the Device ID (in ROM), configuration and code control block and other information for the device.
	2	0x0A	
	3–10	Destination ID	
	11–18	Source ID	
	19–21	Start Location	
	22	Length	
	23–38	Sent Data	
	39	ACK	
	40	CHECKSUM	
READ	1	TR	Used to read values from the local memory address space of a network device. The local memory address space of a device can address on-board ROM; RAM or peripheral registers, and can contain the Device ID (in ROM), configuration and code control block and other information for the device.
	2	0x0B	
	3–10	Destination ID	
	11–18	Source ID	
	19–21	Start Location	
	22	Length	
	23–38	Returned Data	
	39	ACK	
	40	CHECKSUM	
TALK ASSIGN	1	TR	Used (e.g., by a "smart" system controller device) to assign a data stream "transmit" channel to a network device by associating individual "network nibble streams" of the data stream (identified via the Transmit Enable Mask and Bank fields) with one of
	2	0x0C	
	3–10	Destination ID	
	11–18	Source ID	
	19–20	Zeros	
	21	Media Stream ID	
	22	Bank	
	23–38	Transmit Enable Mask	
	39	ACK	

TABLE V-continued

SYSTEM COMMANDS

SYSTEM COMMAND		CONTENTS	PURPOSE
	40	CHECKSUM	the device's "transmit media streams" (identified via the Media Stream ID field).
TALK QUERY	1	TR	Used (e.g., by a "smart" system controller device) to query a network device to determine, for a specified one of the device's "transmit media streams" (identified via the Media Stream ID field), which individual "network nibble streams" of the data stream (identified via the Returned Transmit Enable Mask and Bank fields) are currently associated with that "transmit media stream".
	2	0x0D	
	3–10	Destination ID	
	11–18	Source ID	
	19–20	Zeros	
	21	Media Stream ID	
	22	Bank	
	23–38	Returned Transmit Enable Mask	
	39	ACK	
	40	CHECKSUM	
LISTEN ASSIGN	1	TR	Used (e.g., by a "smart" system controller device) to assign a data stream "receive" channel to a network device by associating individual "network nibble streams" of the data stream (identified via the Receive Enable Mask and Bank fields) with one of the device's "receive media streams" (identified via the Media Stream ID field).
	2	0x0E	
	3–10	Destination ID	
	11–18	Source ID	
	19–20	Zeros	
	21	Media Stream ID	
	22	Bank	
	23–38	Receive Enable Mask	
	39	ACK	
	40	CHECKSUM	
LISTEN QUERY	1	TR	Used (e.g., by a "smart" system controller device) to query a network device to determine, for a specified one of the device's "receive media streams" (identified via the Media Stream ID field), which individual "network nibble streams" of the data stream (identified via the Returned Receive Enable Mask and Bank fields) are currently associated with that "receive media stream".
	2	0x0F	
	3–10	Destination ID	
	11–18	Source ID	
	19–20	Zeros	
	21	Media Stream ID	
	22	Bank	
	23–38	Returned Receive Enable Mask	
	39	ACK	
	40	CHECKSUM	
START STREAMS	1	TR	Used (e.g., by a "smart" system controller device after reallocating data stream channels) to signal one or more network devices to start transmitting/receiving data (at the time specified via the Timestamp field) on whichever "network nibble streams" of the data stream are currently associated with specified ones of the device's "transmit media streams" (specified via the Mask Number and OUT Stream Mask fields) and specified ones of the device's "receive media streams" (specified via the Mask Number and IN Stream Mask fields).
