Fig. 10

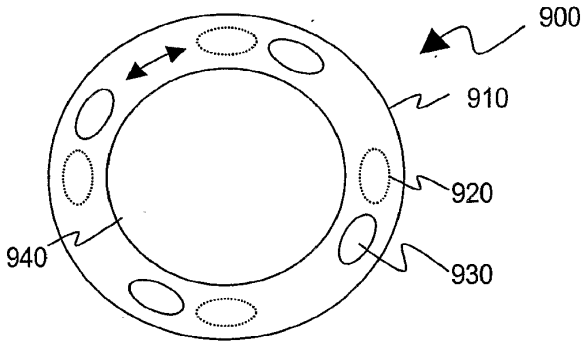


Fig. 11A

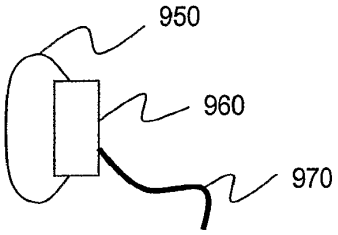


Fig. 11B

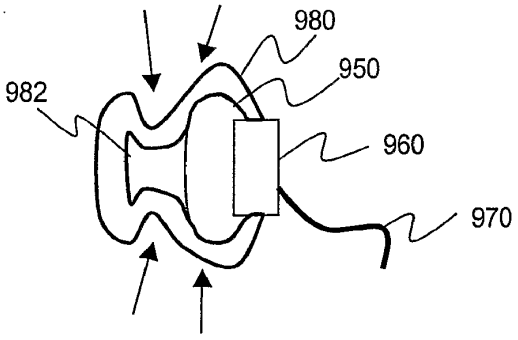


Fig. 12A

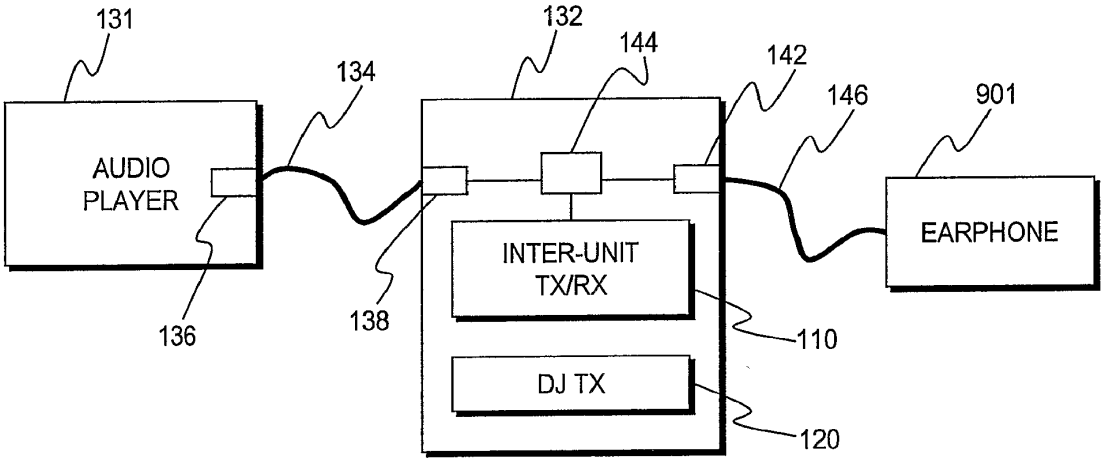


Fig. 12B

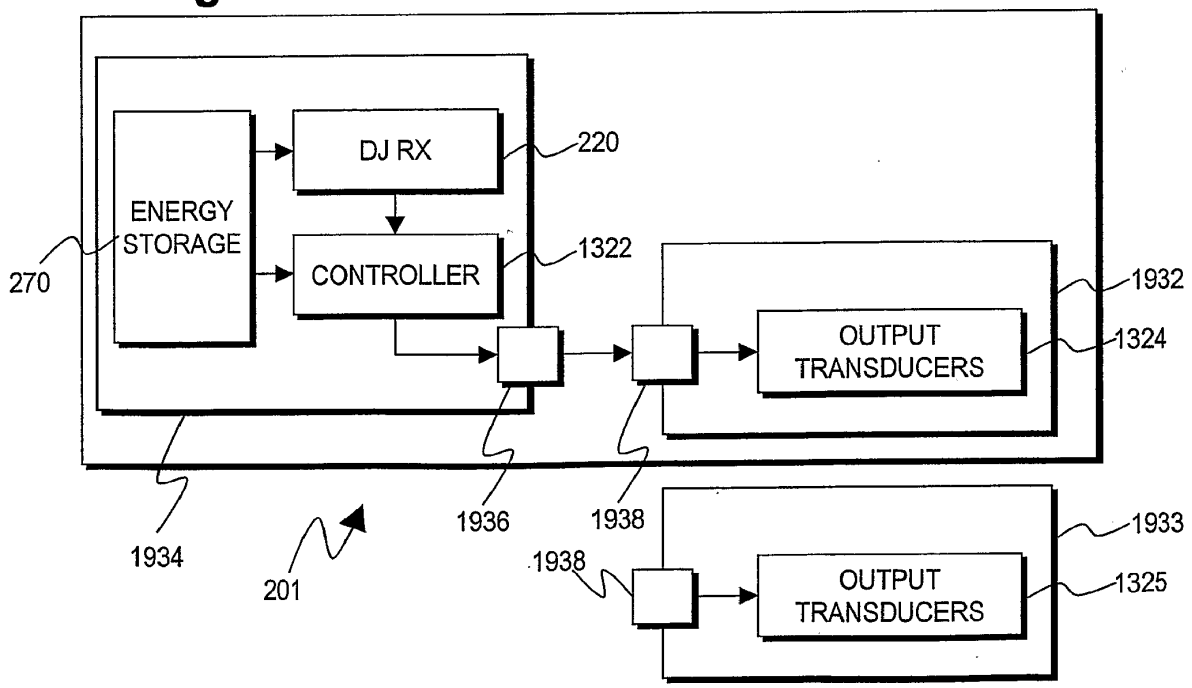
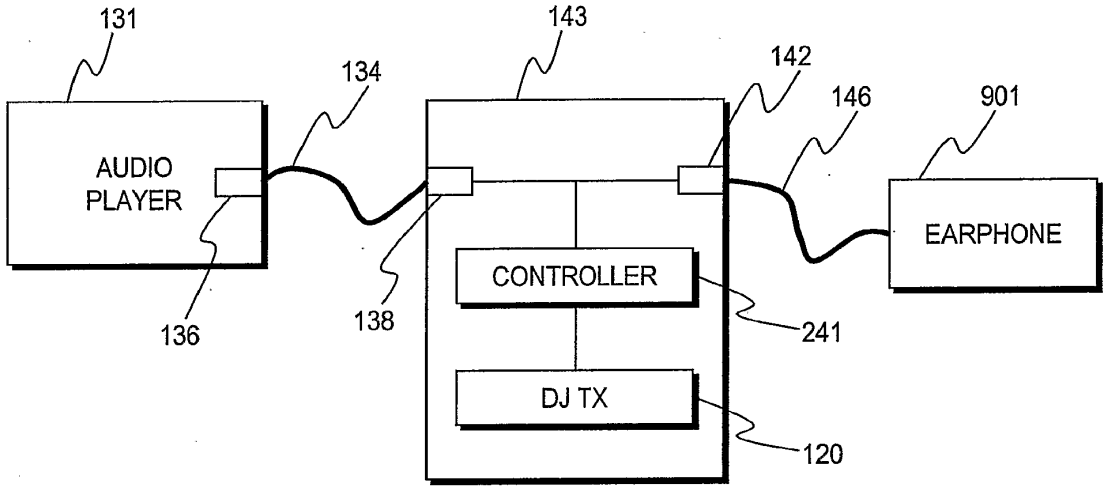


Fig. 12C


131
134
143
142
146
901
AUDIO PLAYER
EARPHONE
CONTROLLER
DJ TX
136
138
241
120

BROADCAST UNIT 710 SEARCH UNIT 750

Fig. 13A

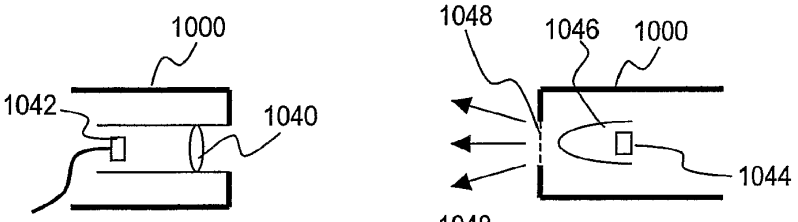


Fig. 13B

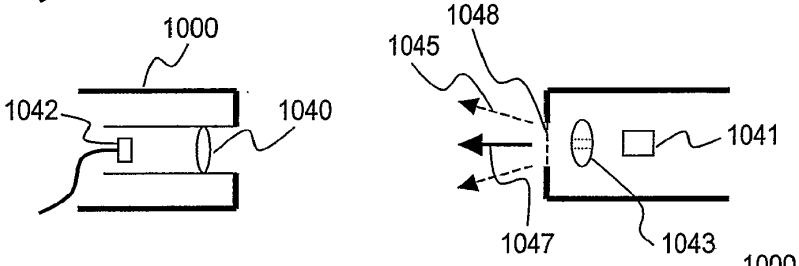


Fig. 13C

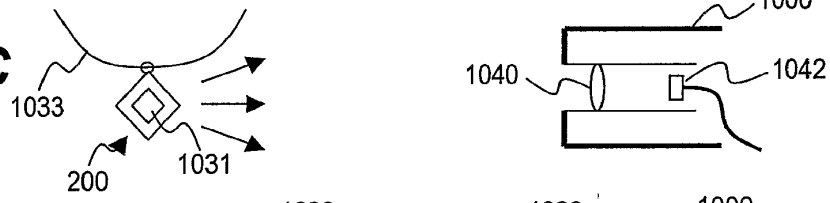


Fig. 13D

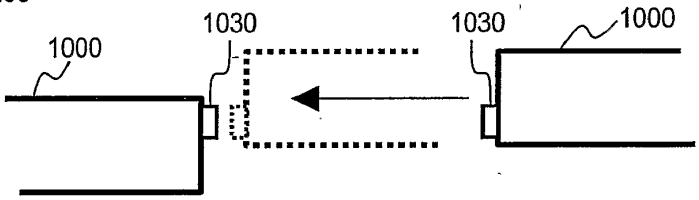


Fig. 13E

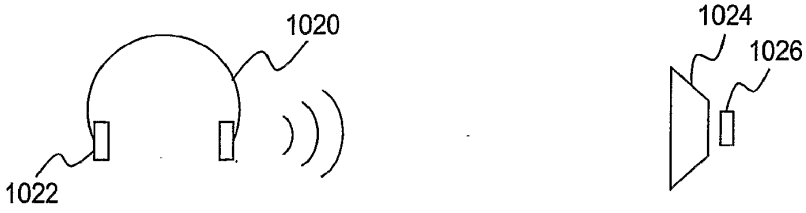


Fig. 13F

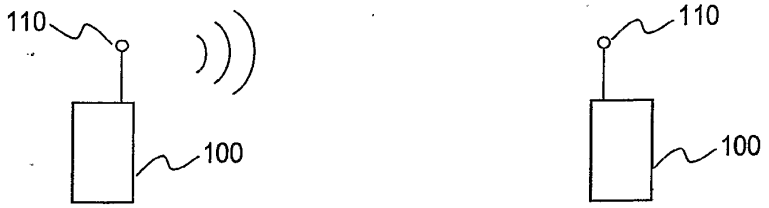


Fig. 14A

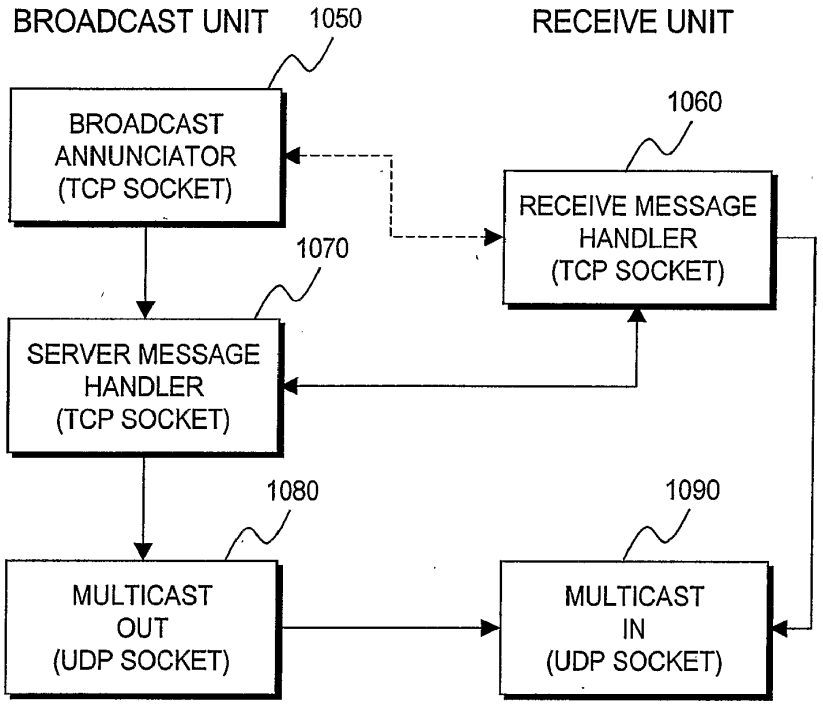

BROADCAST UNIT
1050
RECEIVE UNIT
BROADCAST ANNUNCIATOR (TCP SOCKET)
1060
RECEIVE MESSAGE HANDLER (TCP SOCKET)
1070
SERVER MESSAGE HANDLER (TCP SOCKET)
1080
1090
MULTICAST OUT (UDP SOCKET)
MULTICAST IN (UDP SOCKET)

Fig. 14B

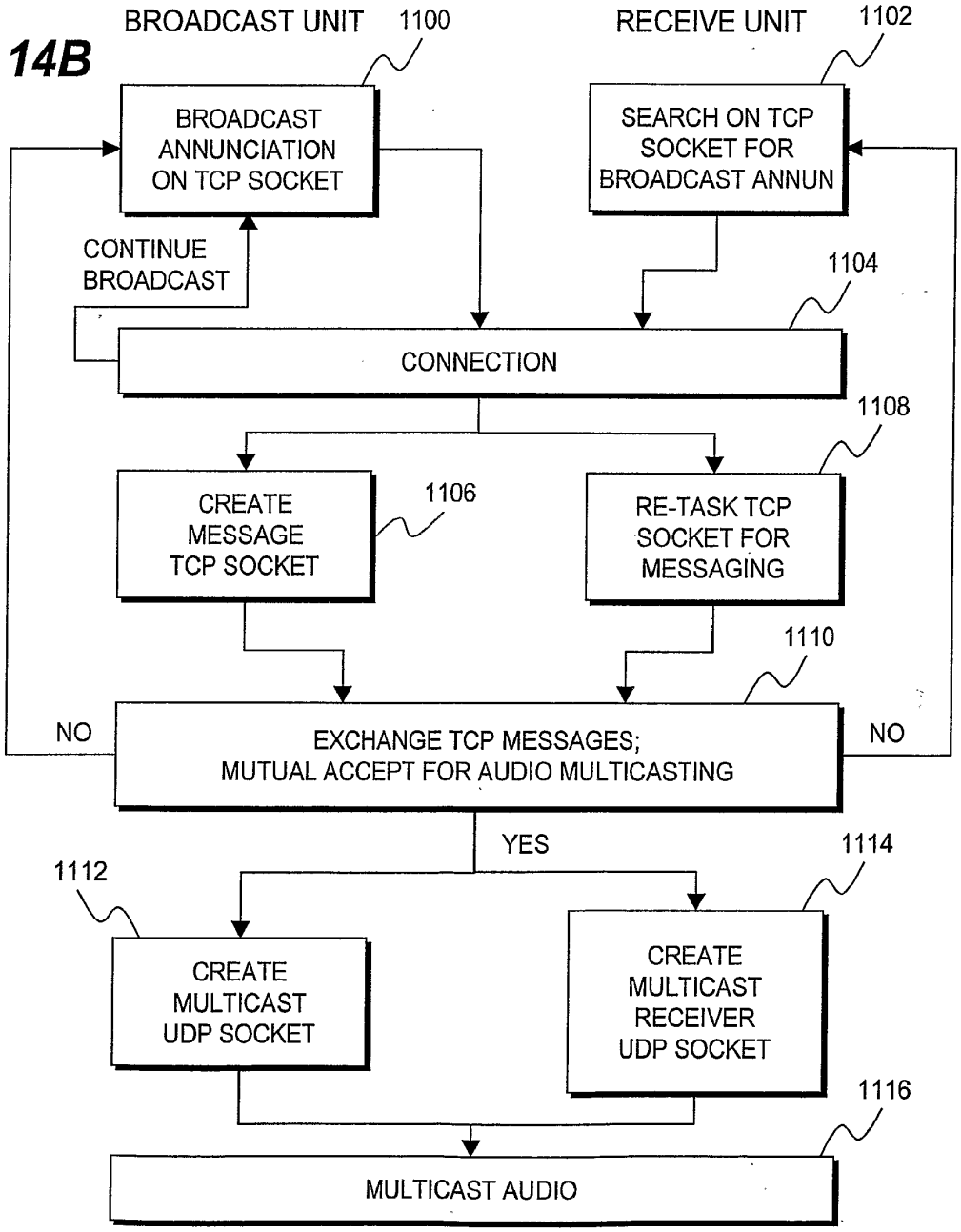

BROADCAST UNIT
1100
RECEIVE UNIT
1102
BROADCAST ANNUNCIATION ON TCP SOCKET
SEARCH ON TCP SOCKET FOR BROADCAST ANNUN
CONTINUE BROADCAST
1104
CONNECTION
1108
CREATE MESSAGE TCP SOCKET
1106
RE-TASK TCP SOCKET FOR MESSAGING
1110
NO
EXCHANGE TCP MESSAGES; MUTUAL ACCEPT FOR AUDIO MULTICASTING
NO
YES
1112
1114
CREATE MULTICAST UDP SOCKET
CREATE MULTICAST RECEIVER UDP SOCKET
1116
MULTICAST AUDIO

Fig. 15

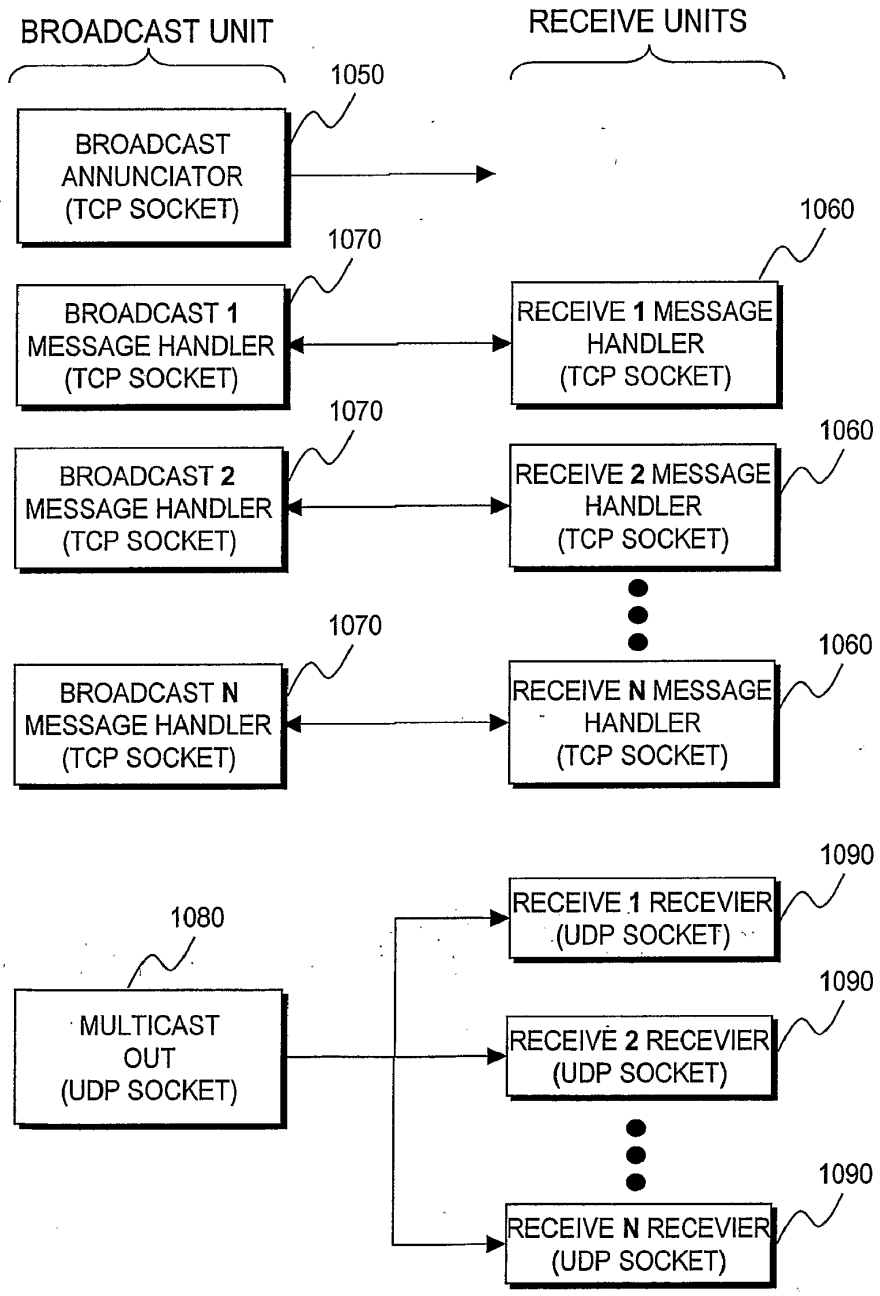

BROADCAST UNIT
RECEIVE UNITS
1050
BROADCAST ANNUNCIATOR (TCP SOCKET)
1060
1070
BROADCAST 1 MESSAGE HANDLER (TCP SOCKET)
RECEIVE 1 MESSAGE HANDLER (TCP SOCKET)
1070
1060
BROADCAST 2 MESSAGE HANDLER (TCP SOCKET)
RECEIVE 2 MESSAGE HANDLER (TCP SOCKET)
1070
1060
BROADCAST N MESSAGE HANDLER (TCP SOCKET)
RECEIVE N MESSAGE HANDLER (TCP SOCKET)
1090
1080
RECEIVE 1 RECEVIER (UDP SOCKET)
1090
MULTICAST OUT (UDP SOCKET)
RECEIVE 2 RECEVIER (UDP SOCKET)
1090
RECEIVE N RECEVIER (UDP SOCKET)

Fig. 16

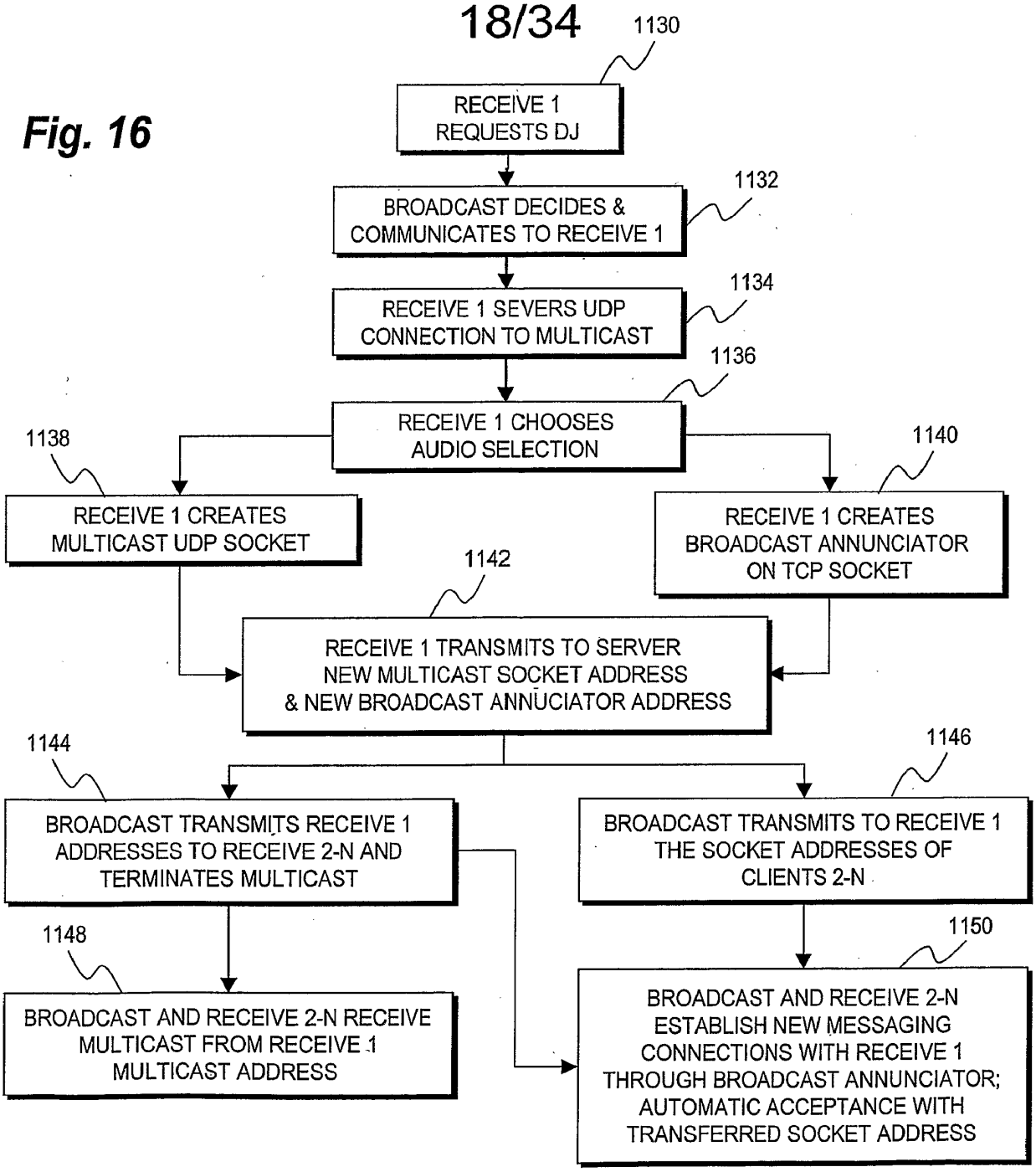

1130
RECEIVE 1 REQUESTS DJ
1132
BROADCAST DECIDES & COMMUNICATES TO RECEIVE 1
1134
RECEIVE 1 SEVERS UDP CONNECTION TO MULTICAST
1136
RECEIVE 1 CHOOSES AUDIO SELECTION
1138
RECEIVE 1 CREATES MULTICAST UDP SOCKET
1140
RECEIVE 1 CREATES BROADCAST ANNUNCIATOR ON TCP SOCKET
1142
RECEIVE 1 TRANSMITS TO SERVER NEW MULTICAST SOCKET ADDRESS & NEW BROADCAST ANNUCIATOR ADDRESS
1144
BROADCAST TRANSMITS RECEIVE 1 ADDRESSES TO RECEIVE 2-N AND TERMINATES MULTICAST
1146
BROADCAST TRANSMITS TO RECEIVE 1 THE SOCKET ADDRESSES OF CLIENTS 2-N
1148
BROADCAST AND RECEIVE 2-N RECEIVE MULTICAST FROM RECEIVE 1 MULTICAST ADDRESS
1150
BROADCAST AND RECEIVE 2-N ESTABLISH NEW MESSAGING CONNECTIONS WITH RECEIVE 1 THROUGH BROADCAST ANNUNCIATOR; AUTOMATIC ACCEPTANCE WITH TRANSFERRED SOCKET ADDRESS

Fig. 17

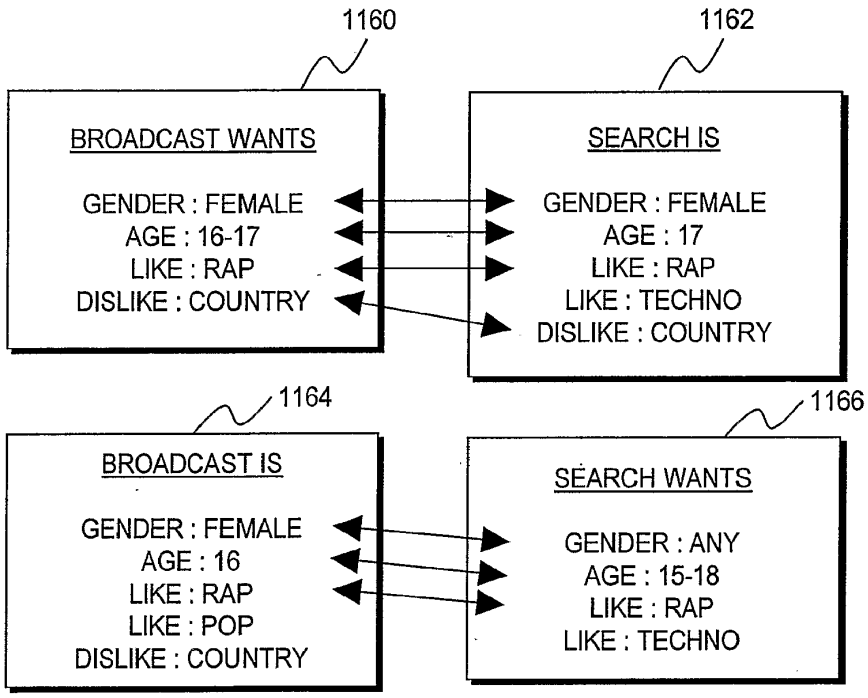


Fig. 18A

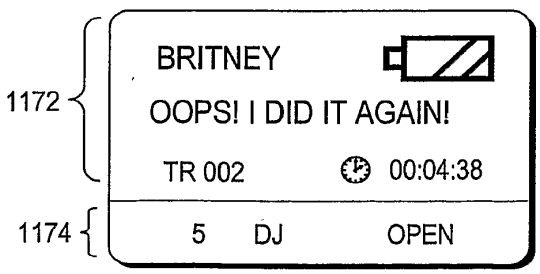


Fig. 18B

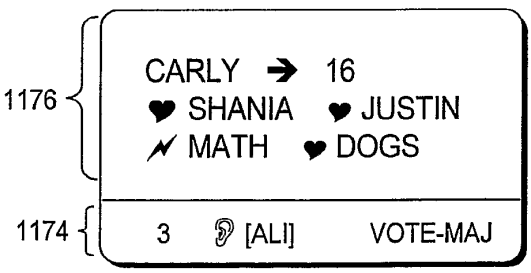


Fig. 19

RULE	METHOD
BROADCASTER	ACCEPTED WHEN BROADCASTER INDICATES "YES". REJECTED WHEN BROADCASTER INDICATES "NO"
MAJORITY	ACCEPTED WHEN (N/2)+1 INDICATE "YES". REJECTED WHEN (N/2) INDICATE "NO".
UNANIMOUS	ACCEPTED WHEN N MEMBERS INDICATE "YES". REJECTED WHEN 1 MEMBER INDICATES "NO".
TIMED MAJORITY	MACHINE INDICATES ONSET OF VOTING, AND COUNTS DOWN TO VOTING TERMINATION. ACCEPTED IF (Q/2)+1 INDICATE "YES" BEFORE TERMINATION; OTHERWISE "NO".
SYNCHRONIZED MAJORITY	MACHINE COUNTS DOWN TO VOTE. ACCEPTED IF (Q/2)+1 INDICATE "YES" WITHIN PREDETERMINED TIME OF COUNTDOWN. OTHERWISE "NO".

Fig. 20

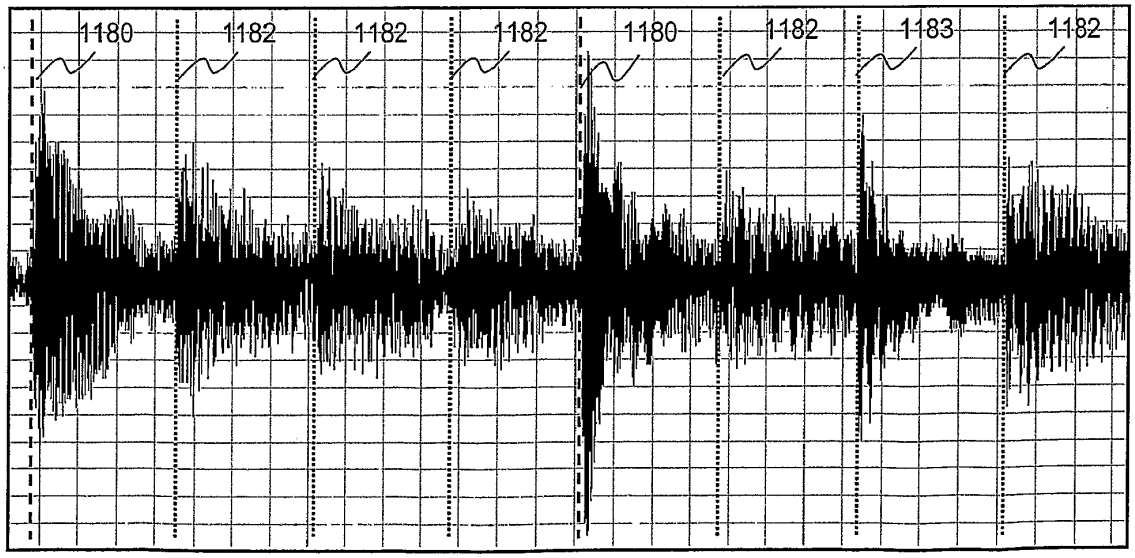


Fig. 21A

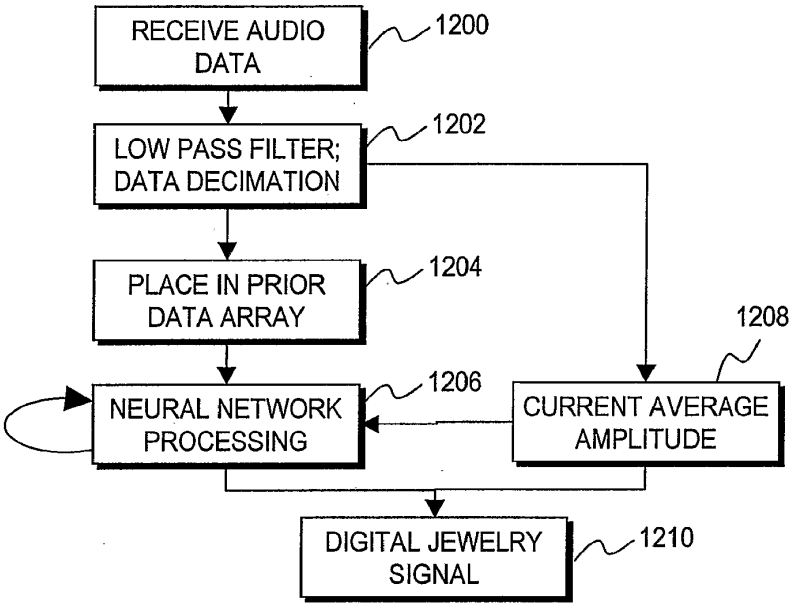


Fig. 21B

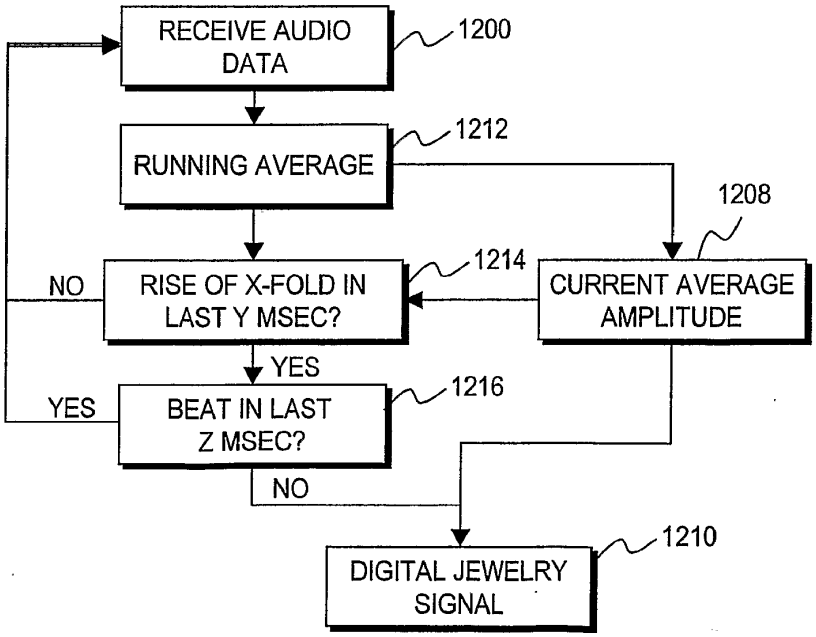


Fig. 21C

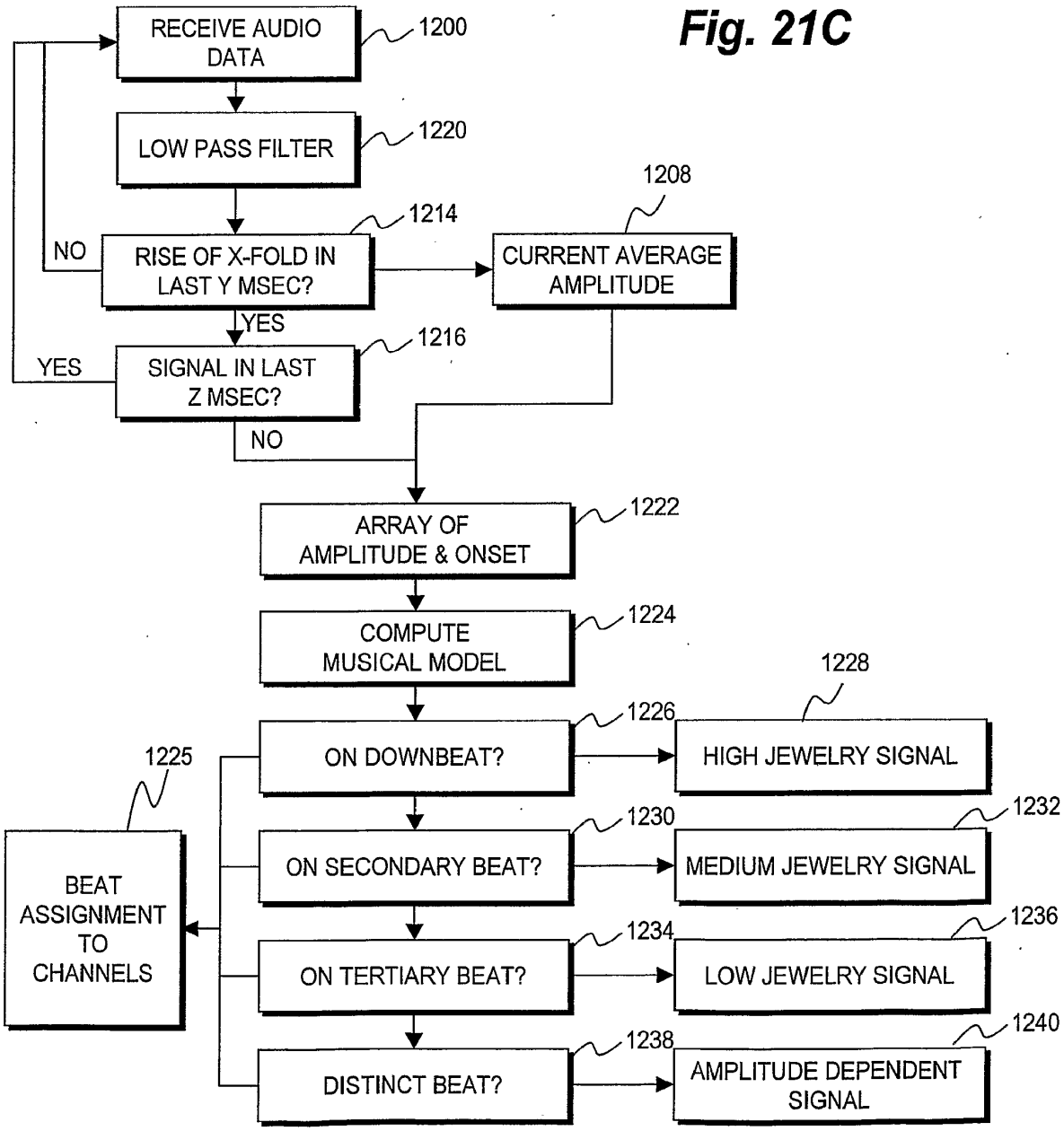
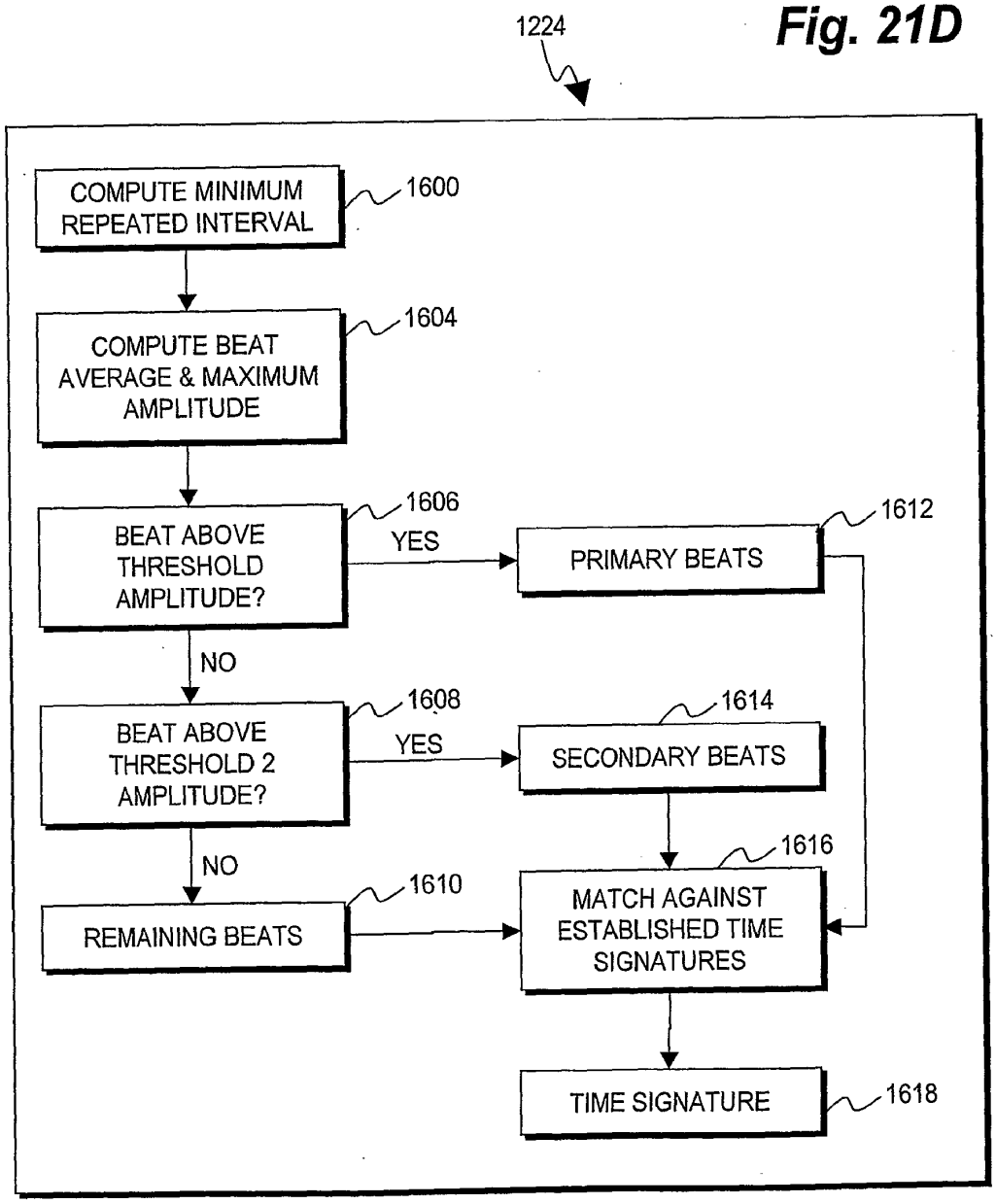

RECEIVE AUDIO DATA
1200
LOW PASS FILTER
1220
1208
1214
NO
RISE OF X-FOLD IN LAST Y MSEC?
CURRENT AVERAGE AMPLITUDE
YES
1216
YES
SIGNAL IN LAST Z MSEC?
NO
ARRAY OF AMPLITUDE & ONSET
1222
COMPUTE MUSICAL MODEL
1224
1228
1226
ON DOWNBEAT?
HIGH JEWELRY SIGNAL
1225
1230
1232
ON SECONDARY BEAT?
MEDIUM JEWELRY SIGNAL
BEAT ASSIGNMENT TO CHANNELS
1234
1236
ON TERTIARY BEAT?
LOW JEWELRY SIGNAL
1238
1240
DISTINCT BEAT?
AMPLITUDE DEPENDENT SIGNAL

Fig. 21D


1224
COMPUTE MINIMUM REPEATED INTERVAL
1600
COMPUTE BEAT AVERAGE & MAXIMUM AMPLITUDE
1604
BEAT ABOVE THRESHOLD AMPLITUDE?
1606
YES
PRIMARY BEATS
1612
NO
BEAT ABOVE THRESHOLD 2 AMPLITUDE?
1608
YES
SECONDARY BEATS
1614
NO
REMAINING BEATS
1610
MATCH AGAINST ESTABLISHED TIME SIGNATURES
1616
TIME SIGNATURE
1618

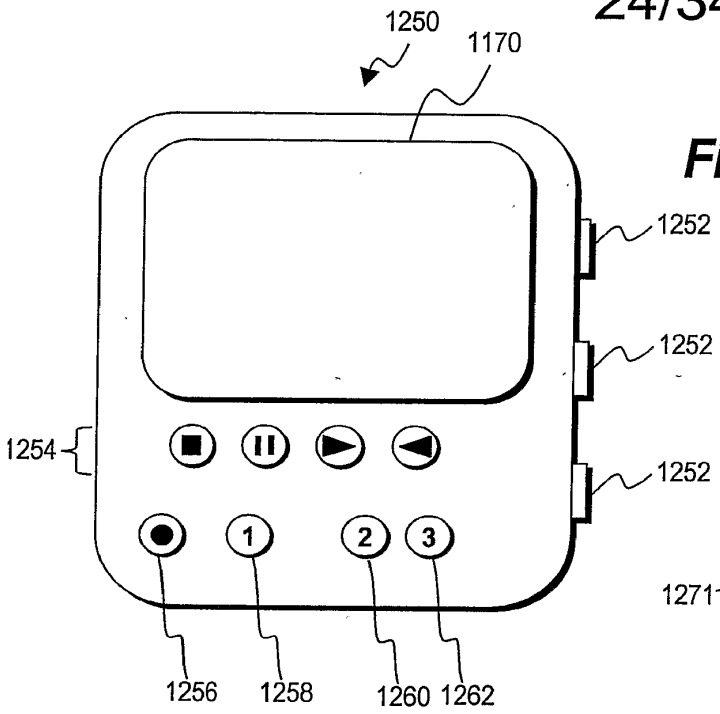


Fig. 22A

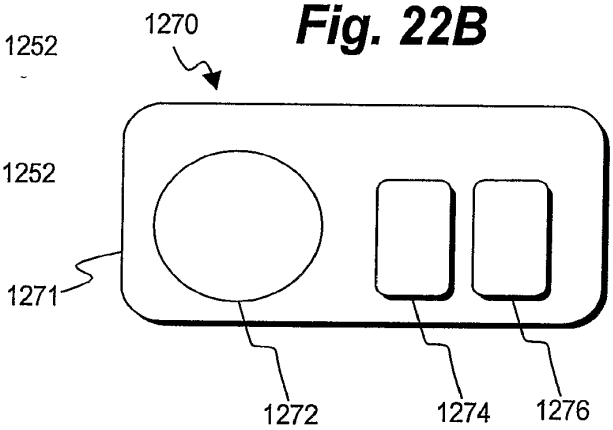


Fig. 22B

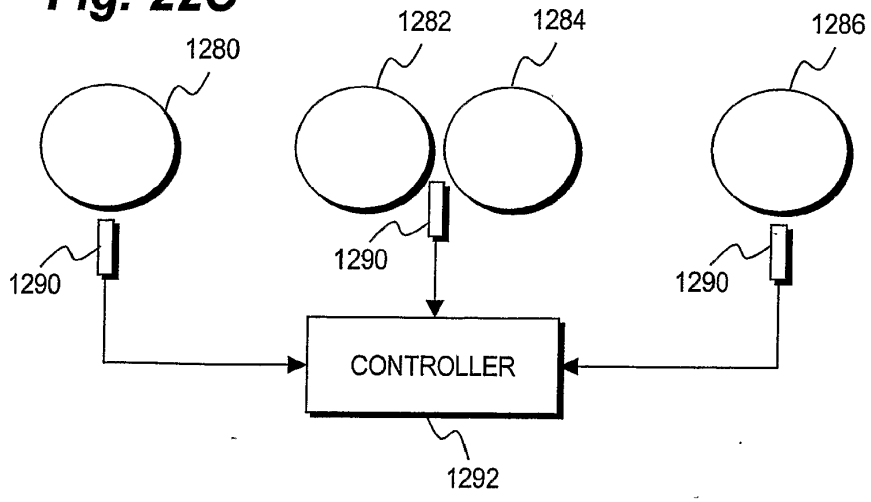


Fig. 22C

Fig. 23

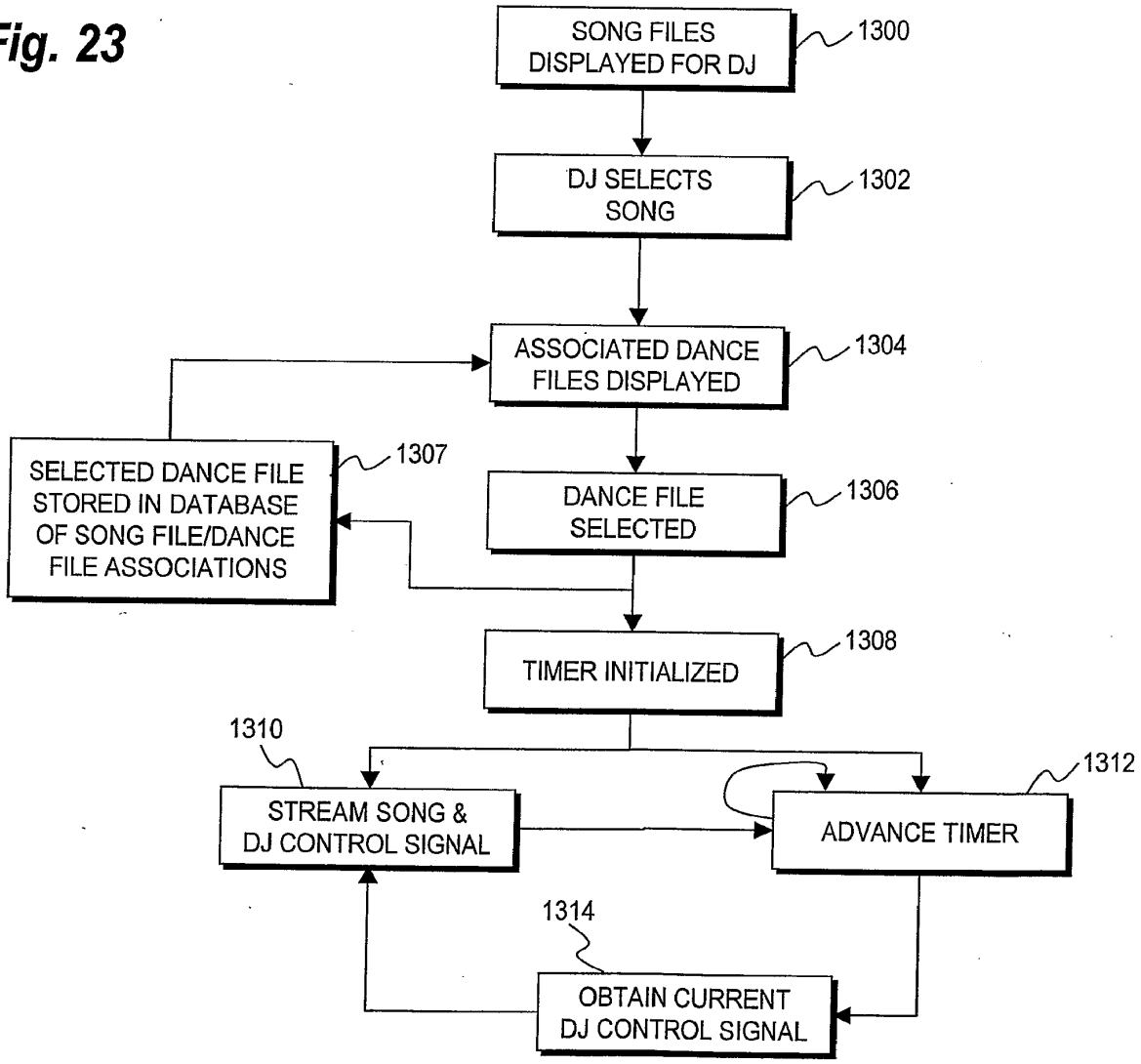

SONG FILES DISPLAYED FOR DJ
1300
DJ SELECTS SONG
1302
ASSOCIATED DANCE FILES DISPLAYED
1304
SELECTED DANCE FILE STORED IN DATABASE OF SONG FILE/DANCE FILE ASSOCIATIONS
1307
DANCE FILE SELECTED
1306
TIMER INITIALIZED
1308
1310
STREAM SONG & DJ CONTROL SIGNAL
ADVANCE TIMER
1312
1314
OBTAIN CURRENT DJ CONTROL SIGNAL