	2	0x10	
	3–10	Destination ID*	
	11–18	Source ID	
	19–21	Zeros	
	22	Mask Number	
	23–26	IN Stream Mask	
	27–30	OUT Stream Mask	
	31–32	Zeros	
	33–38	Timestamp**	
	39	ACK	
	40	CHECKSUM	
STOP STREAMS	1	TR	Used (e.g., by a "smart" system controller device following a sequence of QUERY STREAMS system commands) to signal one or more network devices to stop transmitting/receiving data (at the time specified via the Timestamp field) on whichever "network nibble streams" of the data stream are currently associated with specified ones of the device's "transmit media streams" (specified via the Mask Number and OUT Stream Mask fields) and specified ones of the device's "receive media streams" (specified via the Mask Number and IN Stream Mask fields).
	2	0x11	
	3–10	Destination ID*	
	11–19	Source ID	
	19–21	Zeros	
	22	Mask Number	
	23–26	IN Stream Mask	
	27–30	OUT Stream Mask	
	31–32	Zeros	
	33–38	Timestamp**	
	39	ACK	
	40	CHECKSUM	
QUERY STREAMS	1	TR	Used (e.g., by a "smart" system controller device prior to initiating a STOP STREAMS system command and reallocating data stream channels) to query a network device to determine, from among specified ones of the device's "transmit media streams" and "receive media streams" (identified via the Mask Number field), on which of those transmit media streams (identified via the OUT Stream Mask field) and receive media streams (identified via the IN Stream Mask field) a network device currently is transmitting/receiving data.
	2	0x12	
	3–10	Destination ID	
	11–18	Source ID	
	19–21	Zeros	
	22	Mask Number	
	23–26	IN Stream Mask	
	27–30	OUT Stream Mask	
	31–38	Zeros	
	39	ACK	
	40	CHECKSUM	
TIME MARK	1	TR	Broadcast by the network clock device to announce that the next Time Sync frame header ("WK," transmitted periodically in lieu of the "JK" Clock Sync frame header) it transmits will mark the exact time of day specified in the Timestamp field of this TIME MARK system command.
	2	0x13	
	3–10	Broadcast ID	
	11 –18	CLK Device ID	
	19–32	Zeros	
	33–38	Timestamp**	
	39	ACK	
	40	CHECKSUM	
PLL LOCK	1	TR	Used by a network device to synchronize to another network device at a reference frequency that differs from the logical ring network frequency. The source device calculates and transmits to the destination device(s) an identifying PLL Number and a "phase error" (via the Phase Error field) based on the difference between the reference and network frequencies. The destination device(s) calculate an analogous "phase error" using a free-running clock which is phase-locked over the network to the reference frequency based on the difference between the transmitted and calculated phase errors. A Timestamp can be used, along with the phase error, to synchronize external devices not on the logical ring network.
	2	0x14	
	3–10	Destination ID*	
	11–18	Source ID	
	19–20	Zeros	
	21	PLL Number	
	22	Zero	
	23–30	Phase Error	
	31–32	Zeros	
	33–38	Timestamp**	
	39	ACK	
	40	CHECKSUM	
EXTENDED	1	TR	Used to extend the system command set (using the system command data field
	2	0x7F	
	3–10	Destination ID*	

TABLE V-continued

SYSTEM COMMANDS

SYSTEM COMMAND	CONTENTS	PURPOSE
	11–18 Source ID 9–39 Extended CMD ID and Data 40 CHECKSUM	for the extended system command identifier codes as well as system command-specific data) after exhausting the available system command identifier codes in the system command ID field.

*The Destination ID of 0x0000000000000000 is the broadcast address.
**The first three bytes of a Timestamp respectively represent hours, minutes and seconds in binary coded decimal (BCD) format. The next two bytes represent further "sub-second" resolution via an unsigned binary frame count, and the final byte represents still further "sub-frame" resolution via an unsigned binary sub-frame count. A Timestamp value of 0xFFFFFFFFFFFF is used to indicate immediate action (e.g., when broadcasting a system command to network devices only some of which support timestamps).

g) Device Identification, Addressing and Security

(1) Device ID

As noted above, in one embodiment, every network device is identified by a unique 64-bit (8 byte) "Device ID." Conflicts among these Device IDs can be avoided by centralizing their issuance within a single operation. Thus, every network device ever manufactured can be uniquely identified. By accommodating a virtually unlimited number of network devices, logical ring networks can be interconnected without device conflict across homes, vehicles, buildings, and companies throughout the world.

A network device's Device ID is used in the Destination ID and Source ID "address" fields of system commands, and can be discerned by capable network devices during network initialization and used to access a device's local memory address space (discussed below). In addition, as will be explained below, the Device ID is used during network initialization to elect the network clock device—i.e., the competing device with the greatest Device ID value. One embodiment of the Device ID format is specified in Table VI below. In this embodiment, only the "Switch" field can be modified.

The Switch field, which occupies the initial (most significant) three bits of the Device ID, can be used to "force" the election of a device as the network clock device. The Switch field is set by default to all "0"s, but can be modified via a switch on the network device itself, or programmed dynamically by another network device. A user might, for example, set the Switch field of a particular network device to "010" (using a switch on the device itself) to force a medium priority which likely will cause that device to become the network clock device during network initialization (because the user probably will not set any switches on other devices).

Following the Switch field is a 5-bit "Network Revision" field that indicates whether the device is capable of becoming the network clock device and, if so, also identifies the version of the logical ring network for which this potential network clock device was manufactured. In this embodiment, the network version will be used for electing the network clock device during network initialization, with greater numbers indicating a more recent network protocol. This ensures that the network device capable of using the most recent clock protocol will be elected as the network clock device (unless overridden via the Switch field). A Network Revision field value of "00000" indicates that the device is not capable of becoming the network clock device.

In one embodiment (discussed below), the clock protocol would require "clock-capable" devices to initialize and auto-configure the logical ring network, and broadcast the "time of day" periodically (e.g., once per minute) via the TIME MARK system command and Time Sync ("WK") frame header. More advanced protocols could require support for initializing network devices capable of transmitting/receiving information on multiple different paths, as well as direct support for hot-pluggable smart jacks and switching routers (as will be discussed in greater detail below).

The final field of the Device ID is a 56-bit "Serial Number" which uniquely identifies and distinguishes network devices from one another. The number of distinct combinations is sufficiently large to guarantee, as a practical matter, that no two network devices ever will conflict with each other. In other words, it is unlikely that the number of network devices (or, for that matter, any article of manufacture) produced worldwide will ever exceed 2^{56}.

TABLE VI

DEVICE ID FORMAT

FIELD	SIZE	DESCRIPTION
Switch	3 bits	Programmable/switchable field for overriding priority (e.g., for network clock arbitration)
Network Revision	5 bits	Identifier of clock capability and network version (e.g., for resolving version compatibility)
Serial Number	56 bits	Device unique identifier: 2^{56} combinations

(2) Local Memory and I/O Address Space

In one embodiment, each network device has at least some memory, addressable via READ and WRITE system commands. This area of memory, referred to as the device's "local memory address space," can include RAM and peripheral registers as well as ROM. In addition, a network device also may have a "local I/O address space," e.g., a set of physical registers for storing I/O information relating to network device peripheral hardware.

In one embodiment, the local memory address space of a network device is 24 bits wide and is byte-addressable. Network devices stored their Device ID (8 bytes) in ROM, typically along with a "pointer" (e.g., 3-byte starting location and 3-byte length) to their configuration and code control block. This on-board information can, of course, contain virtually any type and format of information (e.g., interpretive bytecodes, URLs, etc.) which other devices, such as a "smart" CPU-based controller, can interpret.

Devices embed this information into SCAN REPLY system commands during network initialization (as explained below). Other interested devices can read this information for subsequent use in communicating directly with a particular device and/or obtaining additional information about a device from an external resource (e.g., the Internet via a URL "pointer"). For example, having discerned another device's Device ID and "pointer" from a SCAN REPLY system command, a "smart" controller could read information from that device's variable-length configuration and code control block (perhaps containing that device's capabilities) by initiating a READ system command.

Network devices thus can communicate directly with one another (via their Device IDs), and can send "messages" via

the Message Data field of the MESSAGE system command. Such messages also can include a timestamp (in the Timestamp field) to indicate, for example, the precise "time of day" when an event (contained in the message) occurred or will/should occur. For example, one device could tell another device when to turn itself off.