Fig. 24

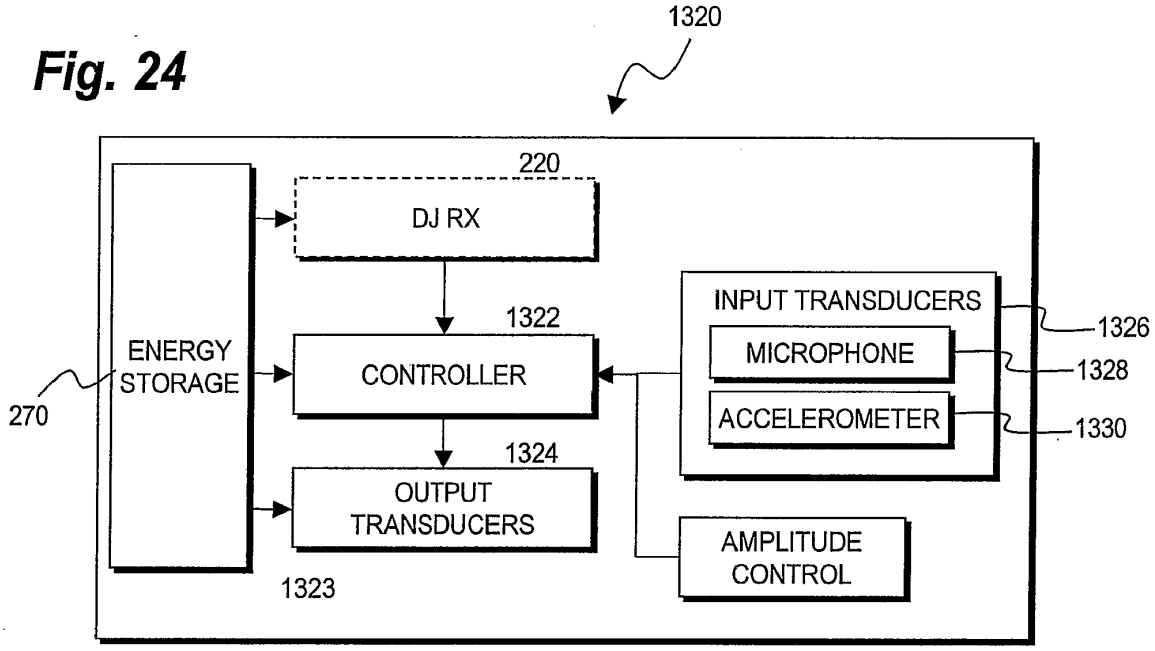

1320
220
DJ RX
1322
ENERGY STORAGE
CONTROLLER
270
1324
OUTPUT TRANSDUCERS
1323
INPUT TRANSDUCERS
MICROPHONE
ACCELEROMETER
1326
1328
1330
AMPLITUDE CONTROL

Fig. 25

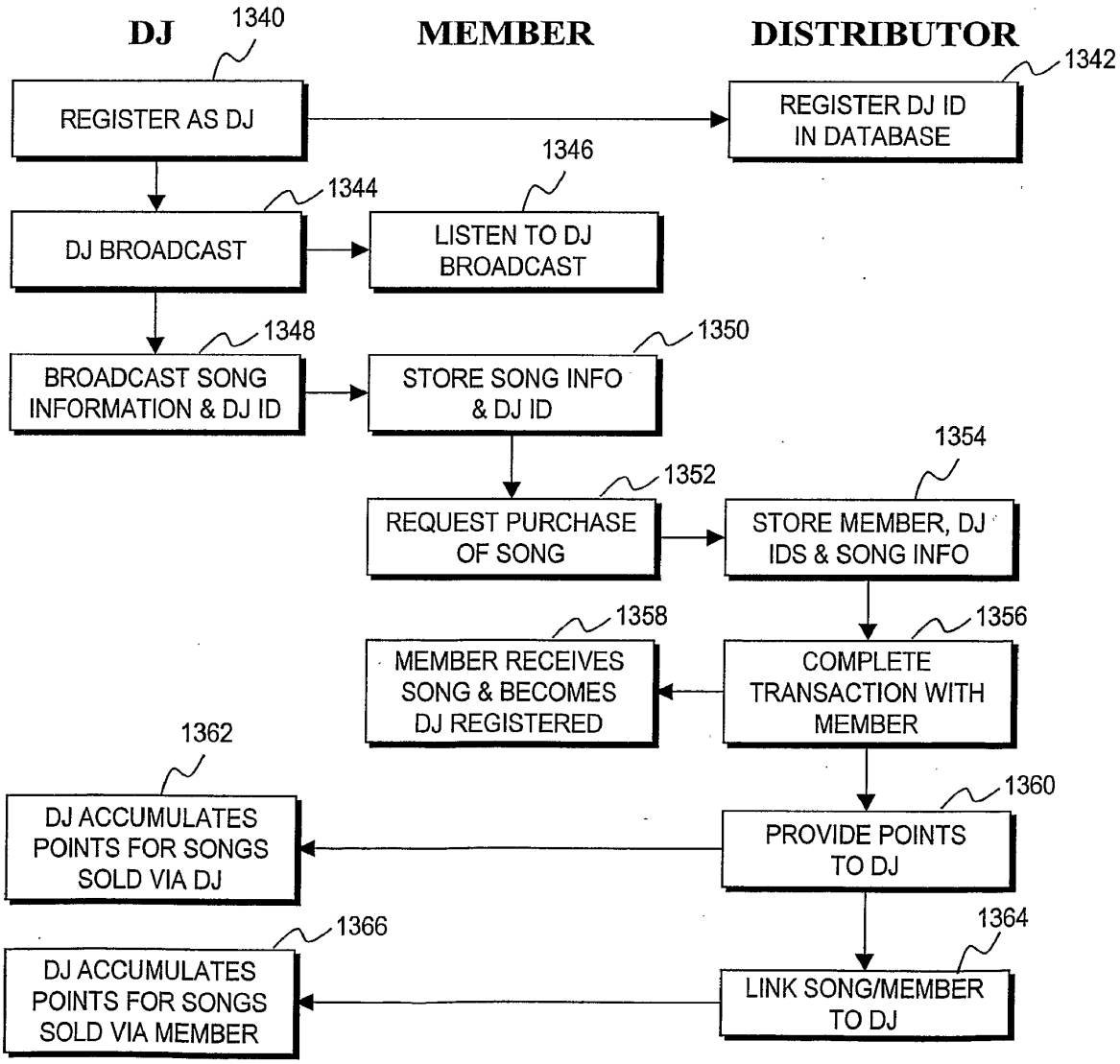

DJ
MEMBER
DISTRIBUTOR
1340
1342
REGISTER AS DJ
REGISTER DJ ID IN DATABASE
1346
1344
DJ BROADCAST
LISTEN TO DJ BROADCAST
1348
1350
BROADCAST SONG INFORMATION & DJ ID
STORE SONG INFO & DJ ID
1354
1352
REQUEST PURCHASE OF SONG
STORE MEMBER, DJ IDS & SONG INFO
1358
1356
MEMBER RECEIVES SONG & BECOMES DJ REGISTERED
COMPLETE TRANSACTION WITH MEMBER
1362
1360
DJ ACCUMULATES POINTS FOR SONGS SOLD VIA DJ
PROVIDE POINTS TO DJ
1366
1364
DJ ACCUMULATES POINTS FOR SONGS SOLD VIA MEMBER
LINK SONG/MEMBER TO DJ

Fig. 26

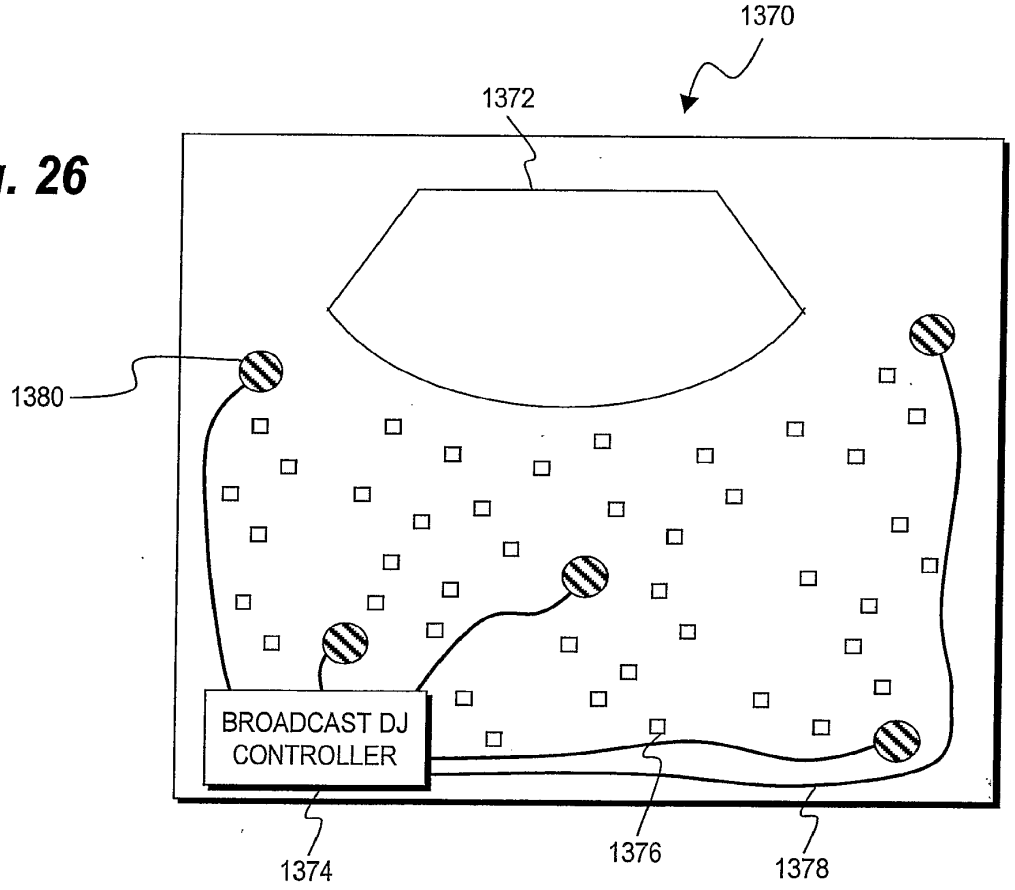

1370
1372
1380
BROADCAST DJ CONTROLLER
1374
1376
1378

Fig. 35

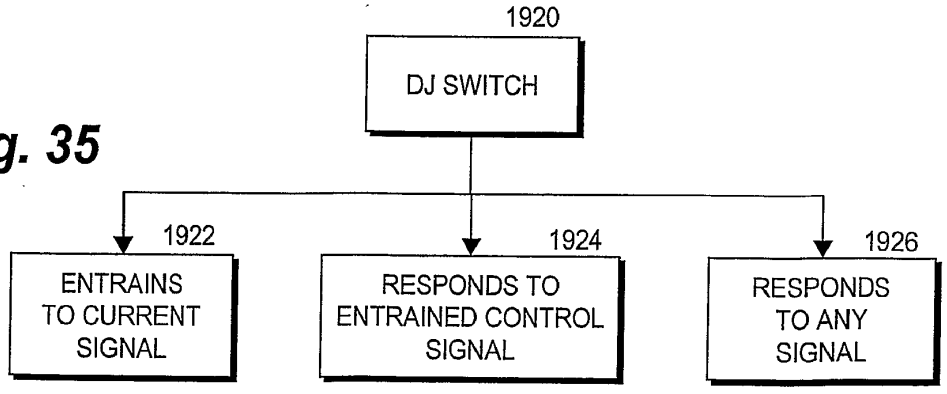

1920
DJ SWITCH
1922
ENTRAINS TO CURRENT SIGNAL
1924
RESPONDS TO ENTRAINED CONTROL SIGNAL
1926
RESPONDS TO ANY SIGNAL

Fig. 27

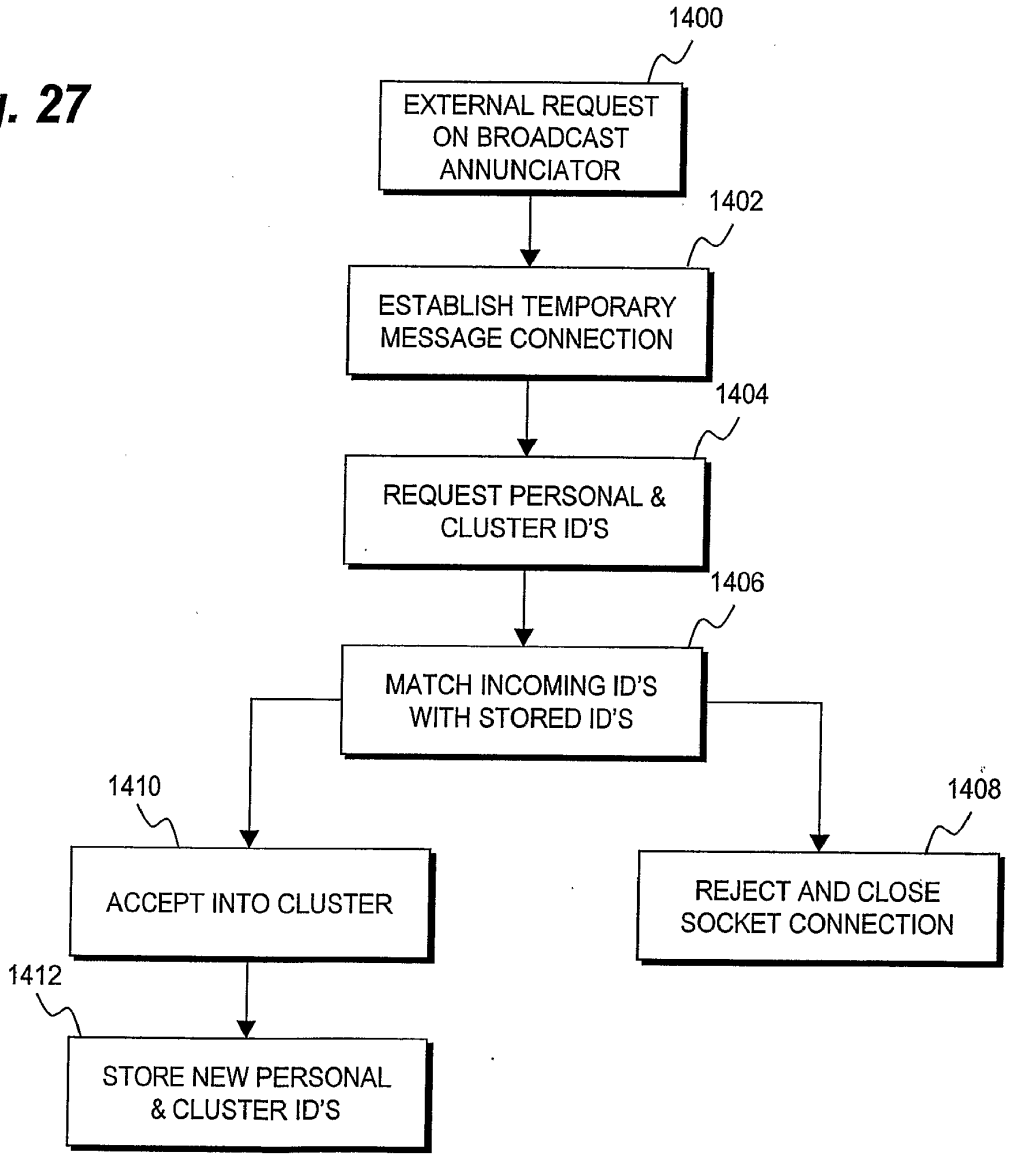

1400
EXTERNAL REQUEST ON BROADCAST ANNUNCIATOR
1402
ESTABLISH TEMPORARY MESSAGE CONNECTION
1404
REQUEST PERSONAL & CLUSTER ID'S
1406
MATCH INCOMING ID'S WITH STORED ID'S
1410
ACCEPT INTO CLUSTER
1408
REJECT AND CLOSE SOCKET CONNECTION
1412
STORE NEW PERSONAL & CLUSTER ID'S

Fig. 28

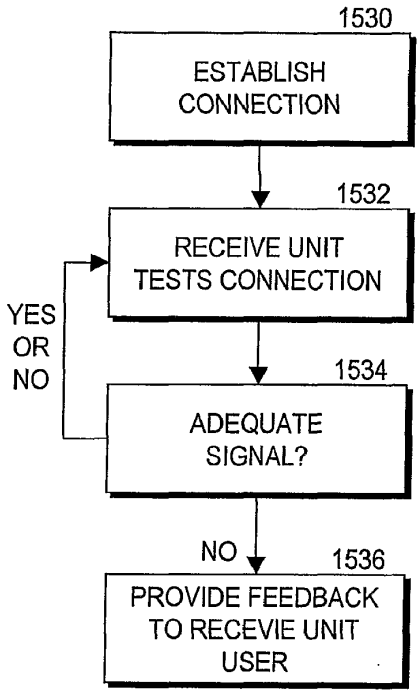

1530
ESTABLISH CONNECTION
1532
RECEIVE UNIT TESTS CONNECTION
YES OR NO
1534
ADEQUATE SIGNAL?
NO
1536
PROVIDE FEEDBACK TO RECEVIE UNIT USER

Fig. 29A

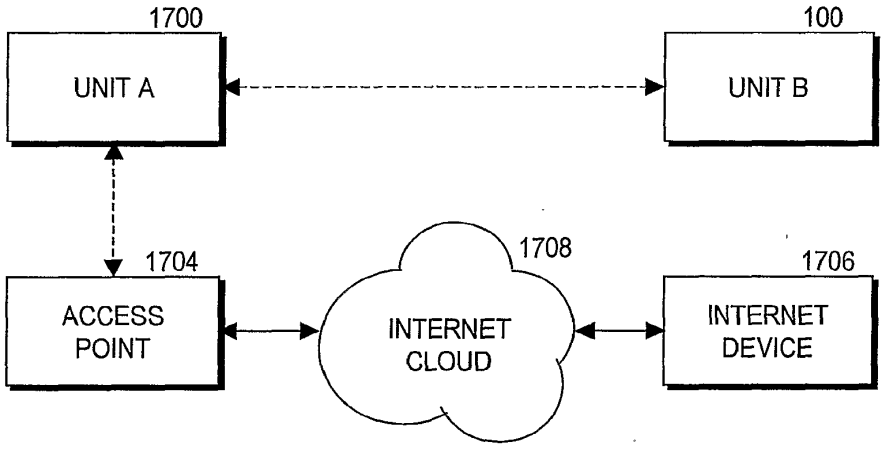


Fig. 29B

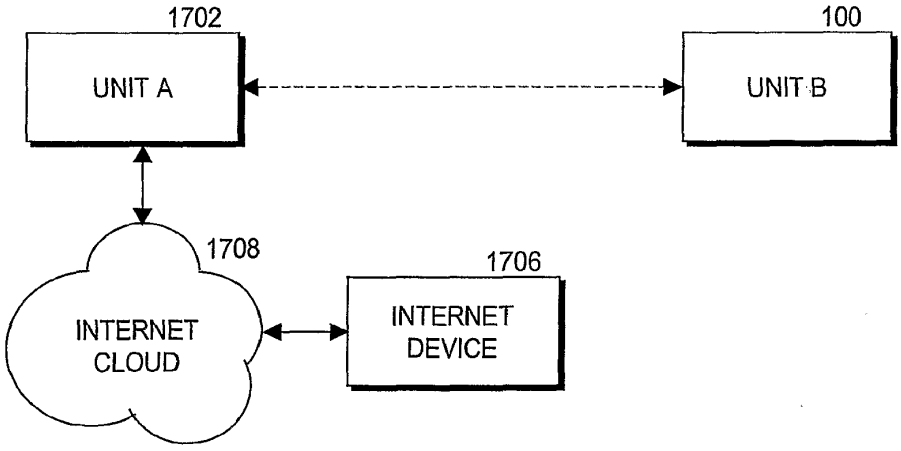


Fig. 30

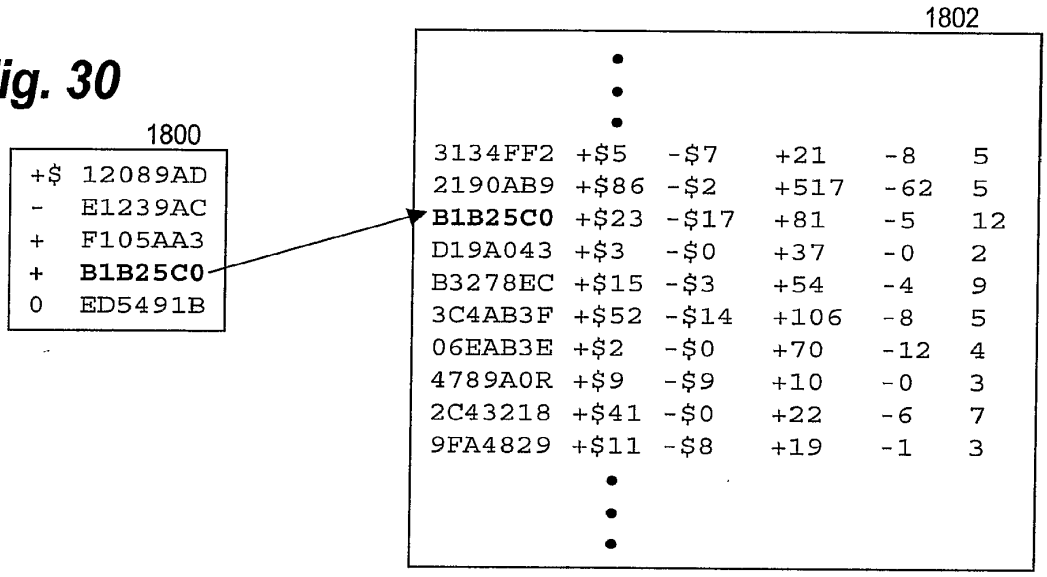

1800
+$ 12089AD
- E1239AC
+ F105AA3
+ B1B25C0
0 ED5491B
1802
3134FF2 +$5 -$7 +21 -8 5
2190AB9 +$86 -$2 +517 -62 5
B1B25C0 +$23 -$17 +81 -5 12
D19A043 +$3 -$0 +37 -0 2
B3278EC +$15 -$3 +54 -4 9
3C4AB3F +$52 -$14 +106 -8 5
06EAB3E +$2 -$0 +70 -12 4
4789A0R +$9 -$9 +10 -0 3
2C43218 +$41 -$0 +22 -6 7
9FA4829 +$11 -$8 +19 -1 3

Fig. 31

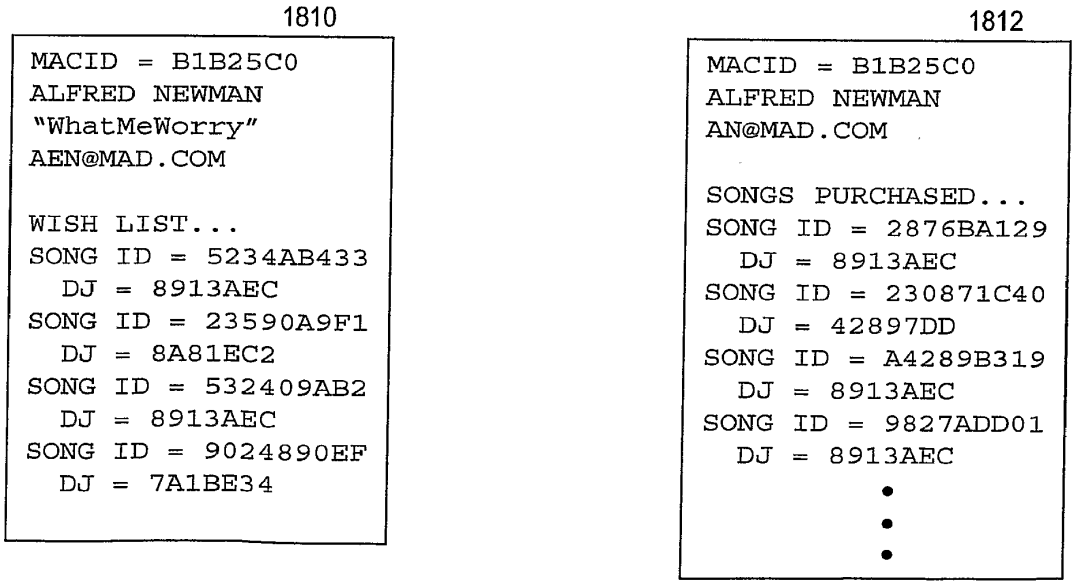

USER
1810
MACID = B1B25C0
ALFRED NEWMAN
"WhatMeWorry"
AEN@MAD.COM
WISH LIST...
SONG ID = 5234AB433
DJ = 8913AEC
SONG ID = 23590A9F1
DJ = 8A81EC2
SONG ID = 532409AB2
DJ = 8913AEC
SONG ID = 9024890EF
DJ = 7A1BE34
DISTRIBUTOR
1812
MACID = B1B25C0
ALFRED NEWMAN
AN@MAD.COM
SONGS PURCHASED...
SONG ID = 2876BA129
DJ = 8913AEC
SONG ID = 230871C40
DJ = 42897DD
SONG ID = A4289B319
DJ = 8913AEC
SONG ID = 9827ADD01
DJ = 8913AEC

Fig. 32A

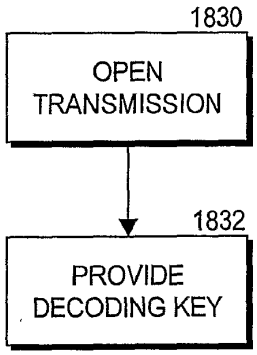


Fig. 32B

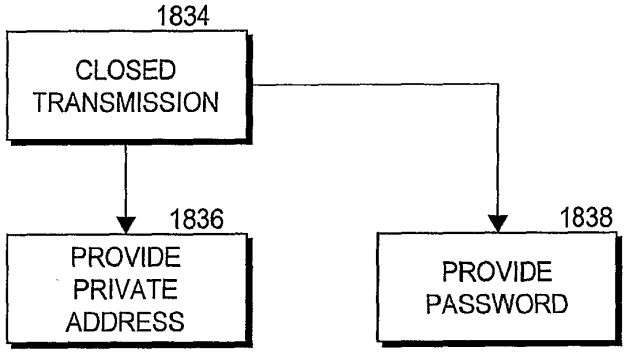


Fig. 33

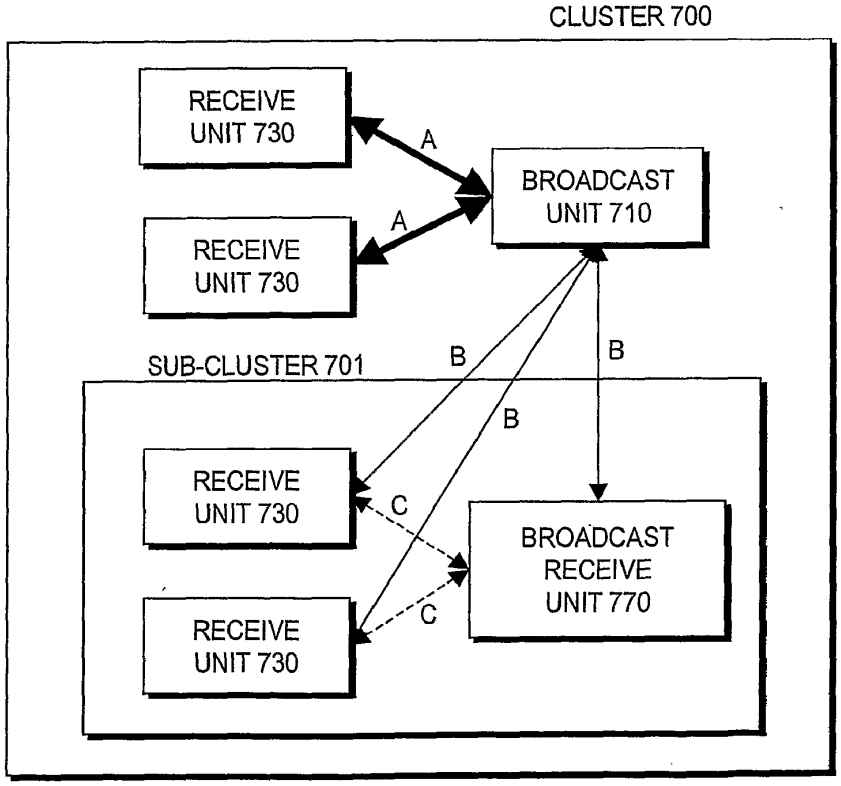


Fig. 34A

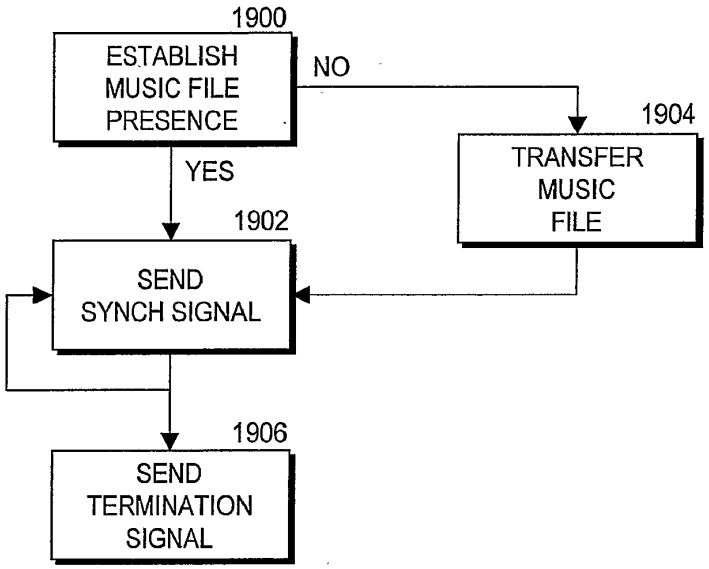
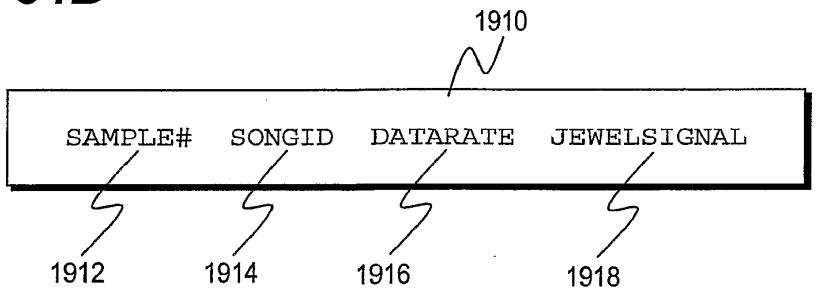


Fig. 34B



(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
10 February 2005 (10.02.2005)

PCT

(10) International Publication Number
WO 2005/013047 A2

(51) International Patent Classification[7]: G06F

(21) International Application Number:
PCT/US2004/023102

(22) International Filing Date: 2 July 2004 (02.07.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/490,768 28 July 2003 (28.07.2003) US
10/816,217 1 April 2004 (01.04.2004) US

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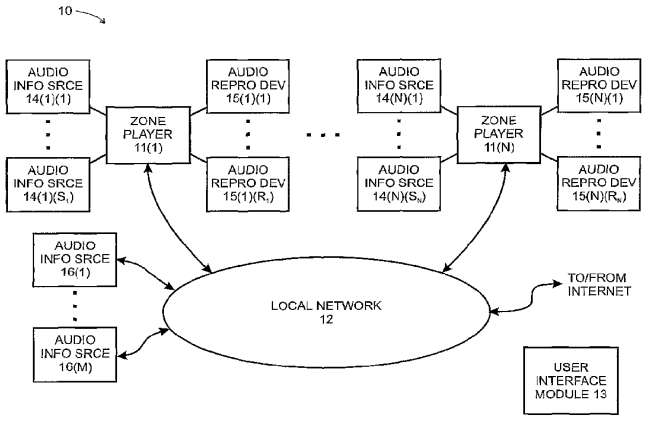
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report*

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

(54) **Title:** SYSTEM AND METHOD FOR SYNCHRONIZING OPERATIONS AMONG A PLURALITY OF INDEPENDENTLY CLOCKED DIGITAL DATA PROCESSING DEVICES



(57) **Abstract:** A system is described for maintaining synchrony of operations among a plurality of devices hat 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.

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System and Method For Synchronizing Operations Among A Plurality Of Independently Clocked Digital Data Processing Devices

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. 2A 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 player11(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. 2A. 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. 2A. With reference to FIG. 2A, that FIG. depicts elements of two synchrony groups, identified by reference numerals 20(1) and 20(2), respectively. For clarity, FIG. 2A 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. 2A 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. 2A 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. 2A 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. 2A 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. 2A, 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. 2A, 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. 2A 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. 2A, 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. 2A 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. 2A, 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 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+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. 2A) 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. 2A) 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 multi-cast 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 multi-cast 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 is:

CLAIMS

1. A system comprising plurality of devices, one of the devices operating as a task source device and at least one other device operating as a member of a synchrony group,

A. the task source device being configured to distribute a series of tasks to the synchrony group, each task being associated with a time stamp indicating a time, relative to a clock maintained by the task source device, at which the devices comprising the synchrony group are to execute the respective task;

B each member device being configured to:

(i) periodically obtain from the task source device an indication of a current time value indicated by the task source device's clock, and

(ii) determine, from the time stamp associated with each respective task and a time differential value representing a difference between the current time value indicated by the task source device's clock, and a current time value indicated by its respective clock, a time, relative to its respective clock, at which it is to execute the task.

2. A system as defined in claim 1 in which the synchrony group comprises a plurality of member devices.

3. A system as defined in claim 2 in which each device comprising a member of the synchrony group is further configured to execute each task that it receives from the task source device at the determined time, thereby to facilitate execution by them of respective tasks in the series in respective timing relationships relative to the time indicated by the task source device's clock.

4. A system as defined in claim 3 in which the member devices are configured to execute respective tasks in synchrony.

5. A system as defined in claim 2 in which one of the member devices operates as a master device for the synchrony group, any other member devices comprising respective slave devices, the master device being configured to perform at least one type of synchrony group management operation in connection with the member devices comprising the synchrony group.

6. A system as defined in claim 5 further including a user interface module configured to control the master device's performance of said at least one type of synchrony group management operation, the master device being further configured to provide status information relating to the status of the synchrony group to the user interface module.

7. A system as defined in claim 6 in which the status information includes identifications of the devices comprising the synchrony group.

8. A system as defined in claim 6 in which the status information includes an identification of the task currently being executed.

9. A system as defined in claim 5, the system comprising at least one additional device, in which, in one type of synchrony group management operation, the master device is configured to enable the at least one additional device to join the synchrony group as a slave device.

10. A system as defined in claim 9 in which the task source device is configured to distribute tasks to the member devices using a selected multi-cast transmission methodology, the member devices being configured to buffer the tasks until they are to be executed, and further in which, when the at least one additional device joins the synchrony group as a slave device, the task source device is enabled to transmit at least one previously distributed task to the slave device using a selected unicast transmission methodology.

11. A system as defined in claim 5 in which, in at least one type of synchrony group management operation, the master device is configured to enable the task source device to join the synchrony group as a slave device, the task source device continuing to operate as the task source device for the synchrony group.

12. A system as defined in claim 5 in which, in at least one type of synchrony group management operation, the master device is configured to enable a slave device to disengage from the synchrony group, the disengaged slave device thereafter not being a member device in the synchrony group.

13. A system as defined in claim 5 in which, in at least one type of synchrony group management operation, the master device is configured to control the series of tasks to be distributed by the task source device.

14. A system as defined in claim 5 in which, in at least one type of synchrony group management operation, the master device is further configured to control execution by the member devices of the tasks that have been distributed by the task source device.

15. A system as defined in claim 14 in which the series of tasks includes a series of task sequences with each task sequence including a sub-set of the series of tasks, and further in which in at least one type of synchrony group management operation, the master device is configured to enable the member devices to terminate execution of a task sequence that is currently being executed.

16. A system as defined in claim 15 in which, in the synchrony group management operation enabling the member devices to terminate execution of a task sequence that is currently being executed, the master device enables the task source device to distribute a command to enable the

member devices to terminate execution of the task sequence, the member devices being configured to, after receiving the command, terminate execution of the task sequence.

17. A system as defined in claim 14 in which the series of tasks includes a series of task sequences with each task sequence including a sub-set of the series of tasks, and further in which at least one type of synchrony group management operation, the master device is configured to enable the member devices to cancel execution of a task sequence that has been previously distributed, but for which execution has not begun.

18. A system as defined in claim 17 in which, in the synchrony group management operation enabling the member devices to cancel execution of a task sequence that has been previously distributed but for which execution has not begun, the master device enables the task source device to distribute a command to enable the member devices to cancel execution of the task sequence, the member devices being configured to, after receiving the command, cancel execution of the task sequence.

19. A system as defined in claim 5 in which, in at least one type of synchrony group management operation, the member device operating as the master device is configured to enable the master device to migrate from one member device to another member device in the synchrony group.

20. A system as defined in claim 5 in which, in at least one type of synchrony group management operation, the master device is configured to enable the task source device to migrate from one device to another device in the system.

21. A system as defined in claim 20 in which

A. the device operating as the task source device is configured to, after being enabled to migrate the task source device to said other device, provide migration information to the other device, the migration information including a source for information respecting the tasks to be distributed, timing information relative to the clock maintained by the task source device and identifications of the member devices,

B. the other device being configured to, after receiving the migration information,

   i. distribute the series of tasks to the synchrony group, each task being associated with a time stamp indicating a time, relative to the timing information that it receives from the device operating as the task source device, at which the devices comprising the synchrony group are to execute the respective task, and

   ii. notify the members of the synchrony group that it is to thereafter operate as the task source device.

22. A system as defined in claim 21 in which the information respecting the tasks that are to be distributed is a source of streaming information, the other device being configured to, after receiving the migration information, assemble the streaming information into tasks and associate each task with a said time stamp.

23. A system as defined in claim 21 in which the information respecting the tasks that are to be distributed is in a file identified in the migration information, the other device being configured to obtain information from the identified file, assemble the information into tasks and associate each task with a said time stamp.

24.A system as defined in claim 23 in which the information respecting the tasks that are to be distributed begins at an offset, identified in the migration information, into the identified file, the other device being configured to assemble the information from a position in the file associated with the identified offset.

25. A system as defined in claim 23 in which the information respecting the tasks that are to be distributed is in a series of files identified in the migration information, the other device being configured to obtain information from successive files in the series assemble the information into tasks and associate each task with as said time stamp.

26. A system as defined in claim 1 in which the task source device is further configured to distribute the tasks using a selected multi-cast message transmission methodology.

27. A system as defined in claim 1 in which the task source device is configured to provide, associated with at least one task, a time stamp indicating a task execution time later than the time currently indicated by the clock maintained by the task source device.

28. A system as defined in claim 27 in which the task source device is configured to select the delay interval between the time indicated by the time stamp and the current time so to be sufficient to provide that the at least one task distributed by the task source device can be executed by the member devices at the time indicated by the time stamp.

29. A system as defined in claim 28 in which the task source device is configured to select the delay interval between the time indicated by the time stamp and the current time so to be sufficient to provide that the at least one task distributed by the task source device can be distributed to the member devices for execution at the time indicated by the time stamp

30. A system as defined in claim 27 in which task source device is configured to obtain information associated with the tasks from at least two types of information sources, the task source device being further configured to select, for each task the delay interval between the time indicated by the time

stamp and the current time based on the information source type that is associated with the respective task.

31. A system as defined in claim 1 in which at least one member device is further configured to adjust its clock rate in relation to a clock rate value maintained by the task source device's clock.

32. A system as defined in claim 31 in which the at least one member device is configured to adjust its clock rate in relation to time stamps associated with respective ones of the tasks received from the task source device.

33. A system as defined in claim 1 in which at least one other device operates as a task source device configured to distribute tasks to a second synchrony group, the device operating as the task source device for the first synchrony group also operating as a member device of a second synchrony group.

34. A system as defined in claim 1 in which at least one member device comprises:

A. a task receiving module configured to receive the series of tasks,

B. a current time retrieval module configured to obtain, from the task source device, the current time value as indicated by the task source's clock;

C. an execution time determination module configured to determine, from the time stamp associated with each respective task and a time differential value representing a difference between the current time value obtained by the current time retrieval module and a current time value indicated by a clock maintained by the device, a time, relative to the member device's respective clock at which the task is to be executed; and

D. a task execution module configured to execute each respective task at the time determined by the execution time determination module.

35. A system as defined in claim 34 further including a control module for controlling execution of commands received by said interface module.

36. A system as defined in claim 35 in which the at least one member device further comprises a buffer configured to buffer tasks that the task receiving module receives from the task source device until they are to be executed, the task execution module being configured to execute the buffered tasks at the times determined by the execution time determination module.

37. A system as defined in claim 36 in which the series of tasks includes a series of task sequences with each task sequence including a subset of the series of tasks, the interface module being further configured to receive task execution control commands for controlling task execution, the control module being configured to, in response to receipt of at least one task execution control command for controlling task execution, enable the task execution module to terminate execution of a task

sequence currently being executed, being configured to not execute subsequent tasks in the task sequence that have been buffered.

38. A system as defined in claim 37 in which the control module is configured to enable the task execution module to resume execution of at least one task associated with a subsequent task sequence at a time determined by the execution time determination module.

39. A system as defined in claim 36 in which the series of tasks includes a series of task sequences with each task sequence including a subset of the series of tasks, the interface module being further configured to receive task execution control commands for controlling task execution, the control module being configured to, in response to receipt of at least one task execution control command to cancel execution of a task sequence for which at least one task has been buffered but for which execution has not begun, enable the task execution module to not execute tasks from that task sequence that have been buffered.

40. A system as defined in claim 39 in which the control module is configured to enable the task execution module to resume execution of at least one task associated with a task sequence subsequent to the task sequence for which at least one task has been buffered but for which execution has not begun.

41. A system as defined in claim 34 in which the member device includes:

A. a migration information receiving module configured to receive migration information from the task source device, the migration information including a source for information respecting the tasks to be distributed, timing information relative to the clock maintained by the task source device and identifications of the member devices of the synchrony group, and

B. a migration control module configure to, after the migration information has been received.,

   i. distribute the series of tasks to the synchrony group, each task being associated with a time stamp indicating a time, relative to the timing information that it receives from the device operating as the task source device, at which the devices comprising the synchrony group are to execute the respective task, and

   ii. notify the members of the synchrony group that it is to thereafter operate as the task source device.

42. A system as defined in claim 41 in which the information respecting the tasks that are to be distributed is a source of streaming information, the migration control module being configured to, after the migration information has been received, assembling the streaming information into tasks and associate each task with a said time stamp.

43. A system as defined in claim 41 in which the information respecting the tasks that are to be distributed is in a file identified in the migration information, the migration control module being configured to obtain information from the identified file, assemble the information into tasks and associate each task with a said time stamp.

44.A system as defined in claim 43 in which the information respecting the tasks that are to be distributed begins at an offset, identified in the migration information, into the identified file, the migration control module being configured to assemble the information from a position in the file associated with the identified offset.

45. A system as defined in claim 43 in which the information respecting the tasks that are to be distributed is in a series of files identified in the migration information, the migration control module being configured to obtain information from successive files in the series assemble the information into tasks and associate each task with as said time stamp.

46. A system as defined in claim 34 in which the member device further includes a clock rate adjustment module configured to adjust the member device's clock rate in relation to a clock rate value maintained by the task source device's clock.

47. A system as defined in claim 46 in which the clock rate adjustment module is configured to adjust the clock rate in relation to time stamps associated with respective ones of the tasks received from the task source device.

48. A system as defined in claim 1 in which the task source device comprises:

A. a task acquisition module configured to obtain respective ones of the tasks;

B. a task execution time determination module configured to determine a time at which each respective task is to be executed, and to associate the respective task with a time stamp indicating its execution time;

C. a task transmission module configured to transmit the series of tasks to said at least one other device; and

D. an execution control command generation module configured to, in response to a predetermined event, enable the task transmission module to insert into the series of tasks transmitted by the task transmission module a command to enable the at least one other device to modify the execution sequence of the tasks transmitted thereto.

49. A system as defined in claim 48 in which the task transmission module is configured to utilize a selected multi-cast transmission methodology.

50. A system as defined in claim 48 in which the predetermined event comprises input indicia provided by an operator.

51. A system as defined in claim 50 in which, in response to said predetermined event, the execution control command generation module is configured to enable the task transmission module to insert into the series of tasks transmitted by the task transmission module a command to enable the at least one other device to control execution of at least one task in relation to the time the predetermined event occurs.

52. A system as defined in claim 51 in which, in response to said predetermined event, the execution control command generation module is configured to enable the task transmission module to insert into the series of tasks transmitted by the task transmission module a command to enable the at least one other device to terminate execution of a task that it is currently executing and/or to not execute at least one task that is to be executed subsequent to the predetermined event.

53. A system as defined in claim 51 in which the series of tasks includes a series of task sequences with each task sequence including a sub-set of the series of tasks, the execution control command generation module being configured to, in response to said predetermined event,

(i) enable the task transmission module to insert into the series of tasks transmitted by the task transmission module, a command enabling the at least one other device to terminate execution of the currently executing task and/or to not execute at least one subsequent task, if any, in the task sequence including the currently executing task; and

(ii) enable

(a) the task execution time determination module to provide that time stamps associated with tasks of task sequences subsequent to the task sequence currently being executed will reflect the termination and/or non-execution of tasks from the task sequence of the task that is currently being executed, and

(b) the task transmission module to transmit the tasks of the subsequent task sequences to the at least one other device.

54. A system as defined in claim 53 in which the task transmission module is configured to insert a command to enable the at least one other device to not execute all tasks in the task sequence subsequent to the terminated and/or non-executed task.

55. A system as defined in claim 48 in which, in response to said predetermined event, the execution control command generation module is configured to enable the task transmission module to insert

into the series of tasks transmitted by the task transmission module a command to enable the at least one other device to control execution of a task in relation to the task's position in the series of tasks.

56. A system as defined in claim 55 in which, in response to said predetermined event, the execution control command generation module is configured to enable the task transmission module to insert into the series of tasks transmitted by the task transmission module a command to enable the at least one other device to cancel execution of a task in relation to the task's position in the series of tasks.

57. A system as defined in claim 55 in which, in response to said predetermined event, the execution control command generation module is configured to enable the task transmission module to insert into the series of tasks transmitted by the task transmission module a command to enable the at least one other device to cancel execution of a previously-transmitted task in relation to the task's position in the series of tasks.

58. A system as defined in claim 57 in which, in response to said predetermined event, the execution control command generation module is configured to enable the task transmission module to insert into the series of tasks transmitted by the task transmission module a command to enable the at least one other device to cancel execution of a previously-transmitted task, in relation to the task's position in the series of tasks, for which execution has not begun.

59. A system as defined in claim 55 in which the series of tasks includes a series of task sequences with each task sequence including a sub-set of the series of tasks, the execution control command generation module being configured to, in response to said predetermined event,

(i) enable the task transmission module to insert into the series of tasks transmitted by the task transmission module, a command enabling the at least one other device to cancel execution of a task sequence for which execution has not begun; and

(ii) enable

  (a) the task execution time determination module to provide that time stamps associated with tasks of task sequences subsequent to the task sequence whose execution was cancelled will reflect the cancellation, and

  (b) the task transmission module to transmit the tasks of the subsequent task sequences to the at least one other device.

60 A system as defined in claim 1 in which the task source device comprises:

A. a task acquisition module configured to obtain respective ones of the tasks;

B. a task execution time determination module configured to determine a time at which each respective task is to be executed, and to associate the respective task with a time stamp indicating its execution time;

C. a task transmission module configured to transmit the series of tasks to said at least one other device; and

D. a task source device migration control module configured to, in response to a predetermined event, provide migration information to another device, the migration information including a source for information respecting the tasks to be distributed, timing information relative to the clock maintained by the task source device and identifications of the member devices of the synchrony group.

61. A system as defined in claim 60 in which the task source device is configured to provide, associated with at least one task, a time stamp indicating a task execution time later than the time currently indicated by the clock maintained by the task source device.

62. A system as defined in claim 61 in which the task source device is configured to select the delay interval between the time indicated by the time stamp and the current time so to be sufficient to provide that the at least one task distributed by the task source device can be executed by the member devices at the time indicated by the time stamp.

63. A system as defined in claim 62 in which the task source device is configured to select the delay interval between the time indicated by the time stamp and the current time so to be sufficient to provide that the at least one task distributed by the task source device can be distributed to the member devices for execution at the time indicated by the time stamp

64. A system as defined in claim 62 in which task source device is configured to obtain information associated with the tasks from at least two types of information sources, the task source device being further configured to select, for each task the delay interval between the time indicated by the time stamp and the current time based on the information source type that is associated with the respective task.

65. A device for executing a series of tasks provided by a task source at times specified by the task source in relation to a clock maintained by the task source, the device comprising

A. an interface module configured to receive the series of tasks, each task being associated with a time stamp, each time stamp indicating a time value relative to a time indicated a clock maintained by the task source, at which the device is to execute the respective task;

B. a current time retrieval module configured to obtain, from the task source, a current time value as indicated by the task source's clock;

C. an execution time determination module configured to determine, from the time stamp associated with each respective task and a time differential value representing a difference between the current time value obtained by the current time retrieval module and a current time value indicated by a clock maintained by the device, a time, relative to the device's respective clock, at which the task is to be executed; and

D. a task execution module configured to execute each respective task at the time determined by the execution time determination module.

66. A device as defined in claim 65 further including a control module for controlling execution of commands received by said interface module.

67. A device as defined in claim 65 further comprising a buffer configured to buffer tasks that the interface module has received until they are to be executed, the task execution module being configured to execute the buffered tasks at the times determined by the execution time determination module.

68. A device as defined in claim 67 in which the series of tasks includes a series of task sequences with each task sequence including a subset of the series of tasks, the interface module being further configured to receive task execution control commands for controlling task execution, the control module being configured to, in response to receipt of at least one task execution control command for controlling task execution, enable the task execution module to terminate execution of a task sequence currently being executed, being configured to not execute subsequent tasks in the task sequence that have been buffered.

69. A device as defined in claim 68 in which the control module is configured to enable the task execution module to resume execution of at least one task associated with a subsequent task sequence at a time determined by the execution time determination module.

70. A device as defined in claim 69 in which the series of tasks includes a series of task sequences with each task sequence including a subset of the series of tasks, the interface module being further configured to receive task execution control commands for controlling task execution, the control module being configured to, in response to receipt of at least one task execution control command to cancel execution of a task sequence for which at least one task has been buffered but for which execution has not begun, enable the task execution module to not execute tasks from that task sequence that have been buffered.

71. A device as defined in claim 70 in which the control module is configured to enable the task execution module to resume execution of at least one task associated with a task sequence subsequent to the task sequence for which at least one task has been buffered but for which execution has not begun.

72. A device as defined in claim 66, the control module being configured to, in response to receipt of a command to become a member of a synchrony group, enable the interface module to receive tasks for execution by the task execution module.

73. A device as defined in claim 72 in which the control module is configured to, in response to receipt of a command to become a member of a synchrony group, enable the interface module to receive tasks currently being transmitted using a selected multi-cast transmission methodology, and further to retrieve at least one previously distributed task using a selected unicast transmission methodology.

74. A device as defined in claim 65 in which the control module is configured to, in receipt of a command to disengage from a synchrony group, disable the interface module from receiving tasks and the task execution module from executing previously received tasks that have not yet been executed.

75. A device as defined in claim 65 further comprising a user interface module interface module configured to receive control information from a user interface module, the control module being configured to enable selected operations to be performed in response to the control information.

76. A device as defined in claim 75 in which, in response to control information to enable another device to become a member of the device's synchrony group, the control module enables the interface module to transmit a command to the other device to enable the other device to become a member of the synchrony group.

77. A device as defined in claim 75 in which, in response to control information to enable another device that is a member of the device's synchrony group to disengage from the synchrony group, the control module enables the interface module to transmit a command to the other device to enable the other device to disengage from the synchrony group.

78. A device as defined in claim 75 in which, in response to control information to enable the task source to begin operating, the control module performs selected operations to enable the task source to begin operating.

79. A device as defined in claim 78, the device also operating as the task source, the device including a task generator module configured to, under control of the control module, obtain information from which the tasks are to be generated and generate the tasks.

80. A device as defined in claim 79 in which the interface module is further configured to transmit the tasks to at least one other device.

81. A device as defined in claim 79 in which the device is not the task source, the control module being configured to enable the interface module to transmit a command to enable the task source to operate.

82. A device as defined in claim 81 in which tasks are divided into a series of task sequences, and, in response to receipt of control information enabling execution of a sequence of tasks currently being executed to be terminated , the control module is configured to enable the interface module to transmit a command to enable the task source to insert a resynchronize command in the series of tasks associated with the task sequence to enable termination of execution of the task sequence.

83. A device as defined in claim 81 in which tasks are divided into a series of task sequences, and, in response to receipt of control information enabling execution of a sequence of tasks at least a portion of which have been received, but which are not being executed, the control module is configured to enable the interface module to transmit a command to enable the task source to insert a resynchronize command in the series of commands to disable execution of the task sequence.

84. A device as defined in claim 75 in which the control module is configured to enable the user interface module interface module to transmit status information to the user interface module.

85. A device as defined in claim 84 in which the status information includes the execution status of at least one task.

86. A device as defined in claim 65 further including:

A. a migration information receiving module configured to receive migration information from the task source device, the migration information including a source for information respecting the tasks to be distributed, timing information relative to the clock maintained by the task source device and identifications of the member devices of the synchrony group, and

B. a migration control module configured to, after the migration information has been received.,

   i. distribute the series of tasks to the synchrony group, each task being associated with a time stamp indicating a time, relative to the timing information that it receives from the device operating as the task source device, at which the devices comprising the synchrony group are to execute the respective task, and

ii. notify the members of the synchrony group that it is to thereafter operate as the task source device.

87. A device as defined in claim 86 in which the information respecting the tasks that are to be distributed is a source of streaming information, the migration control module being configured to, after the migration information has been received, assembling the streaming information into tasks and associate each task with a said time stamp.

88. A device as defined in claim 86 in which the information respecting the tasks that are to be distributed is in a file identified in the migration information, the migration control module being configured to obtain information from the identified file, assemble the information into tasks and associate each task with a said time stamp.

89. A device as defined in claim 88 in which the information respecting the tasks that are to be distributed begins at an offset, identified in the migration information, into the identified file, the migration control module being configured to assemble the information from a position in the file associated with the identified offset.

90. A device as defined in claim 89 in which the information respecting the tasks that are to be distributed is in a series of files identified in the migration information, the migration control module being configured to obtain information from successive files in the series assemble the information into tasks and associate each task with as said time stamp.

91. A device as defined in claim 65 further including a clock rate adjustment module configured to adjust the member device's clock rate in relation to a clock rate value maintained by the task source device's clock.

92. A task source device for distributing a series of tasks for execution by at least one other device at respective execution times, the task source device comprising:

A. a task acquisition module configured to obtain respective ones of the tasks;

B. a task execution time determination module configured to determine a time at which each respective task is to be executed, and to associate the respective task with a time stamp indicating its execution time;

C. a task transmission module configured to transmit the series of tasks to said at least one other device; and

D. an execution control command generation module configured to, in response to a predetermined event, enable the task transmission module to insert into the series of tasks

transmitted by the task transmission module a command to enable the at least one other device to modify the execution sequence of the tasks transmitted thereto.

93. A task source device as defined in claim 92 in which the task transmission module is configured to utilize a selected multi-cast transmission methodology.

94. A task source device as defined in claim 92 in which the predetermined event comprises input indicia provided by an operator.

95. A task source device as defined in claim 94 in which, in response to said predetermined event, the execution control command generation module is configured to enable the task transmission module to insert into the series of tasks transmitted by the task transmission module a command to enable the at least one other device to control execution of at least one task in relation to the time the predetermined event occurs.

96. A task source device as defined in claim 95 in which, in response to said predetermined event, the execution control command generation module is configured to enable the task transmission module to insert into the series of tasks transmitted by the task transmission module a command to enable the at least one other device to terminate execution of a task that it is currently executing and/or to not execute at least one task that is to be executed subsequent to the predetermined event.