Using these mechanisms, relatively "dumb" devices (even though incapable of initiating system commands) can be configured, for example, by a "smart" controller device that modifies configuration data in the configuration and control block of the "dumb" network device via READ and WRITE system commands.

The configuration and code control block of a network device could include information such as a machine-independent (e.g., interpreted bytecode written in Java, Smalltalk, etc.) device driver which a "smart" system controller could access and then execute on behalf of the "dumb" network device. It could also include a version number, as well as a pointer to a location (e.g., an Internet URL or BBS phone number) where a current version of this device driver can be found.

In one embodiment, a genetic URL could be employed to point to the location of the device driver either at an Internet address (e.g., "http://www.vendor.com/driverloc") or at an address within the device's local memory address space (e.g., "deviceaddress://deviceloc/driverloc"). Other similar pointers could be used for a variety of purposes, such as defining a device's user interface or enabling a user to sign up for selected services. A pointer to device vendor information, such as warranty registration data, could even be used to register a network device automatically—even a "dumb" device whose warranty data could be registered by a "smart" system controller.

Encryption codes also could be included to ensure that digital media on the logical ring network could only be accessed by "authorized" network devices. These codes might, for example, be accessible only to authorized television/monitor network devices.

If the network device also includes a local I/O address space containing, for example, byte-addressable "registers", the location and function of these registers could be identified in the configuration and code control block. These registers could contain configuration information, for example, relating to network device peripheral hardware. A "smart" system controller could initiate GET and SET system commands to read/write these registers.

As will be apparent to one reasonably skilled in the art, many different data structures (e.g., a linked list of objects) and combinations of RAM/ROM/registers can be employed to accommodate the various types of data contained within the configuration and code control block, as well as any other information stored in a network device's local memory and I/O address space, including "pointers" to external information.

3. Synchronous Logical Ring Network in Operation

a) Network Initialization and Auto-Configuration

In one embodiment, the initialization and auto-configuration of a logical ring network involves what is essentially a two-step process: (1) network clock device arbitration (to synchronize network devices to a single network clock device) and (2) logical ring network topology scan (to establish the default network plan and enable interested network devices to discern the network topology). As will become apparent, this entire process can be completed in less than one second for typical logical ring networks.

Should one desire to avoid any interruption of the data stream (e.g., to avoid even a short "glitch" in a song, television program or telephone conversation) whenever a new network device is added or removed, one can daisy-chain network devices to hot-pluggable smart jacks. When such network devices are added or removed, the hot-pluggable smart jack will, in effect, isolate the rest of the logical ring network, leaving the data stream intact. As noted above, the data stream can operate independently from the system command stream provided that network devices remain synchronized to the network clock device. A hot-pluggable smart jack maintains this synchronization (as will be explained in greater detail below) by maintaining a consistent cumulative device delay among network devices daisy-chained to that jack, even as such network devices are added or removed. Such jacks thereby avoid the need for another network clock device arbitration, though they will send a SCAN INITIATE system command to cause the network clock device to initiate a logical ring network topology scan to make interested network devices aware of the newly added or removed device(s).

A logical ring network is first initialized when the first "clock-capable" network device is added to the network, and is reinitialized during normal operation whenever a CLOCK ID system command is broadcast (e.g., in response to detection of an error condition, as described below). To initialize a logical ring network, all "clock-capable" network devices arbitrate to be elected as the network clock device to which all other network devices will be synchronized. Following network initialization is an auto-configuration process, managed by the network clock device, during which devices on the logical ring network are scanned to establish the network topology—i.e., the default network path and other paths along which information propagates from device to device on a logical ring network.

At this point, the logical ring network begins "normal operation"—i.e., network devices transmit digital media and other data to one another via the data stream while sending system commands via the system command stream. Though not required, if one or more "smart" system controller devices are present on the network, they can further configure network devices and enhance the functionality and effective bandwidth of the logical ring network in various ways (discussed in greater detail below)—e.g., enabling the functionality of hot-pluggable jacks and switching routers by redistributing network propagation delays among such devices, initializing user interfaces, causing device drivers to be executed, reallocating default data stream channels, and so forth.

In one embodiment, illustrated in FIG. **8**, each network device is "reset" **1002** when it is powered on, and whatever it receives a CLOCK ID system command during normal operation. Upon being reset, network devices act differently, depending upon whether they are capable of becoming the network clock device.

A network device also can be "reset" upon receiving a MASTER RESET system command (not shown); though, in this embodiment, such a system command will not result in a reinitialization of the logical ring network. Instead, the device might merely reinitialize certain internal state information and registers, if any, and resort to a default allocation of its media streams (e.g., based upon its most recent stream allocation settings, or its default switch settings, discussed in greater detail below in connection with the default data stream channel allocation).

To initiate the network clock device arbitration process, each "clock-capable" network device immediately broad-

casts repeated CLOCK ID system commands (with its own Device ID in the source address field) **1004**. Because the logical ring network is not yet synchronized to a network clock device, each such device ignores all received information other than CLOCK ID system commands (i.e., resynchronizing to each received frame header). Upon receiving a CLOCK ID system command, it compares the received "source" Device ID with its own Device ID **1006**. The "clock-capable" network device having the highest Device ID will win the arbitration. As will become apparent, this arbitration process will be decided very quickly—i.e., in a single "revolution" of a system command around the default network path of the logical ring network.

If the received Device ID is lower than its own Device ID, it is ignored (i.e., that CLOCK ID system command is not propagated to the next device on the logical ring network) because the "clock-capable" network device having that lower Device ID has already lost its bid to become the network clock device. It thus continues to broadcast CLOCK ID system commands with its own Device ID **1004** until the source Device ID of a received CLOCK ID system command either is:

(i) greater than its own Device ID, in which case it "loses" the arbitration, disables its "clock-capable" functionality and effectively becomes a "non-clock-capable" network device **1010** until the next reset, or

(ii) is equal to its own Device ID, in which case it "wins" the arbitration and becomes the network clock device **1012** (i.e., because its Device ID is greater than that of all other devices, and thus propagated completely around the logical ring network).

In the interim, other network devices (including "clock-capable" network devices that have "lost" the network clock device arbitration process) begin "normal operation" **1010**—i.e., they propagate received frames, and thus system commands (including CLOCK ID system commands initiated by "clock-capable" network devices), to the next device on the logical ring network until they received a SCAN RESET system command. They do not yet, however, transmit data on the data stream. The network clock device broadcasts this SCAN RESET system command **1012** upon winning the arbitration, effectively initiating the logical ring network topology scan phase of the process (during which data may be transmitted on the data stream).

It should be noted that, during the network clock device arbitration phase, network devices do not stand actual data on the data stream. Each network device instead waits (in one embodiment) for a sufficient passage of time, indicating likely completion of the network clock device arbitration phase and logical ring network topology scan phase (described below), before sending/receiving data (e.g., in accordance with its default channels or the channels it most recently used). If a smart controller device is present, such device may dynamically reallocate the default channels and/or enable particular streams following completion of the logical ring network topology scan phase.

Once the network clock device wins the arbitration and broadcasts a SCAN RESET system command, all other network devices receive this system command and switch to a "scan mode" (e.g., by setting a bit in an internal register) **1014** pursuant to which they will modify a subsequently received SCAN REQUEST system command by converting it into a SCAN REPLY system command, as explained below. In all other respects, network devices continue normal operation (i.e., they continue to propagate received frames to the next device on the logical ring network), and may begin to send actual data on the data stream, e.g., once a sufficient amount of time has elapsed.