97. A task source device as defined in claim 95 in which the series of tasks includes a series of task sequences with each task sequence including a sub-set of the series of tasks, the execution control command generation module being configured to, in response to said predetermined event,

(i) enable the task transmission module to insert into the series of tasks transmitted by the task transmission module, a command enabling the at least one other device to terminate execution of the currently executing task and/or to not execute at least one subsequent task, if any, in the task sequence including the currently executing task; and

(ii) enable

(a) the task execution time determination module to provide that time stamps associated with tasks of task sequences subsequent to the task sequence currently being executed will reflect the termination and/or non-execution of tasks from the task sequence of the task that is currently being executed, and

(b) the task transmission module to transmit the tasks of the subsequent task sequences to the at least one other device.

98. A task source device as defined in claim 97 in which the task transmission module is configured to insert a command to enable the at least one other device to not execute all tasks in the task sequence subsequent to the terminated and/or non-executed task.

99. A task source device as defined in claim 92 in which, in response to said predetermined event, the execution control command generation module is configured to enable the task transmission module to insert into the series of tasks transmitted by the task transmission module a command to enable the at least one other device to control execution of a task in relation to the task's position in the series of tasks.

100. A task source device as defined in claim 99 in which, in response to said predetermined event, the execution control command generation module is configured to enable the task transmission module to insert into the series of tasks transmitted by the task transmission module a command to enable the at least one other device to cancel execution of a task in relation to the task's position in the series of tasks.

101. A task source device as defined in claim 99 in which, in response to said predetermined event, the execution control command generation module is configured to enable the task transmission module to insert into the series of tasks transmitted by the task transmission module a command to enable the at least one other device to cancel execution of a previously-transmitted task in relation to the task's position in the series of tasks.

102. A task source device as defined in claim 101 in which, in response to said predetermined event, the execution control command generation module is configured to enable the task transmission module to insert into the series of tasks transmitted by the task transmission module a command to enable the at least one other device to cancel execution of a previously-transmitted task, in relation to the task's position in the series of tasks, for which execution has not begun.

103. A task source device as defined in claim 99 in which the series of tasks includes a series of task sequences with each task sequence including a sub-set of the series of tasks, the execution control command generation module being configured to, in response to said predetermined event,

(i) enable the task transmission module to insert into the series of tasks transmitted by the task transmission module, a command enabling the at least one other device to cancel execution of a task sequence for which execution has not begun; and

(ii) enable

(a) the task execution time determination module to provide that time stamps associated with tasks of task sequences subsequent to the task sequence whose execution was cancelled will reflect the cancellation, and

(b) the task transmission module to transmit the tasks of the subsequent task sequences to the at least one other device.

104. A task source device for distributing a series of tasks for execution by at least one other device at respective execution times, the task source device comprising:

A. a task acquisition module configured to obtain respective ones of the tasks;

B. a task execution time determination module configured to determine a time at which each respective task is to be executed, and to associate the respective task with a time stamp indicating its execution time, the task execution time determination module being configured to provide, associated with at least one task, a time stamp indicating a task execution time later than the time currently indicated by a clock maintained by the task source device; and

C. a task transmission module configured to transmit the series of tasks to said at least one other device.

105. A system as defined in claim 104 in which the task source device is configured to select the delay interval between the time indicated by the time stamp and the current time so to be sufficient to provide that the at least one task distributed by the task source device can be executed by the member devices at the time indicated by the time stamp.

106. A system as defined in claim 105 in which the task source device is configured to select the delay interval between the time indicated by the time stamp and the current time so to be sufficient to provide that the at least one task distributed by the task source device can be distributed to the member devices for execution at the time indicated by the time stamp

107. A system as defined in claim 104 in which task source device is configured to obtain information associated with the tasks from at least two types of information sources, the task source device being further configured to select, for each task the delay interval between the time indicated by the time stamp and the current time based on the information source type that is associated with the respective task.

108. A task source device for distributing a series of tasks for execution by at least one other device, the task source device comprising:

A. a task acquisition module configured to obtain respective ones of the tasks;

B. a task execution time determination module configured to determine a time at which each respective task is to be executed, and to associate the respective task with a time stamp indicating its execution time;

C. a task transmission module configured to transmit the series of tasks to said at least one other device; and

D. a task source device migration control module configured to, in response to a predetermined event, provide migration information to another device, the migration information including a source for information respecting the tasks to be distributed, timing information relative to the clock maintained by the task source device and identifications of the member devices of the synchrony group.

109. A method of operating a system comprising plurality of devices, one of the devices operating as a task source device and at least one other device operating as a member of a synchrony group,

A. the task source device being enabled to distribute a series of tasks to the synchrony group, each task being associated with a time stamp indicating a time, relative to a clock maintained by the task source device, at which the devices comprising the synchrony group are to execute the respective task;

B each member device being enabled to:

(i) periodically obtain from the task source device an indication of a current time value indicated by the task source device's clock, and

(ii) determine, from the time stamp associated with each respective task and a time differential value representing a difference between the current time value indicated by the task source device's clock, and a current time value indicated by its respective clock, a time, relative to its respective clock, at which it is to execute the task.

110. A method as defined in claim 109 in which the synchrony group comprises a plurality of member devices.

111. A method as defined in claim 110 in which each device comprising a member of the synchrony group is further enabled to execute each task that it receives from the task source device at the determined time, thereby to facilitate execution by them of respective tasks in the series in respective timing relationships relative to the time indicated by the task source device's clock.

112. A method as defined in claim 111 in which the member devices are enabled to execute respective tasks in synchrony.

113. A method as defined in claim 110 in which one of the member devices operates as a master device for the synchrony group, any other member devices comprising respective slave devices, the master device being enabled to perform at least one type of synchrony group management operation in connection with the member devices comprising the synchrony group.

114. A method as defined in claim 113 further including a user interface module enabled to control the master device's performance of said at least one type of synchrony group management operation, the master device being further enabled to provide status information relating to the status of the synchrony group to the user interface module.

115. A method as defined in claim 114 in which the status information includes identifications of the devices comprising the synchrony group.

116. A method as defined in claim 114 in which the status information includes an identification of the task currently being executed.

117. A method as defined in claim 113, the method comprising at least one additional device, in which, in one type of synchrony group management operation, the master device is enabled to enable the at least one additional device to join the synchrony group as a slave device.

118. A method as defined in claim 117 in which the task source device is enabled to distribute tasks to the member devices using a selected multi-cast transmission methodology, the member devices being enabled to buffer the tasks until they are to be executed, and further in which, when the at least one additional device joins the synchrony group as a slave device, the task source device is enabled to transmit at least one previously distributed task to the slave device using a selected unicast transmission methodology.

119. A method as defined in claim 113 in which, in at least one type of synchrony group management operation, the master device is enabled to enable the task source device to join the synchrony group as a slave device, the task source device continuing to operate as the task source device for the synchrony group.

120. A method as defined in claim 113 in which, in at least one type of synchrony group management operation, the master device is enabled to enable a slave device to disengage from the synchrony group, the disengaged slave device thereafter not being a member device in the synchrony group.

121. A method as defined in claim 113 in which, in at least one type of synchrony group management operation, the master device is enabled to control the series of tasks to be distributed by the task source device.

122. A method as defined in claim 113 in which, in at least one type of synchrony group management operation, the master device is further enabled to control execution by the member devices of the tasks that have been distributed by the task source device.

123. A method as defined in claim 122 in which the series of tasks includes a series of task sequences with each task sequence including a sub-set of the series of tasks, and further in which in at least one type of synchrony group management operation, the master device is enabled to enable the member devices to terminate execution of a task sequence that is currently being executed.

124. A method as defined in claim 123 in which, in the synchrony group management operation enabling the member devices to terminate execution of a task sequence that is currently being executed, the master device enables the task source device to distribute a command to enable the member devices to terminate execution of the task sequence, the member devices being enabled to, after receiving the command, terminating execution of the task sequence.

125. A method as defined in claim 122 in which the series of tasks includes a series of task sequences with each task sequence including a sub-set of the series of tasks, and further in which at least one type of synchrony group management operation, the master device is enabled to enable the member devices to cancel execution of a task sequence that has been previously distributed, but for which execution has not begun.

126. A method as defined in claim 125 in which, in the synchrony group management operation enabling the member devices to cancel execution of a task sequence that has been previously distributed but for which execution has not begun, the master device enables the task source device to distribute a command to enable the member devices to cancel execution of the task sequence, the member devices being enabled to, after receiving the command, cancel execution of the task sequence.

127. A method as defined in claim 113 in which, in at least one type of synchrony group management operation, the member device operating as the master device is enabled to enable the master device to migrate from one member device to another member device in the synchrony group.

128. A method as defined in claim 113 in which, in at least one type of synchrony group management operation, the master device is enabled to perform the step of enabling the task source device to migrate from one device to another device in the system.

129. A method as defined in claim 128 in which

A. the device operating as the task source device is enable to perform the step of, after being enabled to migrate the task source device to said other device, providing migration

information to the other device, the migration information including a source for information respecting the tasks to be distributed, timing information relative to the clock maintained by the task source device and identifications of the member devices,

B. the other device is enabled to, after receiving the migration information, perform the steps of

i. distributing the series of tasks to the synchrony group, each task being associated with a time stamp indicating a time, relative to the timing information that it receives from the device operating as the task source device, at which the devices comprising the synchrony group are to execute the respective task, and

ii. notifying the members of the synchrony group that it is to thereafter operate as the task source device.

130. A method as defined in claim 129 in which the information respecting the tasks that are to be distributed is a source of streaming information, the other device being enabled to, after receiving the migration information, perform the steps of assembling the streaming information into tasks and associating each task with a said time stamp.

131. A method as defined in claim 129 in which the information respecting the tasks that are to be distributed is in a file identified in the migration information, the other device being enabled to perform the steps of obtaining information from the identified file, assembling the information into tasks and associating each task with a said time stamp.

132.A method as defined in claim 131 in which the information respecting the tasks that are to be distributed begins at an offset, identified in the migration information, into the identified file, the other device being enabled to perform the step of assembling the information from a position in the file associated with the identified offset.

133. A method as defined in claim 131 in which the information respecting the tasks that are to be distributed is in a series of files identified in the migration information, the other device being enabled to perform the step of obtaining information from successive files in the series assemble the information into tasks and associate each task with as said time stamp.

134. A method as defined in claim 109 in which the task source device is further enabled to distribute the tasks using a selected multi-cast message transmission methodology.

135. A method as defined in claim 109 in which the task source device is enabled to perform the step of providing, provide, associated with at least one task, a time stamp indicating a task execution time later than the time currently indicated by the clock maintained by the task source device.

136. A method as defined in claim 135 in which the task source device is enabled to perform the step of selecting the delay interval between the time indicated by the time stamp and the current time so to be sufficient to provide that the at least one task distributed by the task source device can be executed by the member devices at the time indicated by the time stamp.

137. A method as defined in claim 136 in which the task source device is enabled to perform the step of selecting the delay interval between the time indicated by the time stamp and the current time so to be sufficient to provide that the at least one task distributed by the task source device can be distributed to the member devices for execution at the time indicated by the time stamp

138. A method as defined in claim 135 in which task source device is enabled to perform the steps of obtaining information associated with the tasks from at least two types of information sources, and selecting, for each task, the delay interval between the time indicated by the time stamp and the current time based on the information source type that is associated with the respective task.

139. A method as defined in claim 109 in which at least one member device is further enabled to perform the step of adjusting its clock rate in relation to a clock rate value maintained by the task source device's clock.

140. A method as defined in claim 139 in which the at least one member device is enabled to perform the step of adjusting its clock rate in relation to time stamps associated with respective ones of the tasks received from the task source device.

141. A method as defined in claim 109 in which at least one other device operates as a task source device enabled to distribute tasks to a second synchrony group, the device operating as the task source device for the first synchrony group also operating as a member device of a second synchrony group.

142. A method as defined in claim 109 including, within a member device,

A. a task receiving step of receiving the series of tasks,

B. a current time retrieval step of obtaining, from the task source device, the current time value as indicated by the task source's clock;

C. an execution time determination step of determining, from the time stamp associated with each respective task and a time differential value representing a difference between the current time value obtained during the current time retrieval step and a current time value indicated by a clock maintained by the device, a time, relative to the member device's respective clock at which the task is to be executed; and

D. a task execution step of executing each respective task at the time determined during the execution time determination step.

143. A method as defined in claim 142 further including a control step for controlling execution of commands received during the task receiving step

144. A method as defined in claim 143 in which the at least one member device further comprises a buffer configured to buffer tasks received from the task source device during the task receiving step until they are to be executed, the task execution step including the step of executing the buffered tasks at the times determined during the execution time determination step.

145. A method as defined in claim 144 in which the series of tasks includes a series of task sequences with each task sequence including a subset of the series of tasks, the task receiving step being further enabled to receive task execution control commands for controlling task execution, the control step including the step of, in response to receipt of at least one task execution control command for controlling task execution, controlling the task execution step to terminate execution of a task sequence currently being executed, and further to not execute subsequent tasks in the task sequence that have been buffered.

146. A method as defined in claim 145 in which the control step includes the step of enabling the task execution step to resume execution of at least one task associated with a subsequent task sequence at a time determined during the execution time determination step.

147. A method as defined in claim 144 in which the series of tasks includes a series of task sequences with each task sequence including a subset of the series of tasks, the task receiving step including the step of receiving task execution control commands for controlling task execution, the control step including the step of, in response to receipt of at least one task execution control command to cancel execution of a task sequence for which at least one task has been buffered but for which execution has not begun, providing that tasks from that task sequence that have been buffered not be executed.

148. A method as defined in claim 147 in which the control step includes the step of enabling execution to resume of at least one task associated with a task sequence subsequent to the task sequence for which at least one task has been buffered but for which execution has not begun.

149. A method as defined in claim 142 in which the member device performs:

A. migration information receiving step of receiving migration information from the task source device, the migration information including a source for information respecting the tasks to be distributed, timing information relative to the clock maintained by the task source device and identifications of the member devices of the synchrony group, and

B. a migration control step of, after the migration information has been received.,

i. distributing the series of tasks to the synchrony group, each task being associated with a time stamp indicating a time, relative to the timing information that it receives from the device operating as the task source device, at which the devices comprising the synchrony group are to execute the respective task, and

ii. notifying the members of the synchrony group that it is to thereafter operate as the task source device.

150. A method as defined in claim 149 in which the information respecting the tasks that are to be distributed is a source of streaming information, the migration control step includes the steps of, after the migration information has been received, assembling the streaming information into tasks and associating each task with a said time stamp.

151. A method as defined in claim 149 in which the information respecting the tasks that are to be distributed is in a file identified in the migration information, the migration control step including the steps of obtaining information from the identified file, assembling the information into tasks and associating each task with a said time stamp.

152. A method as defined in claim 151 in which the information respecting the tasks that are to be distributed begins at an offset, identified in the migration information, into the identified file, the migration control step including the step of assembling the information from a position in the file associated with the identified offset.

153. A method as defined in claim 151 in which the information respecting the tasks that are to be distributed is in a series of files identified in the migration information, the migration control step including the steps of obtaining information from successive files in the series assemble the information into tasks and associating each task with as said time stamp.

154. A method as defined in claim 142 in which the member device is further enabled to perform a clock rate adjustment step including the step of adjusting the member device's clock rate in relation to a clock rate value maintained by the task source device's clock.

155. A method as defined in claim 154 in which the clock rate adjustment step includes the step of determining adjust the clock rate in relation to time stamps associated with respective ones of the tasks received from the task source device.

156. A method as defined in claim 109 including, within a task source device,

A. a task acquisition step of obtaining respective ones of the tasks;

B. a task execution time determination step of determining a time at which each respective task is to be executed, and to associate the respective task with a time stamp indicating its execution time;

C. a task transmission step of transmitting the series of tasks to said at least one other device; and

D. an execution control command generation step of, in response to a predetermined event and during the task transmission step, the insertion into the series of tasks transmitted by the task transmission module of a command to enable the at least one other device to modify the execution sequence of the tasks transmitted thereto.

157. A method as defined in claim 156 in which the task transmission step includes the step of utilizing a selected multi-cast transmission methodology.

158. A method as defined in claim 156 in which the predetermined event includes the step of receiving input indicia provided by an operator.

159. A method as defined in claim 158 in which the execution control command generation step includes the step of enabling, in response to said predetermined event and during the task transmission step, the insertion into the series of tasks of a command to enable the at least one other device to control execution of at least one task in relation to the time the predetermined event occurs.

160. A method as defined in claim 159 in which, the execution control command generation step includes the step of enabling, in response to said predetermined event and during the task transmission step, the insertion into the series of tasks of a command to enable the at least one other device to terminate execution of a task that it is currently executing and/or to not execute at least one task that is to be executed subsequent to the predetermined event.

161. A method as defined in claim 159 in which the series of tasks includes a series of task sequences with each task sequence including a sub-set of the series of tasks, the execution control command generation step including the steps of, in response to said predetermined event,

(i) enabling during the task transmission step the insertion, into the series of tasks, of a command enabling the at least one other device to terminate execution of the currently executing task and/or to not execute at least one subsequent task, if any, in the task sequence including the currently executing task; and

(ii) enabling

(a) during the task execution time determination step, that time stamps associated with tasks of task sequences subsequent to the task sequence currently being executed will

reflect the termination and/or non-execution of tasks from the task sequence of the task that is currently being executed, and

(b) during the task transmission step, the transmission of the tasks of the subsequent task sequences to the at least one other device.

162. A method as defined in claim 161 in which the task transmission step includes the step of inserting a command into the task sequence to enable the at least one other device to not execute all tasks in the task sequence subsequent to the terminated and/or non-executed task.

163. A method as defined in claim 159 in which the execution control command generation step include the step of enabling, in response to said predetermined event and during the task transmission step, the insertion into the series of tasks of a command to enable the at least one other device to control execution of a task in relation to the task's position in the series of tasks.

164. A method as defined in claim 163 in which the execution control command generation step includes the step of, in response to said predetermined event and during the task transmission step, the insertion into the series of tasks of a command to enable the at least one other device to cancel execution of a task in relation to the task's position in the series of tasks.

165. A method as defined in claim 163 in which the execution control command generation step includes the step of enabling, in response to said predetermined event and during the task transmission step, the inserting into the series of tasks of a command to enable the at least one other device to cancel execution of a previously-transmitted task in relation to the task's position in the series of tasks.

166. A method as defined in claim 165 in which, the execution control command generation step includes the step of, in response to said predetermined event and during the task transmission step, the insertion into the series of tasks of a command to enable the at least one other device to cancel execution of a previously-transmitted task, in relation to the task's position in the series of tasks, for which execution has not begun.

167. A method as defined in claim 163 in which the series of tasks includes a series of task sequences with each task sequence including a sub-set of the series of tasks, the execution control command generation step including the steps of, in response to said predetermined event,

(i) enabling, during the task transmission step, the insertion, into the series of tasks, of a command enabling the at least one other device to cancel execution of a task sequence for which execution has not begun; and

(ii) enabling

(a) during the task execution time determination step, that time stamps associated with tasks of task sequences subsequent to the task sequence whose execution was cancelled will reflect the cancellation, and

(b) during the task transmission step, the transmission of the tasks of the subsequent task sequences to the at least one other device.

168. A method as defined in claim 109 in which the task source device is enabled to perform

A. a task acquisition step of obtaining respective ones of the tasks;

B. a task execution time determination step of determining a time at which each respective task is to be executed, and to associate the respective task with a time stamp indicating its execution time;

C. a task transmission step of transmitting the series of tasks to said at least one other device; and

D. a task source device migration control step of, in response to a predetermined event, providing migration information to another device, the migration information including a source for information respecting the tasks to be distributed, timing information relative to the clock maintained by the task source device and identifications of the member devices of the synchrony group.

169. A method as defined in claim 109 in which the task source device is enabled to perform the step of providing, associated with at least one task, a time stamp indicating a task execution time later than the time currently indicated by the clock maintained by the task source device.

170. A method as defined in claim 169 in which the task source device is enabled to perform the step of selecting the delay interval between the time indicated by the time stamp and the current time so to be sufficient to provide that the at least one task distributed by the task source device can be executed by the member devices at the time indicated by the time stamp.

171. A method as defined in claim 170 in which the task source device is enabled to perform the step of selecting the delay interval between the time indicated by the time stamp and the current time so to be sufficient to provide that the at least one task distributed by the task source device can be distributed to the member devices for execution at the time indicated by the time stamp

172. A method as defined in claim 169 in which task source device is enabled to perform the step of obtaining information associated with the tasks from at least two types of information sources, and selecting for each task the delay interval between the time indicated by the time stamp and the current time based on the information source type that is associated with the respective task.

173. A method of operating a device for executing a series of tasks provided by a task source at times specified by the task source in relation to a clock maintained by the task source, the method including

A. a task receiving step of receiving the series of tasks, each task being associated with a time stamp, each time stamp indicating a time value relative to a time indicated a clock maintained by the task source, at which the device is to execute the respective task;

B. a current time retrieval module of obtaining, from the task source, a current time value as indicated by the task source's clock;

C. an execution time determination step of determining, from the time stamp associated with each respective task and a time differential value representing a difference between the current time value obtained during the current time retrieval step and a current time value indicated by a clock maintained by the device, a time, relative to the device's respective clock, at which the task is to be executed; and

D. a task execution module step of executing each respective task at the time determined during the execution time determination step.

174. A method as defined in claim 173 further including a control step for controlling execution of commands received by said interface module.

175. A method as defined in claim 174 further comprising a buffer configured to buffer tasks that have been received until they are to be executed, the task execution step including the step of executing the buffered tasks at the times determined during the execution time determination step.

176. A method as defined in claim 175 in which the series of tasks includes a series of task sequences with each task sequence including a subset of the series of tasks, the interface module being further enabled to receive task execution control commands for controlling task execution, the control module being enabled to, in response to receipt of at least one task execution control command for controlling task execution, enable the task execution module to terminate execution of a task sequence currently being executed, being enabled to not execute subsequent tasks in the task sequence that have been buffered.

177. A method as defined in claim 176 in which the control step includes the step of enabling task execution to resume execution with at least one task associated with a subsequent task sequence at a time determined during the execution time determination step.

178. A method as defined in claim 175 in which the series of tasks includes a series of task sequences with each task sequence including a subset of the series of tasks, the task receiving step including

the step of receiving task execution control commands for controlling task execution, the control step, in response to receipt of at least one task execution control command to cancel execution of a task sequence for which at least one task has been buffered but for which execution has not begun, including the step of providing that task execution not including execution of tasks from that task sequence that have been buffered.

179. A method as defined in claim 178 in which the control step includes the step of enabling task execution to resume execution of at least one task associated with a task sequence subsequent to the task sequence for which at least one task has been buffered but for which execution has not begun.

180. A method as defined in claim 173, the control step including the step of, in response to receipt of a command to become a member of a synchrony group, receiving tasks during the task receiving step for execution during the task execution step.

181. A method as defined in claim 180 in which the control step includes the step of, in response to receipt of a command to become a member of a synchrony group, enable the task receiving step to include the step of receiving tasks currently being transmitted using a selected multi-cast transmission methodology, and further to include the step of retrieving at least one previously distributed task using a selected unicast transmission methodology.

182. A method as defined in claim 173 in which the control step includes the steps of, in receipt of a command to disengage from a synchrony group, disabling the receipt of tasks and the execution of previously-received tasks that have not yet been executed.

183. A method as defined in claim 173 further comprising a user interface module control information receiving step of receiving control information from a user interface module, the control step including the step of enabling selected operations to be performed in response to the control information.

184 A method as defined in claim 183 in which, in response to control information to enable another device to become a member of the device's synchrony group, the control step includes the step of transmitting a command to the other device to enable the other device to become a member of the synchrony group.

185. A method as defined in claim 183 in which, in response to control information to enable another device that is a member of the device's synchrony group to disengage from the synchrony group, the control module enables the interface module to transmit a command to the other device to enable the other device to disengage from the synchrony group.

186. A method as defined in claim 185 in which, in response to control information to enable the task source to begin operating, the control step includes the step of performing selected operations to enable the task source to begin operating.

187. A method as defined in claim 186, the device also operating as the task source, the method including a task generation steps of, under control of the control step, obtaining information from which the tasks are to be generated and generating the tasks.

188. A method as defined in claim 187 further including the step of transmitting the tasks to at least one other device.

189. A method as defined in claim 187 in which the device is not the task source, the control step including the step of enabling the transmission of a command to enable the task source to operate.

190. A method as defined in claim 189 in which tasks are divided into a series of task sequences, and, in response to receipt of control information enabling execution of a sequence of tasks currently being executed to be terminated , the control step includes the step of transmitting a command to enable the task source to insert a resynchronize command in the series of tasks associated with the task sequence to enable termination of execution of the task sequence.

191. A method as defined in claim 189 in which tasks are divided into a series of task sequences, and, in response to receipt of control information enabling execution of a sequence of tasks at least a portion of which have been received, but which are not being executed, the control step includes the step of transmitting a command to enable the task source to insert a resynchronize command in the series of commands to disable execution of the task sequence.

192. A method as defined in claim 174 in which the control step includes the step of transmitting status information to the user interface module.

193. A method as defined in claim 192 in which the status information includes the execution status of at least one task.

194. A method as defined in claim 173 in which the member device performs:

A. migration information receiving step of receiving migration information from the task source device, the migration information including a source for information respecting the tasks to be distributed, timing information relative to the clock maintained by the task source device and identifications of the member devices of the synchrony group, and

B. a migration control step of, after the migration information has been received.,

   i. distributing the series of tasks to the synchrony group, each task being associated with a time stamp indicating a time, relative to the timing information that it receives

from the device operating as the task source device, at which the devices comprising the synchrony group are to execute the respective task, and

ii. notifying the members of the synchrony group that it is to thereafter operate as the task source device.

195. A method as defined in claim 194 in which the information respecting the tasks that are to be distributed is a source of streaming information, the migration control step includes the steps of, after the migration information has been received, assembling the streaming information into tasks and associating each task with a said time stamp.

196. A method as defined in claim 194 in which the information respecting the tasks that are to be distributed is in a file identified in the migration information, the migration control step including the steps of obtaining information from the identified file, assembling the information into tasks and associating each task with a said time stamp.

197. A method as defined in claim 196 in which the information respecting the tasks that are to be distributed begins at an offset, identified in the migration information, into the identified file, the migration control step including the step of assembling the information from a position in the file associated with the identified offset.

198. A method as defined in claim 196 in which the information respecting the tasks that are to be distributed is in a series of files identified in the migration information, the migration control step including the steps of obtaining information from successive files in the series assemble the information into tasks and associating each task with as said time stamp.

199. A method as defined in claim 173 in which the member device is further enabled to perform a clock rate adjustment step including the step of adjusting the member device's clock rate in relation to a clock rate value maintained by the task source device's clock.

200. A method as defined in claim 199 in which the clock rate adjustment step includes the step of determining adjust the clock rate in relation to time stamps associated with respective ones of the tasks received from the task source device.

201. A method of operating a device for distributing a series of tasks for execution by at least one other device at respective execution times, the method comprising:

A. a task acquisition step of obtaining respective ones of the tasks;

B. a task execution time determination step of determining a time at which each respective task is to be executed, and to associate the respective task with a time stamp indicating its execution time;

C. a task transmission step of transmitting the series of tasks to said at least one other device; and

D. an execution control command generation step of, in response to a predetermined event and during the task transmission step, the insertion into the series of tasks transmitted by the task transmission module of a command to enable the at least one other device to modify the execution sequence of the tasks transmitted thereto.

202. A method as defined in claim 201 in which the task transmission step includes the step of utilizing a selected multi-cast transmission methodology.

203. A method as defined in claim 201 in which the predetermined event includes the step of receiving input indicia provided by an operator.

204. A method as defined in claim 203 in which the execution control command generation step includes the step of enabling, in response to said predetermined event and during the task transmission step, the insertion into the series of tasks of a command to enable the at least one other device to control execution of at least one task in relation to the time the predetermined event occurs.

205. A method as defined in claim 204 in which, the execution control command generation step includes the step of enabling, in response to said predetermined event and during the task transmission step, the insertion into the series of tasks of a command to enable the at least one other device to terminate execution of a task that it is currently executing and/or to not execute at least one task that is to be executed subsequent to the predetermined event.

206. A method as defined in claim 203 in which the series of tasks includes a series of task sequences with each task sequence including a sub-set of the series of tasks, the execution control command generation step including the steps of, in response to said predetermined event,

(i) enabling during the task transmission step the insertion, into the series of tasks, of a command enabling the at least one other device to terminate execution of the currently executing task and/or to not execute at least one subsequent task, if any, in the task sequence including the currently executing task; and

(ii) enabling

(a) during the task execution time determination step, that time stamps associated with tasks of task sequences subsequent to the task sequence currently being executed will reflect the termination and/or non-execution of tasks from the task sequence of the task that is currently being executed, and

(b) during the task transmission step, the transmission of the tasks of the subsequent task sequences to the at least one other device.

207. A method as defined in claim 206 in which the task transmission step includes the step of inserting a command into the task sequence to enable the at least one other device to not execute all tasks in the task sequence subsequent to the terminated and/or non-executed task.

208. A method as defined in claim 201 in which the execution control command generation step include the step of enabling, in response to said predetermined event and during the task transmission step, the insertion into the series of tasks of a command to enable the at least one other device to control execution of a task in relation to the task's position in the series of tasks.

209. A method as defined in claim 208 in which the execution control command generation step includes the step of, in response to said predetermined event and during the task transmission step, the insertion into the series of tasks of a command to enable the at least one other device to cancel execution of a task in relation to the task's position in the series of tasks.

210. A method as defined in claim 208 in which the execution control command generation step includes the step of enabling, in response to said predetermined event and during the task transmission step, the inserting into the series of tasks of a command to enable the at least one other device to cancel execution of a previously-transmitted task in relation to the task's position in the series of tasks.

211. A method as defined in claim 210 in which, the execution control command generation step includes the step of, in response to said predetermined event and during the task transmission step, the insertion into the series of tasks of a command to enable the at least one other device to cancel execution of a previously-transmitted task, in relation to the task's position in the series of tasks, for which execution has not begun.

212. A method as defined in claim 208 in which the series of tasks includes a series of task sequences with each task sequence including a sub-set of the series of tasks, the execution control command generation step including the steps of, in response to said predetermined event,

(i) enabling, during the task transmission step, the insertion, into the series of tasks, of a command enabling the at least one other device to cancel execution of a task sequence for which execution has not begun; and

(ii) enabling

(a) during the task execution time determination step, that time stamps associated with tasks of task sequences subsequent to the task sequence whose execution was cancelled will reflect the cancellation, and

(b) during the task transmission step, the transmission of the tasks of the subsequent task sequences to the at least one other device.

213. A method of operating a device for distributing a series of tasks for execution by at least one other device at respective execution times, the method comprising:

A. a task acquisition step of obtaining respective ones of the tasks;

B. a task execution time determination step of determining a time at which each respective task is to be executed, and to associating the respective task with a time stamp indicating its execution time, the task execution time determination step including the step of providing, associated with at least one task, a time stamp indicating a task execution time later than the time currently indicated by a clock maintained by the task source device; and

C. a task transmission step of transmitting the series of tasks to said at least one other device.

214. A method as defined in claim 213 in which the task execution time determination step includes the step of selecting the delay interval between the time indicated by the time stamp and the current time so to be sufficient to provide that the at least one task distributed by the device can be executed by at least one other device at the time indicated by the time stamp.

215. A method as defined in claim 214 in which the task execution time determination step includes the step of selecting the delay interval between the time indicated by the time stamp and the current time so to be sufficient to provide that the at least one task distributed by the device can be distributed to other devices over a network for execution by the other devices at the time indicated by the time stamp.

216. A method as defined in claim 213 in which task acquisition step includes the step of obtaining information associated with the tasks from at least two types of information sources, the task execution time determination step including the step of selecting, for each task the delay interval between the time indicated by the time stamp and the current time based on the information source type that is associated with the respective task.

217. A method of operating a device for distributing a series of tasks for execution by at least one other device, the method comprising:

A. a task acquisition module configured to obtain respective ones of the tasks;

B. a task execution time determination module configured to determine a time at which each respective task is to be executed, and to associate the respective task with a time stamp indicating its execution time;

C. a task transmission module configured to transmit the series of tasks to said at least one other device; and

D. a task source device migration control module configured to, in response to a predetermined event, provide migration information to another device, the migration information including a source for information respecting the tasks to be distributed, timing information relative to the clock maintained by the task source device and identifications of the member devices of the synchrony group.

218. A computer program product for use in connection with a computer to provide a device for executing a series of tasks provided by a task source at times specified by the task source in relation to a clock maintained by the task source, the computer program product comprising a computer-readable medium having encoded thereon:

A. an interface module configured to enable the computer to receive the series of tasks, each task being associated with a time stamp, each time stamp indicating a time value relative to a time indicated a clock maintained by the task source, at which the device is to execute the respective task;

B. a current time retrieval module configured to enable the computer to obtain, from the task source, a current time value as indicated by the task source's clock;

C. an execution time determination module configured to enable the computer to determine, from the time stamp associated with each respective task and a time differential value representing a difference between the current time value obtained by the current time retrieval module and a current time value indicated by a clock maintained by the device, a time, relative to the device's respective clock, at which the task is to be executed; and

D. a task execution module configured to enable the computer to execute each respective task at the time determined by the execution time determination module.

219. A computer program product as defined in claim 218 further including a control module for enabling said computer to control execution of commands received by the interface module.

220. A computer program product as defined in claim 219 further comprising a buffer module configured to enable the computer to buffer tasks received by the interface module until they are to

be executed, the task execution module being configured to enable the computer to execute the buffered tasks at the times determined by the execution time determination module.

221. A computer program product as defined in claim 220 in which the series of tasks includes a series of task sequences with each task sequence including a subset of the series of tasks, the interface module being further configured to enable the computer to receive task execution control commands for controlling task execution, the control module being configured to enable the computer to, in response to receipt of at least one task execution control command for controlling task execution, enable the task execution module to terminate execution of a task sequence currently being executed, being configured to enable the computer to not execute subsequent tasks in the task sequence that have been buffered.

222. A computer program product as defined in claim 220 in which the control module is configured to enable the computer to enable the task execution module to resume execution of at least one task associated with a subsequent task sequence at a time determined by the execution time determination module.

223. A computer program product as defined in claim 219 in which the series of tasks includes a series of task sequences with each task sequence including a subset of the series of tasks, the interface module being further configured to enable the computer to receive task execution control commands for controlling task execution, the control module being configured to enable the computer to, in response to receipt of at least one task execution control command to cancel execution of a task sequence for which at least one task has been buffered but for which execution has not begun, enable the task execution module to not execute tasks from that task sequence that have been buffered.

224. A computer program product as defined in claim 223 in which the control module is configured to enable the computer to enable the task execution module to resume execution of at least one task associated with a task sequence subsequent to the task sequence for which at least one task has been buffered but for which execution has not begun.

225. A computer program product as defined in claim 219, the control module being configured to enable the computer to, in response to receipt of a command to become a member of a synchrony group, enable the interface module to receive tasks for execution by the task execution module.

226. A computer program product as defined in claim 225 in which the control module is configured to enable the computer to, in response to receipt of a command to become a member of a synchrony group, enable the interface module to receive tasks currently being transmitted using a selected

multi-cast transmission methodology, and further to retrieve at least one previously distributed task using a selected unicast transmission methodology.

227. A computer program product as defined in claim 219 in which the control module is configured to enable the computer to, in receipt of a command to disengage from a synchrony group, disable the interface module from receiving tasks and the task execution module from executing previously received tasks that have not yet been executed.

228. A computer program product as defined in claim 219 further comprising a user interface module interface module configured to receive control information from a user interface module, the control module being configured to enable the computer to enable selected operations to be performed in response to the control information.

229. A computer program product as defined in claim 228 in which, in response to control information to enable another device to become a member of the device's synchrony group, the control module enables the interface module to transmit a command to the other device to enable the other device to become a member of the synchrony group.

230. A computer program product as defined in claim 228 in which, in response to control information to enable another device that is a member of the device's synchrony group to disengage from the synchrony group, the control module enables the interface module to transmit a command to the other device to enable the other device to disengage from the synchrony group.

231. A computer program product as defined in claim 228 in which, in response to control information to enable the task source to begin operating, the control module performs selected operations to enable the task source to begin operating.

232. A computer program product as defined in claim 231, the device also operating as the task source, the device including a task generator module configured to enable the computer to, under control of the control module, obtain information from which the tasks are to be generated and generate the tasks.

233. A computer program product as defined in claim 232 in which the interface module is further configured to enable the computer to transmit the tasks to at least one other device.

234. A computer program product as defined in claim 232 in which the device is not the task source, the control module being configured to enable the computer to enable the interface module to transmit a command to enable the task source to operate.

235. A computer program product as defined in claim 234 in which tasks are divided into a series of task sequences, and, in response to receipt of control information enabling execution of a sequence

of tasks currently being executed to be terminated , the control module is configured to enable the computer to enable the interface module to transmit a command to enable the task source to insert a resynchronize command in the series of tasks associated with the task sequence to enable termination of execution of the task sequence.

236. A computer program product as defined in claim 234 in which tasks are divided into a series of task sequences, and, in response to receipt of control information enabling execution of a sequence of tasks at least a portion of which have been received, but which are not being executed, the control module is configured to enable the computer to enable the interface module to transmit a command to enable the task source to insert a resynchronize command in the series of commands to disable execution of the task sequence.

237. A computer program product as defined in claim 228 in which the control module is configured to enable the computer to enable the user interface module interface module to transmit status information to the user interface module.

238. A computer program product as defined in claim 237 in which the status information includes the execution status of at least one task.

239. A computer program product as defined in claim 218 further including:

A. a migration information receiving module configured to enable the computer to receive migration information from the task source device, the migration information including a source for information respecting the tasks to be distributed, timing information relative to the clock maintained by the task source device and identifications of the member devices of the synchrony group, and

B. a migration control module configured to enable the computer to, after the migration information has been received.,

   i. distribute the series of tasks to the synchrony group, each task being associated with a time stamp indicating a time, relative to the timing information that it receives from the device operating as the task source device, at which the devices comprising the synchrony group are to execute the respective task, and

   ii. notify the members of the synchrony group that it is to thereafter operate as the task source device.

240. A computer program product as defined in claim 239 in which the information respecting the tasks that are to be distributed is a source of streaming information, the migration control module

being configured to enable the computer to, after the migration information has been received, assemble the streaming information into tasks and associate each task with a said time stamp.

241. A computer program product as defined in claim 239 in which the information respecting the tasks that are to be distributed is in a file identified in the migration information, the migration control module being configured to enable the computer to obtain information from the identified file, assemble the information into tasks and associate each task with a said time stamp.

242. A computer program product as defined in claim 241 in which the information respecting the tasks that are to be distributed begins at an offset, identified in the migration information, into the identified file, the migration control module being configured to enable the computer to assemble the information from a position in the file associated with the identified offset.

243. A computer program product as defined in claim 241 in which the information respecting the tasks that are to be distributed is in a series of files identified in the migration information, the migration control module being configured to enable the computer to obtain information from successive files in the series assemble the information into tasks and associate each task with as said time stamp.

244. A computer program product as defined in claim 218 further including a clock rate adjustment module configured to enable the computer to adjust the member device's clock rate in relation to a clock rate value maintained by the task source device's clock.

245. A computer program product as defined in claim 244 in which the clock rate adjustment module is configured to enable the computer to adjust the clock rate in relation to time stamps associated with respective ones of the tasks received from the task source device.

246. A computer program product for use in connection with a computer to provide a task source device for distributing a series of tasks for execution by at least one other device at respective execution times, the computer program product comprising a computer readable medium having encoded thereon:

A. a task acquisition module configured to enable the computer to obtain respective ones of the tasks;

B. a task execution time determination module configured to enable the computer to determine a time at which each respective task is to be executed, and to associate the respective task with a time stamp indicating its execution time;

C. a task transmission module configured to enable the computer to transmit the series of tasks to said at least one other device; and

D. an execution control command generation module configured to enable the computer to , in response to a predetermined event, enable the task transmission module to insert into the series of tasks transmitted by the task transmission module a command to enable the at least one other device to modify the execution sequence of the tasks transmitted thereto.

247. A computer program product as defined in claim 246 which the task transmission module is configured to enable the computer to utilize a selected multi-cast transmission methodology.

248. A computer program product as defined in claim 246 in which the predetermined event comprises input indicia provided by an operator.

249. A computer program product as defined in claim 246 in which, in response to said predetermined event, the execution control command generation module is configured to enable the computer to enable the task transmission module to insert into the series of tasks transmitted by the task transmission module a command to enable the at least one other device to control execution of at least one task in relation to the time the predetermined event occurs.

250. A computer program product as defined in claim 249 in which, in response to said predetermined event, the execution control command generation module is configured to enable the computer to enable the task transmission module to insert into the series of tasks transmitted by the task transmission module a command to enable the at least one other device to terminate execution of a task that it is currently executing and/or to not execute at least one task that is to be executed subsequent to the predetermined event.

251. A computer program product as defined in claim 249 in which the series of tasks includes a series of task sequences with each task sequence including a sub-set of the series of tasks, the execution control command generation module being configured to enable the computer to , in response to said predetermined event,

(i) enable the task transmission module to insert into the series of tasks transmitted by the task transmission module, a command enabling the at least one other device to terminate execution of the currently executing task and/or to not execute at least one subsequent task, if any, in the task sequence including the currently executing task; and

(ii) enable

(a) the task execution time determination module to provide that time stamps associated with tasks of task sequences subsequent to the task sequence currently being executed will reflect the termination and/or non-execution of tasks from the task sequence of the task that is currently being executed, and

(b) the task transmission module to transmit the tasks of the subsequent task sequences to the at least one other device.

252. A computer program product as defined in claim 251 in which the task transmission module is configured to enable the computer to insert a command to enable the at least one other device to not execute all tasks in the task sequence subsequent to the terminated and/or non-executed task.

253. A computer program product as defined in claim 246 in which, in response to said predetermined event, the execution control command generation module is configured to enable the computer to enable the task transmission module to insert into the series of tasks transmitted by the task transmission module a command to enable the at least one other device to control execution of a task in relation to the task's position in the series of tasks.

254. A computer program product as defined in claim 253 in which, in response to said predetermined event, the execution control command generation module is configured to enable the computer to enable the task transmission module to insert into the series of tasks transmitted by the task transmission module a command to enable the at least one other device to cancel execution of a task in relation to the task's position in the series of tasks.

255. A computer program product as defined in claim 254 in which, in response to said predetermined event, the execution control command generation module is configured to enable the computer to enable the task transmission module to insert into the series of tasks transmitted by the task transmission module a command to enable the at least one other device to cancel execution of a previously-transmitted task in relation to the task's position in the series of tasks.

256. A computer program product as defined in claim 255 in which, in response to said predetermined event, the execution control command generation module is configured to enable the computer to enable the task transmission module to insert into the series of tasks transmitted by the task transmission module a command to enable the at least one other device to cancel execution of a previously-transmitted task, in relation to the task's position in the series of tasks, for which execution has not begun.

257. A computer program product as defined in claim 253 in which the series of tasks includes a series of task sequences with each task sequence including a sub-set of the series of tasks, the execution control command generation module being configured to enable the computer to , in response to said predetermined event,

(i) enable the task transmission module to insert into the series of tasks transmitted by the task transmission module, a command enabling the at least one other device to cancel execution of a task sequence for which execution has not begun; and

(ii) enable

(a) the task execution time determination module to provide that time stamps associated with tasks of task sequences subsequent to the task sequence whose execution was cancelled will reflect the cancellation, and

(b) the task transmission module to transmit the tasks of the subsequent task sequences to the at least one other device.

258. A computer program product for use in connection with a computer to provide a task source device for distributing a series of tasks for execution by at least one other device at respective execution times, the computer program product comprising a computer readable medium having encoded thereon:

A. a task acquisition module configured to enable the computer to obtain respective ones of the tasks;

B. a task execution time determination module configured to enable the computer to determine a time at which each respective task is to be executed, and to associate the respective task with a time stamp indicating its execution time, the task execution time determination module being configured to enable the computer to provide, associated with at least one task, a time stamp indicating a task execution time later than the time currently indicated by a clock maintained by the task source device; and

C. a task transmission module configured to enable the computer to transmit the series of tasks to said at least one other device.

259. A computer program product as defined in claim 258 in which the task execution time determination module is configured to enable the computer to select the delay interval between the time indicated by the time stamp and the current time so to be sufficient to provide that the at least one task distributed by the task source device can be executed by the member devices at the time indicated by the time stamp.

260. A computer program product as defined in claim 259 in which the task execution time determination module is configured to enable the computer to select the delay interval between the time indicated by the time stamp and the current time so to be sufficient to provide that the at least

one task distributed by the task source device can be distributed to the member devices for execution at the time indicated by the time stamp.

261. A computer program product as defined in claim 258 in which task acquisition module is configured to enable the computer to obtain information associated with the tasks from at least two types of information sources, the task execution time determination module being configured to enable the computer to select, for each task the delay interval between the time indicated by the time stamp and the current time based on the information source type that is associated with the respective task.

262. A computer program product for use in connection with a computer to provide a task source device for distributing a series of tasks for execution by at least one other device, the computer program product comprising a computer readable medium having encoded thereon:

A. a task acquisition module configured to enable the computer to obtain respective ones of the tasks;

B. a task execution time determination module configured to enable the computer to determine a time at which each respective task is to be executed, and to associate the respective task with a time stamp indicating its execution time;

C. a task transmission module configured to enable the computer to transmit the series of tasks to said at least one other device; and

D. a task source device migration control module configured to enable the computer to, in response to a predetermined event, provide migration information to another device, the migration information including a source for information respecting the tasks to be distributed, timing information relative to the clock maintained by the task source device and identifications of the member devices of the synchrony group.

263. A system comprising a plurality of devices,

A one device being enabled to operate as a task source device, the task source device being enabled to transmit a series of tasks to the other devices, each task being associated with execution time information;

B. at least one device being enabled to operate as a task execution device, the task execution device being enabled to receive the series of tasks from the network and executing each respective task at a time in relation to the timing information associated with the respective task; and

C. one device being enabled to operate as a control device, the control device being enabled to control operations of the task source device and the task execution device.

264. A system as defined in claim 263 in which the device that is enabled to operate as the control device is also enabled to operate as a task execution device.

265. A system as defined in claim 263 in which the device that is enabled to operate as the control device is also enabled to operate as the task source device.

266. A system as defined in claim 263 in which the device that is enabled to operate as the task source device is also enabled to operate as a task execution device.

267. A system for facilitating processing of data by device operating as a member of a synchrony group, synchronously with a clock maintained by a data source device that provides the data to the synchrony group,

A. the data source device being configured to divide the data into a series of frames for distribution to the synchrony group, each frame being associated with a time stamp indicating a time, relative to a clock maintained by the data source device, at which the devices comprising the synchrony group are to process the frame;

B each member device in the synchrony group being configured to:

(i) periodically obtain from the data source device an indication of a current time value indicated by the data source device's clock;

(ii) receive the series of frames from the data source device;

(iii) determine, from the time stamp associated with each respective frame and a time differential value representing a difference between the current time value indicated by the data source device's clock, a current time value indicated by the member device's respective clock, a time, relative to the member device's respective clock, at which the member device is to process the frame; and

(iv) process the respective frame at the determined time.

268. A system as defined in claim 267 in which at least one frame comprises audio data, each member device, while processing each frame, producing sound represented by the respective frame.

269. A system as defined in claim 267 comprising a plurality of member devices, the member devices processing each frame synchronously in relation to the clock maintained by the data source device so that they all produce sound represented by the respective frame synchronously.

270. A system as defined in claim 269 in which the data source device is configured to provide time stamps for at least two successive frames so that the member devices will play them with a selected time interval therebetween.

271. A system as defined in claim 270 in which the time interval is zero.

272. A system as defined in claim 269 in which one of the member devices operates as a master device for the synchrony group, any other member devices comprising respective slave devices, the master device being configured to perform at least one type of synchrony group management operation in connection with the member devices comprising the synchrony group.

273. A system as defined in claim 272 in which the master device is further configured to provide status information relating to the status of the synchrony group to the user interface module.

274. A system as defined in claim 273 in which the status information includes identifications of the devices comprising the synchrony group.

275. A system as defined in claim 273 in which each frame is associated with a frame sequence, each frame sequence comprising at least one frame, the frame or frames comprising each frame sequence being associated with an audio track, each audio track being associated with an identifier, the status information including the identification of the audio track currently being played.

276. A system as defined in claim 272, the system comprising at least one additional device, in which, in one type of synchrony group management operation, the master device is configured to enable the at least one additional device to join the synchrony group as a slave device.

277. A system as defined in claim 276 in which the data source device is configured to distribute frames to the member devices using a selected multi-cast transmission methodology, the member devices being configured to buffer the frames until they are to be played, and further in which, when the at least one additional device joins the synchrony group as a slave device, the data source device is enabled to transmit at least one previously distributed frame to the slave device using a selected unicast transmission methodology.

278. A system as defined in claim 272 in which, in at least one type of synchrony group management operation, the master device is configured to enable the data source device to join the synchrony group as a slave device, the data source device continuing to operate as the data source device for the synchrony group.

279. A system as defined in claim 272 in which, in at least one type of synchrony group management operation, the master device is configured to enable a slave device to disengage from the synchrony

group, the disengaged slave device thereafter not being a member device in the synchrony group and not playing frames distributed by the data source device.

280. A system as defined in claim 272 in which, in at least one type of synchrony group management operation, the master device is configured to control the series of frames to be distributed by the data source device.

281. A system as defined in claim 280 in which each frame is associated with a frame sequence, each frame sequence comprising at least one frame, the frame or frames comprising each frame sequence being associated with an audio track, the master device being configured to control the frames to be distributed by the data source device on a track-by-track basis.

282. A system as defined in claim 281 in which, in at least one type of synchrony group management operation, the master device is further configured to control playback by the member devices of the frames associated with the respective audio tracks that have been distributed by the data source device in response to control information from the user interface module.

283. A system as defined in claim 282 in which, in response to control information from the user interface module to facilitate control of playback by the member devices, the master device is configured to enable the data source device to distribute a playback control command to the member devices.

284. A system as defined in claim 283 in which a playback control command enables the member devices to terminate playback of a track that is currently being played back.

285. A system as defined in claim 284 in which the playback control command enables the member devices to terminate playback of a track with a frame subsequent to a frame currently being played.

286. A system as defined in claim 283 in which the playback control command enables the member devices to cancel playback of a track at least one of whose frames has been previously distributed, but for which playback has not begun.

287. A system as defined in claim 272 in which, in at least one type of synchrony group management operation, the member device operating as the master device is configured to enable the master device to migrate from itself to another member device in the synchrony group.

288. A system as defined in claim 272 in which, in at least one type of synchrony group management operation, the master device is configured to enable the data source device to migrate from one device to another device in the system.

289. A system as defined in claim 288 in which

A. the device operating as the data source device is configured to, after being enabled to migrate the data source device to said other device, provide migration information to the other device, the migration information including a source for information respecting the frames to be distributed, timing information relative to the clock maintained by the data source device and identifications of the member devices,

B. the other device being configured to, after receiving the migration information,

i. distribute the series of frames to the synchrony group, each frame being associated with a time stamp indicating a time, relative to the timing information that it receives from the device operating as the data source device, at which the devices comprising the synchrony group are to execute the respective frame, and

ii. notify the members of the synchrony group that it is to thereafter operate as the data source device.

290. A system as defined in claim 289 in which the information respecting the frames that are to be distributed is a source of streaming information, the other device being configured to, after receiving the migration information, assemble the streaming information into frames and associate each frame with a said time stamp.

291. A system as defined in claim 289 in which the information respecting the frames that are to be distributed is in a file identified in the migration information, the other device being configured to obtain information from the identified file, assemble the information into frames and associate each frame with a said time stamp.

292.A system as defined in claim 291 in which the information respecting the frames that are to be distributed begins at an offset, identified in the migration information, into the identified file, the other device being configured to assemble the information from a position in the file associated with the identified offset.

293. A system as defined in claim 291 in which the information respecting the frames that are to be distributed is in a series of files identified in the migration information, the other device being configured to obtain information from successive files in the series assemble the information into frames and associate each frame with as said time stamp.

294. A system as defined in claim 267 in which the data source device is further configured to distribute the frames using a selected multi-cast message transmission methodology.

295. A system as defined in claim 267 in which the data source device is configured to provide, associated with at least one frame, a time stamp indicating a frame execution time later than the time currently indicated by the clock maintained by the data source device.

296. A system as defined in claim 295 in which the data source device is configured to select the delay interval between the time indicated by the time stamp and the current time so to be sufficient to provide that the at least one frame distributed by the data source device can be executed by the member devices at the time indicated by the time stamp.

297. A system as defined in claim 296 in which the data source device is configured to select the delay interval between the time indicated by the time stamp and the current time so to be sufficient to provide that the at least one frame distributed by the data source device can be distributed to the member devices for execution at the time indicated by the time stamp

298. A system as defined in claim 295 in which data source device is configured to obtain information associated with the frames from at least two types of information sources, the data source device being further configured to select, for each frame the delay interval between the time indicated by the time stamp and the current time based on the information source type that is associated with the respective frame.

299. A system as defined in claim 267 in which at least one member device is further configured to adjust its clock rate in relation to a clock rate value maintained by the data source device's clock.

300. A system as defined in claim 299 in which the at least one member device is configured to adjust its clock rate in relation to time stamps associated with respective ones of the frames received from the data source device.

301. A system as defined in claim 267 in which at least one other device operates as a data source device configured to distribute frames to a second synchrony group, the device operating as the data source device for the first synchrony group also operating as a member device of a second synchrony group.

302. A system as defined in claim 267 in which at least one member device comprises:

A. an interface module configured to receive the series of frames, each frame being associated with a time stamp, each time stamp indicating a time value relative to a time indicated a clock maintained by the data source, at which the device is to process the respective frame;

B. a current time retrieval module configured to obtain, from the data source, a current time value as indicated by the data source's clock;

C. an processing time determination module configured to determine, from the time stamp associated with each respective frame and a time differential value representing a difference between the current time value obtained by the current time retrieval module and a current time value indicated by a clock maintained by the device, a time, relative to the device's respective clock, at which the frame is to be processed; and

D. a frame processing module configured to process each respective frame at the time determined by the processing time determination module.

303. A system as defined in claim 302 in which the at least one frame comprises audio data, each member device, while processing each frame, producing a signal representing sound represented by the respective frame.

304. A system as defined in claim 302 further including a control module for controlling execution of commands received by said interface module.

305. A device as defined in claim 304 further comprising a buffer configured to buffer frames that the interface module has received until they are to be processed, the frame processing module being configured to process the buffered frames at the times determined by the processing time determination module.

306. A system as defined in claim 305 in which the each frame is associated with a track, each track including at least one frame, the interface module being further configured to receive playback control commands for controlling processing of tracks, the control module being configured to execute at least one playback control command controlling track processing.

307. A system as defined in claim 306 in which at least one type of playback control command enables the control module to, in turn, enable the frame processing module to terminate playback of a track that is currently being played back.

308. A system as defined in claim 307 in which the playback control command enables the control module to terminate playback of a track with a frame subsequent to a frame currently being played.