The network clock device, upon receiving its own SCAN RESET system command (indicating that all other network devices have seen this system command and switched to their "scan mode"), effectively "broadcasts" repeated (interleaving empty system commands, in one embodiment) SCAN REQUEST system commands, embedding its own Device ID in both the source and destination address fields **1016**. Each network device, upon receiving one of these SCAN REQUEST system commands **1018**, (i) converts it to a SCAN REPLY system command (by modifying the system command identifier field), (ii) embeds device-specific information (i.e., its Device ID and the location and length of its configuration and code control block) into the system command data field, and (iii) switches from scan mode back to its normal mode of operation (e.g., by resetting a bit in an internal register) in which it ignores subsequent SCAN REQUEST system commands, passing them on to the next device on the logical ring network. The network device remains in this normal mode of operation **1020** until it is reset **1002** as above, or until it switches back into "scan mode" **1014** upon receiving another SCAN RESET system command.

The network clock device, upon receiving SCAN REPLY system commands from each network device, ages and rebroadcasts such system commands, enabling interested devices to discern the logical ring network topology by monitoring the device-specific information embedded in such SCAN REPLY system commands. Upon receiving its own unmodified SCAN REQUEST system command (e.g., the (n)th SCAN REQUEST system command for a network of "n" devices), the network clock device converts it to a SCAN REPLY system command and embeds its own device-specific information **1021**, and then begins "normal" operation **1012**, creating and transmitting frames (including embedding "empty" system commands into the system command stream) into which other network devices can embed information, such as digital media streams and system commands.

In one embodiment (not shown), the network clock device creates and monitors sequence numbers in both the unaged and aged/rebroadcast SCAN REPLY system commands it receives. If a lost or garbled system command is detected (e.g., if the sequence numbers are not received in order), then the network clock device reinitiates another logical ring network topology scan by transmitting a SCAN RESET system command.

Upon completion of a successful logical ring network topology scan, the network clock device resumes its normal mode of operation until it (i) is reset **1002** as above; (ii) receives a SCAN INITIATE system command (e.g., from a hot-pluggable smart jack upon detecting the addition or removal of a network device), causing it to reinitiate a logical ring network topology scan **1012** by first broadcasting a SCAN RESET system command as above; or (iii) detects an error condition indicating a loss of network synchronization (e.g., the loss of actual data or the lack of expected frame headers), causing it to return to the network clock device arbitration phase by broadcasting repeated CLOCK ID system commands **1004** as above, which will reset all other network devices. The manner in which the network clock device detects error conditions indicating that a network device has been added to or removed from the network, or has malfunctioned or been turned on or off, is discussed in greater detail below with respect to the clock processing hardware of a logical ring network adapter.

Once the logical ring network is initialized and the network topology scan has completed, "smart" system con-

troller devices, for example, can further configure the network. For example, a "smart" network clock device, upon detecting the presence of switching routers and/or hot-pluggable smart jacks, could redistribute the cumulative frame propagation delay among such devices (e.g., by writing device-specific registers via WRITE system commands) to enable them to handle the addition and/or removal of network devices without interrupting the data stream. As will be discussed in greater detail below, maintaining a consistent delay through such network devices avoids the need for another network clock device arbitration, which would disrupt the data stream. Upon detecting the addition or removal of a network device, the hot-pluggable smart jack or switching router could broadcast a SCAN INITIATE system command (as discussed above) to enable other network devices to discern the "new" network topology, without disrupting the data stream.

A system controller also could load and execute device drivers (obtained, for example, via READ system commands) on behalf of particular network devices, as well as dynamically reallocate data stream channels based upon the types of devices currently present on the network (as explained in greater detail below). For example, if three MPEG2 video source devices (e.g., DVD players or DSS receivers) are present on the network, and only two are accommodated by the default allocation, a system controller might be able to reallocate an unused data stream channel to accommodate the additional MPEG2 source. Moreover, a system controller also could initialize user interfaces present on remote control displays; televisions and other similar devices.

Finally, in one embodiment of the current network clock device protocol, the network clock device periodically broadcasts a common "time of day" reference for interested network devices. The network clock device might, for example, transmit the "time of day" once every minute to provide a common reference point for network devices capable of tracking time and supporting time-based events.