309. A system as defined in claim 306 in which the playback control command enables the control module to cancel playback of a track at least one of whose frames has been previously distributed, but for which playback has not begun.

310. A system as defined in claim 306 in which the control module is configured to enable the frame processing module to resume processing of at least one frame associated with a subsequent track at a time determined by the processing time determination module.

311. A system as defined in claim 302 in which the member device includes:

A. a migration information receiving module configured to receive migration information from the task source device, the migration information including a source for information respecting the tasks to be distributed, timing information relative to the clock maintained by the task source device and identifications of the member devices of the synchrony group, and

B. a migration control module configure to, after the migration information has been received.,

i. distribute the series of tasks to the synchrony group, each task being associated with a time stamp indicating a time, relative to the timing information that it receives from the device operating as the task source device, at which the devices comprising the synchrony group are to execute the respective task, and

ii. notify the members of the synchrony group that it is to thereafter operate as the task source device.

312. A system as defined in claim 311 in which the information respecting the frames that are to be distributed is a source of streaming information, the migration control module being configured to, after the migration information has been received, assembling the streaming information into frames and associate each frame with a said time stamp.

313. A system as defined in claim 311 in which the information respecting the frames that are to be distributed is in a file identified in the migration information, the migration control module being configured to obtain information from the identified file, assemble the information into frames and associate each frame with a said time stamp.

314. A system as defined in claim 313 in which the information respecting the frames that are to be distributed begins at an offset, identified in the migration information, into the identified file, the migration control module being configured to assemble the information from a position in the file associated with the identified offset.

315. A system as defined in claim 313 in which the information respecting the frames that are to be distributed is in a series of files identified in the migration information, the migration control module being configured to obtain information from successive files in the series assemble the information into frames and associate each frame with as said time stamp.

316. A system as defined in claim 302 in which the member device further includes a clock rate adjustment module configured to adjust the member device's clock rate in relation to a clock rate value maintained by the data source device's clock.

317. A system as defined in claim 316 in which the clock rate adjustment module is configured to adjust the clock rate in relation to time stamps associated with respective ones of the frames received from the data source device.

318. A system as defined in claim 267 in which the data source device comprises:

A. a frame acquisition module configured to obtain respective ones of the frames;

B. a frame execution time determination module configured to determine a time at which each respective frame is to be executed, and to associate the respective frame with a time stamp indicating its execution time;

C. a frame transmission module configured to transmit the series of frames to said at least one other device; and

D. an execution control command generation module configured to, in response to a predetermined event, enable the frame transmission module to insert into the series of frames transmitted by the frame transmission module a command to enable the at least one other device to modify the execution sequence of the frames transmitted thereto.

319. A system as defined in claim 318 in which at least one frame comprises audio data, each member device, while processing each frame, producing generating a signal representing sound represented by the respective frame.

320. A system as defined in claim 318 in which the frame transmission module is configured to utilize a selected multi-cast transmission methodology.

321. A system as defined in claim 318 in which the predetermined event comprises input indicia provided by an operator.

322. A system as defined in claim 321 in which, in response to said predetermined event, the execution control command generation module is configured to enable the frame transmission module to insert into the series of frames transmitted by the frame transmission module a command to enable the at least one other device to control execution of at least one frame in relation to the time the predetermined event occurs.

323. A system as defined in claim 322 in which, in response to said predetermined event, the execution control command generation module is configured to enable the frame transmission module to insert into the series of frames transmitted by the frame transmission module a command to enable the at least one other device to terminate execution of a frame that it is currently executing and/or to not execute at least one frame that is to be executed subsequent to the predetermined event.

324. A data source device as defined in claim 323 in which the series of frames includes a series of frame sequences with each frame sequence including a sub-set of the series of frames, the execution control command generation module being configured to, in response to said predetermined event,

(i) enable the frame transmission module to insert into the series of frames transmitted by the frame transmission module, a command enabling the at least one other device to terminate execution of the currently executing frame and/or to not execute at least one subsequent frame, if any, in the frame sequence including the currently executing frame; and

(ii) enable

(a) the frame execution time determination module to provide that time stamps associated with frames of frame sequences subsequent to the frame sequence currently being executed will reflect the termination and/or non-execution of frames from the frame sequence of the frame that is currently being executed, and

(b) the frame transmission module to transmit the frames of the subsequent frame sequences to the at least one other device.

325. A system as defined in claim 324 in which the frame transmission module is configured to insert a command to enable the at least one other device to not execute all frames in the frame sequence subsequent to the terminated and/or non-executed frame.

326. A system as defined in claim 267 in which, in response to said predetermined event, the execution control command generation module is configured to enable the frame transmission module to insert into the series of frames transmitted by the frame transmission module a command to enable the at least one other device to control execution of a frame in relation to the frame's position in the series of frames.

327. A system as defined in claim 326 in which, in response to said predetermined event, the execution control command generation module is configured to enable the frame transmission module to insert into the series of frames transmitted by the frame transmission module a command to enable the at least one other device to cancel execution of a frame in relation to the frame's position in the series of frames.

328. A system as defined in claim 326 in which, in response to said predetermined event, the execution control command generation module is configured to enable the frame transmission module to insert into the series of frames transmitted by the frame transmission module a command to enable the at least one other device to cancel execution of a previously-transmitted frame in relation to the frame's position in the series of frames.

329. A system as defined in claim 328 in which, in response to said predetermined event, the execution control command generation module is configured to enable the frame transmission module to insert into the series of frames transmitted by the frame transmission module a command to enable the at least one other device to cancel execution of a previously-transmitted frame, in relation to the frame's position in the series of frames, for which execution has not begun.

330. A system as defined in claim 327 in which the series of frames includes a series of frame sequences with each frame sequence including a sub-set of the series of frames, the execution control command generation module being configured to, in response to said predetermined event,

(i) enable the frame transmission module to insert into the series of frames transmitted by the frame transmission module, a command enabling the at least one other device to cancel execution of a frame sequence for which execution has not begun; and

(ii) enable

(a) the frame execution time determination module to provide that time stamps associated with frames of frame sequences subsequent to the frame sequence whose execution was cancelled will reflect the cancellation, and

(b) the frame transmission module to transmit the frames of the subsequent frame sequences to the at least one other device.

331. A system as defined in claim 267 in which the data source device comprises:

A. a frame acquisition module configured to obtain respective ones of the frames;

B. a frame execution time determination module configured to determine a time at which each respective frame is to be executed, and to associate the respective frame with a time stamp indicating its execution time;

C. a frame transmission module configured to transmit the series of frames to said at least one other device; and

D. a data source device migration control module configured to, in response to a predetermined event, provide migration information to another device, the migration information including a source for information respecting the frames to be distributed, timing information relative to the clock maintained by the data source device and identifications of the member devices of the synchrony group.

332. A system as defined in claim 331 in which the data source device is configured to provide, associated with at least one frame, a time stamp indicating a frame execution time later than the time currently indicated by the clock maintained by the data source device.

333. A system as defined in claim 332 in which the data source device is configured to select the delay interval between the time indicated by the time stamp and the current time so to be sufficient to provide that the at least one frame distributed by the data source device can be executed by the member devices at the time indicated by the time stamp.

334. A system as defined in claim 333 in which the data source device is configured to select the delay interval between the time indicated by the time stamp and the current time so to be sufficient to provide that the at least one frame distributed by the data source device can be distributed to the member devices for execution at the time indicated by the time stamp

335. A system as defined in claim 333 in which data source device is configured to obtain information associated with the frames from at least two types of information sources, the data source device being further configured to select, for each frame the delay interval between the time indicated by the time stamp and the current time based on the information source type that is associated with the respective frame.

336. A device for processing a series of frames of data provided by a data source at times specified by the data source in relation to a clock maintained by the data source, the device comprising

A. an interface module configured to receive the series of frames, each frame being associated with a time stamp, each time stamp indicating a time value relative to a time indicated a clock maintained by the data source, at which the device is to process the respective frame;

B. a current time retrieval module configured to obtain, from the data source, a current time value as indicated by the data source's clock;

C. an processing time determination module configured to determine, from the time stamp associated with each respective frame and a time differential value representing a difference between the current time value obtained by the current time retrieval module and a current time value indicated by a clock maintained by the device, a time, relative to the device's respective clock, at which the frame is to be processed; and

D. a frame processing module configured to process each respective frame at the time determined by the processing time determination module.

337. A device as defined in claim 336 in which the frame comprises audio data, each member device, while processing each frame, producing a signal representing sound represented by the respective frame.

338. A device as defined in claim 336 further including a control module for controlling execution of commands received by said interface module.

333. A system as defined in claim 332 in which the data source device is configured to select the delay interval between the time indicated by the time stamp and the current time so to be sufficient to provide that the at least one frame distributed by the data source device can be executed by the member devices at the time indicated by the time stamp.

334. A system as defined in claim 333 in which the data source device is configured to select the delay interval between the time indicated by the time stamp and the current time so to be sufficient to provide that the at least one frame distributed by the data source device can be distributed to the member devices for execution at the time indicated by the time stamp

335. A system as defined in claim 333 in which data source device is configured to obtain information associated with the frames from at least two types of information sources, the data source device being further configured to select, for each frame the delay interval between the time indicated by the time stamp and the current time based on the information source type that is associated with the respective frame.

336. A device for processing a series of frames of data provided by a data source at times specified by the data source in relation to a clock maintained by the data source, the device comprising

A. an interface module configured to receive the series of frames, each frame being associated with a time stamp, each time stamp indicating a time value relative to a time indicated a clock maintained by the data source, at which the device is to process the respective frame;

B. a current time retrieval module configured to obtain, from the data source, a current time value as indicated by the data source's clock;

C. an processing time determination module configured to determine, from the time stamp associated with each respective frame and a time differential value representing a difference between the current time value obtained by the current time retrieval module and a current time value indicated by a clock maintained by the device, a time, relative to the device's respective clock, at which the frame is to be processed; and

D. a frame processing module configured to process each respective frame at the time determined by the processing time determination module.

337. A device as defined in claim 336 in which the frame comprises audio data, each member device, while processing each frame, producing a signal representing sound represented by the respective frame.

338. A device as defined in claim 336 further including a control module for controlling execution of commands received by said interface module.

339. A device as defined in claim 336 further comprising a buffer configured to buffer frames that the interface module has received until they are to be processed, the frame processing module being configured to process the buffered frames at the times determined by the processing time determination module.

340. A device as defined in claim 339 in which the each frame is associated with a track, each track including at least one frame, the interface module being further configured to receive playback control commands for controlling processing of tracks, the control module being configured to execute at least one playback control command controlling track processing.

341. A device as defined in claim 340 in which at least one type of playback control command enables the control module to, in turn, enable the frame processing module to terminate playback of a track that is currently being played back.

342. A device as defined in claim 341 in which the playback control command enables the control module to terminate playback of a track with a frame subsequent to a frame currently being played.

343. A device as defined in claim 340 in which the playback control command enables the control module to cancel playback of a track at least one of whose frames has been previously distributed, but for which playback has not begun.

344. A device as defined in claim 340 in which the control module is configured to enable the frame processing module to resume processing of at least one frame associated with a subsequent track at a time determined by the processing time determination module.

345. A device as defined in claim 338, the control module being configured to, in response to receipt of a command to become a member of a synchrony group, enable the interface module to receive frames for processing by the frame processing module.

346. A device as defined in claim 345 in which the control module is configured to, in response to receipt of a command to become a member of a synchrony group, enable the interface module to receive frames currently being transmitted using a selected multi-cast transmission methodology, and further to retrieve at least one previously distributed frame using a selected unicast transmission methodology.

347. A device as defined in claim 346 in which the control module is configured to, in receipt of a command to disengage from a synchrony group, disable the interface module from receiving frames and the frame processing module from processing previously received frames that have not yet been processed.

348. A device as defined in claim 336 further comprising a user interface module interface module configured to receive control information from a user interface module, the control module being configured to enable selected operations to be performed in response to the control information.

349. A device as defined in claim 348 in which, in response to control information to enable another device to become a member of the device's synchrony group, the control module enables the interface module to transmit a command to the other device to enable the other device to become a member of the synchrony group.

350. A device as defined in claim 349 in which, in response to control information to enable another device that is a member of the device's synchrony group to disengage from the synchrony group, the control module enables the interface module to transmit a command to the other device to enable the other device to disengage from the synchrony group.

351. A device as defined in claim 348 in which, in response to control information to enable the data source to begin operating, the control module performs selected operations to enable the data source to begin operating.

352. A device as defined in claim 351, the device also operating as the data source, the device including a frame generator module configured to, under control of the control module, obtain information from which the frames are to be generated and generate the frames.

353. A device as defined in claim 342 in which the interface module is further configured to transmit the frames to at least one other device.

354. A device as defined in claim 343 in which the device is not the data source, the control module being configured to enable the interface module to transmit a command to enable the data source to operate.

355. A device as defined in claim 354 in which each frame is associated with a track, each track including at least one frame, and, in response to receipt of control information enabling processing of a track currently being processed to be terminated , the control module is configured to enable the interface module to transmit a command to enable the data source to insert a resynchronize command in the series of frames associated with the track to enable termination of processing of the track.

356. A device as defined in claim 354 in which each frame is associated with a track, each track including at least one frame, and, in response to receipt of control information enabling processing of a track at least a portion of which has been received, but for which processing has not begun, the control module is configured to enable the interface module to transmit a command to enable the data

source to insert a resynchronize command in the series of commands to disable processing of the track.

357. A device as defined in claim 344 in which the control module is configured to enable the user interface module interface module to transmit status information to the user interface module.

358. A device as defined in claim 357 in which the status information includes the processing status of at least one frame.

359. A device as defined in claim 336 further including:

A. a migration information receiving module configured to receive migration information from the data source device, the migration information including a source for information respecting the frames to be distributed, timing information relative to the clock maintained by the data source device and identifications of the member devices of the synchrony group, and

B. a migration control module configured to, after the migration information has been received.,

i. distribute the series of frames to the synchrony group, each frame being associated with a time stamp indicating a time, relative to the timing information that it receives from the device operating as the data source device, at which the devices comprising the synchrony group are to execute the respective frame, and

ii. notify the members of the synchrony group that it is to thereafter operate as the data source device.

360. A device as defined in claim 359 in which the information respecting the frames that are to be distributed is a source of streaming information, the migration control module being configured to, after the migration information has been received, assembling the streaming information into frames and associate each frame with a said time stamp.

361. A device as defined in claim 359 in which the information respecting the frames that are to be distributed is in a file identified in the migration information, the migration control module being configured to obtain information from the identified file, assemble the information into frames and associate each frame with a said time stamp.

362. A device as defined in claim 361 in which the information respecting the frames that are to be distributed begins at an offset, identified in the migration information, into the identified file, the migration control module being configured to assemble the information from a position in the file associated with the identified offset.

363. A device as defined in claim 361 in which the information respecting the frames that are to be distributed is in a series of files identified in the migration information, the migration control module being configured to obtain information from successive files in the series assemble the information into frames and associate each frame with as said time stamp.

364. A device as defined in claim 336 further including a clock rate adjustment module configured to adjust the member device's clock rate in relation to a clock rate value maintained by the data source device's clock.

365. A data source device for distributing a series of frames for execution by at least one other device at respective execution times, the data source device comprising:

A. a frame acquisition module configured to obtain respective ones of the frames;

B. a frame execution time determination module configured to determine a time at which each respective frame is to be executed, and to associate the respective frame with a time stamp indicating its execution time;

C. a frame transmission module configured to transmit the series of frames to said at least one other device; and

D. an execution control command generation module configured to, in response to a predetermined event, enable the frame transmission module to insert into the series of frames transmitted by the frame transmission module a command to enable the at least one other device to modify the execution sequence of the frames transmitted thereto.

366. A data source device as defined in claim 365 in which the frame transmission module is configured to utilize a selected multi-cast transmission methodology.

367. A data source device as defined in claim 365 in which the predetermined event comprises input indicia provided by an operator.

368. A data source device as defined in claim 367 in which, in response to said predetermined event, the execution control command generation module is configured to enable the frame transmission module to insert into the series of frames transmitted by the frame transmission module a command to enable the at least one other device to control execution of at least one frame in relation to the time the predetermined event occurs.

369. A data source device as defined in claim 368 in which, in response to said predetermined event, the execution control command generation module is configured to enable the frame transmission module to insert into the series of frames transmitted by the frame transmission module a command

to enable the at least one other device to terminate execution of a frame that it is currently executing and/or to not execute at least one frame that is to be executed subsequent to the predetermined event.

370. A data source device as defined in claim 368 in which the series of frames includes a series of frame sequences with each frame sequence including a sub-set of the series of frames, the execution control command generation module being configured to, in response to said predetermined event,

(i) enable the frame transmission module to insert into the series of frames transmitted by the frame transmission module, a command enabling the at least one other device to terminate execution of the currently executing frame and/or to not execute at least one subsequent frame, if any, in the frame sequence including the currently executing frame; and

(ii) enable

(a) the frame execution time determination module to provide that time stamps associated with frames of frame sequences subsequent to the frame sequence currently being executed will reflect the termination and/or non-execution of frames from the frame sequence of the frame that is currently being executed, and

(b) the frame transmission module to transmit the frames of the subsequent frame sequences to the at least one other device.

371. A data source device as defined in claim 370 in which the frame transmission module is configured to insert a command to enable the at least one other device to not execute all frames in the frame sequence subsequent to the terminated and/or non-executed frame.

372. A data source device as defined in claim 362 in which, in response to said predetermined event, the execution control command generation module is configured to enable the frame transmission module to insert into the series of frames transmitted by the frame transmission module a command to enable the at least one other device to control execution of a frame in relation to the frame's position in the series of frames.

373. A data source device as defined in claim 372 in which, in response to said predetermined event, the execution control command generation module is configured to enable the frame transmission module to insert into the series of frames transmitted by the frame transmission module a command to enable the at least one other device to cancel execution of a frame in relation to the frame's position in the series of frames.

374. A data source device as defined in claim 371 in which, in response to said predetermined event, the execution control command generation module is configured to enable the frame transmission module to insert into the series of frames transmitted by the frame transmission module a command

to enable the at least one other device to cancel execution of a previously-transmitted frame in relation to the frame's position in the series of frames.

375. A data source device as defined in claim 374 in which, in response to said predetermined event, the execution control command generation module is configured to enable the frame transmission module to insert into the series of frames transmitted by the frame transmission module a command to enable the at least one other device to cancel execution of a previously-transmitted frame, in relation to the frame's position in the series of frames, for which execution has not begun.

376. A data source device as defined in claim 371 in which the series of frames includes a series of frame sequences with each frame sequence including a sub-set of the series of frames, the execution control command generation module being configured to, in response to said predetermined event,

(i) enable the frame transmission module to insert into the series of frames transmitted by the frame transmission module, a command enabling the at least one other device to cancel execution of a frame sequence for which execution has not begun; and

(ii) enable

(a) the frame execution time determination module to provide that time stamps associated with frames of frame sequences subsequent to the frame sequence whose execution was cancelled will reflect the cancellation, and

(b) the frame transmission module to transmit the frames of the subsequent frame sequences to the at least one other device.

377. A data source device for distributing a series of frames for execution by at least one other device at respective execution times, the data source device comprising:

A. a frame acquisition module configured to obtain respective ones of the frames;

B. a frame execution time determination module configured to determine a time at which each respective frame is to be executed, and to associate the respective frame with a time stamp indicating its execution time, the frame execution time determination module being configured to provide, associated with at least one frame, a time stamp indicating a frame execution time later than the time currently indicated by a clock maintained by the data source device; and

C. a frame transmission module configured to transmit the series of frames to said at least one other device.

377. A system as defined in claim 377 in which the data source device is configured to select the delay interval between the time indicated by the time stamp and the current time so to be sufficient

to provide that the at least one frame distributed by the data source device can be executed by the member devices at the time indicated by the time stamp.

379. A system as defined in claim 378 in which the data source device is configured to select the delay interval between the time indicated by the time stamp and the current time so to be sufficient to provide that the at least one frame distributed by the data source device can be distributed to the member devices for execution at the time indicated by the time stamp

380. A system as defined in claim 377 in which data source device is configured to obtain information associated with the frames from at least two types of information sources, the data source device being further configured to select, for each frame the delay interval between the time indicated by the time stamp and the current time based on the information source type that is associated with the respective frame.

381. A data source device for distributing a series of frames for execution by at least one other device, the data source device comprising:

A. a frame acquisition module configured to obtain respective ones of the frames;

B. a frame execution time determination module configured to determine a time at which each respective frame is to be executed, and to associate the respective frame with a time stamp indicating its execution time;

C. a frame transmission module configured to transmit the series of frames to said at least one other device; and

D. a data source device migration control module configured to, in response to a predetermined event, provide migration information to another device, the migration information including a source for information respecting the frames to be distributed, timing information relative to the clock maintained by the data source device and identifications of the member devices of the synchrony group.

382. A method for operating a system to facilitate processing of data by device operating as a member of a synchrony group, synchronously with a clock maintained by a data source device that provides the data to the synchrony group, the method including the steps of

A. enabling the data source device being to divide the data into a series of frames for distribution to the synchrony group, each frame being associated with a time stamp indicating a time, relative to a clock maintained by the data source device, at which the devices comprising the synchrony group are to process the frame;

B enabling each member device in the synchrony group to:

(i) periodically obtain from the data source device an indication of a current time value indicated by the data source device's clock;

(ii) receive the series of frames from the data source device;

(iii) determine, from the time stamp associated with each respective frame and a time differential value representing a difference between the current time value indicated by the data source device's clock, a current time value indicated by the member device's respective clock, a time, relative to the member device's respective clock, at which the member device is to process the frame; and

(iv) process the respective frame at the determined time.

383. A method as defined in claim 382 in which at least one frame comprises audio data, each member device, while processing each frame, being enabled to generate a signal representing sound represented by the respective frame.

384. A method as defined in claim 382, the system comprising a plurality of member devices, the method including the steps of enabling the member devices to process each frame synchronously in relation to the clock maintained by the data source device so that they all produce sound represented by the respective frame synchronously.

385. A method as defined in claim 384 including the step of enabling the data source device to provide time stamps for at least two successive frames so that the member devices will play them with a selected time interval therebetween.

386. A method as defined in claim 385 in which the time interval is zero.

387. A method as defined in claim 382 in which one of the member devices operates as a master device for the synchrony group, any other member devices comprising respective slave devices, the method including the step of enabling the master device to perform at least one type of synchrony group management operation in connection with the member devices comprising the synchrony group.

388. A method as defined in claim 387, the method including the step of enabling the master device to perform at least one type of synchrony group management operation in response to control information provided thereto by a user interface module.

389. A method as defined in claim 388 further including the step of enabling the master device to provide status information relating to the status of the synchrony group to the user interface module.

390. A method as defined in claim 389 in which the status information includes identifications of the devices comprising the synchrony group.

391. A method as defined in claim 389 in which each frame is associated with a frame sequence, each frame sequence comprising at least one frame, the frame or frames comprising each frame sequence being associated with an audio track, each audio track being associated with an identifier, the status information including the identification of the audio track currently being played.

392. A method as defined in claim 388 the method comprising at least one additional device, in which, in one type of synchrony group management operation, the master device is configured to enable the at least one additional device to join the synchrony group as a slave device.

393. A method as defined in claim 392 in which the data source device is configured to distribute frames to the member devices using a selected multi-cast transmission methodology, the member devices being configured to buffer the frames until they are to be played, the method including the step of, when the at least one additional device joins the synchrony group as a slave device, the enabling the data source device to transmit at least one previously distributed frame to the slave device using a selected unicast transmission methodology.

394. A method as defined in claim 387 in which, in at least one type of synchrony group management operation, the method includes the step of enabling the master device to enable the data source device to join the synchrony group as a slave device, the data source device continuing to operate as the data source device for the synchrony group.

395. A method as defined in claim 387 in which, in at least one type of synchrony group management operation, the method includes the step of enabling the master device to enable a slave device to disengage from the synchrony group, the disengaged slave device thereafter not being a member device in the synchrony group and not playing frames distributed by the data source device.

396. A method as defined in claim 387 in which, in at least one type of synchrony group management operation, the method includes the step of enabling the master device to control the series of frames to be distributed by the data source device.

397. A method as defined in claim 387 in which each frame is associated with a frame sequence, each frame sequence comprising at least one frame, the frame or frames comprising each frame sequence being associated with an audio track, the method including the step of enabling the master device being configured to control the frames to be distributed by the data source device on a track-by-track basis.

398. A method as defined in claim 387 in which, in at least one type of synchrony group management operation, the method includes the step of enabling the master device to control playback by the member devices of the frames associated with the respective audio tracks that have

been distributed by the data source device in response to control information from the user interface module.

399. A method as defined in claim 387 in which, in response to control information from the user interface module to facilitate control of playback by the member devices, the method includes the step of enabling the master device to enable the data source device to distribute a playback control command to the member devices.

400. A method as defined in claim 399 in which a playback control command enables the member devices to terminate playback of a track that is currently being played back.

401. A method as defined in claim 399 in which the playback control command enables the member devices to terminate playback of a track with a frame subsequent to a frame currently being played.

402. A method as defined in claim 399 in which the playback control command enables the member devices to cancel playback of a track at least one of whose frames has been previously distributed, but for which playback has not begun.

403. A method as defined in claim 387 in which, in at least one type of synchrony group management operation, the method includes the step of enabling the member device operating as the master device to enable the master device to migrate from itself to another member device in the synchrony group.

404. A method as defined in claim 403 in which, in at least one type of synchrony group management operation, the method includes the step of enabling the master device to enable the data source device to migrate from one device to another device in the system.

405. A method as defined in claim 404 in which

A. the device operating as the data source device is enable to perform the step of, after being enabled to migrate the data source device to said other device, providing migration information to the other device, the migration information including a source for information respecting the frames to be distributed, timing information relative to the clock maintained by the data source device and identifications of the member devices,

B. the other device is enabled to, after receiving the migration information, perform the steps of

    i. distributing the series of frames to the synchrony group, each frame being associated with a time stamp indicating a time, relative to the timing information that it receives from the device operating as the data source device, at which the devices comprising the synchrony group are to execute the respective frame, and

ii. notifying the members of the synchrony group that it is to thereafter operate as the data source device.

406. A method as defined in claim 405 in which the information respecting the frames that are to be distributed is a source of streaming information, the other device being enabled to, after receiving the migration information, perform the steps of assembling the streaming information into frames and associating each frame with a said time stamp.

407. A method as defined in claim 405 in which the information respecting the frames that are to be distributed is in a file identified in the migration information, the other device being enabled to perform the steps of obtaining information from the identified file, assembling the information into frames and associating each frame with a said time stamp.

408.A method as defined in claim 407 in which the information respecting the frames that are to be distributed begins at an offset, identified in the migration information, into the identified file, the other device being enabled to perform the step of assembling the information from a position in the file associated with the identified offset.

409. A method as defined in claim 407 in which the information respecting the frames that are to be distributed is in a series of files identified in the migration information, the other device being enabled to perform the step of obtaining information from successive files in the series assemble the information into frames and associate each frame with as said time stamp.

410. A method as defined in claim 382 including the step in which the data source is further configured to distribute the frames using a selected multi-cast message transmission methodology, the device being enabled to receive the frames using the selected multi-cast message transmission methodology.

411. A method as defined in claim 382 in which the data source device is enabled to perform the step of providing, provide, associated with at least one frame, a time stamp indicating a frame execution time later than the time currently indicated by the clock maintained by the data source device.

412. A method as defined in claim 411 in which the data source device is enabled to perform the step of selecting the delay interval between the time indicated by the time stamp and the current time so to be sufficient to provide that the at least one frame distributed by the data source device can be executed by the member devices at the time indicated by the time stamp.

413. A method as defined in claim 411 in which the data source device is enabled to perform the step of selecting the delay interval between the time indicated by the time stamp and the current time so

to be sufficient to provide that the at least one frame distributed by the data source device can be distributed to the member devices for execution at the time indicated by the time stamp

414. A method as defined in claim 411 in which data source device is enabled to perform the steps of obtaining information associated with the frames from at least two types of information sources, and selecting, for each frame, the delay interval between the time indicated by the time stamp and the current time based on the information source type that is associated with the respective frame.

415. A method as defined in claim 382 in which at least one member device is further enabled to perform the step of adjusting its clock rate in relation to a clock rate value maintained by the data source device's clock.

416. A method as defined in claim 415 in which the at least one member device is enabled to perform the step of adjusting its clock rate in relation to time stamps associated with respective ones of the frames received from the data source device.

417. A method as defined in claim 382 in which at least one other device operates as a data source device configured to distribute frames to a second synchrony group, the method including the steps of enabling the device to operate both as the data source device for the first synchrony group and also operating as a member device of a second synchrony group.

418. A method as defined in claim 382 including, within a member device,

A. a frame receiving step of receiving the series of frames,

B. a current time retrieval step of obtaining, from the data source device, the current time value as indicated by the frame source's clock;

C. an execution time determination step of determining, from the time stamp associated with each respective frame and a time differential value representing a difference between the current time value obtained during the current time retrieval step and a current time value indicated by a clock maintained by the device, a time, relative to the member device's respective clock at which the frame is to be executed; and

D. a frame execution step of executing each respective frame at the time determined during the execution time determination step.

419. A method as defined in claim 418 further including a control step for controlling execution of commands received during the frame receiving step

420. A method as defined in claim 419 in which the at least one member device further comprises a buffer configured to buffer frames received from the data source device during the frame receiving

step until they are to be executed, the frame execution step including the step of executing the buffered frames at the times determined during the execution time determination step.

420. A method as defined in claim 420 in which the series of frames includes a series of frame sequences with each frame sequence including a subset of the series of frames, the frame receiving step being further enabled to receive frame execution control commands for controlling frame execution, the control step including the step of, in response to receipt of at least one frame execution control command for controlling frame execution, controlling the frame execution step to terminate execution of a frame sequence currently being executed, and further to not execute subsequent frames in the frame sequence that have been buffered.

422. A method as defined in claim 421 in which the control step includes the step of enabling the frame execution step to resume execution of at least one frame associated with a subsequent frame sequence at a time determined during the execution time determination step.

423. A method as defined in claim 420 in which the series of frames includes a series of frame sequences with each frame sequence including a subset of the series of frames, the frame receiving step including the step of receiving frame execution control commands for controlling frame execution, the control step including the step of, in response to receipt of at least one frame execution control command to cancel execution of a frame sequence for which at least one frame has been buffered but for which execution has not begun, providing that frames from that frame sequence that have been buffered not be executed.

424. A method as defined in claim 423 in which the control step includes the step of enabling execution to resume of at least one frame associated with a frame sequence subsequent to the frame sequence for which at least one frame has been buffered but for which execution has not begun.

425. A method as defined in claim 418 in which the member device performs:

A. migration information receiving step of receiving migration information from the data source device, the migration information including a source for information respecting the frames to be distributed, timing information relative to the clock maintained by the data source device and identifications of the member devices of the synchrony group, and

B. a migration control step of, after the migration information has been received.,

   i. distributing the series of frames to the synchrony group, each frame being associated with a time stamp indicating a time, relative to the timing information that it receives from the device operating as the data source device, at which the devices comprising the synchrony group are to execute the respective frame, and

ii. notifying the members of the synchrony group that it is to thereafter operate as the data source device.

426. A method as defined in claim 425 in which the information respecting the frames that are to be distributed is a source of streaming information, the migration control step includes the steps of, after the migration information has been received, assembling the streaming information into frames and associating each frame with a said time stamp.

427. A method as defined in claim 425 in which the information respecting the frames that are to be distributed is in a file identified in the migration information, the migration control step including the steps of obtaining information from the identified file, assembling the information into frames and associating each frame with a said time stamp.

428. A method as defined in claim 427 in which the information respecting the frames that are to be distributed begins at an offset, identified in the migration information, into the identified file, the migration control step including the step of assembling the information from a position in the file associated with the identified offset.

429. A method as defined in claim 427 in which the information respecting the frames that are to be distributed is in a series of files identified in the migration information, the migration control step including the steps of obtaining information from successive files in the series assemble the information into frames and associating each frame with as said time stamp.

430. A method as defined in claim 418 in which the member device is further enabled to perform a clock rate adjustment step including the step of adjusting the member device's clock rate in relation to a clock rate value maintained by the data source device's clock.

431. A method as defined in claim 430 in which the clock rate adjustment step includes the step of determining adjust the clock rate in relation to time stamps associated with respective ones of the frames received from the data source device.

432. A method as defined in claim 382 of operating a device for distributing a series of frames for execution by at least one other device at respective execution times, the method comprising:

A. a frame acquisition step of obtaining respective ones of the frames;

B. a frame execution time determination step of determining a time at which each respective frame is to be executed, and to associate the respective frame with a time stamp indicating its execution time;

C. a frame transmission step of transmitting the series of frames to said at least one other device; and

D. an execution control command generation step of, in response to a predetermined event and during the frame transmission step, the insertion into the series of frames transmitted by the frame transmission module of a command to enable the at least one other device to modify the execution sequence of the frames transmitted thereto.

433. A method as defined in claim 432 in which the frame transmission step includes the step of utilizing a selected multi-cast transmission methodology.

434. A method as defined in claim 432 in which the predetermined event includes the step of receiving input indicia provided by an operator.

435. A method as defined in claim 434 in which the execution control command generation step includes the step of enabling, in response to said predetermined event and during the frame transmission step, the insertion into the series of frames of a command to enable the at least one other device to control execution of at least one frame in relation to the time the predetermined event occurs.

436. A method as defined in claim 435 in which, the execution control command generation step includes the step of enabling, in response to said predetermined event and during the frame transmission step, the insertion into the series of frames of a command to enable the at least one other device to terminate execution of a frame that it is currently executing and/or to not execute at least one frame that is to be executed subsequent to the predetermined event.

437. A method as defined in claim 434 in which the series of frames includes a series of frame sequences with each frame sequence including a sub-set of the series of frames, the execution control command generation step including the steps of, in response to said predetermined event,

(i) enabling during the frame transmission step the insertion, into the series of frames, of a command enabling the at least one other device to terminate execution of the currently executing frame and/or to not execute at least one subsequent frame, if any, in the frame sequence including the currently executing frame; and

(ii) enabling

(a) during the frame execution time determination step, that time stamps associated with frames of frame sequences subsequent to the frame sequence currently being executed will reflect the termination and/or non-execution of frames from the frame sequence of the frame that is currently being executed, and

(b) during the frame transmission step, the transmission of the frames of the subsequent frame sequences to the at least one other device.

438. A method as defined in claim 437 in which the frame transmission step includes the step of inserting a command into the frame sequence to enable the at least one other device to not execute all frames in the frame sequence subsequent to the terminated and/or non-executed frame.

439. A method as defined in claim 435 in which the execution control command generation step include the step of enabling, in response to said predetermined event and during the frame transmission step, the insertion into the series of frames of a command to enable the at least one other device to control execution of a frame in relation to the frame's position in the series of frames.

440. A method as defined in claim 439 in which the execution control command generation step includes the step of, in response to said predetermined event and during the frame transmission step, the insertion into the series of frames of a command to enable the at least one other device to cancel execution of a frame in relation to the frame's position in the series of frames.

441. A method as defined in claim 439 in which the execution control command generation step includes the step of enabling, in response to said predetermined event and during the frame transmission step, the inserting into the series of frames of a command to enable the at least one other device to cancel execution of a previously-transmitted frame in relation to the frame's position in the series of frames.

442. A method as defined in claim 441 in which, the execution control command generation step includes the step of, in response to said predetermined event and during the frame transmission step, the insertion into the series of frames of a command to enable the at least one other device to cancel execution of a previously-transmitted frame, in relation to the frame's position in the series of frames, for which execution has not begun.

443. A method as defined in claim 439 in which the series of frames includes a series of frame sequences with each frame sequence including a sub-set of the series of frames, the execution control command generation step including the steps of, in response to said predetermined event,

(i) enabling, during the frame transmission step, the insertion, into the series of frames, of a command enabling the at least one other device to cancel execution of a frame sequence for which execution has not begun; and

(ii) enabling

  (a) during the frame execution time determination step, that time stamps associated with frames of frame sequences subsequent to the frame sequence whose execution was cancelled will reflect the cancellation, and

(b) during the frame transmission step, the transmission of the frames of the subsequent frame sequences to the at least one other device.

444. A method as defined in claim 382 in which the data source device is enabled to perform

A. a frame acquisition step of obtaining respective ones of the frames;

B. a frame execution time determination step of determining a time at which each respective frame is to be executed, and to associate the respective frame with a time stamp indicating its execution time;

C. a frame transmission step of transmitting the series of frames to said at least one other device; and

D. a data source device migration control step of, in response to a predetermined event, providing migration information to another device, the migration information including a source for information respecting the frames to be distributed, timing information relative to the clock maintained by the data source device and identifications of the member devices of the synchrony group.

445. A method as defined in claim 382 in which the data source device is enabled to perform the step of providing, associated with at least one frame, a time stamp indicating a frame execution time later than the time currently indicated by the clock maintained by the data source device.

446. A method as defined in claim 445 in which the data source device is enabled to perform the step of selecting the delay interval between the time indicated by the time stamp and the current time so to be sufficient to provide that the at least one frame distributed by the data source device can be executed by the member devices at the time indicated by the time stamp.

447. A method as defined in claim 446 in which the data source device is enabled to perform the step of selecting the delay interval between the time indicated by the time stamp and the current time so to be sufficient to provide that the at least one frame distributed by the data source device can be distributed to the member devices for execution at the time indicated by the time stamp.

448. A method as defined in claim 445 in which data source device is enabled to perform the step of obtaining information associated with the frames from at least two types of information sources, and selecting for each frame the delay interval between the time indicated by the time stamp and the current time based on the information source type that is associated with the respective frame.

449. A method of enabling a device to process a series of frames of data provided by a data source at times specified by the data source in relation to a clock maintained by the data source, the device comprising

A. an interface step of receiving the series of frames, each frame being associated with a time stamp, each time stamp indicating a time value relative to a time indicated a clock maintained by the data source, at which the device is to process the respective frame;

B. a current time retrieval step of obtaining, from the data source, a current time value as indicated by the data source's clock;

C. an processing time determination step of determining, from the time stamp associated with each respective frame and a time differential value representing a difference between the current time value obtained during the current time retrieval step and a current time value indicated by a clock maintained by the device, a time, relative to the device's respective clock, at which the frame is to be processed; and

D. a frame processing step of processing each respective frame at the time determined during the processing time determination step.

450. A method as defined in claim 449 in which at least one frame comprises audio data, each member device, while processing said at least one frame, generating a signal representing sound represented by the respective frame.

451. A method as defined in claim 449 further including a control step for controlling execution of commands received by said device.

452. A method as defined in claim 451 further comprising a buffer configured to buffer frames that the interface module has received until they are to be processed, the frame processing step including the step of processing the buffered frames at the times determined during the processing time determination step.

453 . A method as defined in claim 451 in which the each frame is associated with a track, each track including at least one frame, the interface module being further configured to receive playback control commands for controlling processing of tracks, the method including the step of enabling the control module to execute at least one playback control command controlling track processing.

454. A method as defined in claim 453 including the step of, in response to at least one type of playback control command, enabling the control module to, in turn, enable the frame processing module to terminate playback of a track that is currently being played back.

455. A method as defined in claim 454 including the step of, in response to the playback control command, enabling the control module to terminate playback of a track with a frame subsequent to a frame currently being played.

456. A method as defined in claim 452 including the step of, in response to the playback control command, enabling the control module to cancel playback of a track at least one of whose frames has been previously distributed, but for which playback has not begun.

457. A method as defined in claim 453 including the step of enabling the control module to enable the frame processing module to resume processing of at least one frame associated with a subsequent track at a time determined by the processing time determination module.

458. A method as defined in claim 449 including the step of enabling the control module to, in response to receipt of a command to become a member of a synchrony group, enable the interface module to receive frames for processing by the frame processing module.

459. A method as defined in claim 458 including the step of enabling the control module to, in response to receipt of a command to become a member of a synchrony group, enable the interface module to receive frames currently being transmitted using a selected multi-cast transmission methodology, and further to retrieve at least one previously distributed frame using a selected unicast transmission methodology.

460. A method as defined in claim 449 including the step of enabling the control module to, in receipt of a command to disengage from a synchrony group, disable the interface module from receiving frames and the frame processing module from processing previously received frames that have not yet been processed.

461. A method as defined in claim 449, further including the steps of receiving control information from a user interface module, and enabling the control module to enable selected operations to be performed in response to the control information.

462. A method as defined in claim 461 including the step of, in response to control information to enable another device to become a member of the device's synchrony group, enabling the control module to enable the interface module to transmit a command to the other device to enable the other device to become a member of the synchrony group.

463. A method as defined in claim 461 including the step of, in response to control information to enable another device that is a member of the device's synchrony group to disengage from the synchrony group, enabling the control module to enable transmission of a command to the other device to enable the other device to disengage from the synchrony group.

464. A method as defined in claim 461 including the step of, in response to control information to enable the data source to begin operating, enabling the control module to perform selected operations to enable the data source to begin operating.

465. A method as defined in claim 464, the device also operating as the data source, the method including a frame generator step of, under control of the control module, obtaining information from which the frames are to be generated and generating the frames.

466. A method as defined in claim 465 further comprising the step of transmitting the frames to at least one other device.

467. A method as defined in claim 465 in which the device is not the data source, the method including the step of enabling the control module to enable transmission of a command to enable the data source to operate.

468. A method as defined in claim 467 in which each frame is associated with a track, each track including at least one frame, and, in response to receipt of control information enabling processing of a track currently being processed to be terminated , the method including the step of enabling the control module to enable transmission of a command to enable the data source to insert a resynchronize command in the series of frames associated with the track to enable termination of processing of the track.

469. A method as defined in claim 467 in which each frame is associated with a track, each track including at least one frame, and, in response to receipt of control information enabling processing of a track at least a portion of which has been received, but for which processing has not begun, the method including the step of enabling the control module to enable transmission of a command to enable the data source to insert a resynchronize command in the series of commands to disable processing of the track.

470. A method as defined in claim 451 further including the step of enabling the control module to enable the user interface module interface module to transmit status information to the user interface module.

471. A method as defined in claim 470 in which the status information includes the processing status of at least one frame.

472. A method as defined in claim 469 in which the member device performs:

A. migration information receiving step of receiving migration information from the data source device, the migration information including a source for information respecting the frames to be distributed, timing information relative to the clock maintained by the data source device and identifications of the member devices of the synchrony group, and

B. a migration control step of, after the migration information has been received.,

i. distributing the series of frames to the synchrony group, each frame being associated with a time stamp indicating a time, relative to the timing information that it receives from the device operating as the data source device, at which the devices comprising the synchrony group are to execute the respective frame, and

ii. notifying the members of the synchrony group that it is to thereafter operate as the data source device.

473. A method as defined in claim 472 in which the information respecting the frames that are to be distributed is a source of streaming information, the migration control step includes the steps of, after the migration information has been received, assembling the streaming information into frames and associating each frame with a said time stamp.

474. A method as defined in claim 472 in which the information respecting the frames that are to be distributed is in a file identified in the migration information, the migration control step including the steps of obtaining information from the identified file, assembling the information into frames and associating each frame with a said time stamp.

475. A method as defined in claim 474 in which the information respecting the frames that are to be distributed begins at an offset, identified in the migration information, into the identified file, the migration control step including the step of assembling the information from a position in the file associated with the identified offset.

476. A method as defined in claim 474 in which the information respecting the frames that are to be distributed is in a series of files identified in the migration information, the migration control step including the steps of obtaining information from successive files in the series assemble the information into frames and associating each frame with as said time stamp.

477. A method as defined in claim 449 in which the member device is further enabled to perform a clock rate adjustment step including the step of adjusting the member device's clock rate in relation to a clock rate value maintained by the data source device's clock.

478. A method as defined in claim 477 in which the clock rate adjustment step includes the step of determining adjust the clock rate in relation to time stamps associated with respective ones of the frames received from the data source device.

479. A method of operating a device for distributing a series of frames for execution by at least one other device at respective execution times, the method comprising:

A. a frame acquisition step of obtaining respective ones of the frames;

B. a frame execution time determination step of determining a time at which each respective frame is to be executed, and to associate the respective frame with a time stamp indicating its execution time;

C. a frame transmission step of transmitting the series of frames to said at least one other device; and

D. an execution control command generation step of, in response to a predetermined event and during the frame transmission step, the insertion into the series of frames transmitted by the frame transmission module of a command to enable the at least one other device to modify the execution sequence of the frames transmitted thereto.

480. A method as defined in claim 479 in which at least one frame comprises audio data.

481. A method as defined in claim 479 in which the frame transmission step includes the step of utilizing a selected multi-cast transmission methodology.

482. A method as defined in claim 479 in which the predetermined event includes the step of receiving input indicia provided by an operator.

483. A method as defined in claim 482 in which the execution control command generation step includes the step of enabling, in response to said predetermined event and during the frame transmission step, the insertion into the series of frames of a command to enable the at least one other device to control execution of at least one frame in relation to the time the predetermined event occurs.

484. A method as defined in claim 483 in which, the execution control command generation step includes the step of enabling, in response to said predetermined event and during the frame transmission step, the insertion into the series of frames of a command to enable the at least one other device to terminate execution of a frame that it is currently executing and/or to not execute at least one frame that is to be executed subsequent to the predetermined event.

485. A method as defined in claim 482 in which the series of frames includes a series of frame sequences with each frame sequence including a sub-set of the series of frames, the execution control command generation step including the steps of, in response to said predetermined event,

(i) enabling during the frame transmission step the insertion, into the series of frames, of a command enabling the at least one other device to terminate execution of the currently executing frame and/or to not execute at least one subsequent frame, if any, in the frame sequence including the currently executing frame; and

(ii) enabling

(a) during the frame execution time determination step, that time stamps associated with frames of frame sequences subsequent to the frame sequence currently being executed will reflect the termination and/or non-execution of frames from the frame sequence of the frame that is currently being executed, and

(b) during the frame transmission step, the transmission of the frames of the subsequent frame sequences to the at least one other device.

486. A method as defined in claim 485 in which the frame transmission step includes the step of inserting a command into the frame sequence to enable the at least one other device to not execute all frames in the frame sequence subsequent to the terminated and/or non-executed frame.

487. A method as defined in claim 479 in which the execution control command generation step include the step of enabling, in response to said predetermined event and during the frame transmission step, the insertion into the series of frames of a command to enable the at least one other device to control execution of a frame in relation to the frame's position in the series of frames.

488. A method as defined in claim 487 in which the execution control command generation step includes the step of, in response to said predetermined event and during the frame transmission step, the insertion into the series of frames of a command to enable the at least one other device to cancel execution of a frame in relation to the frame's position in the series of frames.

489. A method as defined in claim 487 in which the execution control command generation step includes the step of enabling, in response to said predetermined event and during the frame transmission step, the inserting into the series of frames of a command to enable the at least one other device to cancel execution of a previously-transmitted frame in relation to the frame's position in the series of frames.

490. A method as defined in claim 489 in which, the execution control command generation step includes the step of, in response to said predetermined event and during the frame transmission step, the insertion into the series of frames of a command to enable the at least one other device to cancel execution of a previously-transmitted frame, in relation to the frame's position in the series of frames, for which execution has not begun.

491. A method as defined in claim 488 in which the series of frames includes a series of frame sequences with each frame sequence including a sub-set of the series of frames, the execution control command generation step including the steps of, in response to said predetermined event,

(i) enabling, during the frame transmission step, the insertion, into the series of frames, of a command enabling the at least one other device to cancel execution of a frame sequence for which execution has not begun; and

(ii) enabling

(a) during the frame execution time determination step, that time stamps associated with frames of frame sequences subsequent to the frame sequence whose execution was cancelled will reflect the cancellation, and

(b) during the frame transmission step, the transmission of the frames of the subsequent frame sequences to the at least one other device.

492. A method of operating a device for distributing a series of frames for execution by at least one other device at respective execution times, the method comprising:

A. a frame acquisition step of obtaining respective ones of the frames;

B. a frame execution time determination step of determining a time at which each respective frame is to be executed, and to associating the respective frame with a time stamp indicating its execution time, the frame execution time determination step including the step of providing, associated with at least one frame, a time stamp indicating a frame execution time later than the time currently indicated by a clock maintained by the data source device; and

C. a frame transmission step of transmitting the series of frames to said at least one other device.

493. A method as defined in claim 492 in which at least one frame comprises audio data.

494. A method as defined in claim 492 in which the frame execution time determination step includes the step of selecting the delay interval between the time indicated by the time stamp and the current time so to be sufficient to provide that the at least one frame distributed by the device can be executed by at least one other device at the time indicated by the time stamp.

495. A method as defined in claim 494 in which the frame execution time determination step includes the step of selecting the delay interval between the time indicated by the time stamp and the current time so to be sufficient to provide that the at least one frame distributed by the device can be distributed to other devices over a network for execution by the other devices at the time indicated by the time stamp.

496. A method as defined in claim 492 in which frame acquisition step includes the step of obtaining information associated with the frames from at least two types of information sources, the frame execution time determination step including the step of selecting, for each frame the delay interval

between the time indicated by the time stamp and the current time based on the information source type that is associated with the respective frame.

497. A method of operating a device for distributing a series of frames for execution by at least one other device, the method comprising:

A. a frame acquisition module configured to obtain respective ones of the frames;

B. a frame execution time determination module configured to determine a time at which each respective frame is to be executed, and to associate the respective frame with a time stamp indicating its execution time;

C. a frame transmission module configured to transmit the series of frames to said at least one other device; and

D. a data source device migration control module configured to, in response to a predetermined event, provide migration information to another device, the migration information including a source for information respecting the frames to be distributed, timing information relative to the clock maintained by the data source device and identifications of the member devices of the synchrony group.

498. A method as defined in claim 497 in which at least one frame comprises audio data.

499. A computer program product for use in connection with a computer to provide a device for processing a series of frames of data provided by a data source at times specified by the data source in relation to a clock maintained by the data source, the computer program product comprising a computer-readable medium having encoded thereon

A. an interface module configured to enable the computer to receive the series of frames, each frame being associated with a time stamp, each time stamp indicating a time value relative to a time indicated a clock maintained by the data source, at which the device is to process the respective frame;

B. a current time retrieval module configured to enable the computer to obtain, from the data source, a current time value as indicated by the data source's clock;

C. an processing time determination module configured to enable the computer to determine, from the time stamp associated with each respective frame and a time differential value representing a difference between the current time value obtained by the current time retrieval module and a current time value indicated by a clock maintained by the device, a time, relative to the device's respective clock, at which the frame is to be processed; and

D. a frame processing module configured to enable the computer to process each respective frame at the time determined by the processing time determination module.

500. A computer program product as defined in claim 499 in which at least one frame comprises audio data, the computer, while processing said frame, generating a signal representing sound represented by the respective frame.

501. A computer program product as defined in claim 499 further including a control module a control module for enabling said computer to control execution of commands received by the interface module.

502. A computer program product as defined in claim 501 further comprising a buffer configured to enable the computer to buffer frames that the interface module has received until they are to be processed, the frame processing module being configured to enable the computer to process the buffered frames at the times determined by the processing time determination module.

503. A computer program product as defined in claim 502 in which the each frame is associated with a track, each track including at least one frame, the interface module being further configured to enable the computer to receive playback control commands for controlling processing of tracks, the control module being configured to enable the computer to execute at least one playback control command controlling track processing.

504. A computer program product as defined in claim 503 in which at least one type of playback control command enables the control module to, in turn, enable the frame processing module to terminate playback of a track that is currently being played back.

505. A computer program product as defined in claim 504 in which the playback control command enables the control module to terminate playback of a track with a frame subsequent to a frame currently being played.

506. A computer program product as defined in claim 503 in which the playback control command enables the control module to cancel playback of a track at least one of whose frames has been previously distributed, but for which playback has not begun.

507. A computer program product as defined in claim 503 in which the control module is configured to enable the computer to enable the frame processing module to resume processing of at least one frame associated with a subsequent track at a time determined by the processing time determination module.

508. A computer program product as defined in claim 501, the control module being configured to enable the computer to, in response to receipt of a command to become a member of a synchrony group, enable the interface module to receive frames for processing by the frame processing module.

509. A computer program product as defined in claim 508 in which the control module is configured to enable the computer to, in response to receipt of a command to become a member of a synchrony group, enable the interface module to receive frames currently being transmitted using a selected multi-cast transmission methodology, and further to retrieve at least one previously distributed frame using a selected unicast transmission methodology.

510. A computer program product as defined in claim 501 in which the control module is configured to enable the computer to, in receipt of a command to disengage from a synchrony group, disable the interface module from receiving frames and the frame processing module from processing previously received frames that have not yet been processed.

511. A computer program product as defined in claim 501 further comprising a user interface module interface module configured to receive control information from a user interface module, the control module being configured to enable the computer to enable selected operations to be performed in response to the control information.

512. A computer program product as defined in claim 511 in which, in response to control information to enable another device to become a member of the device's synchrony group, the control module enables the interface module to transmit a command to the other device to enable the other device to become a member of the synchrony group.

513. A computer program product as defined in claim 511 in which, in response to control information to enable another device that is a member of the device's synchrony group to disengage from the synchrony group, the control module enables the interface module to transmit a command to the other device to enable the other device to disengage from the synchrony group.

514. A computer program product as defined in claim 511 in which, in response to control information to enable the data source to begin operating, the control module performs selected operations to enable the data source to begin operating.

515. A computer program product as defined in claim 514, the device also operating as the data source, the device including a frame generator module configured to enable the computer to, under control of the control module, obtain information from which the frames are to be generated and generate the frames.

516. A computer program product as defined in claim 515 in which the interface module is further configured to enable the computer to transmit the frames to at least one other device.

517. A computer program product as defined in claim 515 in which the device is not the data source, the control module being configured to enable the computer to enable the interface module to transmit a command to enable the data source to operate.

518. A computer program product as defined in claim 517 in which each frame is associated with a track, each track including at least one frame, and, in response to receipt of control information enabling processing of a track currently being processed to be terminated , the control module is configured to enable the computer to enable the interface module to transmit a command to enable the data source to insert a resynchronize command in the series of frames associated with the track to enable termination of processing of the track.

519. A computer program product as defined in claim 517 in which each frame is associated with a track, each track including at least one frame, and, in response to receipt of control information enabling processing of a track at least a portion of which has been received, but for which processing has not begun, the control module is configured to enable the computer to enable the interface module to transmit a command to enable the data source to insert a resynchronize command in the series of commands to disable processing of the track.

520. A computer program product as defined in claim 517 in which the control module is configured to enable the computer to enable the user interface module interface module to transmit status information to the user interface module.

521. A computer program product as defined in claim 520 in which the status information includes the processing status of at least one frame.

522. A computer program product as defined in claim 499 further including:

A. a migration information receiving module configured to enable the computer to receive migration information from the data source device, the migration information including a source for information respecting the frames to be distributed, timing information relative to the clock maintained by the data source device and identifications of the member devices of the synchrony group, and

B. a migration control module configured to enable the computer to, after the migration information has been received.,

   i. distribute the series of frames to the synchrony group, each frame being associated with a time stamp indicating a time, relative to the timing information that it receives

from the device operating as the data source device, at which the devices comprising the synchrony group are to execute the respective frame, and

ii. notify the members of the synchrony group that it is to thereafter operate as the data source device.