In one embodiment, the network clock device transmits this "time of day" reference by first broadcasting a TIME MARK system command with the "time of day" specified in the Timestamp field, which indicates to interested network devices that such "time of day" will occur upon receipt of the next "WK" frame header. At the appropriate time, the network clock device then substitutes the Time Sync ("WK") frame header (in lieu of the far more common Clock Sync ("JK") frame header) to "mark" the previously specified time of day.

It should be noted that this "time of day" is a very accurate relative time marker. Although it is received at slightly different times by network devices due to propagation delays along the logical ring network, these relative time differences remain constant due to the synchronous nature of the logical ring network. Moreover, in one embodiment, the delay does not exceed one (44.1 kHz audio sample) frame time. The "sub-frame" field of the Timestamp therefore is set to zero in this embodiment.

b) Sending and Receiving Information over a Logical Ring Network via the System Command Stream and Data Stream Channels

Upon completion of the network clock device arbitration and logical ring network topology scan process, network devices begin (or perhaps continue) "normal" operation—i.e., they transmit and receive data to/from one another via the data stream. As noted above, if any "smart" system controller devices are present on the network, they may perform additional network device configuration, via the system command stream, in parallel with the data stream.

For example, such devices may utilize the MESSAGE, READ, WRITE, SET and GET system commands to further configure particular network devices and/or establish proprietary protocols to communicate relatively small amounts of information. Moreover, network devices that transmit and receive MPEG2 streams (or other streams clocked at an external rate differing from the logical ring network rate) may utilize the PLL LOCK system command and associated circuitry (as discussed in greater detail below) to create, in effect, a "network phase-locked loop." This network phase-locked loop enables network devices to decode MPEG2 data, for example, at the MPEG2 external clock rate (approximately 27 MHz).

Briefly, the MPEG2 data stream would be (i) received/generated at the MPEG2 clock rate by a "source" device (such as a DSS receiver or DVD player), (ii) transmitted at the logical ring network data bit rate to a "destination" network device having an MPEG2 decoder (which could be embedded into a "digital" television or connected to a television via a traditional analog video cable); and (iii) decoded at the MPEG2 clock rate by the MPEG2 decoder, which contains a clock that is synchronized, via the "network phase-locked loop," to the reference MPEG2 clock received/generated at the "source" device.

(1) Default Data Stream Channel Allocation

In normal operation, network devices can transmit and receive information via the data stream even if no "smart" network devices are present on the logical ring network. As noted above, network devices can utilize a switch (e.g., a physical slide, toggle or rotary switch, or RAM, EEROM, etc.) setting to select from among multiple default data stream channels. If "smart" network devices are present on the network, they can override these default data stream channels by reassigning their "network nibble streams" dynamically, as explained below.

In one embodiment, network devices have up to 256 "IN Device Media Streams" and 256 "OUT Device Media Streams," each of which can be associated with a set of "network nibble streams"—i.e., nibbles (not necessarily contiguous) from among the 128 available nibbles in each "bank" of the data stream (less than four nibbles assigned to the frame header and system command byte in the initial bank—see Table III above). Multiple 128-nibble "banks" of the data stream may arise as additional network bandwidth is made available—e.g., by employing bidirectional network devices or advanced modulation techniques such as 5-level coding (as will be discussed in greater detail below).

For example, a simple CD player network device might not have any IN Device Media Streams, and have only two OUT Device Media Streams, each associated (initially by means of a switch setting) with a set of network nibble streams corresponding to one of the default data stream channel assignments (e.g., Audio Left Channel **1**, occupying nibbles **10–15**, and Audio Right Channel **1**, occupying nibbles **74–79**). During normal operation, the CD player would transmit its digital audio stream by overwriting nibbles **10–15** (left channel) and **74–79** (right channel) of each frame. A simple speaker network device might have a single IN Device Media Stream associated (e.g., via its switch) with default Audio Left Channel **1** (nibbles **10–15**) to receive and play that "left channel" digital audio stream. Another simple speaker network device could be associated in an analogous manner with default Audio Right Channel **1** (nibbles **74–79**) to receive and play the corresponding "right channel" digital audio stream.

As each frame propagates around the default network path (or alternate path) of the logic ring networks, the CD player