523. A computer program product as defined in claim 522 in which the information respecting the frames that are to be distributed is a source of streaming information, the migration control module being configured to enable the computer to, after the migration information has been received, assemble the streaming information into frames and associate each frame with a said time stamp.

524. A computer program product as defined in claim 522 in which the information respecting the frames that are to be distributed is in a file identified in the migration information, the migration control module being configured to enable the computer to obtain information from the identified file, assemble the information into frames and associate each frame with a said time stamp.

525. A computer program product as defined in claim 524 in which the information respecting the frames that are to be distributed begins at an offset, identified in the migration information, into the identified file, the migration control module being configured to enable the computer to assemble the information from a position in the file associated with the identified offset.

526. A computer program product as defined in claim 524 in which the information respecting the frames that are to be distributed is in a series of files identified in the migration information, the migration control module being configured to enable the computer to obtain information from successive files in the series assemble the information into frames and associate each frame with as said time stamp.

527. A computer program product as defined in claim 499 further including a clock rate adjustment module configured to enable the computer to adjust the member device's clock rate in relation to a clock rate value maintained by the data source device's clock.

528. A computer program product as defined in claim 527 in which the clock rate adjustment module is configured to enable the computer to adjust the clock rate in relation to time stamps associated with respective ones of the frames received from the data source device.

529. A computer program product for use in connection with a computer to provide a data source device for distributing a series of frames for execution by at least one other device at respective execution times, the computer program product comprising a computer readable medium having encoded thereon:

A. a frame acquisition module configured to enable the computer to obtain respective ones of the frames;

B. a frame execution time determination module configured to enable the computer to determine a time at which each respective frame is to be executed, and to associate the respective frame with a time stamp indicating its execution time;

C. a frame transmission module configured to enable the computer to transmit the series of frames to said at least one other device; and

D. an execution control command generation module configured to enable the computer to , in response to a predetermined event, enable the frame transmission module to insert into the series of frames transmitted by the frame transmission module a command to enable the at least one other device to modify the execution sequence of the frames transmitted thereto.

530. A computer program product as defined in claim 529 in which at least one frame comprises audio data.

531. A computer program product as defined in claim 529 in which the frame transmission module is configured to enable the computer to utilize a selected multi-cast transmission methodology.

532. A computer program product as defined in claim 529 in which the predetermined event comprises input indicia provided by an operator.

533. A computer program product as defined in claim 529 in which, in response to said predetermined event, the execution control command generation module is configured to enable the computer to enable the frame transmission module to insert into the series of frames transmitted by the frame transmission module a command to enable the at least one other device to control execution of at least one frame in relation to the time the predetermined event occurs.

534. A computer program product as defined in claim 533 in which, in response to said predetermined event, the execution control command generation module is configured to enable the computer to enable the frame transmission module to insert into the series of frames transmitted by the frame transmission module a command to enable the at least one other device to terminate execution of a frame that it is currently executing and/or to not execute at least one frame that is to be executed subsequent to the predetermined event.

535. A computer program product as defined in claim 533 in which the series of frames includes a series of frame sequences with each frame sequence including a sub-set of the series of frames, the execution control command generation module being configured to enable the computer to , in response to said predetermined event,

(i) enable the frame transmission module to insert into the series of frames transmitted by the frame transmission module, a command enabling the at least one other device to terminate execution of the currently executing frame and/or to not execute at least one subsequent frame, if any, in the frame sequence including the currently executing frame; and

(ii) enable

(a) the frame execution time determination module to provide that time stamps associated with frames of frame sequences subsequent to the frame sequence currently being executed will reflect the termination and/or non-execution of frames from the frame sequence of the frame that is currently being executed, and

(b) the frame transmission module to transmit the frames of the subsequent frame sequences to the at least one other device.

536. A computer program product as defined in claim 535 in which the frame transmission module is configured to enable the computer to insert a command to enable the at least one other device to not execute all frames in the frame sequence subsequent to the terminated and/or non-executed frame.

537. A computer program product as defined in claim 529 in which, in response to said predetermined event, the execution control command generation module is configured to enable the computer to enable the frame transmission module to insert into the series of frames transmitted by the frame transmission module a command to enable the at least one other device to control execution of a frame in relation to the frame's position in the series of frames.

538. A computer program product as defined in claim 537 in which, in response to said predetermined event, the execution control command generation module is configured to enable the computer to enable the frame transmission module to insert into the series of frames transmitted by the frame transmission module a command to enable the at least one other device to cancel execution of a frame in relation to the frame's position in the series of frames.

539. A computer program product as defined in claim 537 in which, in response to said predetermined event, the execution control command generation module is configured to enable the computer to enable the frame transmission module to insert into the series of frames transmitted by the frame transmission module a command to enable the at least one other device to cancel execution of a previously-transmitted frame in relation to the frame's position in the series of frames.

540. A computer program product as defined in claim 539 in which, in response to said predetermined event, the execution control command generation module is configured to enable the

computer to enable the frame transmission module to insert into the series of frames transmitted by the frame transmission module a command to enable the at least one other device to cancel execution of a previously-transmitted frame, in relation to the frame's position in the series of frames, for which execution has not begun.

541. A computer program product as defined in claim 537 in which the series of frames includes a series of frame sequences with each frame sequence including a sub-set of the series of frames, the execution control command generation module being configured to enable the computer to , in response to said predetermined event,

(i) enable the frame transmission module to insert into the series of frames transmitted by the frame transmission module, a command enabling the at least one other device to cancel execution of a frame sequence for which execution has not begun; and

(ii) enable

(a) the frame execution time determination module to provide that time stamps associated with frames of frame sequences subsequent to the frame sequence whose execution was cancelled will reflect the cancellation, and

(b) the frame transmission module to transmit the frames of the subsequent frame sequences to the at least one other device.

542. A computer program product for use in connection with a computer to provide a data source device for distributing a series of frames for execution by at least one other device at respective execution times, the computer program product comprising a computer readable medium having encoded thereon:

A. a frame acquisition module configured to enable the computer to obtain respective ones of the frames;

B. a frame execution time determination module configured to enable the computer to determine a time at which each respective frame is to be executed, and to associate the respective frame with a time stamp indicating its execution time, the frame execution time determination module being configured to enable the computer to provide, associated with at least one frame, a time stamp indicating a frame execution time later than the time currently indicated by a clock maintained by the data source device; and

C. a frame transmission module configured to enable the computer to transmit the series of frames to said at least one other device.

543. A computer program product as defined in claim 542 in which the data is audio data.

544. A computer program product as defined in claim 542 in which the frame execution time determination module is configured to enable the computer to select the delay interval between the time indicated by the time stamp and the current time so to be sufficient to provide that the at least one frame distributed by the data source device can be executed by the member devices at the time indicated by the time stamp.

545. A computer program product as defined in claim 544 in which the frame execution time determination module is configured to enable the computer to select the delay interval between the time indicated by the time stamp and the current time so to be sufficient to provide that the at least one frame distributed by the data source device can be distributed to the member devices for execution at the time indicated by the time stamp.

546. A computer program product as defined in claim 542 in which frame acquisition module is configured to enable the computer to obtain information associated with the frames from at least two types of information sources, the frame execution time determination module being configured to enable the computer to select, for each frame the delay interval between the time indicated by the time stamp and the current time based on the information source type that is associated with the respective frame.

547. A computer program product for use in connection with a computer to provide a data source device for distributing a series of frames for execution by at least one other device, the computer program product comprising a computer readable medium having encoded thereon:

A. a frame acquisition module configured to enable the computer to obtain respective ones of the frames;

B. a frame execution time determination module configured to enable the computer to determine a time at which each respective frame is to be executed, and to associate the respective frame with a time stamp indicating its execution time;

C. a frame transmission module configured to enable the computer to transmit the series of frames to said at least one other device; and

D. a data source device migration control module configured to enable the computer to, in response to a predetermined event, provide migration information to another device, the migration information including a source for information respecting the frames to be distributed, timing information relative to the clock maintained by the data source device and identifications of the member devices of the synchrony group.

548. A computer program product as defined in claim 547 in which the data is audio data.

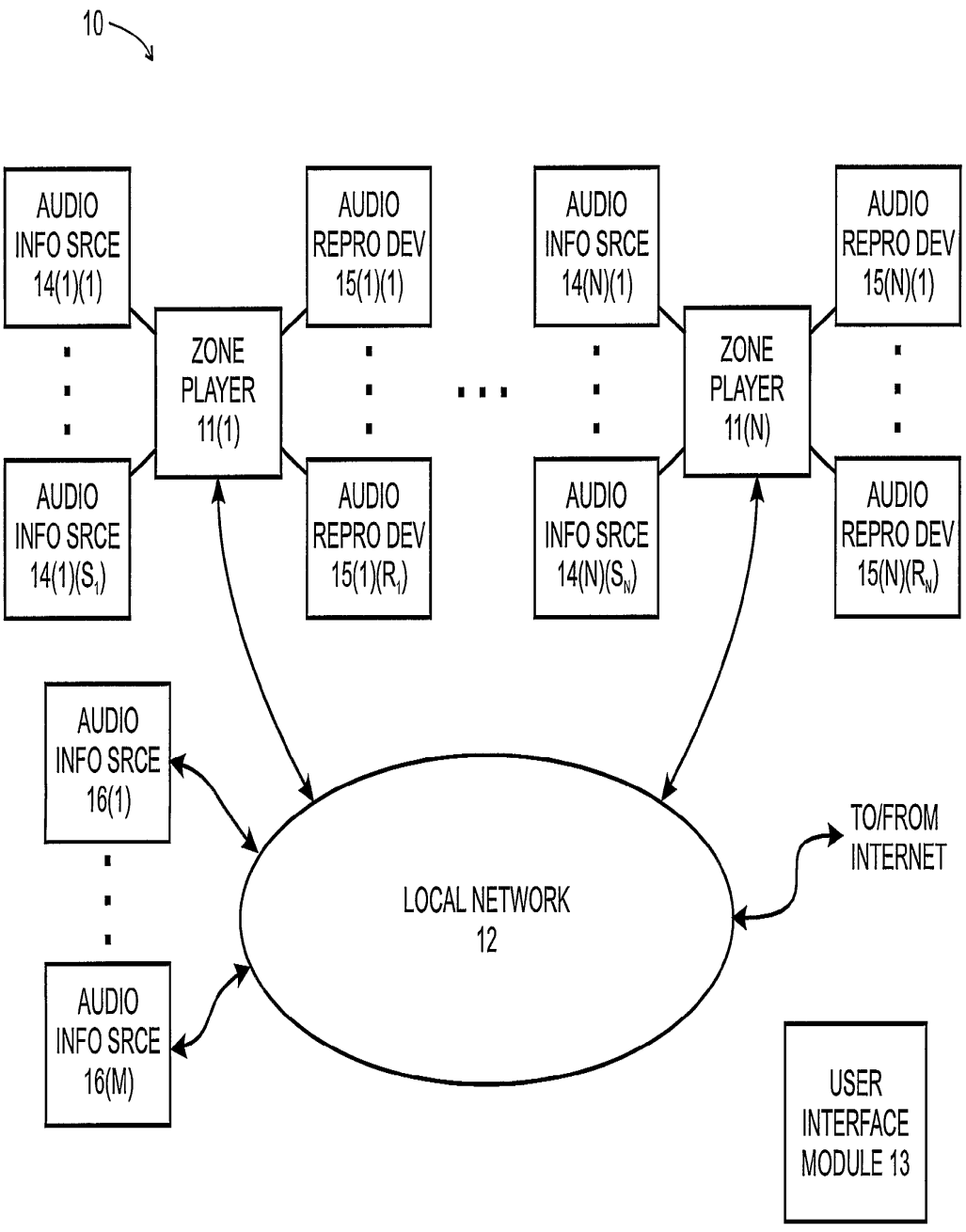

10
AUDIO INFO SRCE 14(1)(1)
AUDIO INFO SRCE 14(1)(S1)
ZONE PLAYER 11(1)
AUDIO REPRO DEV 15(1)(1)
AUDIO REPRO DEV 15(1)(R1)
AUDIO INFO SRCE 14(N)(1)
AUDIO INFO SRCE 14(N)(SN)
ZONE PLAYER 11(N)
AUDIO REPRO DEV 15(N)(1)
AUDIO REPRO DEV 15(N)(RN)
AUDIO INFO SRCE 16(1)
AUDIO INFO SRCE 16(M)
LOCAL NETWORK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

FIG. 1

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

FIG. 2

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

FIG. 2A

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

FIG. 3

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

FIG. 4

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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : G06F 17/30 | A1

(11) International Publication Number: **WO 95/25313**

(43) International Publication Date: 21 September 1995 (21.09.95)

(21) International Application Number: PCT/EP94/00833

(22) International Filing Date: 16 March 1994 (16.03.94)

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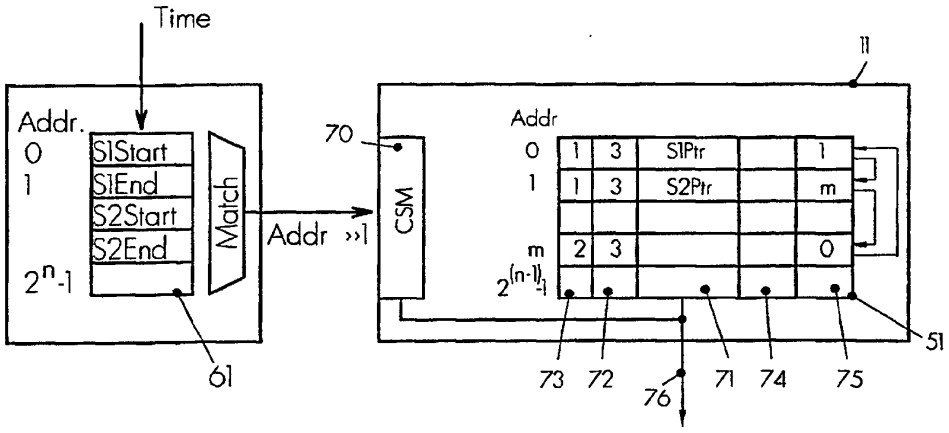
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(81) Designated States: JP, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: METHOD AND APPARATUS FOR SYNCHRONIZATION AND SCHEDULING OF MULTIPLE DATA STREAMS AND REAL TIME TASKS



(57) Abstract

The present application concerns a method and an apparatus for the synchronization and the scheduling of multiple data streams and real time tasks. In accordance with the present invention, pointers pointing to the information streams to be synchronized and processed are kept in the table (51) of a selector (11). The time marks (S1Start etc.) of said information streams are stored in a table (61) of a timer. The system time is checked against said time marks and if a time mark has been reached, the table (51) of said selector (11) is updated. If the status of an information stream is such that its trigger condition is fulfilled, the pointer to said information stream is made available at the output of the selector (11). This pointer is then used to retrieve the respective information stream and to forward it to a playout device.

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DESCRIPTION

Method and Apparatus for Synchronization and Scheduling of Multiple Data Streams and Real Time Tasks

TECHNICAL FIELD

The present invention concerns a method and apparatus for the synchronization and the scheduling of multiple data streams as well as for the scheduling of tasks in operating systems with hard real-time requirements.

BACKGROUND OF THE INVENTION

Multimedia information is composed of several objects that constitute a document. These objects could be of different data types, such as text, still images, video, and sound. In order for these objects to be meaningful to a user, there must be a logical and temporal structure of the objects constituting the documents' contents. To ensure this logical and temporal structure, e.g. when displaying a video sequence on a display device and providing a soundtrack for this video sequence via an adapter card to a speaker, the respective data streams have to be synchronized and scheduled before being sent to the output devices. The same principle applies to other related multimedia information which has to be synchronized in communicating with other devices or users (e.g. teleconferencing), before processing and presentation.

Synchronization and scheduling is a critical task for a wide spectrum of applications ranging from computer-integrated telephony, text with voice annotations, any kind of multi media systems, and interactive services (e.g. interactive television) to cooperative teleworking on documents including

foils and video, and distributed games. A further application, where information streams have to be synchronized, is known as medical imaging, for which high-resolution images must be distributed reliably and fast throughout a hospital.

To date, the synchronization is typically performed in software. However, if the scheduling intervals are too short, or if too many information streams must be synchronized, a software solution, which is very CPU intensive, is often the limiting factor as far as processing speed is concerned.

In real-time systems time-critical tasks have to be scheduled reliably and fast. In the present context, any system in which the time at which an output is produced is significant, is referred to as real-time system. The lag from the input time of a real-time system to its output time, i.e. the delay, must be sufficiently small for acceptable timeliness. With other words, a real-time system has to respond to an externally-generated input stimuli within a finite and specified period. In hard real-time systems, i.e. in those systems where it is absolutely imperative that responses occur within a specified deadline, scheduling of time-critical tasks is of particular interest. However, the present invention is not limited to hard real-time systems. It might be used in soft real-time systems, too. Such a soft real-time system would still function correctly if deadlines are occasionally missed, and a hardware solution in accordance with the present invention might be to costly under certain circumstances.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a method and apparatus for off-loading the synchronization of multiple information streams from the processor of the system handling these information streams.

It is an object of the present invention to provide a method and apparatus for fast and reliable synchronization and scheduling of multiple information streams.

It is another object of the present invention to provide a method and apparatus for scheduling tasks or processes in real-time systems.

The above objects have been accomplished by handling pointers pointing to the information streams to be synchronized and by maintaining a table with status information of each information stream. The time marks of said information streams are stored in a table and the system time is checked against said time marks. If a time mark has been reached the status information of the respective information stream is updated. If the status of an information stream is such that its trigger condition is fulfilled, the pointer to said information stream is made available for playout of this information stream.

DESCRIPTION OF THE DRAWINGS AND NOTATIONS USED

The invention is described in detail below with reference to the following drawings:

FIG. 1 shows a system, in accordance with the present invention, for playout of two information streams.

FIG. 2 illustrates the synchronization of multiple data streams.

FIG. 3 illustrates the synchronization and play out of two data streams when the respective trigger condition is fulfilled.

FIG. 4 illustrates how a priority value might be increased with advancing time.

FIG. 5 shows the two core components of an apparatus for synchronization and scheduling of data streams and real time tasks, in accordance with the present invention.

FIG. 6A shows a first exemplary embodiment of the timer.

FIG. 6B shows a second exemplary embodiment of the timer.

FIG. 7 shows an embodiment of the timer and selector, in accordance with the present invention.

FIG. 8 shows an example of an 8-bit timer where every second bit is used.

GENERAL DESCRIPTION

In multimedia systems multiple data streams must be synchronized and scheduled for playout to, for example, a speaker 15 and a video display 14, as illustrated in Figure 1. The synchronization of multiple data streams is illustrated in Figure 2. The three streams are synchronized at so-called synchronization points (SyncPoint) 22. A stream may be synchronized to one or multiple other streams or to time stamps 23 defined by an external clock. This synchronization is typically performed in software, as mentioned in the introductory portion of the present description. In the following, a mechanism is presented which performs synchronization and output scheduling of multiple data streams in hardware without central processing unit (CPU) interaction. The same mechanism can also be used for scheduling tasks in real-time systems.

A data stream is a sequence of data units. In Figure 3, the synchronization of two data units is illustrated. The SyncPoints are translated to time marks relative to the system which processes the received data streams. The SyncPoints might be translated to time marks by means of a clock or counter of said system. In the example given in Figure 3, a data unit from stream 1 cannot be played out before a time mark 30 (S1Start) and it must be played out before a time mark 31 (S1End). The same applies to the second data stream (stream 2). As illustrated in Figure 3, at least two different states (WAIT, READY) can be associated with a data stream. Before SxStart of a data stream x has been reached, the respective data unit is in the WAIT state. After SxStart and before SxEnd it is in the READY state. It is conceivable to assign further states, such as a DELAYED state, to these data streams. The DELAYED state might be associated to a data unit after SxEnd.

In order to be able to synchronize two data units for playout, trigger conditions are defined in accordance with the present invention. A typical trigger condition might be:

IF both data units are in the READY state
THEN they can be played out.

The trigger conditions are checked and as soon as the condition is fulfilled, the data units are played out. This concept is schematically illustrated in Figure 3, where means for checking the trigger condition 32 are shown.

In general, two or more date units can be related in time by trigger conditions, which can be an arbitrary logical combination of the different states of the respective data units. Fulfilling a given trigger condition then initiates the appropriate operation on the units.

The synchronization can be further enhanced with a priority value P to distinguish between data units (or tasks) which fulfill a trigger condition to select an older or more important stream (or task). This, for example, allows to prioritize streams that should not be delayed, whereas other data streams might be delayed. In Figure 4 an example is shown how the priority value P of a data unit (or task) can be increased in time. In this example, three different states (WAIT, READY, DELAYED) are associated with the data stream. The priority value P might also be increased or decreased by interaction of a processor or upon receipt of a feedback signal of a playout device.

A first embodiment of the present invention is schematically illustrated in Figure 1. According to this example, two data streams are received by means 18 for extraction of time marks. The first data stream originates from a storage disk 16, whereas the second data stream is sent via a network 17 to said means 18 for extraction of time marks. After extraction of the time marks, the data units of the two data streams are stored in buffers 19 and 20, and the respective time marks are provided to a timer 10. The buffer addresses are forwarded to a selector 11. In addition, a system clock or counter 13 is connected to said timer 10, and a processor, e.g. a CPU, might

be linked to the timer 10 and selector 11. Two playout devices, a display unit 14 and a loudspeaker 15, are connected via an interfacial playout device to the buffers 19 and 20.

The two core components of the present invention are the timer 10 and the selector 11. Their operation is described in connection with Figure 5.

The timer 10 holds a table 50 with entries concerning the time marks of each data unit received and stored in a buffer. These time marks are relative to a time signal either being generated by a system clock 13 or a counter. Each time mark reached is then output to the selector 11. The table 50 is written by an external processor. The selector comprises a table 51 where for each data unit in a buffer a pointer to said data unit, i.e. the respective buffer address, the state of said data unit, and the trigger condition are held. Data units to be synchronized are linked into a circular list via their table entries. For each time mark received from the timer 10, the sector 11 updates the status field of the concerned data unit and then checks the trigger condition of all data units to be synchronized with said data unit. Once the trigger condition is fulfilled, the pointer to the data unit (or units) is made available at the output of selector 11. The output of the pointer then triggers retrieval and playout of the data unit by means of the playout device 21. Table 51 of the selector 11 might be maintained and updated by an external processor, e.g. CPU 12.

The timer 10 reads the current system time and returns the address of a unit pointer in the selector 11. This function can be provided in several ways. First, a solution based on a content addressable memory (CAM) is presented which is suitable for a high resolution timer but relatively expensive. The second solution is less expensive and is suitable for lower resolution timers and for implementing timer priority as described below. The two solutions are shown in Figures 6A and 6B, respectively.

The CAM timer 60 is illustrated in Figure 6A. It comprises a CAM 61. The start and end time mark for each data unit to be scheduled are written into consecutive addresses of the CAM 61. The addresses then differ only in the least significant bit. Thus, for a CAM of 2^n addresses, n-1 bits determine the address of the scheduling unit pointer in the selector table 51. The width of a CAM entry is determined by the resolution of the time signal received at input 62. For a 32-bit time signal also a 32-bit wide CAM 61 is required.

For lower time resolution a timer 63 with counter 64, as shown in Figure 6B, might be employed. In this case the difference between the current time and the time mark is calculated and its two's complement is written to the timer table 65. The counter 64 increments each entry for each time tick at input 66. If the carry bit of an entry becomes set, its address is shifted right by one bit and output to the selector 11. As the counter 64 continues to increment the entries, the content of the entry (with its carry bit = 1) can then be used to reflect the time passed since reaching the start and/or end time. The counter value thus describes a time based priority. With this counter value a priority value P might be generated. The width of a timer entry can range from 8 to 32 bits depending on the timer resolution and the required timer differences. A free flag 67 might be provided in order to mark free table entries in table 65. This flag 67 is used by the counter to determine which entries it must increment.

For both schemes, a FIFO can hold free timer table entries to reduce the management load of the external processor. The processor gets a free entry from the FIFO and writes delayed entries, or entries which are freed, to the FIFO. The selector might directly write delayed entries to this FIFO.

It is obvious that the present invention is not limited to the above two implementations of timers since other timers are conceivable which are well suited, too.

The selector 11 comprises a table 51 and a comparator state machine (CSM) 70. The table 51 has $2^{(n-1)}$ entries (rows or columns). The exemplary implementation of the selector 11, given in Figure 7, shows a table 51 with $2^{(n-1)}$ rows. Each row has a pointer field 71 holding the pointer, i.e. the buffer address S1Ptr, to the data unit to be scheduled, a p-bit wide priority field 72, a k-bit wide status field 73, a 2-bit wide trigger field 74, and an (n-1)-bit wide synchronization field 75. The width of said status field 73 depends on the number of different states. In case of three different state (WAIT, READY, DELAYED) the status field 73 is 2-bits wide. The synchronization field 75 holds a pointer linking all those entries with which a data unit must be synchronized into a circular list. This circular list is schematically illustrated by means of arrows on the right hand side of table 51. The CSM 70 receives the address of a unit pointer from the timer 10 and updates the state of the status field 73 in this row. The CSM 70 then follows the linked list of synchronizations entries and computes whether the trigger condition is fulfilled by comparing the status fields 73 with the trigger fields 74. The trigger condition might also be checked by means of simple logical elements such as AND-gates, OR-gates etc.

In the following, it is assumed, without loss of generality, that the trigger condition is fulfilled when all entries in the respective trigger fields 74 are in the READY state. In this case, the trigger state fields are redundant and might be omitted.

Once all the entries linked by the synchronization field 75 are READY, the CSM 70 outputs the entries according to their priorities, if any. With $p=4$, 16 priority classes can be distinguished. The width w of the scheduling unit pointer is determined by the memory (buffer) architecture of the system. The width s of the synchronization field 75 is determined by the size of the selector table 51, with $s=n-1$.

In Figure 7 the problem shown in 3 is elaborated. The time marks 30 (S1Start) and 31 (S1End) of data unit S1 are written to the addresses 0 and 1

of the CAM 61. The address of the pointer to the data unit S1 is the CAM address shifted right by one bit. An external processor 12 writes the time marks to the timer table, i.e. the CAM 61 and the entries to the selector table 51. For a data unit to be scheduled which requires priority, the priority field 72 is set. In this example a 4-bit wide priority field 72 is used. For each time mark reached, the state, reflected by the status field 73, is updated. If the state is READY, the CSM 70 reads the synchronization field 75 and follows the linked list to determine whether the state of all other entries fulfills the trigger condition. If the trigger condition is reached, the unit pointer with the highest priority is made available at output 76 first. If multiple units have the same priority, or in case that no priority fields are provided, the unit pointers might either be output in parallel or in a consecutive manner, e.g. by order of their position in the selector table 51. It is obvious that the priority fields 72 can be omitted, too.

In many systems, multimedia as well as real-time, the scheduling of actions, data streams, tasks, processes, or the playout of data units is determined by a priority which increases with time. If a counter timer, as illustrated in Figure 6B, is used as the timer component 10, the entry in the timer table 65 also describes its priority. This priority can be used in the priority field 72 of the selector 11 to achieve time dependent scheduling. The four most significant bits of the timer entry are used to distinguish again 16 priorities. A different set of bits might be used if the priority must increase non-linearly. Figure 8 shows an example of an 8-bit timer where every second bit is used to get a priority mechanism that maps the 256 timer values to 16 non-linear priority values P.

According to the present invention, a synchronization point (SyncPoint) is set up by writing the time marks to the free entries in the timer table and setting up the associated entries in the selector table. For each stream this takes one write operation to the timer and to the selector table, plus the operations to set up the selector table entry. The actual scheduling takes place in hardware without any further intervention of an external processor.

For a solution in software a similar number of setup operations would be necessary but the search in a list of timers would take much longer. Typically timers involve interrupt processing which is very time consuming in particular in modern RISC processors with a large register file and instruction pipeline. In the present invention these operations are avoided and implemented in hardware. Additionally, the present invention can handle timers with much finer granularity than any software solution.

The present invention, which has been described by means of a multimedia related example, can be used in various multimedia communication subsystems, e.g. for multimedia multiparty teleconferencing, or multimedia protocol adapters. In ST-II and RTP protocol systems, for example, a playout time stamp can be extracted from the protocol header and used in the present scheduler (ST-II is the second version of an experimental Internet stream protocol, and RTP is a transport protocol for real-time applications). The present invention might also be used in multimedia bus systems which provide a time signal. Data units to be triggered at a specified time are written to the scheduler and the multimedia bus provides the timer input to the timer unit. The invention can also be used in a multimedia adapter such as the IBM ActionMedia II adapter (see IBM ActionMedia II Technical Reference, IBM 04G5144, 2nd Edition, June 1992, Mechanicsburg), or the MWave System (see "MWave Multimedia System", Technical Brief, Texas Instruments, 1992) to synchronize multiple data streams. The term ActionMedia is a trademark of the Intel Corporation and MWave is a trademark of the IBM Corporation.

As already mentioned in the introduction, the present invention might also be used in real-time systems for the scheduling of time-critical tasks or processes. For these kind of application there is no synchronization field in the table of the selector required. The CSM selects from the selector table the entry with the highest priority. The scheduling unit pointer, i.e. a pointer pointing to a task control block or to executable code, is then output. The timer priority mechanism described above can be used to implement

scheduling policies with an explicit deadline, e.g. the earliest-deadline-first or least-slack time scheduling algorithm as disclosed in the book "Real-Time Systems and their Programming Languages", by A. Burns and A. Wellings, Addison-Wesley Publishing Company, International Computer Science Series, 1990. An external processor calculates the difference to the time marks and writes it to the timer table. The entries are then used to derive the priority of a job.

CLAIMS

1. Apparatus for synchronization of at least two information streams which comprises:
   a) a timer (10) for holding a first table (50) with time marks for each one of said information streams, and for making each time mark reached available at the timer output,
   b) a selector (11) for holding a second table (51) with
      - pointer fields (71) carrying pointers to each of said information streams,
      - status fields (73) carrying information concerning the status of each of said information streams, the status field of an information stream being updated each time a time mark of said information stream is reached and made available at said timer output,
   c) means for checking whether a trigger condition of an information stream is fulfilled by watching the corresponding status field, and
   d) means for making the pointer to an information stream whose trigger condition is fulfilled available for playout of said information stream.

2. The apparatus of claim 1, wherein said second table (50) further comprises:
   - trigger fields (74) carrying information concerning the trigger conditions of each of said information streams.

3. The apparatus of claims 1 or 2, wherein said second table (51) further comprises:
   - synchronization fields (74) carrying, by means of a linked list, entries concerning information streams to be played out in a certain relationship to each other.

4. The apparatus of claims 1, 2, or 3, wherein said second table (51) further comprises:
   - priority fields (72) carrying priority values (P) such that the information stream with highest priority is played out first if the respective trigger condition has been fulfilled.

5. The apparatus of claim 4, further comprising means for increasing said priority values (P) with advancing time.

6. The apparatus of any of the preceding claims, further comprising:
   - means (18) for extracting said time marks from incoming information streams,
   - buffer means (19, 20) for storing said information streams,
   - playout means (21) for retrieval of said information streams stored in said buffer means (19, 20) and for playout to the respective playout devices (14, 15).

7. A multimedia system comprising an apparatus in accordance with any of the preceding claims.

8. Apparatus for scheduling at least two real time tasks or two processes which comprises:
   a) a timer (10) for holding a first table (50) with time marks for each one of said tasks or processes, and for making each time mark reached available at the timer output,
   b) a selector (11) for holding a second table (51) with
      - pointer fields (71) carrying pointers to task control blocks or executable code,
      - means for making a pointer to a task control block or an executable code available at an output of said selector each time a time mark of said task or process is reached in said timer.

9. The apparatus of claim 8, wherein the pointer to a task or process with highest priority is made available first.

10. Method for synchronization of at least two information streams, characterized by the following steps:
    a) checking whether a time mark of one of said information streams has been reached,
    b) updating the status information of said information stream whose time mark has been reached,
    c) determining whether the trigger condition of said information stream is fulfilled by watching said status information, and
    d) providing a pointer to said information stream for further processing if the trigger condition of said information stream is fulfilled.

11. The method of claim 10, wherein the playout of information streams, which have to be played out in a predefined relationship to each other, is scheduled by means of a linked list being organized such that each time when a status information of one of said information streams is updated, the status information of the other information streams are checked, and said information streams played out when all trigger conditions are fulfilled.

12. The method of claim 10, wherein a priority value (P) is assigned to each of said information streams, the information streams with highest priority being played out first.

13. The method of claim 12, wherein the priority value (P) of an information stream is increased with advancing time.

14. The method of claim 10, further comprising the following steps:
    - extracting and/or synchronizing the time marks of said information streams,
    - storing said information streams in buffers,

- making the addresses of said buffers available as pointers for later retrieval of said information streams,

15. The method of claim 14, wherein said information stream is retrieved from said buffer by means of said pointer, prior to being send to a playout device.

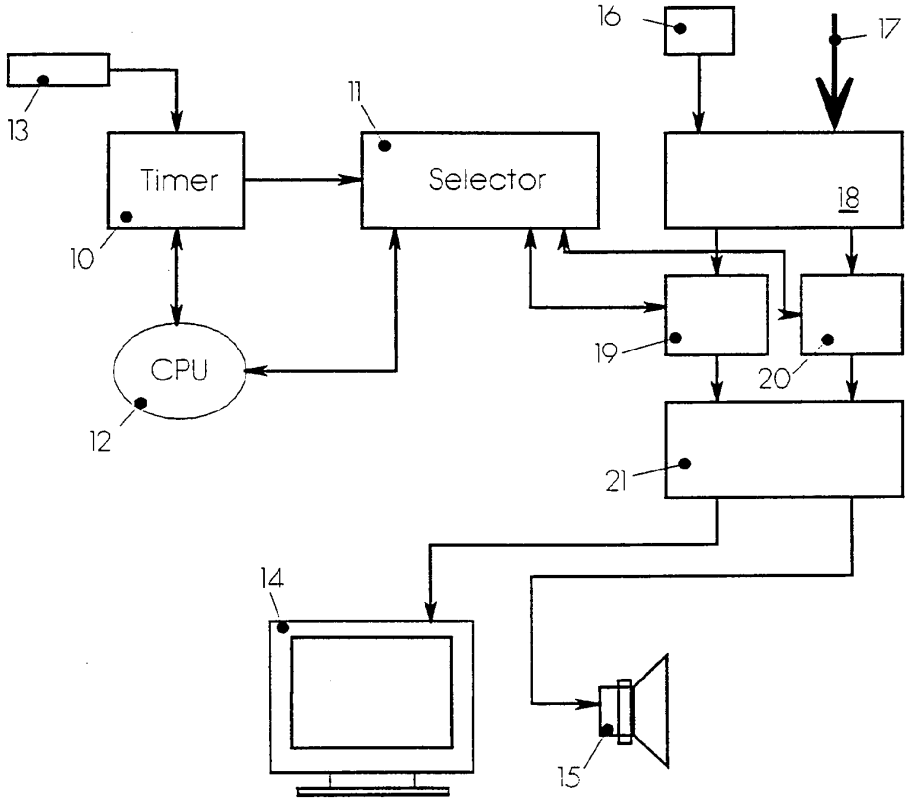

16
17
13
11
Timer
Selector
18
10
CPU
19
20
12
21
14
15

FIG. 1

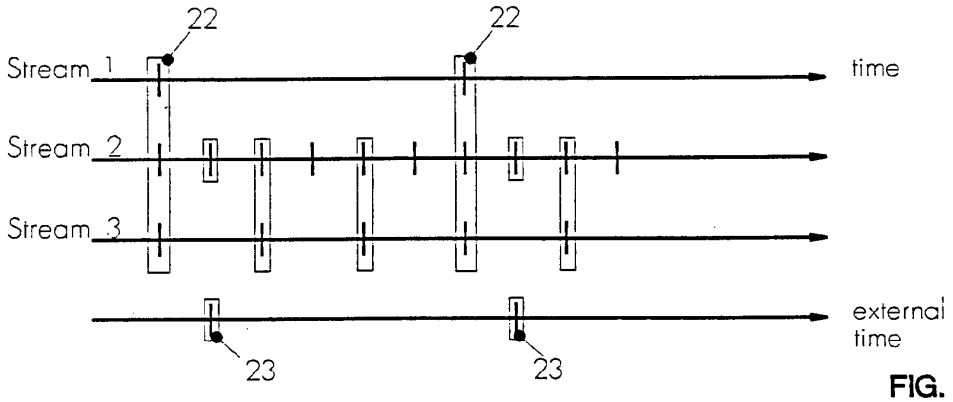

22
22
Stream 1
time
Stream 2
Stream 3
external time
23
23

FIG. 2

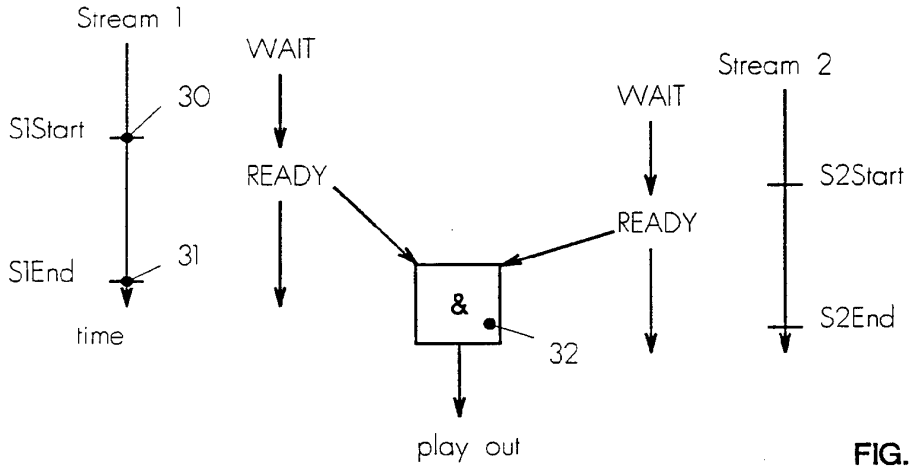


FIG. 3

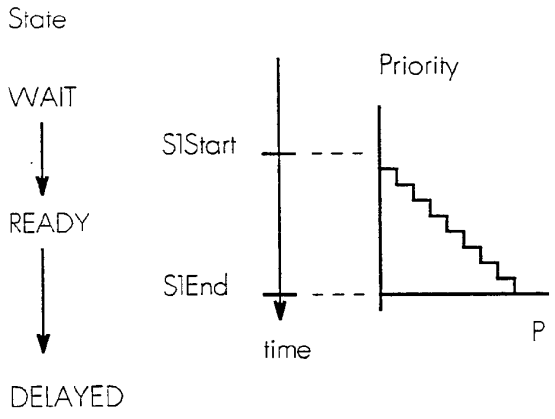


FIG. 4

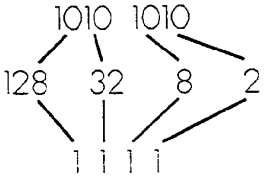


FIG. 8

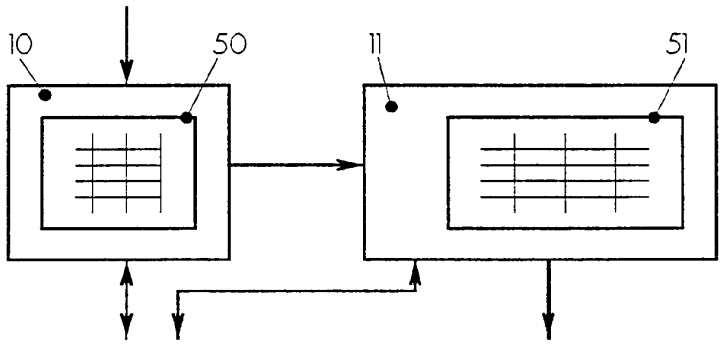


FIG. 5

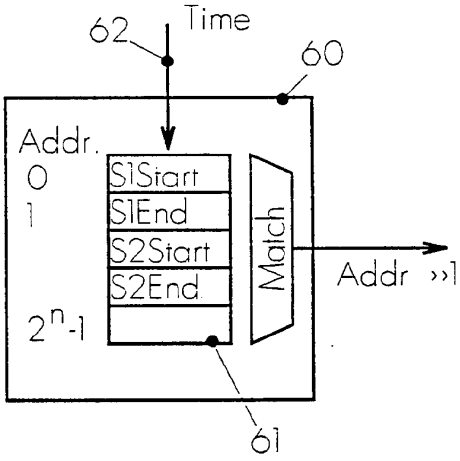


FIG. 6A

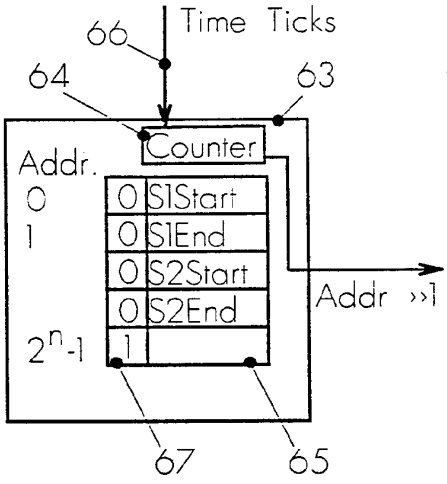


FIG. 6B

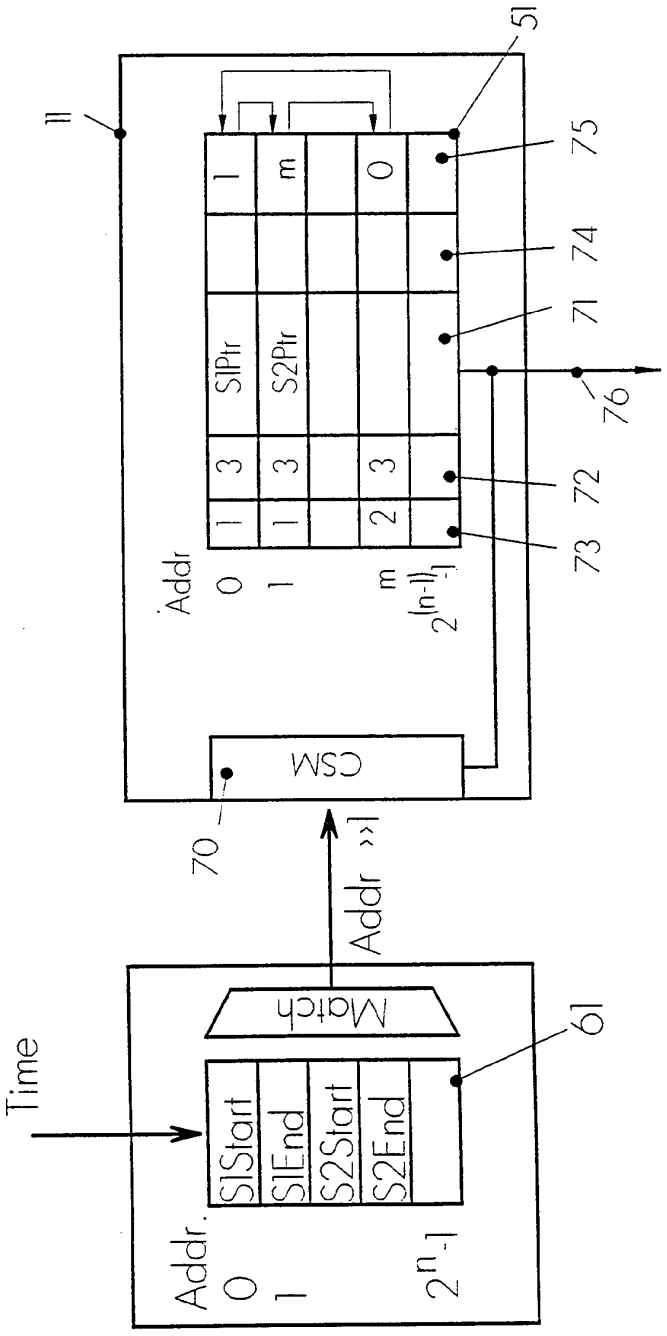

11
51
75
74
71
76
72
73
S1Ptr
S2Ptr
1
m
0
3
2
Addr
0
1
m
$2^{(n-l)}-1$
CSM
70
Addr >>l
Match
61
Time
S1Start
S1End
S2Start
S2End
Addr.
0
1
$2^{n}-1$

FIG. 7

INTERNATIONAL SEARCH REPORT

Intern ..al Application No
PCT/EP 94/00833

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G06F17/30

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G06F

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP,A,0 239 884 (I.B.M. CORPORATION) 7 October 1987 see the whole document ---	1,8,10
A	EP,A,0 550 197 (I.B.M. CORPORATION) 7 July 1993 see the whole document ---	1,8,10
A	COMPUTER COMMUNICATIONS, vol.16, no.3, March 1993, GUILDFORD GB pages 168 - 176 P.V. RANGAN ET AL. 'Techniques for multimedia synchronization in network file systems' see the whole document --- -/--	1,8,10

[X] Further documents are listed in the continuation of box C.

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Date of the actual completion of the international search	Date of mailing of the international search report
10 November 1994	01.12.94

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	COMPUTER, vol.24, no.10, October 1991, LONG BEACH US pages 51 - 57 D.P. ANDERSON ET AL. 'A continuous media I/O server and its synchronization mechanism' see the whole document ---	1,8,10
A	BYTE, vol.18, no.2, February 1993, LONDON, GB pages 225 - 230 A.W. DAVIS ET AL. 'The Mac goes to the movies' see the whole document -----	1,8,10

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Intern. ıal Application No
PCT/EP 94/00833

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
EP-A-0239884	07-10-87	US-A-	4893256	09-01-90
		DE-D-	3787553	04-11-93
		DE-T-	3787553	11-05-94
		JP-B-	6054469	20-07-94
		JP-A-	62239233	20-10-87
EP-A-0550197	07-07-93	US-A-	5333299	26-07-94
		CA-A-	2084574	01-07-93
		JP-A-	5265778	15-10-93

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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : G06F 9/46	A1	(11) International Publication Number: WO 99/61985
		(43) International Publication Date: 2 December 1999 (02.12.99)

(21) International Application Number: PCT/US99/06634

(22) International Filing Date: 26 March 1999 (26.03.99)

(30) Priority Data:
60/086,737 26 May 1998 (26.05.98) US

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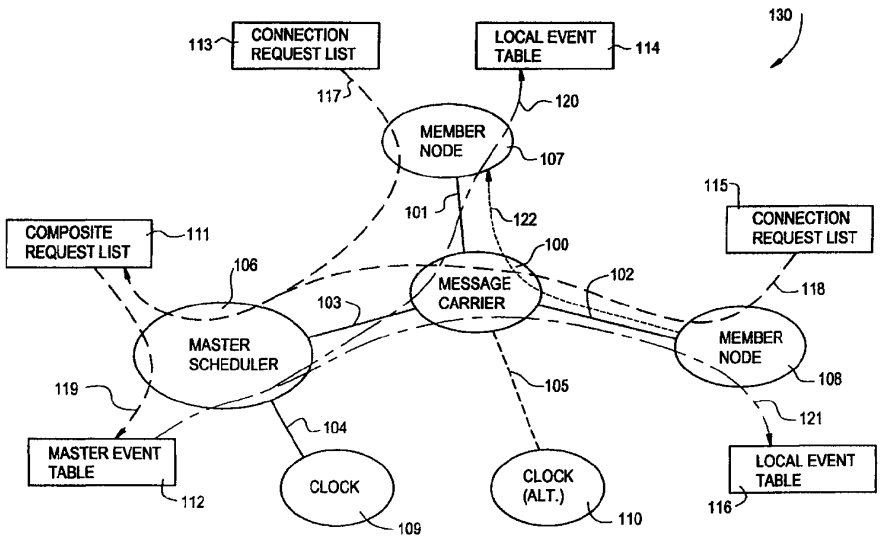
(74) Agent: SCHULTZ, Dale, H.; Patent Dept., P.O. Box 1967, Midland, MI 48641–1967 (US).

(81) Designated States: CA, CN, JP, MX, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: DISTRIBUTED COMPUTING ENVIRONMENT USING REAL–TIME SCHEDULING LOGIC AND TIME DETERMINISTIC ARCHITECTURE

(57) Abstract



A system is presented for a plurality of computer nodes in mutual data communication to execute logic in a coordinated manner. The approach features aligning the definition of the time in the nodes so that each node has essentially the same definition of time,defining a schedule of communications for each computer node, with the schedule having future moments defined for initiating each communication, communicating each schedule to its respective node, and initiating each communication at the time defined in the schedule. The computer network has a message carrier supporting multiple communication paths; a plurality of computers coupled to the message carrier, a clock system for maintaining time synchronism among the computers; and a scheduler coupled to the message carrier for determining the sequence of communication between the computers. The message carrier establishes communication between selected computers based on the time–deterministic tasks being performed by the computers. A computer node in the plurality of computer nodes executes logic in coordination with the other nodes by defining a communication request list of each communication needed by the computer node with any other computer node respective to a future time period, sending the communication request list to the master scheduler, receiving back a communication schedule back from the master scheduler, defining a local task schedule from the communication schedule, and then executing the communication at the scheduled time.

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DISTRIBUTED COMPUTING ENVIRONMENT USING REAL-TIME SCHEDULING LOGIC AND TIME DETERMINISTIC ARCHITECTURE

This invention is directed to the field of data processing control systems, particularly to integrated systems where a plurality of computers execute their logic in a coordinated manner within a network. The primary application of the system described in this specification is for computerized control of machines deployed on a large physical scale (for example a chemical manufacturing facility), although benefits to endeavors related to plural computer processors, parallel computer processors, and networked computer processors are also enabled.

When computational demands or geographical constraints require the physical distribution of computing facilities (for example such as for process control in a large, geographically dispersed chemical plant), implementation factors (such as product quality) may benefit from centralized coordination of the computing tasks. This invention describes a system and method for enabling a plurality of geographically dispersed computers to be networked for enabling time coordinated inter-activity. This resultant network enables task coordination and facilitates the implementation of other qualities beneficial to the task being performed by the system - qualities such as redundancy, security, and high throughput.

One embodiment of a system showing such substantive real-time networking to a set of physically distributed remote field units for use in a process control system is described the United States Patent 5,428,769 issued on Jun. 27, 1995 and entitled "Process control interface system having triply redundant remote field units" to Glaser, Robert S.; Hoy, Robert S.; Fernandez, G. Paul; and Grai, Timothy J. While the system is adequate for many process control situations, the networking methodology effectively addresses each system in each time period on the presumption that there is a need to do so; however, many of these addressing cycles are unnecessary if all variables for exchange are stable -- a more elegant scenario from the standpoint of network efficiency would provide for communications only when the status of either the inputs or the outputs require change.

Physical distribution of computing facilities combined with centralized coordination of the computing tasks is also a driving concept in high performance processors characterized by parallelism. Vector processors, as discussed in sections 7.1 and 7.2 ("Vector Processors") of Computer Architecture A Quantitative Approach by John L. Hennessy and David A.

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Patterson (Morgan Kaufmann; San Mateo, California; 1990; pages 351-363) are one manifestation of such systems, and processor-memory pair approaches such as the Cm* design discussed from pages 11 to 18 of "Parallel Processing - The Cm* Experience" by E. F. Gehringer, D. P. Siewiorek, and Z. Segall (Digital Press via Editorial Inc.; Rockport, Massachusetts; 1987) provide a second example of these types of approaches.

Centralized coordination of computing tasks in a scheduled context for the future also draws on concepts from traditional project scheduling such as is discussed from pages 569 to 584 of the text Productions and Operations Management by J. William Gavett (Harcort, Brace, and World; New York; 1968).

Process control systems development is characterized by an ever-increasing incorporation and management of issues at large in the system being controlled, requiring that a comparably larger amount of logic on a comparably larger amount of data be executed in a time frame which is not permitted to expand. This can be achieved to some degree by hardware which processes logic more quickly and holds more data in an addressed physical store, but there are substantial costs in pursuing this solution. What is needed to resolve the ability of future systems to effectively expand their comprehensive treatment of the control situation is to truly provide a solution path for enabling a very large number of distributed computers to execute massive amounts of logic in a mutual manner which is time-synchronous across an entire network. The present invention provides such a method and system.

The invention provides a computer implemented method for enabling a plurality of computer nodes in mutual data communication to execute logic in a coordinated manner by

(a) aligning the definition of time between the computer nodes so that each computer node has essentially the same "understanding" of time;

(b) defining a schedule of communications for each computer node, where the schedule has a different time in the future defined for initiating each respective communication;

(c) communicating each schedule to its respective computer node; and

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(d) initiating each communication from each node at the time defined in its schedule.

The described embodiment provides a computer network architecture, having a message carrier with a plurality of computers coupled to it; a clock system (accessible by all computers in the network) for maintaining time synchronism among the computers; and a scheduler for determining the sequence of communication between the computers by causing the message carrier to establish communication between selected computers based on time-deterministic tasks being performed by the computers.

The described embodiment further provides a global time system for aligning the sense of time in the set of computers to a globally defined reference.

The described embodiment further provides a computer implemented method for enabling a plurality of member nodes to execute logic in a coordinated manner.

The described embodiment further provides for concurrency in communications between computers via the message carrier.

The described embodiment further provides provides a computer implemented method for scheduling tasks for resource objects in a plurality of resource objects functioning as a collective group.

The described embodiment further provides a method by which different computers can align their definition of time by adjusting their oscillator's rate of oscillation.

The computer network architecture is enabled with a message carrier supporting multiple communication paths; a plurality of computers coupled to the message carrier, with each computer being programmed to perform time-deterministic tasks by cycling through a plurality of different operating states, including a communication state; a clock system accessible by all the computers for maintaining time synchronism among the computers; and a scheduler coupled to the message carrier for determining the sequence of communication between the computers by enabling the message carrier to establish communication

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between selected computers based on the time-deterministic tasks being performed by the computers.

A computer node (element for computing with an independent central processing unit) in the plurality of computer nodes can execute logic in coordination with the other nodes by being connected to a message carrier along with the other computer nodes where there is also a provision for (a) master scheduling capability in one computer node to establish a master scheduler; (b) defining, in each computer node, a communication request list of each communication needed by the computer node with any other computer node respective to a future time period; (c) sending of the communication request list from each computer node to the master scheduler via the message carrier; (d) receiving of, in each computer node, a communication schedule from the master scheduler via the message carrier; and (e) defining, in each computer node, a local task schedule from the communication schedule.

The above approach enables a plurality of member nodes in a system to execute a large amount of logic in a coordinated manner on a group of distributed platforms.

In performing the above, the step of defining a reference moment time value is performed in one embodiment by the master scheduler.

In performing the above, the step of defining a communication request list in each member node in one embodiment limits the communications to a maximum number in the future time period and each communication has an duration time attribute and the value of the duration time attribute is less than a fixed maximum value in order to achieve efficient operation.

Use of a global time system in one embodiment enables a universal understanding of time across a large number of different computer nodes (member nodes) in an extended system.

The method for scheduling involves a process of scheduling tasks for resource (member) objects in a plurality of resource objects functioning as a collective group; and this computer implemented process (called an "apparent critical resource" process) involves the steps of:

defining a set of future tasks for the collective group;

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defining each resource object needed for each future task in the set of future tasks;

defining each interaction needed between any two resource objects respective to the set of future tasks;

defining a use instance for each resource object in achieving each interaction where the use instance has an use duration attribute value;

defining an accessing resource object and an accessed resource object respective to each use instance;

determining a summed accessing time value for each accessing resource object as a sum of all use duration attribute values for all use instances respective to that resource object when it is the accessing resource object;

determining a summed accessed time value for each accessed resource object as a sum of all use duration attribute values for all interactions between the accessed resource object and the accessing resource object;

defining a set of sequential future time increments within a scheduling period in a schedule;

scheduling, into the earliest available time in the first future time increment, a future resource interaction event based on the first available future task in the set of future tasks between

(a) the accessing resource object having the highest summed accessing value respective to the set of future tasks and

(b) the accessed resource object having the highest summed accessed value respective to the set of future tasks (if a use instance exists between the accessed resource object and the accessing resource object -- the future resource interaction event in the schedule record has an initiation time equal to the earliest available time in the

schedule, an accessing resource object identifier attribute respective to the accessing resource object, an accessed resource object identifier attribute respective to the accessed resource object, and the aforementioned use duration attribute value)

removing from scheduling candidacy the use instance respective to the accessed resource object in the scheduled future resource interaction event and the accessing member object identifier attribute in the scheduled future resource interaction event to redefine the set of future tasks to those future tasks for which interactions have not been scheduled;

repeating the steps of determining a summed accessed value, determining a summed accessing value, scheduling a future communication task, and removing all use instances respective to scheduled resource objects until all use instances have been scheduled which can be scheduled into the first future time increments; and

recurrently executing the steps of determining a summed accessed value, determining a summed accessing value, scheduling a future resource interaction event, removing all resource objects respective to scheduled resource objects, and repeating such steps until all resource interaction events have been scheduled which can be scheduled into each future time increment and until all resource interaction events have been scheduled into the scheduling period.

In one embodiment, the message carrier has a plurality of channels for permitting concurrency in the communication events, the step of scheduling being respective to the plurality of channels as a group wherein the earliest available time is respective to any channel in the message carrier.

In some embodiments, each member node has a variable speed oscillator for adjusting a local clock to align with a global clock on the network. Time alignment logic and oscillator rate adjustment logic for execution by the computer circuitry are also provided to achieve rapid time alignment of the particular member node (computer node).

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The message carrier used in the described embodiment is enabled with a network topology which can be manifested (in the preferred embodiment) with a crossbar switch, or, in an alternative embodiment, with a radio frequency communications system.

Additional features and advantages of the present invention will become more fully apparent from a reading of the detailed description of the preferred embodiment and the accompanying drawings.

Figure 1 presents a diagram of the data flows between the various elements in a distributed network.

Figure 2 depicts a distributed network of computing elements which are resident in physically different locations throughout the world. This figure includes a network of computing elements, a master scheduler, and a common source of time.

Figure 3 presents a diagram of a network in a bus structure.

Figure 4 shows a distributed computing environment where the network is implemented in a ring topology.

Figure 5 presents a diagram of a network in a switched star topology which is a preferred network architecture embodiment.

Figure 6 presents a diagram of data structures communicated between the computing elements and a master scheduler.

Figure 7 depicts a flowchart of the process implemented in the master scheduler in the scheduling of communications between two separate computing elements.

Figure 8 presents a simplified diagram of the scheduling logic (software in execution by electrical circuitry) implemented in the master scheduler in the scheduling of communications between two separate computing elements.

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Figure 9 presents a detailed flowchart of the scheduling logic which is followed at the master scheduler.

Figures 10 presents a bar chart depicting the first scheduled communications between two separate computing elements after the first connection is scheduled.

Figure 11 presents a bar chart depicting the scheduled communications between computing elements after all connections are scheduled which can be scheduled in the first step.

Figure 12 presents a bar chart depicting the scheduled communications between computing elements after all connections have been scheduled.

Figure 13 provides a detailed composition of the Message Carrier, the Master Scheduler, the Clock, and the Member Nodes.

Figure 14 shows the relationships between the technologies which have been combined in the preferred embodiment, with emphasis on those most critical to the application.

Figure 15 presents a flowchart of the logic which executes in each of the computing elements in order to facilitate communication between the member nodes.

Figure 16 depicts a diagram of the data flows between the various elements in a distributed network where communications are facilitated by radio frequency.

As an introduction to this part of the specification, the system and method of the present invention implement centralized scheduling of cooperatively performed tasks, time deterministic event operations, and effective real-time synchronization and alignment of oscillators respective to the plurality of computers (also referenced as "member nodes") on the network. In this regard, the time deterministic network involves communicating between separate computing elements based on time rather than on some event (examples of events are the reception of a token or the detected availability of a particular bus). Centralized scheduling of cooperatively performed tasks, time deterministic event operations, and effective real-time synchronization and alignment of oscillators respective to the plurality of computers on the network requires that the computers share an essentially common view of the datalogical representation of an actual moment in real-time. This means, for instance

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and assuming for this example (without limitation to the scope of the present invention) a system wide-precision requirement of one millionth of a second , that two different computers in the system essentially perceive that, when the moment of time in real-time defined by an undisputed source respective to the network is 08:00:0000000 hours, that the first of the two computers has a datalogical representation of the moment in real-time between 07:59:9999995 and 08:00:0000005 and that the second of the two computers also has a datalogical representation of the moment in real-time time between 07:59:9999995 and 08:00:0000005; as can be appreciated, the difference in the datalogical representation of the moment in real-time between the two computers is no more than 1 millionth of a second.

When the computers in a distributed computing network share an essentially common view of the datalogical representation of an actual moment in real-time, they can then be programmed to perform specific tasks based on time. Tasks which involve multiple computers can then be scheduled centrally and a basis is established for time-dependent activities to be invoked on geographically dispersed computers in a deterministic manner. In this regard, determinism in real-time operations characterizes the occurrence of a predefined event at a predefined moment of real-time.

The use of such time coordination in communications between computers also facilitates the employment of active redundancy. In active redundancy, there are two or more computers which are each executing essentially identical logic, exchanging the results from these executions, optionally arbitrating the independently derived results to come to a commonly understood mutual conclusion for further use, and acting to concurrently effect the result. This process proceeds most effectively when data received by each computer is shared with the other computer(s) executing the same logic prior to arbitrating the results, so there must be some mechanism by which the time to begin the arbitration process is mutually determined. In the present invention, the mechanism for providing time synchronization between the redundant computers and to schedule the tasks related to a communication instance is (1) to provide an essentially identical datalogical representation of the moment in real-time time among the computers; (2) to use a scheduling approach to define in each computer the moment in time when the communication instance in that computer will occur; and (3) to then to implement the appropriate sending, receiving, and linkage tasks in each system involved in the communication instance at the time defined for the communication instance. In this way, the time at which the referenced arbitration task will be performed is

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pre-determined after the communications tasks have been scheduled (as opposed to the approach of waiting to determine the start time of the arbitration task after the communication tasks have actually executed).

The scheduling approach is implemented by execution of scheduling logic. The concept of logic relates to software (a computer program) whose purpose is achieved in execution by an enabling system of electrical circuitry (usually denoted by the term "computer"). The scheduling logic used for the scheduling of communications is based on analysis of demands for the resources (for example specific computers, data space within each computer, execution time in each computer, and specific circuits within each computer) which are being scheduled. This scheduling logic is used in the scheduling of network communications, but it has further applicability in the scheduling of any resources which require interaction among one another, and it is especially suited for real-time applications. The scheduling logic is further designed to be efficient respective to the resources it is responsible for scheduling and to be predictable as to the amount of time required to generate its output, a schedule, from the inputs (that is a collection of connection requests between any two computers on this network). In achieving this task, the scheduling logic schedules the available resources with the highest demand for the time that the schedule is being created. Reflecting the nature of (1) evaluating the resources with the highest demand at each point in the schedule and (2) giving precedence to the resources which have the highest demand, the particular scheduling logic method described in this specification is also referred to herein as Apparent Critical Resource, or ACR, scheduling logic. In this regard, in the preferred embodiment, the scheduling logic is not iterative in the sense that, once a particular task is scheduled, it is NOT removed from the schedule in order to pursue an alternative to its placement in the schedule. It is this quality which enables the preferred ACR scheduling logic type of scheduling logic to be well-suited for real-time applications.

In the application of scheduling logic to the scheduling of network communications, there are transmission resources and reception resources which are to be considered. Each time a network communication is scheduled, a transmission resource is associated with a reception resource.

In the scheduling of network communications, there are responsibilities which are handled by the master scheduler and those which are handled by the member nodes.

Figure 1 presents a data flow diagram 130 of the general elements and associated data flows between the various general elements in a distributed network and shows a message carrier 100, a first member node 107 and a second member node 108, a master scheduler 106 for coordinating communications between member nodes 107, 108 via data communication path 101 and data communication path 102, clock alternatives (as clock 109 and alternative clock 110) for achieving synchronization between member nodes 107, 108 (via data communication path 104, data communication path 105, data communication path 101, and data communication path 102), and the primary data tables and exchanges required to interact effectively in this distributed computing environment (via data communication path 118, data communication path 117, data communication path 119, data communication path 120, and data communication path 121).

The clock 109 is distributed to the member nodes through the message carrier from the master scheduler (alternatively, the message carrier 100 could distribute an alternative local clock 110 to the member nodes 107, 108 and to the master scheduler 106). This permits all nodes attached to the message carrier to share a common view of time. In this regard, clock 109 represents a global clock for use around the physical globe (for example in North America, in Europe, and in Asia) where the alternative clock 110 represents a clock which has been designated for the network referenced only by message carrier 100 and where a computer executing aspects of message carrier 100 arbitrarily defines time for its affiliated computers in the distributed network. Clock 109 or clock 110 periodically output a common clock signal via either linkage 104 or 105, respectively.

Each member node 107, 108 is responsible for receiving the common clock signal; effectively "synchronizing" (aligning the definition of time in the node to a close tolerance with the definition of time respective to the common clock signal to create a system time base operating in synchronism with an established clock frequency and anchor point) to that common clock signal; receiving an appropriate local event table 114, 116 from the master scheduler 106; formulating a respective task execution list based on the received local event table 116, 114 and any additional tasks which are not described in the local event table 114, 116; executing the task execution list; generating the request list of communications 113, 115; and transmitting the request list of communications to the master scheduler 106. Each member node 107, 108 generates a connection request list 113, 115 based on the tasks required of the node 107, 108, and forwards these requests at a prescribed time through the

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message carrier 100 to the master scheduler 106. The master scheduler 106 combines the connection request lists 113, 115 from the member nodes into a composite request list 111, which it uses to generate a communications schedule represented in the master event table 112. This master event table 112 is then broken apart into sections applicable to each of the member nodes 107, 108 and sent through the message carrier 100 (also at prescribed times) to the member nodes 107, 108 for storage in local event tables 114, 116. The local event tables 114, 116 are used in the member nodes 107, 108 to control timing for applicable time dependent tasks, including communications with other member nodes.

Figure 2 depicts a distributed network 220 of computing elements which are resident in physically different locations throughout the world to show an instance of the situation abstracted in the data flow diagram 130 of Figure 1. This figure includes a network of computers 201-214 and two sources of time in clock 203 and clock 214 representing time sources respective to the data flow diagram clocks 109, 110; in this regard, Figure 2 shows clock 203 as the basis for time definition for all systems in North America and Eurasia while clock 206 defines a basis for time definition for the less globally dispersed domain of computers 206, 207, 208, 209, and 214 in Africa. It should be noted that clock 203, then, "maps" to clock 109 in the data flow diagram context of Figure 1 and that clock 214 "maps" to clock 110 in the data flow diagram context of Figure 1. Figure 2 thereby depicts two possible configurations for distributed computing environments (facilitating the associated message carriers 100, master schedulers 106, and clocks 104, 105). A distributed computing environment can be located in a geographically limited area or dispersed throughout the world. When spread across large geographical areas, the clock 203 is preferably a satellite timing distribution system such as the Global Positioning System.

Figure 3 presents a diagram of a network in a bus structure 330. Figure 3 shows the fundamental components of Figure 1 except that the message carrier 100 is a bus 300 connecting the member nodes 107, 108, to the master scheduler 106.

Figure 4 shows a distributed computing environment where the network is implemented in a ring topology 430. Figure 4 shows the fundamental components of Figure 1 except that the message carrier 100 is a ring enabled by ring segments 402, 403, 405, and 401 to effectively connect the member nodes 107, 108, to the master scheduler 106.

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Figure 5 presents a diagram of a network in a switched star topology 530 which is a preferred network architecture embodiment. Figure 5 also shows the fundamental components of Figure 1 except that the message carrier 100 is explicitly a switched network implemented in a star topology which connects the member nodes 107, 108 and the master scheduler 106, and that this master scheduler 106 is embedded into the network switch 501. This diagram shows the preferred embodiment as it could be used in a large manufacturing process (a manufacturing process referencing the effecting of goods manufacture in an apparatus whose movable components are modified in real-time using control signals from a computer control system executing logic reading measurements from the apparatus and outputting the control signals) through a large number of input/output processing devices and computing platforms in a potentially geographically distributed arrangement. The star topology network 530 enables the reading of measurements and outputting of control signals respective to the apparatus for manufacture through I/O (input signal/output signal) interface 510, I/O interface 511, I/O interface 522, I/O interface 519, I/O interface 512, I/O interface 513, I/O interface 520, and I/O interface 521. I/O interface 510, I/O interface 511, I/O interface 512, and I/O interface 513 are all joined via ring breakout 508 and ring breakout 509 to control computer 504 and historian computer 505 through local network 515. In a similar manner, I/O interface 522, I/O interface 519, I/O interface 520, and I/O interface 521 are all joined via ring breakout 518 and ring breakout 517 to control computer 506 and historian computer 507 through local network 514. I/O interface 510, I/O interface 511, I/O interface 512, I/O interface 513, ring breakout 508, ring breakout 509, control computer 504, historian computer 505, and local network 515 operate with local logical integrity and high real-time datalogical cohesion. In a similar manner, I/O interface 522, I/O interface 519, I/O interface 520, I/O interface 521, ring breakout 518, ring breakout 517, control computer 506, historian computer 507, and local network 514 operate with local logical integrity and high real-time datalogical cohesion. Cohesion between

(a) I/O interface 510, I/O interface 511, I/O interface 512, I/O interface 513, ring breakout 508, ring breakout 509, control computer 504, historian computer 505, and local network 515

and

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(b) I/O interface 522, I/O interface 519, I/O interface 520, I/O interface 521, ring breakout 518, ring breakout 517, control computer 506, historian computer 507, and local network 514

via messaging is enabled by network switch 501 which implements (1) communications for provision of an essentially identical datalogical representation of the moment in real-time time among the computers; (2) master scheduler 106 processes to define for control computer 506, historian computer 507, control computer 504, historian computer 505, user interface 503, network support 502, and network switch 501 each moment in time when each communication instance between any two of computer 506, historian computer 507, control computer 504, historian computer 505, and user interface 503 VIA THE USE OF network switch 501 will occur; and (3) appropriate sending, receiving, and linkage tasks respective to components involved in the communication instance at the time defined for the communication instance. Network support 502 is also coordinated as a node into switched star topology 530 as a single source of information for defining acceptable communication partners in switched star topology 530 and also for accumulating and providing access to diagnostic information in switched star topology 530. Network switch 501 references network support 502 for a listing of acceptable communication partners in switched star topology 530 and confirms communication instance requests against this listing in defining sending, receiving, and linkage tasks.

In one embodiment, I/O interface 522, I/O interface 519, I/O interface 520, and I/O interface 521 are facilitated by a process control system such as is described in United States Patent 5,555,424 (24Sederlund, et. al.) issued on Sept. 10, 1996 and entitled "Extended Harvard architecture computer memory system with programmable variable address increment" to Sederlund, Edward R.; Lindesmith, Robert J.; Root, Larry A.; Dupree, Wayne P.; and Thomas, Lowell V. This patent is expressly incorporated herein by reference in the present application for showing a manner of making and using the present invention.

In a more preferred embodiment, I/O interface 522, I/O interface 519, I/O interface 520, and I/O interface 521, are facilitated via a redundant process control computer system in a general process control system using two process control computers (such as the process control computer described in 24Sederlund, et.) as is described in United States Patent 5,583,757 (Baca, Jr., et. al.) issued on Dec. 10, 1996 and entitled "Method of input signal resolution for actively redundant process control computers" to Baca, Jr., Eloy; Dupree,

Wayne P.; Grinwis, Donald J.; Kanse, Johannes C.; Pelletier, Douglas P.; and Schulze, Oscar E. This patent is expressly incorporated herein by reference in the present application for showing a manner of making and using the present invention.

An embodiment of a system for achieving data access for the process control computer described in 24Sederlund, et al. is described in United States Patent 5,568,615 (15Sederlund, et. al.) issued on Oct. 22, 1996 and entitled "Stealth interface for process control computers" to Sederlund, Edward R.; Thomas, Nadene T.; Lindesmith, Robert J.; and Cowles, Russell W. This patent is expressly incorporated herein by reference in the present application for showing a manner of making and using the present invention.

An embodiment of a system providing a remote field unit for use with the process control computer described in 24Sederlund, et al. is described the United States Patent 5,428,769 (69Glaser, et. al.) issued on Jun. 27, 1995 and entitled "Process control interface system having triply redundant remote field units" to Glaser, Robert S.; Hoy, Robert S.; Fernandez, G. Paul; and Grai, Timothy J. This patent is expressly incorporated herein by reference in the present application for showing a manner of making and using the present invention.

An embodiment of a system providing an interface for reading electrical current in power distribution systems for use with the field unit described in 69Glaser, et. al. is described in United States Patent 5,151,866 (66Glaser, et. al.) issued on Sept. 29, 1992 and entitled "High speed power analyzer " to Glaser, R. Steven and Bade, Jeffrey M. This patent is expressly incorporated herein by reference in the present application for showing a manner of making and using the present invention.

An embodiment of a system providing a high speed gateway for use with the redundant process control computer system described in Baca, et al. and the system for achieving data access for the process control computer described in 24Sederlund, et al. is described in

(a) United States Patent 5,519,603 (Allbery, Jr., et. al.) issued on May 21, 1996 and entitled "Intelligent process control communication system and method having capability to time align corresponding data sets" to Allbery, Jr., James D.; Troisi, Peter A.; Johnson, Susan J.; Cullen, James H.; Butler, Richard L.; Ferreira, James P.; Ellison, Joseph ; Patel, Chiman L.; Uban, James E.; and Schultz, Dale H.;

(b) United States Patent 5,428,745 (45de Bruijn, et. al.) issued on Jun. 27, 1995 and entitled "Secure communication system for re-establishing time limited communication between first and second computers before communication time period expiration using new random number" to de Bruijn, Ronny P.; Verboven, Marc L. K.; van Weele, Leonardus A.; Vermeire, Roger R.; Schulze, Oscar E.; Schultz, Dale H.; and Bell, Brian G.; and

(c) United States Patent 5,561,770 (70de Bruijn, et. al.) issued on Oct. 1, 1996 and entitled "System and method for determining whether to transmit command to control computer by checking status of enable indicator associated with variable identified in the command" to de Bruijn, Ronny P.; van Weele, Leonardus A.; Verboven, Marc L. K.; Vermeire, Roger R.; Schulze, Oscar E.; Bell, Brian G.; and Schultz, Dale H.

These patents are expressly incorporated herein by reference in the present application for showing a manner of making and using the present invention.

An embodiment of a system providing human interfacing for use with the redundant process control computer system and interfaces described in the above patents is described in United States Patent 5,631,825 (van Weele, et. al.) issued on May 20, 1997 and entitled "Operator station for manufacturing process control system" to van Weele, Leonardus A.; de Bruijn, Ronny P.; Vermeire, Roger R.; Zemering, Christo; and Lenting, Ben. This patent is expressly incorporated herein by reference in the present application for showing a manner of making and using the present invention. While this human interface system could be used as one user interface in each or any one of I/O interface 522, I/O interface 519, I/O interface 520, and I/O interface 521, it should be noted that user interface 503 is preferably designed for interface via network switch 501 to the entire set of systems in a particular instance of switched star topology 530.

Embodiments of systems providing real-time interpretation of application program code executing in the above systems are described (a) in United States Patent 5,491,625 (Pressnall, et. al.) issued on Feb. 13, 1996 and entitled "Information display system for actively redundant computerized process control" to Pressnall, Dana W.; Polishak, Jeffery T.; Felix, Bradley K.; Durisin, Michael J.; and Ellison, Joseph. and (b) in United States Patent 5,408,603 (Van de Lavoir, et. al.) issued on Apr. 18, 1995 and entitled "Global process

control information system and method" to Van de Lavoir, Ronny; Follon, Marinus (Neerpelt, BE); and Ravenscroft, Ian. These patents are expressly incorporated herein by reference in the present application for showing a manner of making and using the present invention.

A large graphical overview system providing interface to humans is deployed in the preferred embodiment along with the Operator Station. This graphical overview system is described in United States Patent 5,726,668 (Clement) issued on Mar. 10, 1998 and entitled "Programmable graphics panel" to John L. Clement. This patent is expressly incorporated herein by reference in the present application for showing a manner of making and using the present invention.

In a conceptualized most preferred embodiment, I/O interface 510, I/O interface 511, I/O interface 522, I/O interface 519, I/O interface 512, I/O interface 513, I/O interface 520, I/O interface 521, ring breakout 508, ring breakout 509, control computer 504, historian computer 505, ring breakout 518, ring breakout 517, control computer 506, historian computer 507, I/O interface 522, I/O interface 519, I/O interface 520, I/O interface 521, ring breakout 518, ring breakout 517, control computer 506, network support 502, network switch 501, and historian computer 507 are implemented using a dedicated context cycling computer as is described in US patent application number 08/797,967 which was filed on February 12, 1997 by Wayne Dupree, Jeffery Lucas, Larry Root, Gerrit Verniers, and Stephen Churchill entitled "A Dedicated Context-Cycling Computer" with the system of 69Glaser, et. al. facilitating interface to field instrumentation. This application for patent is expressly incorporated herein by reference in the present application for showing the preferred contemplated manner of making and using the present invention.

The context cycling processor provides for a substantial number and variety of input and output circuits, with each of the specialized circuits having at least one dedicated register for retaining the process and configuration state of pertinent resources, attributes, or aspects associated with either the circuit or function while another context is active; with the combination of specialized circuit and dedicated register(s) establishing the electrical circuitry base for a context. Contexts also include affiliated logic specific for the circuitry. A plurality of contexts share common assets within the CPU.

As needed, a co-processor for use with the context cycling computer is described in United States Patent 5,655,133 (Dupree, et. al.) issued on Aug. 5, 1997 and entitled "Massively

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multiplexed superscalar Harvard architecture computer" to Dupree, Wayne P.; Churchill, Stephen G.; Gallant, Jeffrey R.; Root, Larry A.; Bressette, William J.; Orr, III, Robert A.; Ramaswamy, Srikala; Lucas, Jeffrey A.; and Bleck, James. This patent is expressly incorporated herein by reference in the present application for showing the preferred contemplated manner of making and using the present invention. Network switch 501 also preferably uses a cross-bar (Xbar) switch 516 capable of implementing at least 99 parallel and simultaneous communication linkages.

The master scheduler 106 is implemented in network switch 501 to provide a common clock signal (as an access to either clock 109 or a manifestation of clock 110) and is further responsible for the distribution of the common clock signal; the collection of the requests from each of the member nodes 108, 107 (in this instance of network 530, control computer 506, historian computer 507, control computer 504, historian computer 505, user interface 503, network support 502, and network switch 501 are all instances of member nodes 107 and 108 in the data flow context of Figure 1); the scheduling of the communication tasks for each of the member nodes 108, 107; the transmission of the schedule to each of the member nodes 108, 107; and the implementing of the connections between the member nodes 108, 107.

The purpose of distributing a common clock signal is so that each member node 108, 107 on the network 530 has the same understanding of time. This aspect of having the same understanding of time is crucial in this invention since the scheduling of tasks is done based on time. Thus, the common clock signal is used to effectively synchronize and time-align all member nodes 108, 107 to a common time. On a pre-defined periodic basis, the master scheduler 106 in network switch 501 sends a message that is propagated to each of the member nodes 108, 107 to define the beginning of a time period.

The collection of the requests from each member node 108, 107 (any one of control computer 506, historian computer 507, control computer 504, historian computer 505, user interface 503, network support 502, and network switch 501) occurs once each scheduling period. The master scheduler 106 in network switch 501 sets aside the time to receive requests from each member node 108, 107 (any one of control computer 506, historian computer 507, control computer 504, historian computer 505, user interface 503, network support 502, and network switch 501) each scheduling period. Requests originate from the member nodes 108, 107 which will need the communications requested. The master

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scheduler 106 in network switch 501 receives each of these requests and considers them in its scheduling logic. Each request contains information on the source, destination, and length of the communication. In addition, each request may contain a priority indicator as well as information needed to deliver its message to a particular application which is executing on the destination node. After the task of collecting the connection requests from all of the member nodes 108, 107 is completed, the result is collected into a composite request list 111. Note that it is also possible for entries in the composite request list 111 to originate inside of the master scheduler 106 in network switch 501 itself; it is also possible for particular connection requests to have a repetitive nature such that multiple connections in a set of future time periods are invoked from a single connection request.

The master scheduler 106 in network switch 501 then schedules the communications which are to occur in the future. The method which is used in order to perform the scheduling of the communications is not critical in the functioning of the time deterministic network, although the Apparent Critical Resource approach discussed in this specification is the preferred approach. Logic implements to assign times to the requested communications. The determination of when to stop the scheduling process during the scheduling period can occur in one of three ways: first, all of the communication requests which can be scheduled are scheduled and therefore, there is no more scheduling work remaining; second, there is no more time remaining in which to perform the scheduling (the processor must stop the scheduling process in order to continue on with its next task); and third, there have been more connections requested than could be scheduled in the available scheduling window of time increment (an exhaustion of bandwidth), in which case the excess requests are retained as a queue for the next scheduling attempt.

The resulting schedule is stored in a master event table 112. This master event table 112 contains the start time 621 of the scheduled communication in addition to some of the same information similar to that in the composite request list 111. Note that it is also possible that certain tasks are pre-loaded into the master event table 112 in order to bypass the scheduling process, such as is required to enforce certain timing requirements of a task.

The master scheduler 106 in network switch 501 then communicates the local event table 114, 116 (that portion of the schedule which pertains to a particular member node 107, 108) to each appropriate member node 107, 108. For each event appearing in the master event table 112 which includes an appropriate member node 108, 107 as either the source or the

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destination, an entry exists in the local event table 114, 116. Each member node 108, 107 (any one of control computer 506, historian computer 507, control computer 504, historian computer 505, user interface 503, network support 502, and network switch 501) which is involved in any communication receives its own local event table 114, 116.

The master scheduler 106 in network switch 501 then implements the connections according to the times which are assigned and appear in the master event table 112. The processing of these connections when using the preferred embodiment of the non-blocking switch leads to the situation whereby there may be multiple connections which are implemented concurrently.

The Composite Request List 111 residing in the master scheduler 106 in network switch 501 may contain both continuously repetitive connections to be implemented without contingencies, or dynamically requested connections (implemented when requested, usually initiated by one of the nodes on the network). This Connection Request List contains, at a minimum, a Source specifier, a Destination specifier, and a Duration specifier (see Figure 6 showing record details 600). Additional parameters pertinent to scheduling optionally include such specifiers as Priority 617.

Figure 6 shows the composition of the primary tables and messages 600 used in the scheduling and task coordination process. The connection request list 115 has Source 614, Destination 615, Length 616, and possibly Priority 617 fields 610 in both the member nodes 108, 107 and when combined into the composite request list 111 in the master scheduler 106 in network switch 501. The scheduler logic 611 in master scheduler 106 uses the data in these fields 610 to construct a schedule in the form of a master event table 112 with fields 612 for the Source 618, Destination 619, Length 620 and Start Time 621 for each of the connections. Note that the scheduler logic 611 takes the Source 614, Destination 615, and Length 616 from the connection request list 111, while the Start Time 621 is a product of the scheduling process itself.

The local event tables 114, 116 are simply subsets of the master event table 112, broken into those portions applicable to the respective member node 108, 107 (any one of control computer 506, historian computer 507, control computer 504, historian computer 505, user interface 503, network support 502, and network switch 501) - no manipulation of the fields 613 is required. Virtual paths 601, 602, 603, 606, 607, and 608 show the flow of the

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information from the connection request list fields 610 to the local event table fields 613. Virtual path 604 shows the input of priority 617 to the scheduler; and virtual path 609 shows the start time 621, 625 as communicated from scheduler logic 611.

This data is then used by the scheduler logic 611 to derive a schedule for servicing the requested connections. The outcome of the scheduling process of the scheduler logic 611 is recorded in the Master Event Table 112, which is in turn parsed up into respective Local Event Tables 116 for distribution to the network nodes (see Figure 1). The Event Tables contain Source 622, Destination 623, Duration 624, and Start Time 625 fields 613.

Within the network nodes, the Local Event Tables 114, 116 are merged together with the Local Task Lists and logic executes to ensure that all the necessary work can be completed and that all timing corresponds to (or doesn't conflict with) that specified by the scheduler logic 611.

Figure 7 summarizes the general scheduling process 710. Connection requests are collected during a defined request acceptance period. After a defined period of time, the collection of connection requests must be processed. Additional connection requests are not prohibited, but a cutoff point must be established. Figure 7 shows the basic steps involved in the master scheduler 106 in network switch 501 node which are required in scheduling the connection requests. The first three steps 701-703 provide for aligned time definition in all nodes . In step 704, connection requests are received from all member nodes 107, 108 (the nodes sending their requests as a communication at predefined moments in their local task schedules from prior scheduling operations). In step 705, the connection requesting process ends so that a schedule can be defined for the future as the scheduling process applies to those requests which were collected from the member nodes 108, 107 during a particular window of time increment which is about to conclude. Schedule connections requests step 706 can begin once the requests have been collected (more detail in Figure 8). Once the schedule is complete, the applicable portions of the schedule are extracted from the master event table 112 in the creation of the local event tables 114, 116, in step 707 which are then conveyed to the nodes 107, 108 in step 708 for later implementation in step 709.

For distributed computing environments in general, connections between nodes 107, 108 may be required at any time, meaning that connection requests may originate any time, and some service time must be tolerable in handling the connections. There are four processes,

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then, that repetitively execute at a rate conformant to the desired response in the network 530: collecting connection requests, scheduling connection requests, distributing the resulting schedule to the network nodes, and communicating through the network 530 via the established requested connections (see Table 1).

Table 1 - Four Scheduling Steps

Request Connections
Schedule Connections
Convey Schedule
Communicate

Table 2 shows the timing relationship between these four processes which, as stated, are always in progress.

Table 2 - The Scheduling Pipeline

Request Connections			
Request Connections	Schedule Connections		
Request Connections	Schedule Connections	Convey Schedule A	
Request Connections	Schedule Connections	Convey Schedule B	Communicate A
Request Connections	Schedule Connections	Convey Schedule C	Communicate B
Request Connections	Schedule Connections	Convey Schedule D	Communicate C
Request Connections	Schedule Connections	Convey Schedule E	Communicate D
Request Connections	Schedule Connections	Convey Schedule F	Communicate E

Note in the rightmost column of Table 2 that communications are always taking place after an initial few iterations establish a basis for communications. For any particular communications in a window of time increment, the schedule for the communications being implemented was conveyed in a previous window of time increment, the requests were scheduled in a window of time increment prior to the conveyance of the schedule, and the requests were requested even prior to scheduling. Timing variations can exist in this pipeline, but this resembles the pipeline used in the preferred embodiment.

The logic used in the currently preferred embodiment has been designed with two objectives in mind: an efficient schedule must be the outcome, and the number of cycles required to generate that schedule must be bounded at a reasonable level. Efficient scheduling involves a simple process based on the premise that the efficiency of the resultant schedule is primarily a function of the efficiency to which the busiest resources have been utilized in the schedule. This amounts to making sure that, at all times in the scheduling process,

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scheduling precedence is given to the resources with the highest remaining demands. In order to derive a schedule in an acceptable amount of time, the logic was designed to schedule each request once and only once (trial and error logics deemed unacceptable), and with a moderate handling requirement for each connection request.

The basic process in scheduling 806, as shown in Figure 8, is to

1) define a criteria for measuring resource demand;
2) sort the resources according to criticality;
3) service those connections which can be serviced in this step and in the order of resource criticality;
4) step forward to the completion of the previously serviced requests thereby freeing up the applicable resources;
5) repeat steps 2-4 until all requests have been serviced or until there's no opportunity to service more requests.

Any requests which weren't able to be serviced in this scheduling pass can then be resubmitted during the next scheduling pass.

The flowchart of Figure 8 outlines the process used in the Apparent Critical Resource scheduling logic. The first step is to define the criteria by which resource usage is to be measured 800. For the preferred embodiment, transmit and receive channels are the resources which are scheduled, and the usage duration for each of these resources is the criteria chosen.

Once the resources are evaluated for usage, they are sorted by usage 801. This allows the resources which are used most heavily to be scheduled in step 802 first. When all resources which can be scheduled have been scheduled (the existing requested connections may not require or permit the simultaneous use of all resources), the scheduling window of time increment is advanced in step 803 until applicable resources become available. If there are more connection requests to be serviced and more time in the schedule to service these requests, this process is repeated after step 804 resolves the question respective to the need for another iteration through steps 801 to 803). The sub process 806 of the scheduler logic proceeds to step 805 to exit upon resolution by step 804 that the scheduling instance has been completed.

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Figure 9 presents a more detailed overview of the Apparent Critical Resource (ACR) preferred embodiment sub-process 950 of the scheduling logic. This diagram encompasses the steps mentioned in Figure 8 and some additional actions required for conditional operation and exception handling as the preferred implementation of the process shown in Figure 8. Step 901 represents the initiation point for the preferred ACR process. In step 902, the ACR table is constructed, and a determination is made in step 903 respecting the presence of unscheduled requests based on the values of the SAV in the ACR table (a rapid exit to step 918 is executed if the values indicates that no requests are in the ACR table). If requests exist, the ACR sub-process 950 proceeds to calculate window size in step 904, look for a specific request in step 905, and check on the existence of the specific request and parties for the communication in step 906. If the request and parties exist, the process proceeds to add the event to the event table in step 912 and modify the ACR path in step 913 before proceeding to the next request in step 914. If the high value is not zero in step 915, the process proceeds again to step 904. If the high value is zero in step 915, the definition of (future) time in the ACR is advanced in step 916, the bandwidth is checked in step 917 for sufficiency in time to enable further scheduling in this scheduling operation, and the process returns to step 914 for the next request. If in step 906, a receiver for the communication did not exist, an alternative receiver is defined in step 907 and evaluated in step 908. If step 908 does not define an alternative receiver, an alternative transmitter is selected in step 919 and evaluated in step 920; if acceptable (step 920), step 921 selects the receiver with the highest ACR value and returns the process to step 908; and, if not acceptable (step 920), the process advances to step 916. When an alternative is defined in step 908, the process proceeds to schedule via steps 909, 910 and 911 to step 912. The virtual datalogical process being executed by these steps can be best described by considering an example respective to the list of communication requests for a hypothetical network consisting of five nodes shown in Table 3:

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Table 3: Initial Request List

Source	Destination	Length	Priority
1	2	15	1
1	4	23	1
1	5	2	1
2	1	24	1
3	1	16	1
3	1	12	1
3	2	20	1
3	3	8	1
3	4	19	1
3	4	16	1
3	5	4	1
3	5	9	1
4	1	13	1
4	5	9	1
5	1	21	1
5	1	8	1
5	2	8	1
5	3	1	1
5	4	18	1
Total		246	

Assume that the length is measured in some arbitrary units of time, perhaps in milliseconds, and that there are n different priority levels, 1 through n, where 1 is the most urgent and n is the least.

First, note that with a broadcast type network (where all transactions are required to share the bandwidth, such as a Carrier Sense Multiple Access with Collision Detection or CSMA/CD network), service time required to complete the above requests would require a theoretical minimum of 246 units of time.

The incorporation of a non-blocking switch permits the simultaneous operation of the 5 transmit resources and the 5 receive resources. In analyzing the benefit of implementing a non-blocking network, the scheduler logic of the example first assesses the demands on each of the resources by constructing a table such as Table 4:

Table 4: Initial Summed Access Values

X / R		1	2	3	4	5		SAV
1		-	15	-	23	2		40
2		24	-	-	-	-		24
3		28	20	8	35	13		104
4		13	-	-	-	9		22
5		29	8	1	18	-		56
SAV		94	43	9	76	24		246

The summed access values, or SAVs, are simply the row or column totals for the transmitter (X-in the rows of the table) and receiver (R-in the columns of the table) interaction times and reflect the total demands on the particular resource, as measured in the arbitrary units of length. Note now that the theoretical minimum time required to service the requests has dropped from 246 units of time to 104 by selecting a non-blocking switch solution. The minimum service time for these requests is probably constrained by transmitter 3 since transmitter 3 has the highest SAV and the other transmitters can typically be serviced while transmitter 3 is being serviced. While the theoretical lower limit may be 104 units of time, the actual minimum service time may be greater and may even be dependent upon the order in which the connections are serviced. The next objective, however, is determining the optimum scheduling method in order to maximize the capabilities of the existing network (minimizing the required service time).

Assume for this particular example that the resultant schedule, regardless of the number or composition of the requests, applies to a future window of time increment of time with a duration of 150 units of time. The example begin by looking at the connections to be made at

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Time = 0 for that 150 unit schedule. The primary objective, judging by the SAVs, is to schedule some request involving Transmitter 3 and Receiver 1. Referring back to the initial Request List, the scheduler logic of the example finds a request involving Transmitter 3 and Receiver 1 which has a length of 16 units of time. Since the scheduler logic of the example is currently scheduling connections at Time = 0 and the scheduler logic of the example has 150 units of time, the scheduler logic of the example concludes that the 16 word request fits into the scheduling window of time increment , and records the transaction into the Event Table of Table 5.

Table 5: Intermediate Event Table

Source	Destination	Length	Priority	Start Time
3	1	16	1	0
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-

Pictorially, Table 5 may be shown as schedule chart 1001 in Figure 10. Transmitter scheduled element 1002 and receiver scheduled element 1003 denote the scheduled tasks.

The Request List must then somehow reflect the fact that this last request has been serviced. This modified Request List may now resemble that shown in Table 6.

Table 6: Intermediate Request List

Source	Destination	Length	Priority	Start Time
1	2	15	1	-
1	4	23	1	-
1	5	2	1	-
2	1	24	1	-
3	1	16	1	0
3	1	12	1	-
3	2	20	1	-
3	3	8	1	-
3	4	19	1	-
3	4	16	1	-
3	5	4	1	-
3	5	9	1	-
4	1	13	1	-
4	5	9	1	-
5	1	21	1	-
5	1	8	1	-
5	2	8	1	-
5	3	1	1	-
5	4	18	1	-
Total		246		

Since Transmitter 3 and Receiver 1 are now busy for Time = 0, their status must indicate this, so the updated SAV Table, following some reformatting, may now resemble Table 7:

Table 7: Intermediate Summed Access Value Table

Channel	Transmitter SAV	Receiver SAV
1	40	78
2	24	43
3	88	9
4	22	76
5	56	24

Note that the SAVs for Transmitter 3 and Receiver 1 have been adjusted to reflect the serviced request. This is because the scheduler logic continues to give scheduling precedence to the resources with the highest impact on the schedule. This happens at the expense of the other resource needs, and at some point the inefficiencies injected into the resources with low SAVs may cause those resources to have a higher impact on the remaining portion of the schedule than those resources which had the highest impact at the start. For this reason, the protocol is referred to as Apparent Critical Resource scheduling (scheduling precedence is always given to resources which appear to be on the critical path at the time of consideration), or ACR scheduling.

It is now evident that the scheduler logic of the example should try to schedule a request from Transmitter 5 to Receiver 4, the next two concurrent resources in regards to scheduling impact which remain available for scheduling. There is such a request, so the scheduler logic of the example executes so that the tables now resemble Tables 8, 9, and 10.

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Table 8: Intermediate Request List

Source	Destination	Length	Priority	Start Time
1	2	15	1	-
1	4	23	1	-
1	5	2	1	-
2	1	24	1	-
3	1	16	1	0
3	1	12	1	-
3	2	20	1	-
3	3	8	1	-
3	4	19	1	-
3	4	16	1	-
3	5	4	1	-
3	5	9	1	-
4	1	13	1	-
4	5	9	1	-
5	1	21	1	-
5	1	8	1	-
5	2	8	1	-
5	3	1	1	-
5	4	18	1	0
Total		246		

Table 9: Intermediate Event Table

Source	Destination	Length	Priority	Start Time
3	1	16	1	0
5	4	18	1	0
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-

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Table 10: Intermediate Summed Access Value Table

Channel	Transmitter SAV	Receiver SAV
1	40	78
2	24	43
3	88	9
4	22	58
5	38	24

Note that the Event Table is effectively a (chronologically) sorted list of the scheduled requests from the Request List. For this reason, intermediate stages are not shown for each scheduling step.

Repeating the process as before, the scheduler logic of the example schedules a 1-to-2 communication instance request (that is a connection from Transmitter 1 to Receiver 2), and the tables are modified to Tables 11 and 12 as follows:

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Table 11: Intermediate Request List

Source	Destination	Length	Priority	Start Time
1	2	15	1	0
1	4	23	1	-
1	5	2	1	-
2	1	24	1	-
3	1	16	1	0
3	1	12	1	-
3	2	20	1	-
3	3	8	1	-
3	4	19	1	-
3	4	16	1	-
3	5	4	1	-
3	5	9	1	-
4	1	13	1	-
4	5	9	1	-
5	1	21	1	-
5	1	8	1	-
5	2	8	1	-
5	3	1	1	-
5	4	18	1	0
Total		246		

Table 12: Intermediate Summed Access Value Table

Channel	Transmitter SAV	Receiver SAV
1	25	78
2	24	28
3	88	9
4	22	58
5	38	24

The scheduler logic of the example next looks for a 2-to-5 communication instance request, but such a request was not made. Several alternatives exist in determining the next combination to be attempted, and the optimum solution is chosen based on the desired tradeoffs between bandwidth efficiency and processing costs. (With minimal bandwidth impact, a simple rule set can be chosen, and for the preferred embodiment, an alternative receiver is selected for the existing transmitter until all receiver choices have been exhausted, after which that particular transmitter is ignored and the next transmitter is selected, and the highest impact receiver is re-considered - see Figure 9.)

Using this logic, a 2 to 3 communication instance request is searched for but not found, then a 4 to 5 communication instance request is searched for, found, and selected. The SAV Table is updated, and it is determined that no other connections can be made at Time = 0. The Event Table now is shown in Table 13:

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Table 13: Intermediate Event Table

Source	Destination	Length	Priority	Start Time
3	1	16	1	0
5	4	18	1	0
1	2	15	1	0
4	5	9	1	0
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-

Again, these four connections can be represented pictorially in schedule chart 1101 in Figure 11. Transmitter scheduled element 1002 and receiver scheduled element 1003 from Figure 10 have been denoted as scheduled elements 1102 and 1103, respectively, and have been joined by scheduled elements 1104 and 1105 (the 5-to-4 communication), 1106 and 1107 (the 1-to-2 communication), and 1108 and 1109 (the 4-to-5 communication).

The logic involved in Advancing Time amounts to advancing to the next chronological finish. In this case, the 4 to 5 communication instance connection is the next chronological finish,

so the example advances time to Time = 9, at which time Transmitter 4 and Receiver 5 are again enabled. The Request List and SAV Table are now as shown in Tables 14 and 15.

Table 14: Intermediate Request List

Source	Destination	Length	Priority	Start Time
1	2	15	1	0
1	4	23	1	-
1	5	2	1	-
2	1	24	1	-
3	1	16	1	0
3	1	12	1	-
3	2	20	1	-
3	3	8	1	-
3	4	19	1	-
3	4	16	1	-
3	5	4	1	-
3	5	9	1	-
4	1	13	1	-
4	5	9	1	0
5	1	21	1	-
5	1	8	1	-
5	2	8	1	-
5	3	1	1	-
5	4	18	1	0
Total		246		

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Table 15: Intermediate Summed Access Value Table

Channel	Transmitter SAV	Receiver SAV
1	25	78
2	24	28
3	88	9
4	13	58
5	38	15

After searches for a 2-to-5 communication instance request, a 2-to-3 communication instance request, a 4-to-5 communication instance request and a 4-to-3 communication instance request, the scheduler logic of the example concludes that the example must again advance time - nothing could actually be scheduled at Time = 9. Now, the next finish is at Time = 15, at which time the 1-to-2 communication instance connection finishes and the SAV Table is now Table 16.

Table 16: Intermediate Summed Access Value Table

Channel	Transmitter SAV	Receiver SAV
1	25	78
2	24	28
3	88	9
4	13	58
5	38	15

The scheduler logic of the example now looks for a 1-to-2 communication instance request, but the only 1-to-2 communication instance has already been scheduled, so the example look for a 1-to-5 communication instance request, which the example finds and schedules. The new SAV Table is then Table 17.

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Table 17: Intermediate Summed Access Value Table

Channel	Transmitter SAV	Receiver SAV
1	23	78
2	24	28
3	88	9
4	13	58
5	38	13

The scheduler logic of the example then looks for a 2-to-2 communication instance request, a 2-to-3 communication instance request, a 4-to-2 communication instance request and a 4-to-3 communication instance request before determining that it's time again to advance time. The example advances time from 15 to 16, at which time the SAV Table looks like Table 18.

Table 18: Intermediate Summed Access Value Table

Channel	Transmitter SAV	Receiver SAV
1	23	78
2	24	28
3	88	9
4	13	58
5	38	13

The scheduler logic of the example then schedules a 3-to-1 communication instance request, which turns out to be the only request which can be scheduled at Time = 16. The tables, after the scheduler logic of the example advances time to Time = 17, look like Tables 19, 20, and 21.

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Table 19: Intermediate Summed Access Value Table

Channel	Transmitter SAV	Receiver SAV
1	23	66
2	24	28
3	76	9
4	13	58
5	38	13

Table 20: Intermediate Request List

Source	Destination	Length	Priority	Start Time
1	2	15	1	0
1	4	23	1	-
1	5	2	1	15
2	1	24	1	-
3	1	16	1	0
3	1	12	1	16
3	2	20	1	-
3	3	8	1	-
3	4	19	1	-
3	4	16	1	-
3	5	4	1	-
3	5	9	1	-
4	1	13	1	-
4	5	9	1	0
5	1	21	1	-
5	1	8	1	-
5	2	8	1	-
5	3	1	1	-
5	4	18	1	0
Total		246		

Nothing can be scheduled at Time = 17, so the example advance to Time = 18 where the 5-to-4 communication instance request finishes up.

Table 21: Intermediate Summed Access Value Table

Channel	Transmitter SAV	Receiver SAV
1	23	66
2	24	28
3	76	9
4	13	58
5	38	13

After unsuccessfully searching for a 5-to-4 communication instance request, a 5-to-2 communication instance request is found, a 1-to-4 communication instance request is found, and the tables now look like Tables 22 and 23:

Table 22: Intermediate Summed Access Value Table

Channel	Transmitter SAV	Receiver SAV
1	-	66
2	24	20
3	76	9
4	13	35
5	30	13

Table 23: Intermediate Request List

Source	Destination	Length	Priority	Start Time
1	2	15	1	0
1	4	23	1	18
1	5	2	1	15
2	1	24	1	-
3	1	16	1	0
3	1	12	1	16
3	2	20	1	-
3	3	8	1	-
3	4	19	1	-
3	4	16	1	-
3	5	4	1	-
3	5	9	1	-
4	1	13	1	-
4	5	9	1	0
5	1	21	1	-
5	1	8	1	-
5	2	8	1	18
5	3	1	1	-
5	4	18	1	0
Total		246		

The scheduler logic of the example now advances time to Time = 26 for which the scheduler logic of the example defines Table 24:

Table 24: Intermediate Summed Access Value Table

Channel	Transmitter SAV	Receiver SAV
1	-	66
2	24	20
3	76	9
4	13	35
5	30	13

The scheduler logic of the example now schedules a 5-to-3 communication instance, which is all that can be scheduled at this time. Time is then advanced to 27, then to 28, and the SAV Table looks like Table 25.

Table 25: Intermediate Summed Access Value Table

Channel	Transmitter SAV	Receiver SAV
1	-	66
2	24	20
3	76	8
4	13	35
5	29	13

Since there are no 3-to-1 communication instance requests, the scheduler logic of the example schedules a 3-to-2 communication instance request and a 5-to-1 communication instance request, and advances time to 31 and then to 48, at which time the SAV Table becomes Table 26.

Table 26: Intermediate Summed Access Value Table

Channel	Transmitter SAV	Receiver SAV
1	-	45
2	24	-
3	37	8
4	13	16
5	8	13

The scheduler logic of the example then schedules the 3-to-4 communication instance request and advances time to 49, giving Table 27 as a result.

Table 27: Intermediate Summed Access Value Table

Channel	Transmitter SAV	Receiver SAV
1	-	45
2	24	-
3	37	8
4	13	16
5	8	13

The scheduler logic of the example then books a 2-to-1 communication instance request and advances time to 67, giving Table 28.

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Table 28: Intermediate Summed Access Value Table

Channel	Transmitter SAV	Receiver SAV
1	-	21
2	-	-
3	29	8
4	13	16
5	8	13

The scheduler logic of the example now books the 3-to-3 communication instance request and advances time to 73 as shown in Table 29.

Table 29: Intermediate Summed Access Value Table

Channel	Transmitter SAV	Receiver SAV
1	-	21
2	-	-
3	29	-
4	13	16
5	8	13

The scheduler logic of the example then books the 4-to-1 communication instance request, and advances time to 75, resulting in Table 30.

Table 30: Intermediate Summed Access Value Table

Channel	Transmitter SAV	Receiver SAV
1	-	8
2	-	-
3	29	-
4	-	16
5	8	13

This allows the remaining 3-to-4 communication instance request to be scheduled by the scheduler logic of the example, after which the scheduler logic of the example advances to Time = 86, resulting in Table 31 data.

Table 31: Intermediate Summed Access Value Table

Channel	Transmitter SAV	Receiver SAV
1	-	8
2	-	-
3	13	-
4	-	-
5	8	13

The scheduler logic of the example now schedules the remaining 5-to-1 communication instance request, advances time to 91, schedules the first 3-to-5 communication instance request, advances time to 94, then to 95, and schedules the final request, another 3-to-5 communication instance request. The resultant Event Table then looks like Table 32.

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Table 32: Final Event Table

Source	Destination	Length	Priority	Start Time
3	1	16	1	0
5	4	18	1	0
1	2	15	1	0
4	5	9	1	0
1	5	2	1	15
3	1	12	1	16
5	2	8	1	18
1	4	23	1	18
5	3	1	1	26
3	2	20	1	28
5	1	21	1	28
3	4	19	1	48
2	1	24	1	49
3	3	8	1	67
4	1	13	1	73
3	4	16	1	75
5	1	8	1	86
3	5	4	1	91
3	5	9	1	95

Note that the entire list of request completes in 104 units of time - the theoretical minimum amount of time required to service these particular requests.

Pictorially, the final schedule is shown in as schedule chart 1201 in Figure 12. Transmitter scheduled element 1002 and receiver scheduled element 1003 from Figure 10 have been denoted as scheduled elements 1202 and 1203; scheduled elements 1104 and 1105, 1106 and 1107, and 1108 and 1109 from Figure 11 are denoted as scheduled elements 1204, 1205, 1206, 1207,1208, and 1209; and new elements 1216-1217 for the 1-to-4 communication instance, 1214-1215 for the 5-to-2 communication instance, 1212-1213 for the 3-to-1 communication instance, 1220-1221 for the 3-to-2 communication instance, 1222-1223 for the 5-to-1 communication instance, 1226-1227 for the 2-to-1 communication

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instance, 1224-1225 for the 3-to-4 communication instance, 1228-1229 for the 3-to-3 communication instance, 1230-1231 for the 4-to-1 communication instance, 1232-1233 for the 3-to-4 communication instance, 1234-1235 for the 5-to-1 communication instance, and 1238-1239 for the 3-to-5 communication instance are shown. Three of the interactions are shown without drawing element identifiers (the 1-to-5 communication having a duration of 2, the 5-to-3 communication having a duration of 1, and the 3-to-5 communication having a duration of 4.

Note that transmitter 3, the critical resource, is booked solid until Time = 104, a criteria which must be met in order to reach the theoretical minimum scheduling time. Note also that receiver 1, the second most critical resource, was booked solid until Time = 94. While this logic doesn't always produce the theoretically optimum schedule, it is designed to be efficient with the resources having the highest demands.

If the scheduling process had applied to a 100 unit window of time increment of time rather than a 150 unit window of time increment , the very last request would have been precluded from being scheduled in this window of time increment , but would have been queued until the scheduling process was resumed for the next time window of time increment .

The above example showed a list of requests where all of the requests had priority levels of 1. In one embodiment, four different priority levels are supported. All of the highest level requests are scheduled according to the logic before any of the other priority requests are even considered for scheduling.

Once all of the guaranteed requests have been scheduled, connection requests from the other three priorities are scheduled around the guaranteed requests already in the schedule. When there are already connections in the schedule, the process of calculating the window of time increment size is a little more complex, but the logic is essentially the same. Though the ACR value (or SAV) is still the predominant factor in deciding what gets scheduled when, connection requests between the same two concurrent resources are selected based on priority. This means, for example, that the ACR logic may elect to schedule a low priority 4-to-5 communication instance request before it schedules a medium priority 4-to-2 communication instance request, but never before it schedules a medium priority 4-to-5 communication instance request.

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Since there are requirements for certain connections to happen at a particular time rather than simply in some window of time increment of time, accommodations can be made for having these requests bypass scheduling. These fixed time connections are entered into the Event Table before scheduling begins and the scheduled connections must be worked in around the fixed connections. These fixed time connections obviously have the highest priority of any of the requests.

In the above example, advancing time was simply a matter of finding the next chronological finish of an already scheduled connection. However, the process of advancing time consumes cycles which might be better spent performing other functions. The network scheduler in the preferred embodiment uses a minimum time increment of 256 units (with a scheduling window of time increment of over 25,000 units rather than the 150 unit window of time increment described above) to reduce the processing requirements. While this does have an obvious negative impact on scheduling efficiencies, there is also a less obvious positive impact. On the average, more resources are candidates for scheduling at each time increment as a result of having processed more finishes between increments. With more resources contending simultaneously, those resources with higher critical impact values are less likely to be preempted by some other resource which had simply finished earlier. The end result of this compromise is that compute cycles are saved, but bandwidth efficiencies aren't substantially impacted.

In the above example, all requests were scheduled in their entirety - there was no need to break up the requests. Had any one of the requests been of a length longer than the defined window of time increment (150 units of time in the above example), however, it would have been segmented into at least two portions to enable scheduling. If a long message cannot be avoided by design, by breaking up the message and using a low priority attribute in this situation, long lower priority messages are less likely to preclude higher priority messages contending for the same resources.

In the preferred embodiment, requests greater than 1023 units are broken into 1000 unit "full" blocks and an optional "partial" block up to 1023 units in length.

In the preferred embodiment, the Itineraries (the particular messages used to convey the schedule) are themselves scheduled messages due to their varying, and potentially large,

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size. The Agendas (the messages used to collect the connection requests), however, are small and handled as fixed time connections (they are not literally scheduled). The scheduling pipeline used in the preferred embodiment involves collecting the agendas and scheduling the Itineraries in the first window of time increment, where the second, third, and fourth window of time increments are used as described (for scheduling the messages, conveying the schedule, and implementing the connections, respectively).

Turning now to Figure 13, a more detailed representation of components respective to a member node 107, 108 is depicted. While Figure 13 reprises a number of elements of Figures 1 and 5, details of logic types are shown enabling concurrent transmission and receipt of messages respective to the other nodes. In this regard, Transmit Logic 1301 and Receive Logic 1302 are shown for the Master Scheduler 106, with companion Transmit Logic 1319 and Receive Logic 1320 on member node 107 and further companion Transmit Logic 1321 and Receive Logic 1322 on member node 108. Pathways 1311, 1305, and 1306 show vectored message paths outbound from message carrier 100 (with crossbar switch 516). Such messaging approaches are achievable with a context cycling computer such as has previously been discussed, enabling a particular node 107, 108, 106 to be engaged in highly interleaved transmission and receipt of messages. Further detail showing the local scheduler 1307, oscillator 1308, CPU 1309, and VCXO (Voltage Controlled Crystal Oscillator) 1309 is shown for node 107 along with the previously discussed local task list 1303 and local task schedule 1304 which have also been discussed in general.

Turning now to Figure 14, focus is directed to three technologies which, when combined, illustrate a unique and valuable abstracted characterization of considerations in networking distributed, real-time computers to further put the nature of the present invention into full perspective. In this regard key technologies relate to Tight Synchronization between computers; Time Deterministic operation, including network communications; and Centralized Scheduling of distributed tasks, particularly those involving network communications. This diagram shows the interrelationships 1400 between the various technologies implemented in the preferred embodiment, with emphasis on those technologies considered critical to the implementation. The fundamental technologies which, when combined, provide an architecture amenable to real time computing in a distributed computing environment are (1) Time Deterministic Event Control 1422; (2) Tight Synchronization 1423 between systems; and (3) Centralized Scheduling 1421 of the tasks critical to the operation of the real time systems in the distributed environment.

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The relationships between the technologies are shown using arrows, where the arrowheads point from the enabling technology to the enabled technology, and where the term "enabling" is loosely used here to describe an improvement in the utility of that technology, or in the simplicity of applying the technology. Note that many of the technologies are mutually beneficial, as depicted with a double headed arrow.

The following table explains the relationships between the implementation characteristics as virtual linkages of Figure 14 between the features and goals of tight synchronization 1423, prioritization 1424, time deterministic event control 1422, security 1426, limit checking 1425, centralized scheduling 1421, physical circuit switching 1434, non-blocking tree topology 1429, reliability 1428, active redundancy 1427, and low cost 1435 are interrelated in an abstracted characterization.

Table 33 Interactions of key technical features

Connection In drawing	Quality
1401	Centralized scheduling assures that all network interactions occur at prescribed times. The first requirement for Time Determinism, by this description, is having the nodes on the network in tight synchronization. None of the network nodes can know the needs of the entire network, so in the absence of the central scheduler, the alternatives are to either remove all dynamics or to implement a solution tolerant of the variability. By incorporating centralized connection scheduling, prioritization, and limit checking, the (high priority) time critical interconnections can be time deterministic while the (low priority) high volume interconnections can exist through variability tolerant designs.
1402	In a distributed computing environment, deterministic networking can be achieved either with tightly synchronized systems, or by providing enough excess bandwidth to realize timely delivery in a worst case timing and bandwidth demand situation. Because such an analysis of worst case situation is difficult and because providing the excess bandwidth can be costly, synchronization is an enabling technology for Time

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	Determinism. Additionally, the difficulty in achieving a desired level of synchronization is usually proportional to the extent that the communications are indeterminate.
1403	Active Redundancy enables Time Determinism primarily in regards to failure recovery. It is difficult to manage the possible failure scenarios in the absence of redundancy, yet it is also difficult to manage failure recovery in a Time Deterministic system with passive redundancy. Time Determinism facilitates the use of Active Redundancy in that one of the biggest challenges to active redundancy is in assuring that all sides operate identically. Furthermore, with a Time Deterministic environment, a redundant element of a system can be diagnosed as dysfunctional simply by noting that the appropriate actions aren't occurring at the prescribed times. The time deterministic network involves communicating based on time between separate computing elements. The fact that the communications are scheduled based on time facilitates the employment of active redundancy. In active redundancy, there are two or more computers which are each executing identical logics via its own sequence of program instructions, exchanging the results of this execution, and then arbitrating to come to a result. Due to the fact that the data received by each computer must be shared with the other computer(s) executing the same logic prior to arbitrating this data, there must be some mechanism by which the time to begin the arbitration process in determined. The mechanism which has been chosen is to provide time synchronization between the redundant computers and schedule the tasks related to the communications based on time. In this way, there is known the time at which the arbitration task can begin.
1404	One of the most difficult challenges in implementing active redundancy is in handling the variation between sides. All sides of a redundant system must be expected to match at defined checkpoints, and discrepancies must be resolved in order to retain the value in redundancy. All sides must know when a checkpoint has been reached, and rules must be defined to allow differences to be resolved. With centralized scheduling,

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	variations in connection requests, either in content or in timing, can be reduced or even eliminated, thereby increasing the probability that all sides can maintain operational equivalence. On the other hand, centralized scheduling places a tremendous dependency on the availability of that scheduling element. Centralized scheduling becomes much more viable in the presence of redundancy.
1405	Centralized scheduling requires that all connection requests be assembled together for analysis. This permits limit checking to verify that (1) certain undesirable node-to-node combinations are prohibited and (2) traffic levels (possibly at a particular priority) between certain combinations of nodes doesn't exceed predefined levels.
1406	Limit checking enhances the security of the distributed computing system by assuring that certain restrictions aren't violated. These limit checks help against malicious attacks where certain systems shouldn't be allowed to interact with others, and against accidental complications such as overloading a system with legitimate low priority data or unintentional overloading of high priority data.
1407	Prioritization of the messages enhances the utility of the limit checking. Not only can the highest priority data be made time deterministic without excessively restricting the lower priority messages, but security measures can be put in place which take message priority into account.
1408	Limit checking improves the overall reliability of the system by preventing certain security risks and by retaining the time determinism. In the absence of limit checking, certain network faults could cripple the network, such as when a node were to accidentally request an excessive amount of traffic at the highest priority level.
1409	In the implementation of Limit Checking, the highest priority traffic is testing against throughput thresholds to assure that no errors on one channel preclude the highest priority messaging to take place between any nodes not including the node with errors.
1410	Non-blocking network architectures allow the network to realize throughputs higher than the throughput available to any particular node on the network. This translates to higher bandwidth at any particular

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	price when compared to blocking architectures.
1411	Security can often be implemented more easily when a centralized security agent can be entrusted with the administration of the security policies. Specifically in the preferred embodiment, the central scheduler is given the security tables and the interconnecting systems can delegate the security task to the central authority, allowing the administration to be done in one place rather than in two. Furthermore, the same security policies don't have to be re-implemented in as many environments as can exist on the star.
1412	By introducing a centralized scheduler, the scheduling logic can be implemented so as to enforce prioritization on the received connection requests.
1413	Prioritization simplifies the task of implementing Time Determinism. This is because large but infrequent tasks such as program loading can be set to operate at a low priority, eliminating the analysis of this high impact operation would have on the simpler yet more critical task of peer to peer communications.
1415	On networks employing a broadcast protocol, all network nodes have the opportunity to view the data going to all other nodes (though encryption can make this viewing rather futile). Blocking protocols aren't always implemented in broadcast protocols, but non-blocking protocols preclude the possibility of broadcasting, thereby avoiding the obvious security risks.
1416	One of the obvious ways of achieving reliability is in the introduction of redundancy.
1417	High throughput, the primary objective of high bandwidth, is positively impacted in two ways through the introduction of prioritization. First, there is the perception of high throughput in that the data that has the most value is delivered in a more timely fashion by invoking prioritization. Secondly, higher volumes of data can be permitted knowing that the high priority data, which often must be delivered in a timely fashion, won't be sacrificed by permitting large volumes of low priority traffic to be requested.
1418	Active Redundancy requires that a failed element be capable of

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	recovering from downtime. This often involves the exchange of historical data from the elements which did not fail. In order to minimize the impact of this exchange, prioritization can be introduced assuring that the recovering element can recover and that it can do so without a substantial detrimental impact on the healthy elements.
1419	Certain architectures and topologies are inherently at risk of network outages in the presence of system outages. Use of a non-blocking architecture and physical circuit switching, while not the only means to achieve a higher reliability, offers a level of isolation from network node faults.
1420	Centralized scheduling is an enabling technology for effectively using the bandwidth available to non-blocking networking architectures such as those implementing certain crossbar switches. In the absence of scheduling, fixed connection patterns must be implemented, thereby reducing the practical throughput available to the nodes.
1431	Physical Circuit Switching technology can be difficult to implement for several reasons, including challenges associated with determining what circuits should be put in place at any particular time. By knowing the needs ahead of time, the connection patterns for the circuit switch can be determined a priori and implemented as needed.
1432	Circuit switching of systems configured in a tree topology can be implemented with a separate circuit, or pair of circuits, for each system on the network. This allows each channel to have its own path for communications, permitting a non-blocking architecture.
1433	Because physical circuit switching can reduce the requirement for active circuitry, high line speeds can often lead to higher network bandwidths.
1436	The simplicity of the circuitry associated with physical circuit switching often permits a given set of capabilities to be implemented at a lower cost.

Turning now to Figure 15, the general process 1500 executed respective to scheduling in each member node 108, 107 (any one of control computer 506, historian computer 507, control computer 504, historian computer 505, user interface 503, network support 502, and network switch 501) is discussed. Each member node 108, 107 is responsible for receiving

the common clock signal; synchronizing to that common clock signal; receiving the local event table 114, 116 from the master scheduler 106 in network switch 501; formulating the task execution list based on the received local event table 114, 116 and merging in any additional tasks which are not described in the local event table 114, 116; executing the task execution list; generating the request list of communications; and transmitting the request list of communications to the master scheduler 106 in network switch 501.

Steps 1501 and 1502 - Since the network is so highly dependent on a global time base, the first step 1501 at a member node 108, 107 is to receive the common clock signal. The clock signal is communicated as a message from the master scheduler 106 in network switch 501 to each of the member nodes 108, 107. The member node 108, 107 receives this clock signal in step 1501, stamps the actual time of reception, and validates the integrity of this message. The validated message is used as an input to the process of synchronization and, in step 1502, the difference between the expected and actual times of time message receipt is optionally determined (optionally if the nature of the time message is a pulse instead of a data bearing message).

Steps 1503 and 1504 - Each member node 108, 107 must now synchronize to the common clock signal. The process of performing this synchronization can be broken up into two separate tasks: first, in step 1503, the adjustment of a voltage controlled oscillator (1308) to a frequency which matches the source of the common clock signal and second, in step 1504, the alignment of the time such that the start of each time period which is defined by the common clock signal occurs at the same time in the member nodes 108, 107 as it does in the master scheduler 106 in network switch 501.

Step 1505 - Once the synchronization of a member node 108, 107 to the master scheduler 106 in network switch 501 is complete, the member node 108, 107 must receive the local event table 114, 116 from the master scheduler 106 in network switch 501. The local event table 114, 116 contains the schedule for the communications which are involving this member node. Note that the reception of the local event table 114, 116 itself is scheduled by the master scheduler 106 in network switch 501. Therefore, the first time that the node is to receive the local event table 114, 116 it must be available to receive that message at any possible time that the local event table 114, 116 might be received.

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Step 1506 - The next step for the member node 108, 107 is to formulate the task execution list. The task execution list is formulated from the local event table 114, 116 and the additional tasks which the member node 108, 107 must do which are not described in the local event table 114, 116. The local event table 114, 116 which is communicated from the master scheduler 106 in network switch 501 provides the timing associated with the transmission and reception tasks. In order to formulate the task execution list, the following sub-steps must be taken:

Substep 1506A: Adjust the start time received from the master scheduler 106 in network switch 501 to account for the propagation delay. The timing which is received from the master scheduler 106 in network switch 501 is relative to the master scheduler 106 in network switch 501. Although the member node 108, 107 is synchronized with the master scheduler 106 in network switch 501, there is still an inherent delay in the propagation through the media being communicated. Either this delay must be accounted for by the master scheduler 106 in network switch 501, the member node, or the communication window of time increment must be sufficiently large that the inherent delay is included as overhead in the time allotted to the connection. In the preferred embodiment, this delay is accounted for in the member node.

Substep 1506B: Schedule the tasks which are dependent on the communication tasks. There are tasks which must be scheduled prior to a transmission (for example, the transfer of the data to be transmitted from memory); there are also tasks which must be scheduled after a reception (for example, the arbitration of the data between the multiple, different sources in a redundant computing environment and the transfer of data to memory). The member node 108, 107 is responsible for the scheduling of these tasks.

Substep 1506C: Schedule the tasks which are neither described by the local event table 114, 116 nor are dependent on the communications. There are tasks which the member node 108, 107 must accomplish in addition to communication related tasks. These tasks may be for the operation of other I/O, localized display, etc.

Step 1507 - The next step for the member node 108, 107 is to execute the task execution list. Each task in the list contains the task which is to be executed, the start time for the task, and any parameters which are necessary in order to successfully complete the task.

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Step 1508 - The member node 108, 107 can now formulate the communication request list, which is a list of the member nodes 108, 107 to which this member node 108, 107 is desiring to communicate. The information which is included in this communication request list is the source node identifier, destination node identifier, and the total length of the communication.

Step 1509 - This communication request list is communicated to the master scheduler 106 in network switch 501 for consideration in its scheduling. At this point, the member node 108, 107 has performed all of the necessary functions in a particular time period. The next step 1510 is to determine whether or not it is time to receive the next reference moment message. If it is, then the entire process repeats itself starting with the very first step 1501 of receiving the reference moment message. If it is not time to receive the next reference moment message, then the logic of the member node may forward to step 1505.

As one contemplated embodiment, Figure 16 presents the general data flow diagram 130 of Figure 1 as a data flow diagram 1600 where communications are effected via radio frequency means and transmissions 1601, 1602, and 1603 are effected via radio frequency transmitters and receivers.

The present invention is enabled through use of machines which are considered as a special purpose computers created in one embodiment by combining a computer with computer program code (alternatively termed, for example, software or logic, where logic denotes software in and for execution by an enabling system of electrical circuitry) directed to the particular function of process control so that, when connected to an electrical power source, powered by electricity, and activated to execute its computer program code (software), the special purpose computer executes the particular function related to the present invention pursuant to the instructions from the computer program code. The computer has electrically activated components denoted as a central processing unit, at least one physical memory connected to the central processing unit, an optional input keyboard connected to the central processing unit, an optional output display (which can include, without limitation, a printer, printing terminal where output is printed on paper, cathode ray tube monitor, and/or flat panel monitor) connected to the central processing unit, a computer clock pulse generator, and a connection to electrical power for energizing all of the electrically activated components of the computer. The central processor further has a control bus and specific computer circuits for either temporarily holding data (for example, a register or an

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accumulator) or for executing a fundamental data processing operation (for example, an addition circuit); the specific computer circuits are connected in communication to the control bus through latching circuits which can individually be in either a conducting (communicating) or non-conducting (non-communicating) configuration; the collective configurations of all the latching circuits at a particular moment define a particular state of the central processor; and the state of the central processor is respectively modified and changed as the individual instructions of the computer program code are sequentially accessed by the central processing unit and output from the clock pulse generator is directed to the latches. The computer optionally also has computer program code in the form of a commercially available operating system which functions as a computer program code platform for enabling the execution of the special purpose computer program code directed to the particular function of the present invention. In overview, the present invention in this embodiment is implemented in the preferred embodiment by and through a plurality of computers which have been programmed to contribute to technology by performing the specifically useful purpose and practical application of the described system; each computer functions as a medium for realizing the functionality provided by the computer program code's functionality. In some embodiments, some communication linkages within an extended form of the special purpose computer may be implemented by electrical, optical, or radio-frequency signal communication interfaces and communication media which collectively use electrically-powered transmitter and receiver components which are directly or indirectly linked to at least one central processing unit.

The computer program code resident within a computer provides at least one component part of that machine. The computer program code may be in the form of, without limitation, inter-linked modules, routines and subroutines, program objects, and/or installed interactive processes. In some emergent computer designs, enabled by modern application specific integrated circuitry (ASIC) technology, computer program code may be at least partially expressed in hardwired circuitry reminiscent of traditional hardwired gate arrangements which execute simplified logical scenarios without need for a clock pulse. The Figures of this description show a number structural relationships between key modules and components within the computer program code and other aspects of the invention which enable the functionality of the machine of the present invention to be realized; in this regard, the computing elements in the system are constructed out of a combination of hardware and software.

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The present invention has been described in an illustrative manner. In this regard, it is evident that those skilled in the art, once given the benefit of the foregoing disclosure, may now make modifications to the specific embodiment described herein without departing form the sprit of the present invention. Such modifications are to be considered within the scope of the present invention which is limited solely by the scope and spirit of the appended claims.

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We claim:

1. A computer implemented method for enabling a plurality of computer nodes in mutual data communication to execute logic in a coordinated manner, comprising:

aligning real-time time between said plurality of computer nodes so that each computer node has essentially the same real-time time;

defining a schedule of communications for each computer node, said schedule having a different time in the future defined for initiating each respective communication;

communicating each schedule to its respective computer node; and

initiating each communication from each node at the time defined in its schedule.

2. A computer network architecture, comprising:

a message carrier supporting multiple communication paths;

a plurality of computers coupled to said message carrier, said computers being programmed to perform time-deterministic tasks by cycling through a plurality of different operating states, including a communication state;

a clock system accessible by all said computers for maintaining time synchronism among said computers; and

a scheduler coupled to said message carrier for determining the sequence of communication between said computers by causing said message carrier to establish communication between selected computers based on said time-deterministic tasks being performed by said computers.

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3. A computer implemented method for enabling a computer node in a plurality of computer nodes to execute logic in coordination with the other nodes in said plurality of computer nodes, comprising:

connecting a message carrier to each computer node in said plurality of computer nodes;

providing master scheduling capability in one computer node to establish a master scheduler;

defining, in each computer node, a communication request list of each communication needed by said computer node with any other computer node respective to a future time period;

sending said communication request list from each computer node to said master scheduler via said message carrier;

receiving, in each computer node, a communication schedule from said master scheduler via said message carrier;

defining, in each computer node, a local task schedule from said communication schedule.

4. A computer implemented method for enabling a plurality of member nodes to execute logic in a coordinated manner, comprising:

connecting a message carrier to each member node in said plurality of member nodes;

providing a master scheduler in data communication with each said member node via said message carrier;

defining a reference moment time value for said plurality of member nodes;

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communicating said reference moment time value to each member node and said master scheduler via said message carrier;

defining a communication request list in each said member node showing each communication needed by said member node with any other member node in a future time period;

communicating said communication request list from each member node to said master scheduler via said message carrier;

defining, in said master scheduler, scheduled communications between member nodes at communication event times respective to said reference moment time value and also respective to each said communication listed in each said received communication request list;

defining, in said master scheduler, a communication schedule for each member node respective to said scheduled communications ;

sending each said communication schedule from said master scheduler to each respective member node via said message carrier;

defining, in each member node, the difference in time between said reference moment time value and the time when said reference moment time value is communicated into said member node;

defining, in each member node, a local task schedule from said communication schedule and from said difference in time for the member node so that the member node will communicate to other member nodes via said message carrier at said scheduled communication event times;

executing said scheduled communications between said member nodes respective to each scheduled communication via said message carrier according to said respective local task schedules.

5. The method of Claim 4 wherein said step of defining a reference moment time value is performed by said master scheduler.

6. The method of Claim 4 wherein said step of defining a communication request list in each said member node limits said communications to a maximum number in said future time period.

7. The method of Claim 4 wherein each communication has a duration time attribute and the value of said duration time attribute is less than a fixed maximum value.

8. The method of Claim 4 wherein the step defining a reference moment time value for said plurality of member nodes is done by a global time system.

9. A computer implemented method for enabling a plurality of member nodes to execute logic in a coordinated manner, comprising:

connecting a message carrier to each member node in said plurality of member nodes, each node having a central processing unit;

providing a master scheduler in data communication with each said member node via said message carrier;

defining a reference moment time value as a moment in time for said plurality of member nodes;

communicating said reference moment time value to each member node and said master scheduler via said message carrier;

defining into a communication request list in each said member node, each access to any other member node needed by said member node in achieving a future task increment respective to a future time period;

communicating said communication request list from each said member node to said master scheduler via said message carrier;

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defining, in said master scheduler, a communication event data object respective to each said access to any other member node needed by said member node in achieving a future task increment, said communication event data object having an accessing member identification attribute value, an accessed member identification attribute value, and an access duration attribute value;

collecting, in said master scheduler, all defined communication event data objects into a communication event set;

determining in said master scheduler a summed accessed value for each member node in said communication event set as a sum of all access duration attribute values in all communication event data objects having a accessed member identification attribute value respective to said member node;

determining in said master scheduler a summed accessing value for each member node in said communication event set as a sum of all access duration attribute values in all communication event data objects having an accessing member identification attribute value respective to said member node;

scheduling in said master scheduler and into the earliest available time in a schedule, a future communication task respective to said reference moment time value between the accessing member node having the highest said summed accessing value respective to said communication event set and the accessed member node respective to the accessed member identification attribute value in the communication event data object having the highest affiliated access duration attribute value for all communication event data objects respective to said accessing member node, said future communication task having a task initiation time equal to the earliest available time in the schedule, an accessing member node identifier attribute respective to the accessing member, and an accessed member node identifier attribute respective to the accessed member node;

removing, in said master scheduler, the communication event data object respective to the accessed member node identifier attribute in the scheduled future communication task and the accessed member node identifier attribute in the scheduled future communication task to redefine the communication event set to those communication event data objects which have not been scheduled; and

repeating, in said master scheduler, respective to the redefined communication event set, the steps of determining a summed accessed value, determining a summed accessing value, scheduling a future communication task, and removing all communication event data objects respective to scheduled member nodes until all communication event data objects have been scheduled into a communication schedule for each member node;

sending each said communication schedule from said master scheduler to each respective member node via said message carrier;

defining, in each member node, the difference in time between said reference moment time value and the time when said reference moment time value is communicated into said member node;

defining, in each member node, a local task schedule from said communication schedule and from said difference in time for the member node so that the member node will communicate to other member nodes via said message carrier at said scheduled communication event times; and

executing said scheduled communications between member nodes respective to each scheduled communication event via said message carrier according to said respective local task schedules.

10. A computer implemented method for scheduling communications between member objects in a plurality of member objects functioning as a collective group, comprising the steps of:

providing a computer;

defining in said computer, for each member object, a communication event data object respective to each access to any other member object needed by said member object in achieving a future task increment, said communication event data object having an accessing member identification attribute value, an accessed member identification attribute value, and an access duration attribute value;

collecting, in said computer, all defined communication event data objects into a communication event set;

determining, in said computer, a summed accessed value for each member object in said communication event set as a sum of all access duration attribute values in all communication event data objects having a accessed member identification attribute value respective to said member object;

determining, in said computer, a summed accessing value for each member object in said communication event set as a sum of all access duration attribute values in all communication event data objects having an accessing member identification attribute value respective to said member object;

defining a set of sequential future time increments within a scheduling period respective to a schedule;

scheduling, in said computer, into the earliest available time in the first of said future time increments, a future communication task based on the first available communication event data object in said communication event set between

the accessing member object having the highest said summed accessing value respective to said communication event set and

the accessed member object having the highest said summed accessed value respective to said communication event set if a communication event data object exists between said accessed member object and said accessing member object,

said future communication task having a task initiation time equal to the earliest available time in the schedule, an accessing member object identifier attribute respective to the accessing member object, an accessed member object identifier attribute respective to the accessed member object, and said access duration attribute value;

removing from scheduling candidacy, in said computer, the communication event data object respective to the accessed member object identifier attribute in the scheduled future communication task and the accessing member object identifier attribute in the scheduled future communication task to redefine the communication event set to those communication event data objects which have not been scheduled;

repeating, in said computer respective to the redefined communication event set, the steps of determining a summed accessed value, determining a summed accessing value, scheduling a future communication task, and removing all communication event data objects respective to scheduled member objects until all communication event data objects have been scheduled which can be scheduled into said first future time increment; and

recurrently executing, in said computer respective to the redefined communication event set and sequentially respective to each of the remaining of said plurality of future time increments, the steps of determining a summed accessed value, determining a summed accessing value, scheduling a future communication task, and removing all communication event data objects respective to scheduled member objects, and repeating such steps until all communication event data objects have been scheduled which can be scheduled into each said future time increment and until all communication event data objects have been scheduled into said scheduling period.

11. The method according to 10, wherein said defining is confined to future task increments which are needed within a predefined time period and said scheduling is respective to said predefined time period.

12. The method according to 11, further comprising the step of connecting a message carrier to each member object in said plurality of member objects, said message carrier having a plurality of channels for permitting concurrency in said communication events, said step of scheduling being respective to said plurality of channels as a group wherein said earliest available time is respective to any channel in said message carrier.

13. The method according to Claim 12 wherein each said member object is a member node being in data communication with said message carrier, each member node having a central processing unit.

14. A computer implemented method for scheduling tasks for resource objects in a plurality of resource objects functioning as a collective group, comprising the steps of:

providing a computer;

defining, in said computer, a set of future tasks for said collective group;

defining, in said computer, each resource object needed for each future task in said set of future tasks;

defining, in said computer, each interaction needed between any two resource objects respective to said set of future tasks;

defining, in said computer, a use instance for each said resource object in achieving each said interaction, said use instance having an use duration attribute value;

defining, in said computer, an accessing resource object and an accessed resource object respective to each said use instance;

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Page 1259 of 1434

firstly determining, in said computer, a summed accessing time value for each accessing resource object as a sum of all use duration attribute values for all said use instances respective to that resource object when it is the accessing resource object;

secondly determining, in said computer, a summed accessed time value for each accessed resource object as a sum of all use duration attribute values for all said interactions between said accessed resource object and said accessing resource object;

defining, in said computer, a set of sequential future time increments within a scheduling period respective to a schedule;

scheduling, in said computer, into the earliest available time in the first of said future time increments, a future resource interaction event based on the first available future task in said set of future tasks between

the accessing resource object having the highest said summed accessing value respective to said set of future tasks and

the accessed resource object having the highest said summed accessed value respective to said set of future tasks if a use instance exists between said accessed resource object and said accessing resource object,

said future resource interaction event having an initiation time equal to the earliest available time in the schedule, an accessing resource object identifier attribute respective to the accessing resource object, an accessed resource object identifier attribute respective to the accessed resource object, and said use duration attribute value;

removing from scheduling candidacy, in said computer, the use instance respective to the accessed resource object in the scheduled future resource interaction event and the accessing member object identifier attribute in the

LINKPLAY EXHIBIT 1002
Page 1260 of 1434

scheduled future resource interaction event to redefine the set of future tasks to those future tasks for which interactions have not been scheduled;

repeating, in said computer, respective to the redefined future task set, the steps of determining a summed accessed value, determining a summed accessing value, scheduling a future communication task, and removing all use instances respective to scheduled resource objects until all use instances have been scheduled which can be scheduled into said first future time increment; and

recurrently executing, in said computer, respective to the redefined future task set and sequentially respective to each of the remaining of said plurality of future time increments, the steps of determining a summed accessed value, determining a summed accessing value, scheduling a future resource interaction event, removing all resource objects respective to scheduled resource objects, and repeating such steps until all resource interaction events have been scheduled which can be scheduled into each future time increment and until all resource interaction events have been scheduled into said scheduling period.

15. A computer implemented apparatus for enabling a plurality of computer nodes in mutual data communication to execute logic in a coordinated manner, comprising:

means for aligning real-time time between said plurality of computer nodes so that each computer node has essentially the same real-time time;

means for defining a schedule of communications for each computer node, said schedule having a different time in the future defined for initiating each respective communication;

means for communicating each schedule to its respective computer node;

means for initiating each communication from each node at the time defined in its schedule.

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Page 1261 of 1434

16. A computer-implemented apparatus having a message carrier, comprising:

a plurality of member nodes, each member node being in data communication with said message carrier, each member node having

a central processing unit,

time phase logic for receiving from said message carrier a reference moment message having a reference moment time value and for defining the difference in time between said reference moment time value and the time of receiving said reference moment message,

communication definition logic for identifying each internodal communication needed by said member node in a future time period and for establishing a communication request list respective to all said internodal communications,

communication request sending logic for communicating said communication request list via said message carrier to a master scheduler,

communication task receiving logic for receiving a communication schedule via said message carrier from said master scheduler,

task integration logic for defining a local task schedule from said communication schedule and said difference in time, and

communication implementation logic for communicating via said message carrier with other member nodes according to said local task schedule; and

a master scheduler in data communication with said plurality of member nodes via said message carrier, said master scheduler

having scheduler logic executed by a central processing unit, said scheduler logic having

reference moment definition logic for defining said reference moment time value as a moment in time,
reference moment communication logic for creating a reference moment message having said reference moment time value and for communicating said reference moment message via said message carrier to each member node,

communication request receiving logic for receiving each said communication request list from each said member node via said message carrier,

communication schedule definition logic for scheduling communications between member nodes at communication event times respective to said reference moment time value and also respective to each said internodal communication listed in each said received communication request list and for further defining a communication schedule for each member node respective to said scheduled communications, and

member node communication schedule response logic for sending each said communication schedule to each respective member node via said message carrier.

17. The apparatus of Claim 16, wherein each member node further comprises a variable speed oscillator.

18. The apparatus of Claim 16, wherein each member node further comprises time alignment logic and oscillator rate adjustment logic.

19. The apparatus of Claim 16, wherein said message carrier comprises a crossbar switch.

20. The apparatus of Claim 16, wherein said message carrier comprises a network topology.

21. The apparatus of Claim 16, wherein said message carrier comprises a radio frequency communications system.

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Page 1264 of 1434

FIG. 1

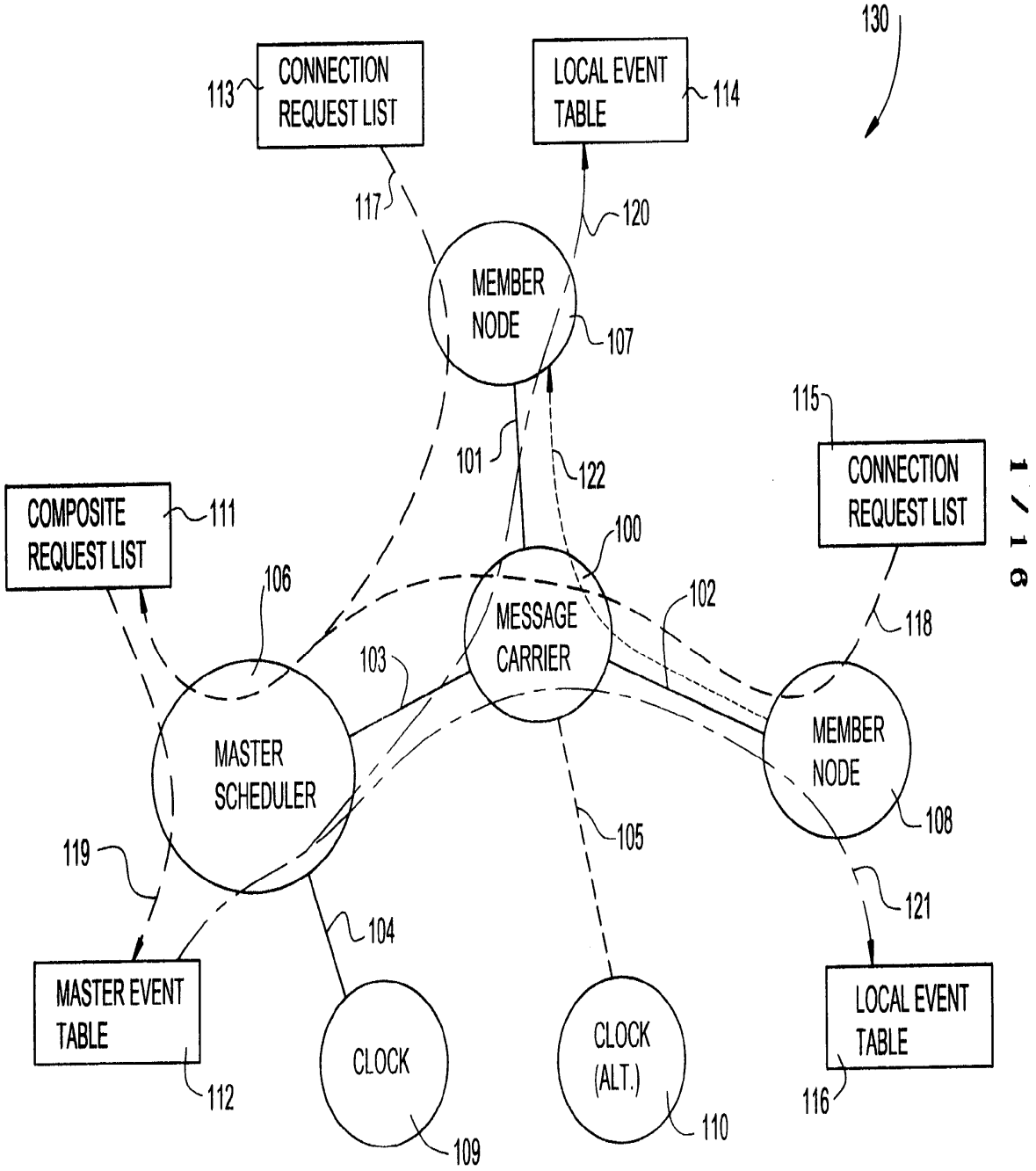
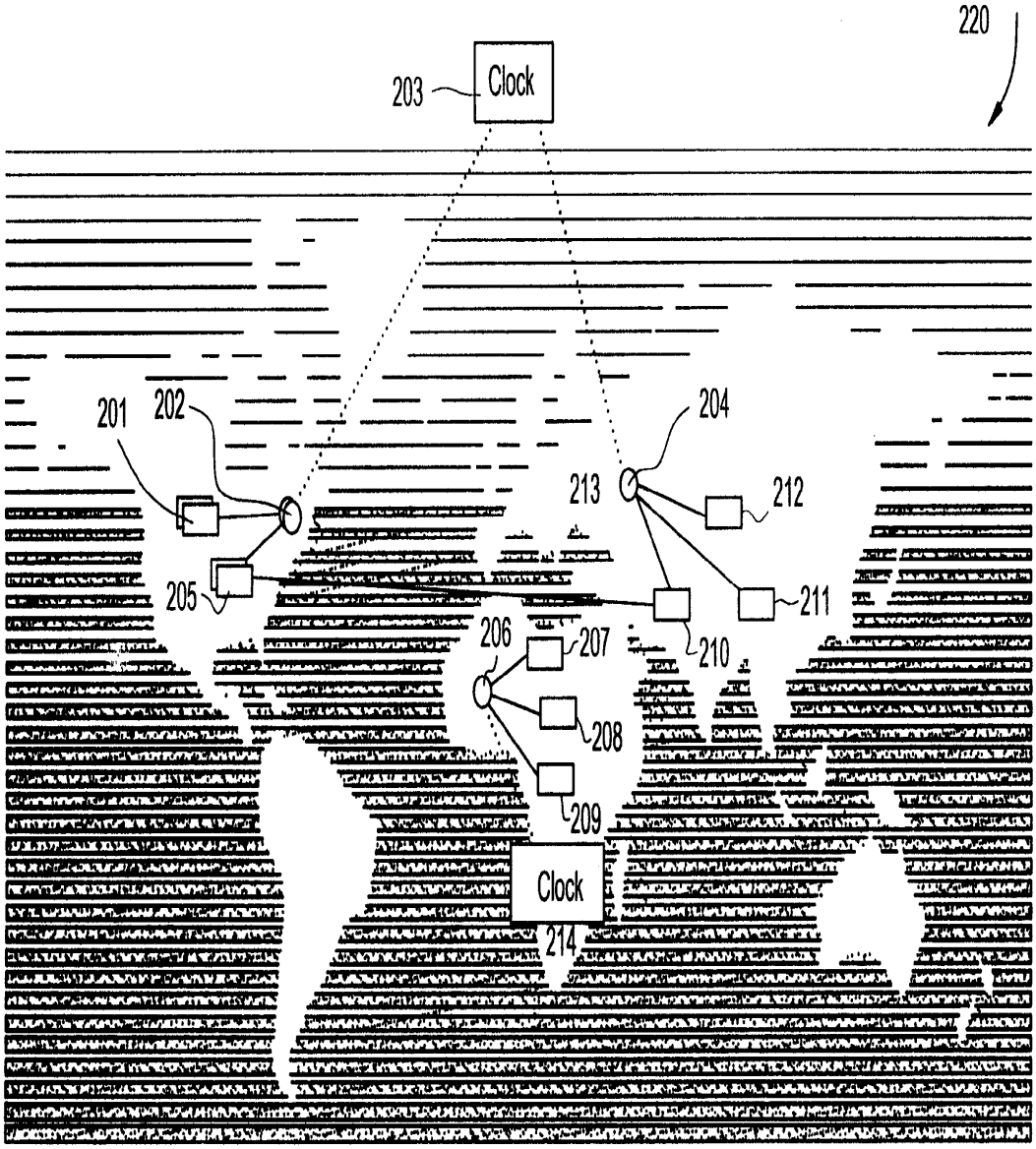

130
CONNECTION REQUEST LIST
113
LOCAL EVENT TABLE
114
117
120
MEMBER NODE
107
101
122
115
CONNECTION REQUEST LIST
COMPOSITE REQUEST LIST
111
100
106
MESSAGE CARRIER
102
118
103
MASTER SCHEDULER
MEMBER NODE
108
105
119
121
104
MASTER EVENT TABLE
CLOCK
CLOCK (ALT.)
LOCAL EVENT TABLE
112
109
110
116

FIG. 2



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FIG. 3

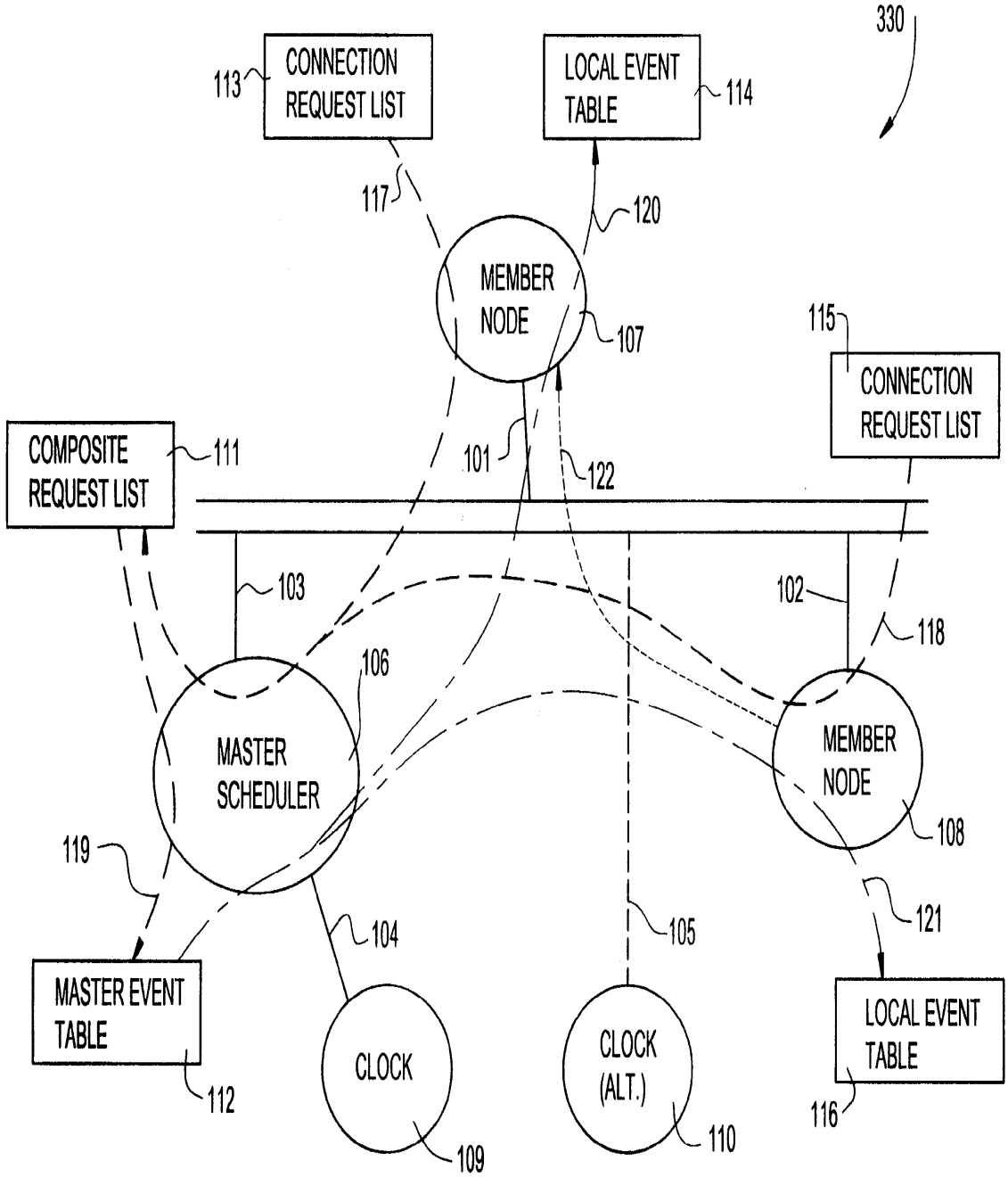
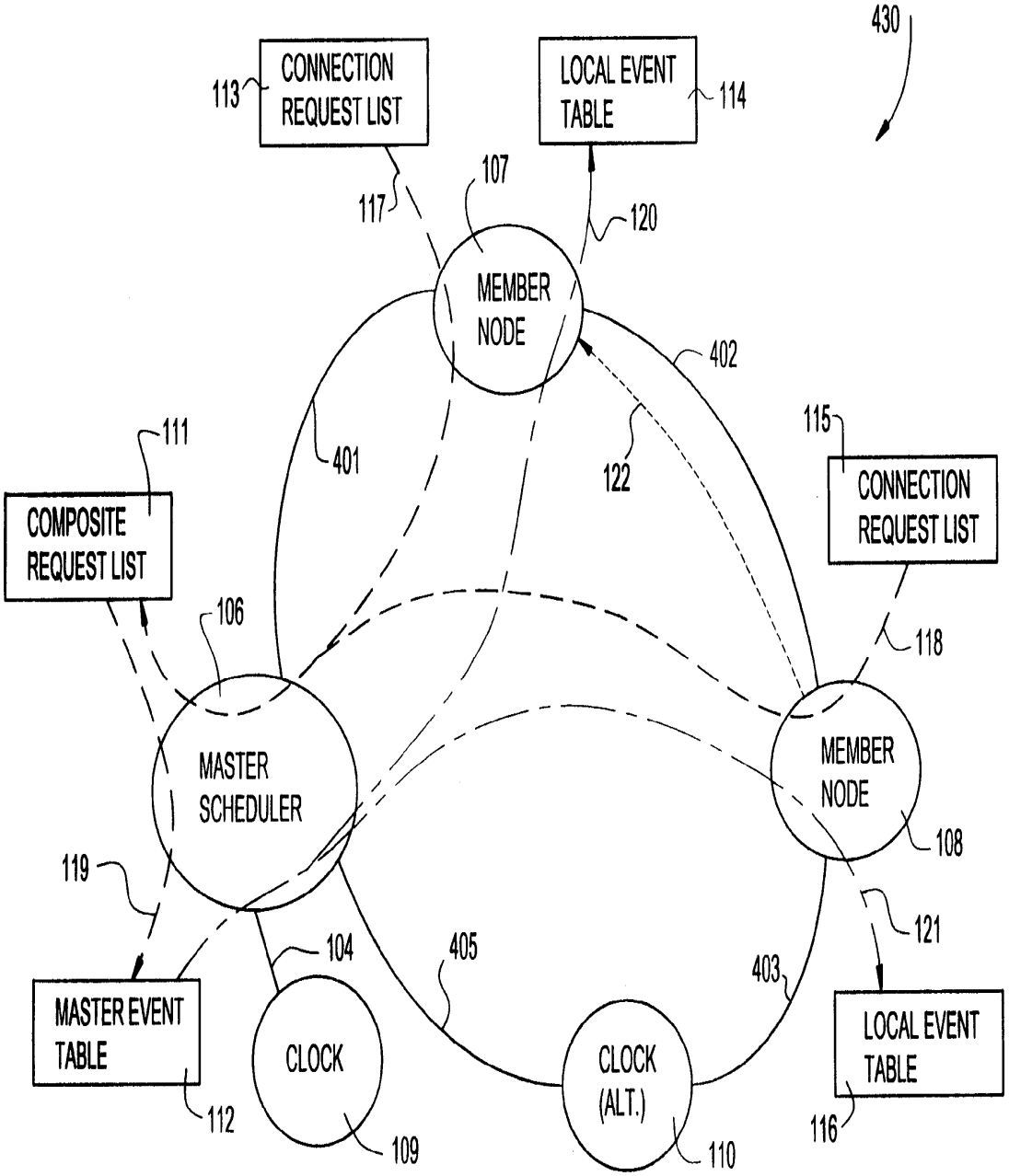


FIG. 4


430
CONNECTION REQUEST LIST
113
LOCAL EVENT TABLE
114
117
107
120
MEMBER NODE
402
401
122
115
111
CONNECTION REQUEST LIST
COMPOSITE REQUEST LIST
106
118
MASTER SCHEDULER
MEMBER NODE
108
119
121
104
405
403
MASTER EVENT TABLE
CLOCK
CLOCK (ALT.)
LOCAL EVENT TABLE
112
109
110
116

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FIG. 5

FIG. 6

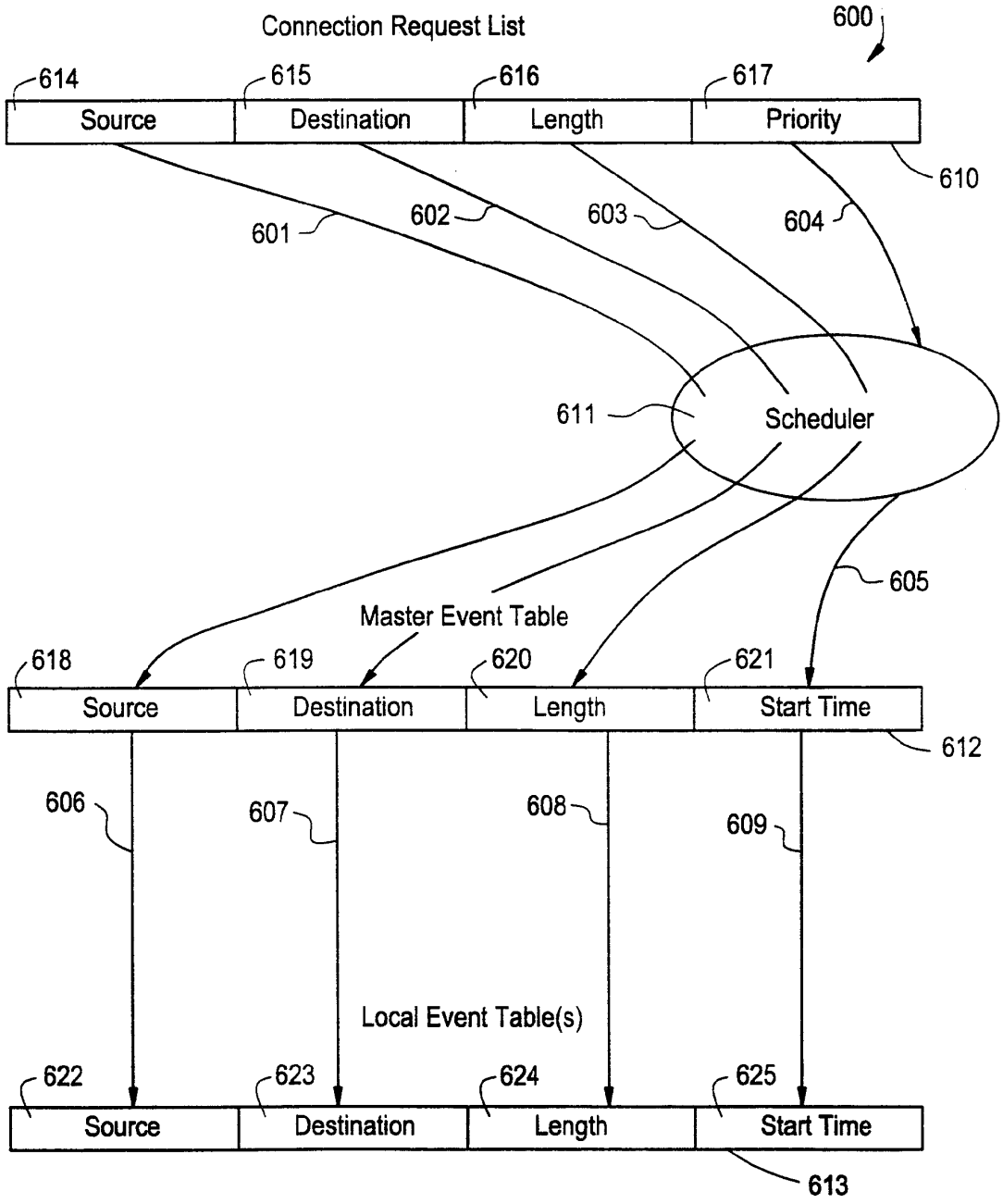

Connection Request List
600
614
615
616
617
Source
Destination
Length
Priority
610
601
602
603
604
611
Scheduler
605
Master Event Table
618
619
620
621
Source
Destination
Length
Start Time
612
606
607
608
609
Local Event Table(s)
622
623
624
625
Source
Destination
Length
Start Time
613

FIG. 7

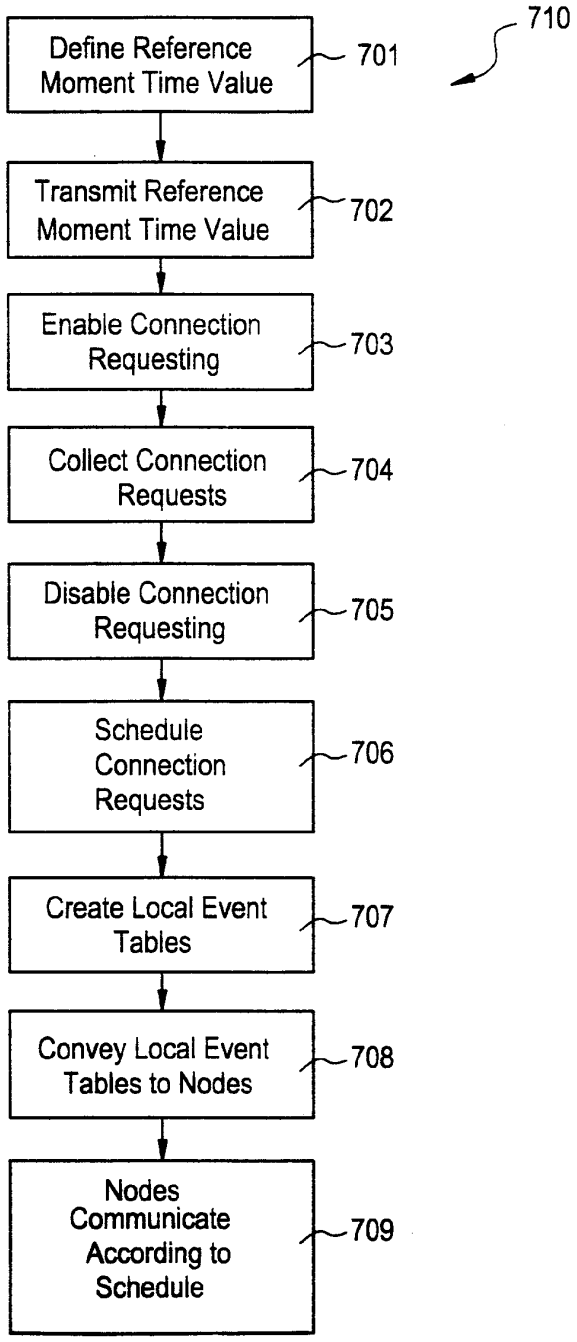

710
Define Reference Moment Time Value
701
Transmit Reference Moment Time Value
702
Enable Connection Requesting
703
Collect Connection Requests
704
Disable Connection Requesting
705
Schedule Connection Requests
706
Create Local Event Tables
707
Convey Local Event Tables to Nodes
708
Nodes Communicate According to Schedule
709

FIG. 8

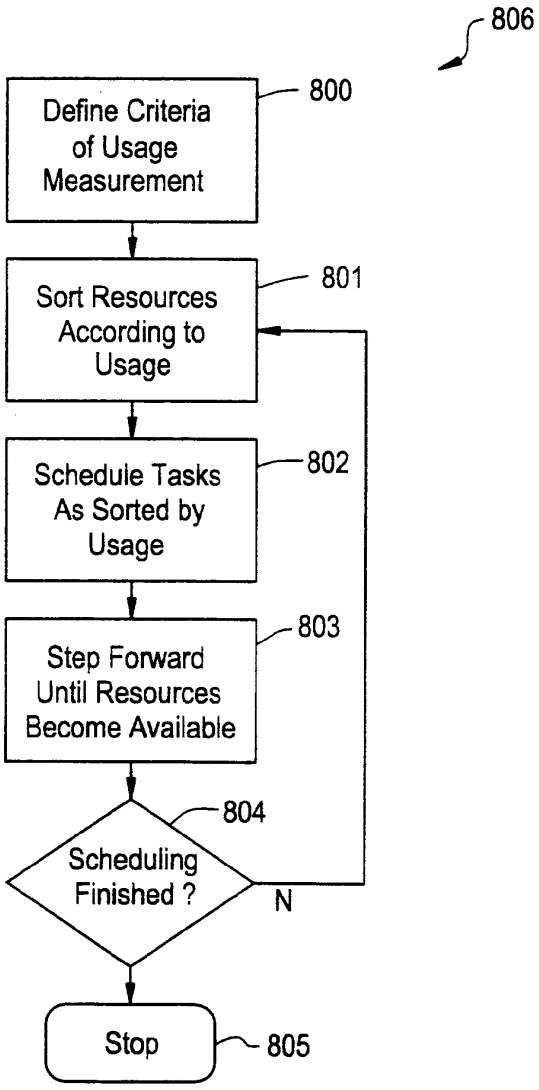

806
Define Criteria of Usage Measurement
800
Sort Resources According to Usage
801
Schedule Tasks As Sorted by Usage
802
Step Forward Until Resources Become Available
803
Scheduling Finished ?
804
N
Stop
805

FIG. 9

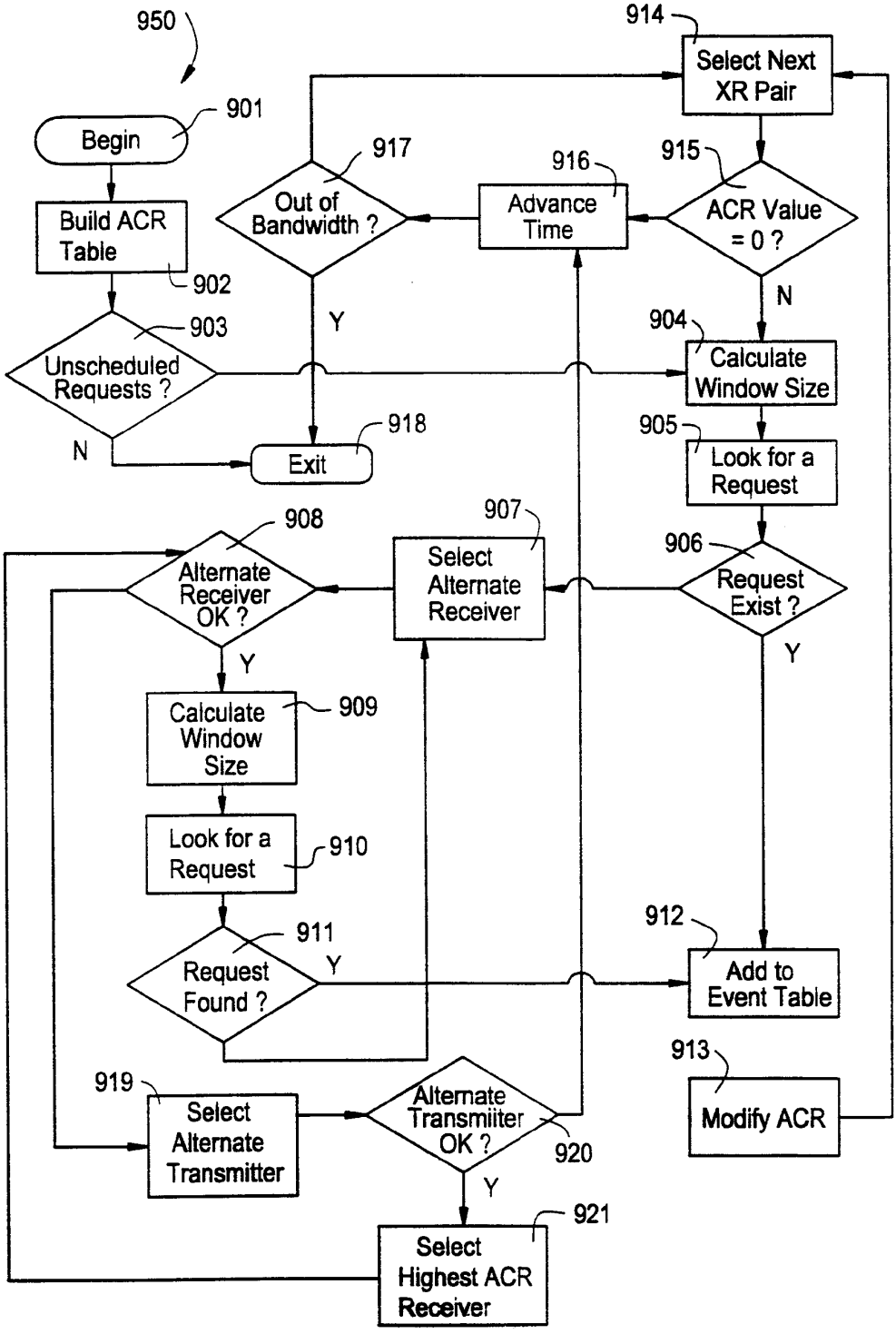
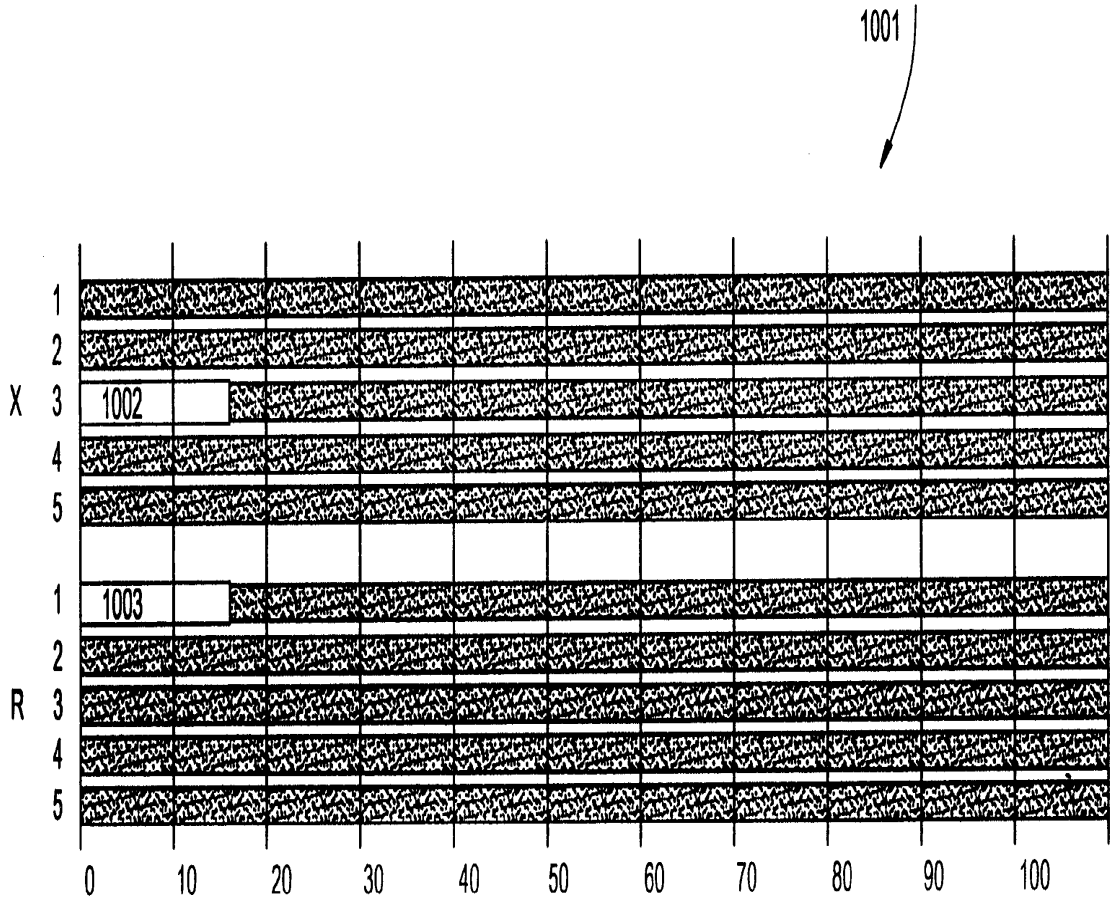

950
914
Select Next XR Pair
901
Begin
917
916
915
Out of Bandwidth ?
Advance Time
ACR Value = 0 ?
Build ACR Table
902
903
Y
N
904
Unscheduled Requests ?
Calculate Window Size
905
N
918
Exit
Look for a Request
908
907
906
Alternate Receiver OK ?
Select Alternate Receiver
Request Exist ?
Y
Y
Calculate Window Size
909
Look for a Request
910
912
911
Request Found ?
Y
Add to Event Table
913
919
Alternate Transmiiter OK ?
Select Alternate Transmitter
Modify ACR
920
Y
921
Select Highest ACR Receiver

FIG. 10

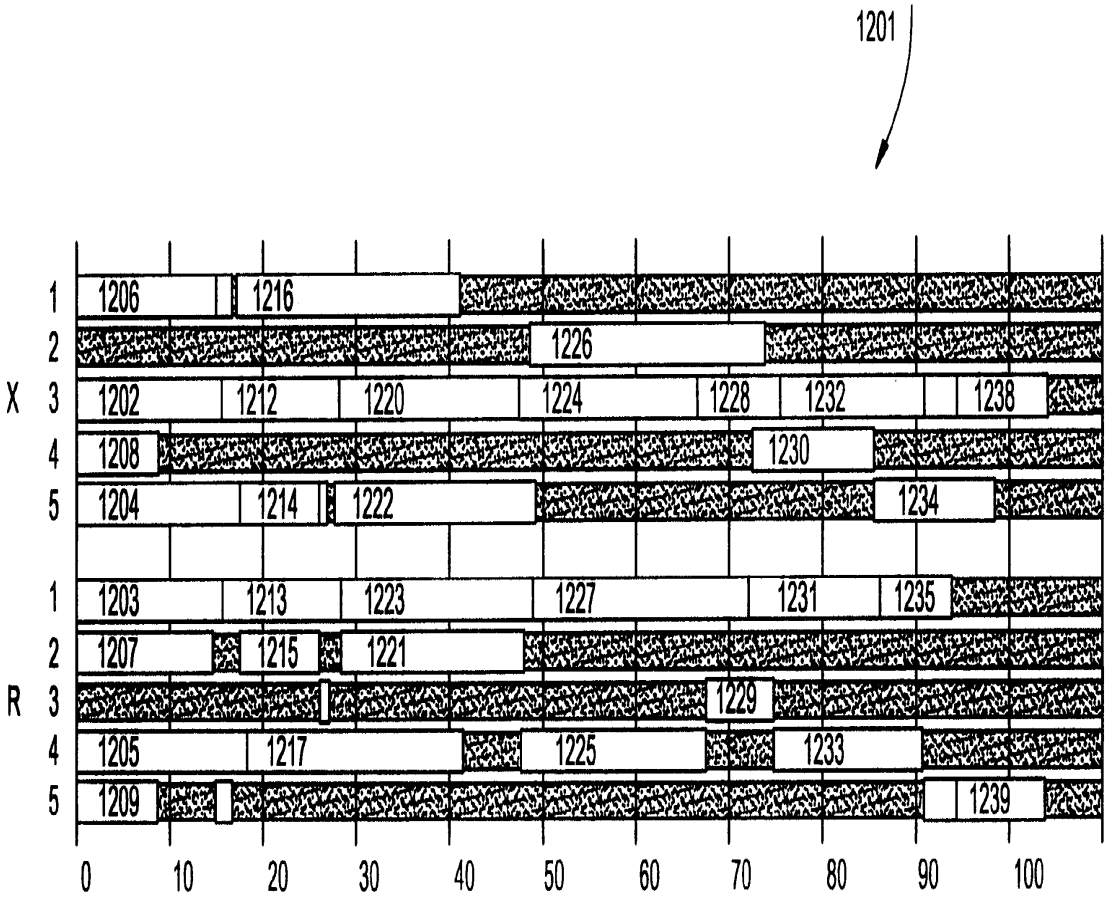


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FIG. 11

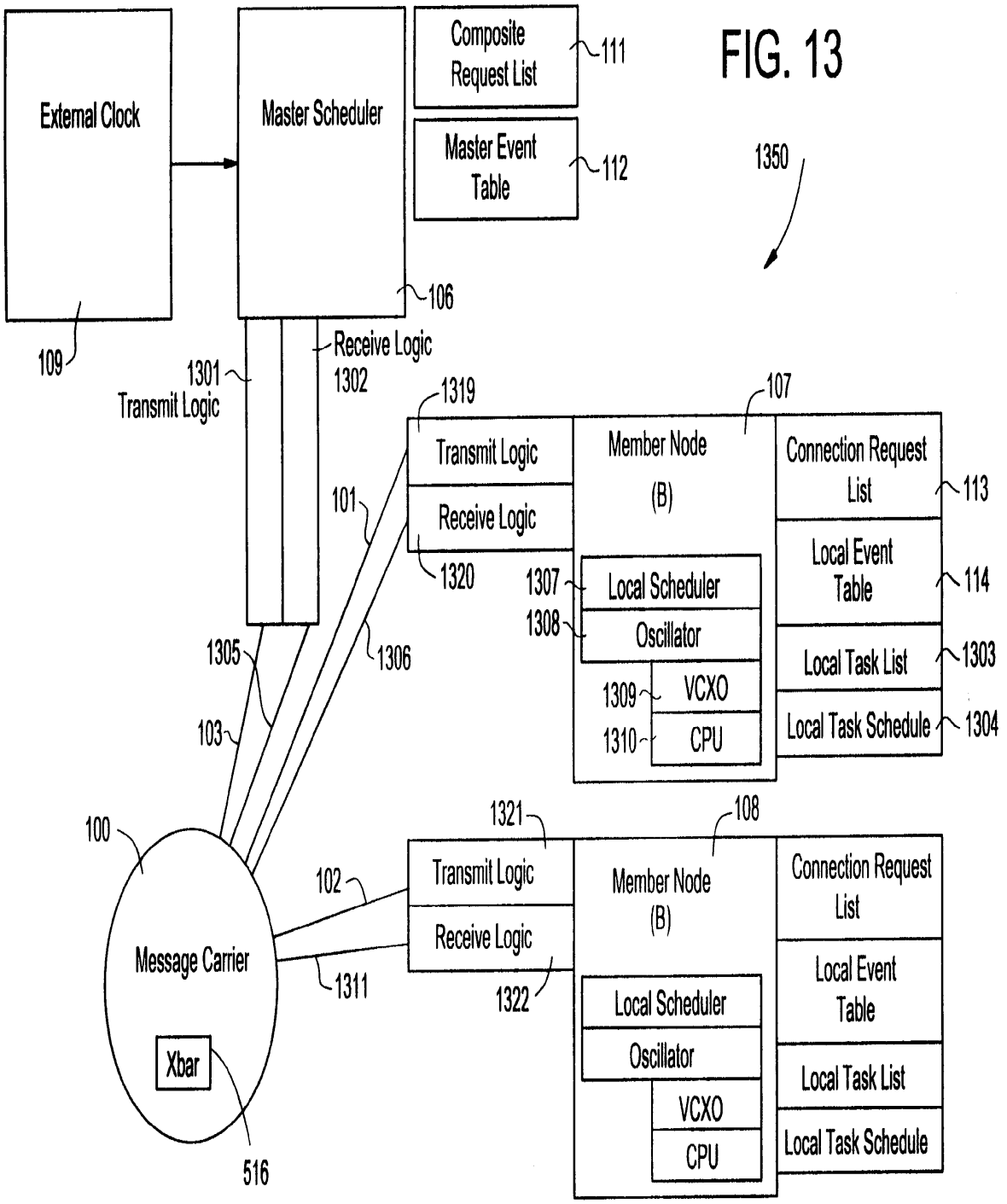
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FIG. 12


1201
X
R
1 1206
2
3 1202
4 1208
5 1204
1 1203
2 1207
3
4 1205
5 1209
1216
1226
1212
1220
1224
1228
1232
1238
1230
1214
1222
1234
1213
1223
1227
1231
1235
1215
1221
1229
1217
1225
1233
1239
0
10
20
30
40
50
60
70
80
90
100

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FIG. 13



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FIG. 14

FIG. 15

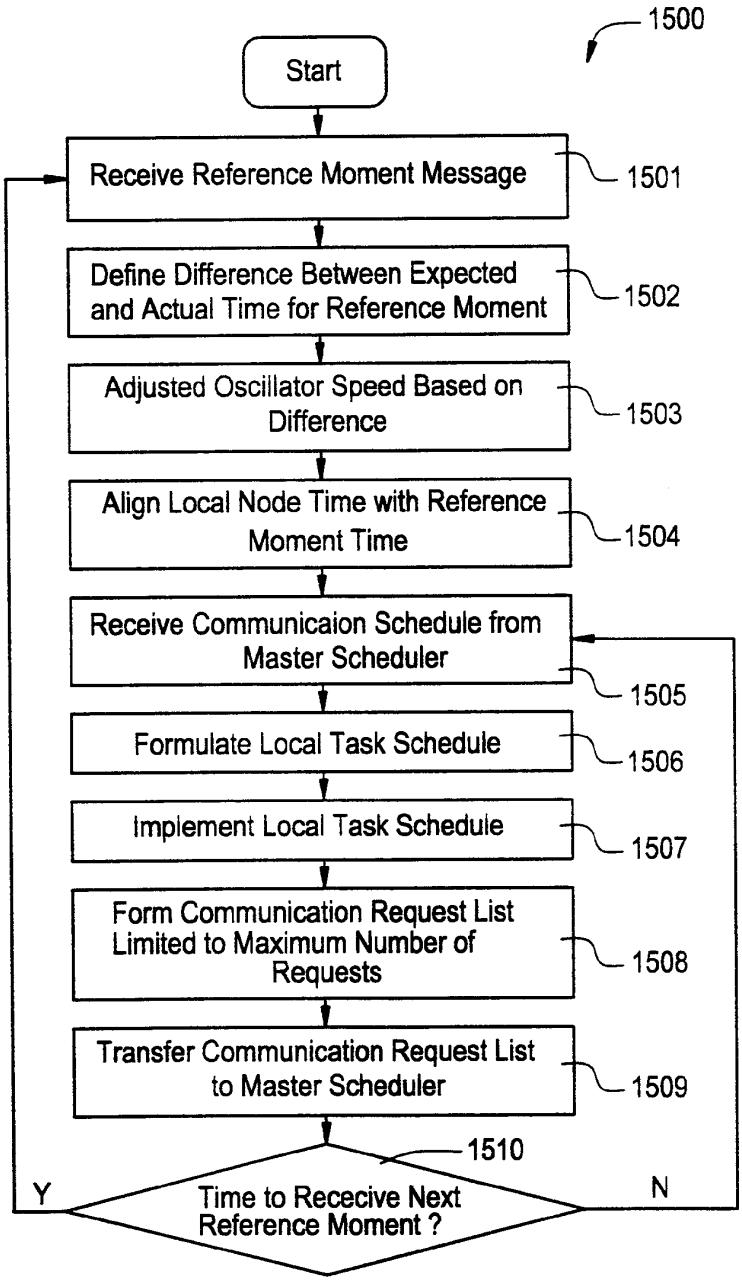
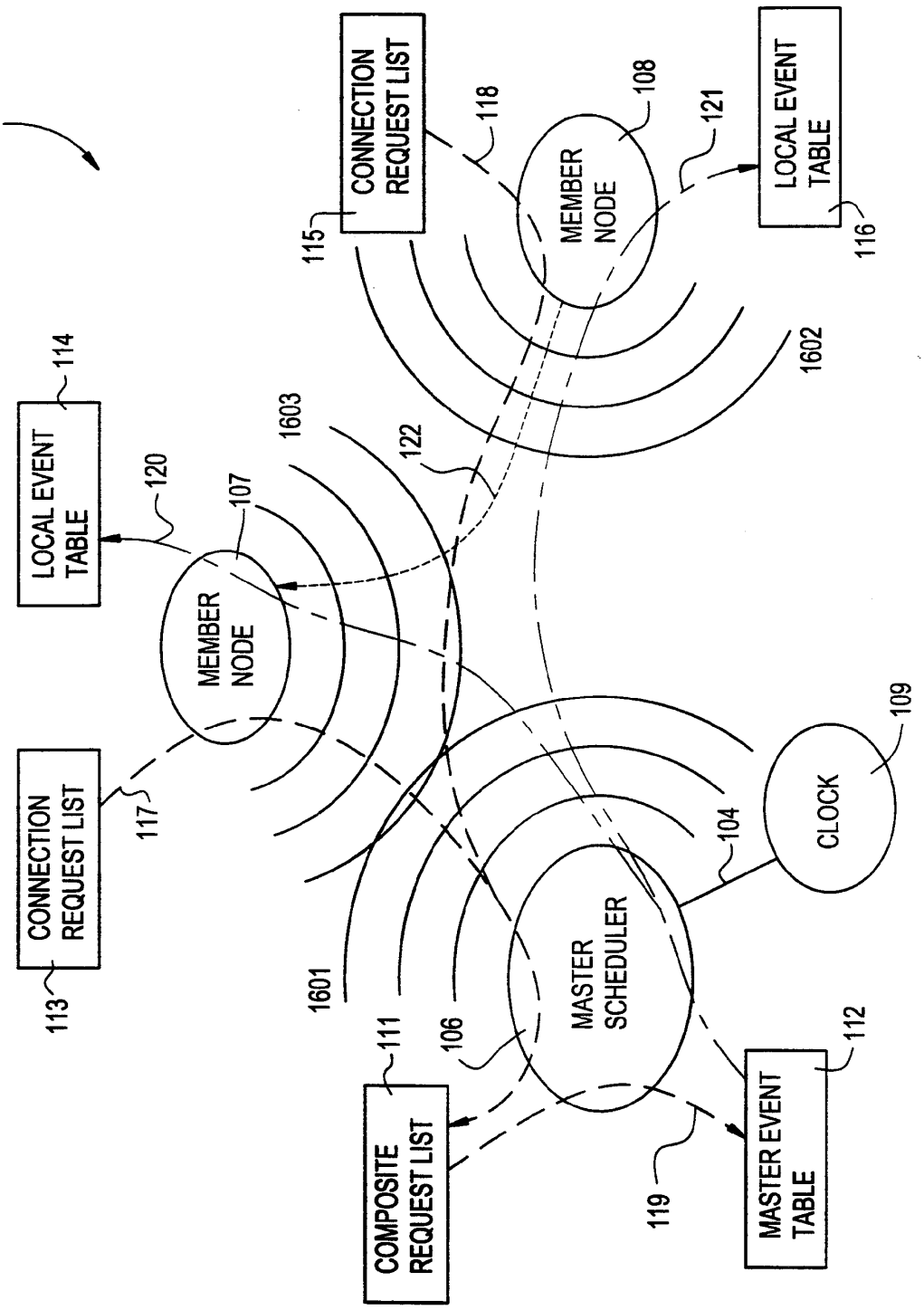

1500
Start
Receive Reference Moment Message
1501
Define Difference Between Expected and Actual Time for Reference Moment
1502
Adjusted Oscillator Speed Based on Difference
1503
Align Local Node Time with Reference Moment Time
1504
Receive Communicaion Schedule from Master Scheduler
1505
Formulate Local Task Schedule
1506
Implement Local Task Schedule
1507
Form Communication Request List Limited to Maximum Number of Requests
1508
Transfer Communication Request List to Master Scheduler
1509
1510
Time to Recevice Next Reference Moment ?
Y
N

FIG. 16


1600
CONNECTION REQUEST LIST
115
118
MEMBER NODE
108
121
LOCAL EVENT TABLE
116
1602
LOCAL EVENT TABLE
114
120
1603
122
107
MEMBER NODE
CONNECTION REQUEST LIST
113
117
1601
CLOCK
109
104
MASTER SCHEDULER
111
106
COMPOSITE REQUEST LIST
119
MASTER EVENT TABLE
112

INTERNATIONAL SEARCH REPORT

Int ional Application No
PCT/US 99/06634

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G06F9/46

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G06F

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	SHIN K G ET AL: "REAL-TIME COMPUTING: A NEW DISCIPLINE OF COMPUTER SCIENCE AND ENGINEERING" PROCEEDINGS OF THE IEEE, vol. 82, no. 1, 1 January 1994 (1994-01-01), pages 6-23, XP000435878 ISSN: 0018-9219 page 8, paragraph II - page 17, paragraph VII	1-4,10, 11,14-16
A	EP 0 183 877 A (INMOS LTD) 11 June 1986 (1986-06-11) the whole document	1-4,10, 11,14-16
A	EP 0 250 011 A (INMOS LTD) 23 December 1987 (1987-12-23) the whole document	1-4,10, 11,14-16

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 July 1999	03/08/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Michel, T

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INTERNATIONAL SEARCH REPORT

Int ional Application No
PCT/US 99/06634

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	RAMAKRISHNAN K V: "AN EVENT SCHEDULER FOR CONTROL APPLICATIONS" EDN ELECTRICAL DESIGN NEWS, vol. 41, no. 12, 6 June 1996 (1996-06-06), pages 155-158, 160, 16, XP000622016 ISSN: 0012-7515 the whole document	9-11

1

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Page 1282 of 1434

INTERNATIONAL SEARCH REPORT

nformation on patent family members

Int ional Application No
PCT/US 99/06634

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0183877 A	11-06-1986	NONE	
EP 0250011 A	23-12-1987	DE 3375844 A	07-04-1988
		DE 3376894 A	07-07-1988
		DE 3378083 A	27-10-1988
		DE 3382708 A	16-09-1993
		DE 3382708 T	10-02-1994
		EP 0111399 A	20-06-1984
		EP 0113178 A	11-07-1984
		EP 0110642 A	13-06-1984
		EP 0113516 A	18-07-1984
		EP 0110643 A	13-06-1984
		JP 1028967 B	07-06-1989
		JP 1547176 C	28-02-1990
		JP 59149543 A	27-08-1984
		JP 1789597 C	29-09-1993
		JP 4070652 B	11-11-1992
		JP 59133647 A	01-08-1984
		JP 1982715 C	25-10-1995
		JP 6101042 B	12-12-1994
		JP 59194256 A	05-11-1984
		JP 2111325 C	21-11-1996
		JP 8007739 B	29-01-1996
		JP 59133662 A	01-08-1984
		JP 2502960 B	29-05-1996
		JP 59133650 A	01-08-1984
		JP 2509453 B	19-06-1996
		JP 6342378 A	13-12-1994
		JP 2688320 B	10-12-1997
		JP 6260551 A	16-09-1994
		US 5452467 A	19-09-1995
		US 5506437 A	09-04-1996
		US 5491359 A	13-02-1996
		US 5031092 A	09-07-1991
		US 4680698 A	14-07-1987
		US 4704678 A	03-11-1987
		US 4724517 A	09-02-1988
		US 5243698 A	07-09-1993
		US 4819151 A	04-04-1989
		US 4967326 A	30-10-1990

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 13-0410-PCT	FOR FURTHER ACTION	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
International application No. **PCT/US2013/046372**	International filing date *(day/month/year)* **18 June 2013 (18.06.2013)**	(Earliest) Priority Date *(day/month/year)* 26 June 2012 (26.06.2012)
Applicant **SONOS, INC.**		

This International search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 3 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the **language**, the international search was carried out on the basis of:
      ☒ the international application in the language in which it was filed
      ☐ a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))
   b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).
   c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.
2. ☐ **Certain claims were found unsearchable** (See Box No. II)
3. ☐ **Unity of invention is lacking** (See Box No. III)
4. With regard to the **title**,
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. With regard to the drawings,
   a. the figure of the drawings to be published with the abstract is Figure No. 7
      ☐ as suggested by the applicant.
      ☒ as selected by this Authority, because the applicant failed to suggest a figure.
      ☐ as selected by this Authority, because this figure better characterizes the invention.
   b. ☐ none of the figure is to be published with the abstract.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/046372

A. CLASSIFICATION OF SUBJECT MATTER

G06F 15/16(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G06F 15/16; G09B 5/00; G06F 17/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: media playback, link, queueplaylist, credentialauthorizeauthenticate

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2007-0048713 A1 (DANIEL PLASTINA et al.) 01 March 2007 See paragraph 8 - paragraph 48; paragraph 73 - paragraph 156;and figures 1-23.	1,4-11,14-20
A		2-3,12-13
A	US 2012-0030366 A1 (COLLART TODD et al.) 02 February 2012 See paragraph 5 - paragraph 35; paragraph 67 - paragraph 107; paragraph 115 - paragraph 163; and figures 1-7,11-19.	1-20
A	US 2006-0143236 A1 (MICHAEL WU) 29 June 2006 See paragraph 14 - paragraph 42; and figures 1-4.	1-20
A	US 2008-0091771 A1 (JEFFREY L. ALLEN et al.) 17 April 2008 See paragraph 28 - paragraph 48; claim 1 and figures 3-6.	1-20

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

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 August 2013 (23.08.2013)	**26 August 2013 (26.08.2013)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea Facsimile No. +82-42-472-7140	Authorized officer PARK Sang Hyun Telephone No. +82-42-481-8263

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2013/046372

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2007-0048713 A1	01/03/2007	CN101243426 A	13/08/2008
		CN101243426 C0	13/08/2008
		KR 10-2008-0033399 A	16/04/2008
		US 2007-0048712 A1	01/03/2007
		US 2007-0048714 A1	01/03/2007
		US 2007-0083556 A1	12/04/2007
		US 7831605 B2	09/11/2010
		US 8140601 B2	20/03/2012
		WO 2007-021831 A1	22/02/2007
US 2012-0030366 A1	02/02/2012	AU 2008-335095 A1	18/06/2009
		AU 2008-335095 B2	28/03/2013
		CA 2708778 A1	18/06/2009
		EP 2232365 A2	29/09/2010
		EP 2232365 A4	31/07/2013
		JP 2011-520302 A	14/07/2011
		US 2009-150553 A1	11/06/2009
		US 8060631 B2	15/11/2011
		WO 2009-076474 A2	18/06/2009
		WO 2009-076474 A3	13/08/2009
US 2006-0143236 A1	29/06/2006	None	
US 2008-0091771 A1	17/04/2008	CN 101523495 A	02/09/2009
		CN 101997910 A	30/03/2011
		CN 101997910 B	13/03/2013
		CN101523495 B	06/04/2011
		EP 2089881 A1	19/08/2009
		EP 2089881 A4	16/01/2013
		JP 2010-507144A	04/03/2010
		KR 10-2009-0079885 A	22/07/2009
		MX 2009002806 A	31/03/2009
		WO 2008-048761 A1	24/04/2008

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:
GEORGE CHRISTOPHER N.

HANLEY, FLIGHT & ZIMMERMAN, LLC 150 S.
WACKER DRIVE SUITE 2100 CHICAGO IL 60606 USA

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43bis.1)

Date of mailing *(day/month/year)*	**26 August 2013 (26.08.2013)**
Applicant's or agent's file reference 13-0410-PCT	**FOR FURTHER ACTION** See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2013/046372	**18 June 2013 (18.06.2013)**	26 June 2012 (26.06.2012)

International Patent Classification (IPC) or both national classification and IPC
G06F 15/16(2006.01)i

Applicant
SONOS, INC.

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1bis(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.
For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/KR	Date of completion of this opinion	Authorized officer
Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea Facsimile No. +82-42-472-7140	23 August 2013 (23.08.2013)	PARK, Sang Hyun Telephone No. +82-42-481-8263

Form PCT/ISA/237 (cover sheet) (July 2011)

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2013/046372

Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed

   ☐ a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of:

   a. a sequence listing filed or furnished
      ☐ on paper
      ☐ in electronic form

   b. time of filing or furnishing
      ☐ contained in the international application as filed.
      ☐ filed together with the international application in electronic form.
      ☐ furnished subsequently to this Authority for the purposes of search.

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additioanl copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2013/046372

Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	2-3,12-13	YES
	Claims	1,4-11,14-20	NO
Inventive step (IS)	Claims	2-3,12-13	YES
	Claims	1,4-11,14-20	NO
Industrial applicability (IA)	Claims	1-20	YES
	Claims	NONE	NO

2. Citations and explanations :

(1) Reference is made to the following documents:

D1: US 2007-0048713 A1 (DANIEL PLASTINA et al.) 01 March 2007
D2: US 2012-0030366 A1 (COLLART TODD et al.) 02 February 2012
D3: US 2006-0143236 A1 (MICHAEL WU) 29 June 2006
D4: US 2008-0091771 A1 (JEFFREY L. ALLEN et al.) 17 April 2008

(2) Novelty & Inventive Steps

Concerning claims 1-10:
Claims 1,4-10
D1 discloses a community media playlist sharing system, wherein system users can upload media playlists which are automatically converted to a standardized format, media playlists can be shared with other users of the community media playlist sharing system, users can link to other playlists and obtain media from playlists automatically from third party points of purchase, users can provide recommendations, ratings and rankings relative to other playlists by system users and receive recommendations from other users and an editorial staff, participate in social networking functions including forums, discussions, weblogs, playlist topic groups and inter-user communications based on affinity for similar playlists, create playlists manually, automatically, or in real time, and wherein system users can obtain points for participation and popularity in the system and obtain profit by meta-affiliate sharing of profit for purchases of music made through playlists submitted by that user as well as through playlist toolbars distributed to third party websites.[paragraph 73 - paragraph 156, and figures 1-23] As all of the features of claims 1,4-10 are disclosed in D1, these claims are anticipated in D1. Therefore, claims 1,4-10 lack novelty under PCT Article 33(2) and are not considered as involving an inventive step under PCT Article 33(3).
Claims 2-3:
The subject matter of claims 2-3 is different from that of D1 in a guest mode. And it is

Continued on Supplemental Box

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
Continuation of: Box No. V

not obvious to a person skilled in the art by the documents, taken alone or in combination. Therefore, claims 2-3 are novel and involve an inventive step under PCT Article 33(2) and (3).

Concerning claims 11-20:
Claims 11,14-20:
D1 discloses a community media playlist sharing system, wherein system users can upload media playlists which are automatically converted to a standardized format, media playlists can be shared with other users of the community media playlist sharing system, users can link to other playlists and obtain media from playlists automatically from third party points of purchase, users can provide recommendations, ratings and rankings relative to other playlists by system users and receive recommendations from other users and an editorial staff, participate in social networking functions including forums, discussions, weblogs, playlist topic groups and inter-user communications based on affinity for similar playlists, create playlists manually, automatically, or in real time, and wherein system users can obtain points for participation and popularity in the system and obtain profit by meta-affiliate sharing of profit for purchases of music made through playlists submitted by that user as well as through playlist toolbars distributed to third party websites.[paragraph 73 - paragraph 156, and figures 1-23] As all of the features of claims 11,14-20 are disclosed in D1, these claims are anticipated in D1. Therefore, claims 11,14-20 lack novelty under PCT Article 33(2) and are not considered as involving an inventive step under PCT Article 33(3).
Claims 12-13:
The subject matter of claims 12-13 is different from that of D1 in a guest mode. And it is not obvious to a person skilled in the art by the documents, taken alone or in combination. Therefore, claims 12-13 are novel and involve an inventive step under PCT Article 33(2) and (3).

(3) Industrial Applicability

The subject matter of claims 1-20 is believed to be industrially applicable under PCT Article 33(4) because the claimed invention can be used in the computer industry.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US04/23102

A. CLASSIFICATION OF SUBJECT MATTER
IPC: **G06F 15/16**(2006.01)

USPC: 709/205,208,209
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 709/205,208,209

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JO et al. 'Synchronized One-to-Many Media Streaming with Adaptive Playout Control.' In: Proceedings of SPIE, Vol. 4861. Edited by Tescher et al. SPIE, December 2002 (12.2002), pp. 71-82. abstract, sections 1-5, all subsections, all figures.	1-64, 109-172
Y	MILLS, David L. 'Network Time Protocol Specification, Implementation and Analysis.' Request for Comments: 1305. Network Working Group, March 1992 (03.2003). pgs ii-iii; pp 5, paragraph 2; pp 14-15, section 3.2.5; pp 24-27, section 3.4.4;	1-64, 109-172
Y	US 2003/0099212 A1 (ANJUM et al) 29 May 2003 (29.05.2003) abstract, [0003]-[0010], [0025]-[0036], All Figures	5-25, 33, 37-45, 50-64, 113-133, 141, 145-153, 158-172

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
09 June 2008 (09.06.2008)	01 AUG 2008
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450 Alexandria, Virginia 22313-1450 Facsimile No. (571) 273-3201	Authorized officer Andrew Caldwell Telephone No. 571-272-2100

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US04/23102

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2001/0032188 A1 (MIYABE et al) 18 October 2001 (18.10.2001) abstract, [0120]-[0134]	21-25, 41-45, 60-64, 129-133, 149-153, 168-172
Y	US 7,312,785 B2 (TSUK et al) 25 December 2007 (25.12.2007) abstract; col 3, lines 35-54; col 13, lines 32-47; col 15, line 63 - col 16, line 12; Figure 7B	6-8, 37-40, 50-59, 114-116, 145-149, 158-167
Y	US 2004/0203378 A1 (POWERS) 14 October 2004 (14.10.2004) abstract	19, 127
A	ISHIBASHI et al. 'A Group Synchronization Mechanism for Live Media in Multicast Communications.' In: IEEE GLOBECOM. November 1997 (11.1997). pp 746-752.	1-64, 109-172
A	HUANG et al. 'A Synchronization Infrastructure for Multicast Multimedia at the Presentation Layer.' In: IEEE Transactions on Comsumer Electronics, Vol. 43, No. 3. August 1997 (08.1997). pp 370-380.	1-64, 109-172

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US04/23102

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
Please See Continuation Sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of any additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: 1-64 and 109-172

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US04/23102

BOX III. OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I, claim(s) 1-64 and 109-172, drawn to a system and method with task source and playback devices.

Group II, claim(s) 65-91, 173-200, and 218-245, drawn to a system, method, and program for a task playback device.

Group III, claim(s) 92-108, 201-217, and 246-262, drawn to a system, method, and program for a task source device.

Group IV, claim(s) 263-266, drawn to a system with task source, playback, and control devices.

Group V, claim(s) 267-335, 382-448, drawn to a system and method for task source and playback devices, specific to audio task characteristics.

Group VI, claim(s) 336-364, 449-478, 499-548, drawn to a system, method, and program for task playback devices, specific to audio task characteristics.

Group VII, claim(s) 365-381, 479-498, 529-548, drawn to a system, method, and program for task source devices, specific to audio task characteristics.

The inventions listed as Groups II-VII do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Group II: Though this group contains equivalent independent claims, the technical features of these independent claims are known in the art (See Jo and Mills), thus there is lack of unity *a posteriori*, as the dependent claims of this group recite technical features unique to task playback device operation.

Group III: Though this group contains equivalent independent claims, the technical features of these independent claims are known in the art (See Jo and Mills), thus there is lack of unity *a posteriori*, as the dependent claims of this group recite technical features unique to task source device operation.

Group IV: This group contains a special technical feature (control devices) that is different than group I and thus there is a lack of unity *a priori*.

Group V: Though this group contains analogous independent claims, the technical features of these independent claims are known in the art (See Jo and Mills), thus there is lack of unity *a posteriori*, as the dependent claims of this group recite technical features unique to audio task characteristics.

Group VI: Though this group contains analogous independent claims, the technical features of these independent claims are known in the art (See Jo and Mills), thus there is lack of unity *a posteriori*, as the dependent claims of this group recite technical features unique to audio task playback device operation.

Group VII: Though this group contains analogous independent claims, the technical features of these independent claims are known in the art (See Jo and Mills), thus there is lack of unity *a posteriori*, as the dependent claims of this group recite technical features unique to audio task source device operation.

Continuation of B. FIELDS SEARCHED Item 3:
US-PAT, US-PGPUB, EPO, JPO, DERWENT, IBM TDB, INTERNET NPL
ntp, inter-client synchronization, adaptive playback, mpeg2, presentation time stamp, bluetooth migration, bluetooth master slave, ipod scroll wheel

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 12-0402-PCT	**FOR FURTHER ACTION**	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
International application No. **PCT/US2013/046386**	International filing date *(day/month/year)* **18 June 2013 (18.06.2013)**	(Earliest) Priority Date *(day/month/year)* 26 June 2012 (26.06.2012)

Applicant

SONOS, INC.

This International search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of **3** sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the **language**, the international search was carried out on the basis of:
      ☒ the international application in the language in which it was filed
      ☐ a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))
   b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).
   c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.
2. ☐ **Certain claims were found unsearchable** (See Box No. II)
3. ☐ **Unity of invention is lacking** (See Box No. III)
4. With regard to the **title,**
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established by this Authority to read as follows:
5. With regard to the **abstract,**
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.
6. With regard to the drawings,
   a. the figure of the **drawings** to be published with the abstract is Figure No. **1**
      ☐ as suggested by the applicant.
      ☒ as selected by this Authority, because the applicant failed to suggest a figure.
      ☐ as selected by this Authority, because this figure better characterizes the invention.
   b. ☐ none of the figure is to be published with the abstract.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/046386

A. CLASSIFICATION OF SUBJECT MATTER

G06Q 50/10(2012.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G06Q 50/10; G06F 15/16; H04N 7/173; G06F 7/00; G06F 17/30; H04L 9/00; H04W 40/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords:playlist, authorization, participate, zone:

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 7483958 B1 (TAREK Z. ELABBADY et al.) 27 January 2009 See abstract, column 7, lines 61-66, column 11, lines 1-20, claims 1, 6 and figure 4.	1-21
Y	US 2010-0228740 A1 (ALAN CANNISTRARO et al.) 09 September 2010 See abstract, paragraphs [0009], [0036]-[0037], [0047]-[0057], [0089], claim 1 and figure 4.	1-21
A	US 2012-0129446 A1 (STEVE KO et al.) 24 May 2012 See abstract, paragraphs [0036]-[0037], claim 1 and figure 4.	1-21
A	US 2009-0031336 A1 (TIMOTHY R. CHAVEZ et al.) 29 January 2009 See abstract, paragraph [0021], claim 1 and figure 3.	1-21
A	US 2007-0299778 A1 (RYAN A. HAVESON et al.) 27 December 2007 See abstract, claim 1 and figure 3.	1-21

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 September 2013 (27.09.2013)	**30 September 2013 (30.09.2013)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea Facsimile No. +82-42-472-7140	Authorized officer KIM Sung Gon Telephone No. +82-42-481-8746

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/US2013/046386

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 7483958 B1	27/01/2009	None	
US 2010-0228740 A1	09/09/2010	None	
US 2012-0129446 A1	24/05/2012	AT 520238 T	15/08/2011
		CN 101346965 A	14/01/2009
		CN 102984041 A	20/03/2013
		EP 1964365 A1	03/09/2008
		EP 1964365 B1	10/08/2011
		EP 2299654 A1	23/03/2011
		HK 1122664 A1	18/11/2011
		JP 2009-521185 A	28/05/2009
		JP 2012-235471 A	29/11/2012
		US 2007-169115 A1	19/07/2007
		US 2010-049835 A1	25/02/2010
		US 2013-080599 A1	28/03/2013
		US 7702279 B2	20/04/2010
		US 8112032 B2	07/02/2012
		US 8315555 B2	20/11/2012
		WO 2007-075376 A1	05/07/2007
US 2009-0031336 A1	29/01/2009	None	
US 2007-0299778 A1	27/12/2007	None	

Electronic Acknowledgement Receipt	
EFS ID:	20699077
Application Number:	14516867
International Application Number:	
Confirmation Number:	9318
Title of Invention:	Obtaining Content from Remote Source for Playback
First Named Inventor/Applicant Name:	Nicholas A.J. Millington
Customer Number:	107361
Filer:	Michael Paul Boyea
Filer Authorized By:	
Attorney Docket Number:	04-0401-CON1014D
Receipt Date:	14-NOV-2014
Filing Date:	17-OCT-2014
Time Stamp:	16:30:29
Application Type:	Utility under 35 USC 111(a)

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	Information Disclosure Statement (IDS) Form (SB08)	MPB__Sonos_04-0401-CON1014D_MBHB_14-1800-CON2_IDS_1of2.pdf	717055 4d4afa90f289d6c0d2c0d5117305766fb28b9abb	no	33
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2	Foreign Reference	EP0251584A2.pdf	1884077 ebc67c6575f5c399dba2d1e4a76152911d5fd8bd	no	33
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3	Foreign Reference	EP0672985B1.pdf	2175065 a9037454188834680 72e0067d06d05f63998c46c	no	36
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4	Foreign Reference	EP1111527B1.pdf	2413427 fca1e0970dd6bf225fb61df259db2f5f8487718b	no	38
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5	Foreign Reference	EP1122931A2.pdf	698059 295927d9d246e375ba624f211e9c49a919eab5a9	no	14
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6	Foreign Reference	EP2713281A1.pdf	6287993 e0bad8f9ccdf164cd3b1e5c4be7514c8122a5421	no	84
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7	Foreign Reference	GB2284327A.pdf	1407480 8994fe8680cdb304fb1ce712869ba65bb6bd97e4	no	44
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8	Foreign Reference	JP2003037585.pdf	1725819 96f567820ee48e199f4071ab50ede187e7c6b1be	no	25
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9	Foreign Reference	JP2003101958.pdf	950993 17257ed4f8a187cb6546ab4fe66fa716732fb265	no	12
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11	Foreign Reference	WO02073851A1.pdf	917956 d2d3113bf7994616b0d3066b9e4ffefb65109070	no	26
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12	Foreign Reference	WO03093950A2.pdf	7403788 45672595a62d0867cd00ade157f38623a4f6a9e8	no	147
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13	Foreign Reference	WO2005013047A2.pdf	9269608 953769d47f04a9db684f7db18a01a31e0aa9bbb1	no	143
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14	Foreign Reference	WO9525313A1.pdf	768644 6c073cc6a1ae2db78fa5e45e3af71a8b8121cdd3	no	25
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15	Foreign Reference	WO9961985A1.pdf	3747367 a91b3429d3b1367d12c8ed7179e7e709659e2571	no	95
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16	Non Patent Literature	10816217_Advisory_Action_09-18-08.pdf	312553 a3d31f840a78967f505f43f514e5126e531e074c	no	8
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17	Non Patent Literature	13907666_Advisory_Action_9-5-14.pdf	152557 6365891123eb2f0138159fc6ca78bb2f396239f8	no	3
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18	Non Patent Literature	Akyildiz_1996.pdf	2498999 b645c8978e8d2d2e9691c4bc5da47bec08b5d640	no	12
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19	Non Patent Literature	VOYETRA-AudioTron_Quick_Start_Guide_2001.PDF	1992657 8b8da58cb9dc81a0e031a4693cc43be380390a91	no	24
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20	Non Patent Literature	VOYETRA-AudioTron_Reference_Manual_2002.PDF	13529678 01552a10a2294bf9b9ed9f75f4141f1f7dd63142	no	70
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25	Non Patent Literature	Bluetooth_Spec_Dec1999_1of4.pdf	17425198 61ca9afb7cd387110124c5c61aaee6764cbda431	no	270
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26	Non Patent Literature	Bluetooth_Spec_Dec1999_2of4.pdf	15742018 decfb19348dd1b8a5d80a216b053e015d72d972b	no	270
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27	Non Patent Literature	Bluetooth_Spec_Dec1999_3of4.pdf	22504018 8f7ca9da545e0622acb1a376fbbd5793430c5c40	no	270
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29	Non Patent Literature	Bluetooth_Spec_Jul_1999-1of4.pdf	25936700 05129b8c88e35a893b39afadfe17f8d9297cadd1	no	267
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33	Non Patent Literature	Bretl_2000.pdf	662578 9679ae51410349cb6b429850c27a6c683e67329a	no	23
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34	Non Patent Literature	Dell_Reference_Guide_June2000.pdf	3684104 f828118a38daa1f2ec0e16248c89c00ce0ddb455	no	70
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35	Non Patent Literature	Dell_Start_Here_June_2000.pdf	6484744 c5eb434a693010e820cbebae3417fa9fe5fdda33	no	2
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36	Other Reference-Patent/App/Search documents	EP_SR_131847477_2-28-14.pdf	275663 8f06d3a92920aa3ab94da588dd6844c03940e86e	no	8
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37	Non Patent Literature	13907666_Final_OA_6-5-14.pdf	407723 a7adfe78c33770836235c29d95ed63b90b3726d3	no	12
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38	Non Patent Literature	10816217_Final_OA_7-13-09.PDF	1141244 d4f2e9b751cc44846b3217800affae3c0da54c14	no	16
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48	Non Patent Literature	Huang_1997.pdf	1084335 047aaf919b65ccc29c5b10fbc4f058ea5c1c203b	no	11
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49	Other Reference-Patent/App/Search documents	PCTUS2013046372_ISR_8-26-13.pdf	128842 f665a6c13841b22a8c7fd50160dbdfd6f69e00ee	no	3
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50	Other Reference-Patent/App/Search documents	PCTUS2013046372_Written_Opinion_8-26-13.pdf	166042 aed54d2da7fafd5488d9e48565bde415cddf01fc	no	4
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51	Other Reference-Patent/App/Search documents	PCTUS0423102_ISR_8-1-08.pdf	175270 8013c54d23d9fd050600fcf8081e5ec46ce90077	no	5
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52	Other Reference-Patent/App/Search documents	PCTUS2013046386_ISR_9-30-13.pdf	128924 c360063c4cfcb334e572ef3064f7682218404801	no	3
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55	Non Patent Literature	JP2012-17811_Decision_of_Rejection_7-8-14.pdf	82465 ef3572f0259eac844d44397f69147b041d569825	no	3
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	14516867
Filing Date	10-17-2014
First Named Inventor	MILLINGTON; Nicholas A.J.
Art Unit	2442
Examiner Name	SURVILLO, OLEG
Attorney Docket Number	04-0401-CON1014D

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	14516867
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	Art Unit	2442
	Examiner Name	SURVILLO, OLEG
	Attorney Docket Number	04-0401-CON1014D

	1	"Non-Final Office Action mailed 17 June 2014 for U.S. Application No. 14/176808 filed 10 February 2014".	☐
	2	"Non-Final Office Action mailed 18 December 2013 for U.S. Application No. 13/907666 filed 31 May 2013".	☐
	3	Non-Final Office Action mailed 18 January 2008 for U.S. Application No. 10/816217 filed 01 April 2004.	☐
	4	"Non-Final Office Action mailed 19 April 2010 for U.S. Application No. 11/801468 filed 09 May 2007, 16 pages".	☐
	5	"Non-Final Office Action mailed 19 March 2013 for U.S. Application No. 13/724048 filed 21 December 2012".	☐
	6	Non-Final Office Action mailed 21 June 2011 for U.S. Application No. 10/816217 filed 01 April 2004.	☐
	7	Non-Final Office Action mailed 22 January 2009 for U.S. Application No. 10/816217 filed 01 April 2004.	☐
	8	"Non-Final Office Action mailed 25 July 2014 for U.S. Application No. 14/184526 filed 19 February 2014".	☐
	9	"Non-Final Office Action mailed 25 July 2014 for U.S. Application No. 14/184935 filed 20 February 2014".	☐
	10	Non-Final Office Action mailed 25 June 2010 for U.S. Application No. 10/816217 filed 01 April 2004.	☐
	11	"Non-Final Office Action mailed 25 November 2013 for U.S. Application No. 13/533105 filed 26 June 2012.".	☐

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	First Named Inventor	MILLINGTON; Nicholas A.J.
	Art Unit	2442
	Examiner Name	SURVILLO, OLEG
	Attorney Docket Number	04-0401-CON1014D

	12	"Non-Final Office Action mailed 27 May 2014 for U.S. Application No. 14/186850 filed 21 February 2014".	☐
	13	Non-Final Office Action mailed 29 February 2012 for U.S. Application No. 13/297000 filed 15 November 2011.	☐
	14	"Non-Final Office Action mailed 29 November 2010 for U.S. Application No. 11/801468 filed 09 May 2007, 17 pages".	☐
	15	"Non-Final Office Action mailed 30 April 2012 for U.S. Patent Application No. 13/204511 filed 5 August 2011".	☐
	16	"Non-Final Office Action mailed 30 July 2013 for U.S. Application No. 13/724048 filed 21 December 2012".	☐
	17	"Non-Final Office Action mailed 31 July 2014 for U.S. Application No. 13/533105 filed 26 June 2012".	☐
	18	"Non-Final Office Action mailed on 23 October 2014, issued in connection with U.S. Patent Application No. 13/848904, filed on 22 March 2013, 11 pages".	☐
	19	"Non-Final Office Action mailed on 23 October 2014, issued in connection with U.S. Patent Application No. 13/864251, filed on 17 April 2013, 11 pages".	☐
	20	"Non-Final Office Action mailed on 23 October 2014, issued in connection with U.S. Patent Application No. 13/888203, filed on 6 May 2013, 9 pages".	☐
	21	"Non-final Office Action mailed on 24 October 2014, issued in connection with U.S. Patent Application No. 13/435776, filed 30 March 2012, 14 pages".	☐
	22	"Non-Final Rejection mailed on 20 August 2009 for U.S. Application No. 11/906,702 filed on 2 October 2007".	☐

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	23	"Notice of Allowability in Application No. 13/619,237", 9-6-2013, 4 pages.	☐
	24	Notice of Allowance 27 December 2011 for U.S. Application No. 10/816217 filed 01 April 2004.	☐
	25	"Notice of Allowance mailed 06 March 2014 for U.S. Application No. 13/827653 filed 14 March 2013".	☐
	26	"Notice of Allowance mailed 06 May 2011 for U.S. Application No. 11/801468 filed 09 May 2007, 10 pages".	☐
	27	"Notice of Allowance mailed 10 November 2011 for U.S. Patent Application No. 11/906,702 filed on 2 October 2007".	☐
	28	"Notice of Allowance mailed 13 November 2013 for U.S. Application No. 13/724048 filed 21 December 2012".	☐
	29	"Notice of Allowance mailed 31 January 2013 for U.S. Patent Application No. 13/298090 filed on 16 November 2011".	☐
	30	"Notice of Allowance mailed 5 October 2012 for U.S. Patent Application No. 13/204511 filed 5 August 2011".	☐
	31	"Notice of Allowance mailed on 25 September 2014, issued in connection with U.S. Patent Application No. 14/176,808, filed on 10 February 2014, 5 pages".	☐
	32	"Palm, Inc. "Handbook for the Palm VII Handheld" May 2000, 311 pages".	☐
	33	PARK S., et al., "Group Synchronization in MultiCast Media Communications," Proceedings of the 5th Research on Multicast Technology Workshop, 2003.	☐

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	Attorney Docket Number	04-0401-CON1014D

	34	"Polycom Conference Composer manual: copyright 2001".	☐
	35	PRISMIQ; Inc., "PRISMIQ Media Player User Guide", 2003, 44 pages.	☐
	36	ROTHERMEL K., et al., "An Adaptive Stream Synchronization Protocol," 5th International Workshop on Network and Operating System Support for Digital Audio and Video, 1995.	☐
	37	SCHULZRINNE H., et al., "RTP: A Transport Protocol for Real-Time Applications, RFC 3550," Network Working Group, 2003, pp. 1-89.	☐
	38	The MPEG-2 Transport Stream. Retrieved from the Internet:< URL: http://www.coolstf.com/mpeg/#ts>.	☐
	39	"UPnP; "Universal Plug and Play Device Architecture"; 08 June 2000; version 1.0; Microsoft Corporation; pp 1-54".	☐
	40	""Welcome. You're watching Apple TV." Apple TV 1st Generation Setup Guide, 8 April 2008 <http://manuals.info.apple.com/MANUALS/0/MA403/en_US/AppleTV_SetupGuide.pdf> Retrieved 10/14/14, 40 pages".	☐
	41	""Welcome. You're watching Apple TV." Apple TV 2nd Generation Setup Guide, 10 March 2011 <http://manuals.info.apple.com/MANUALS/1000/MA1555/en_US/Apple_TV_2nd_gen_Setup_Guide.pdf> Retrieved 10/16/14, 35 pages".	☐
	42	""Welcome. You're watching Apple TV." Apple TV 3rd Generation Setup Guide, 16 March 2012 <http://http://manuals.info.apple.com/MANUALS/1000/MA1607/en_US/apple_tv_3rd_gen_setup.pdf> Retrieved 10/16/14, 35 pages".	☐
	43	"Presentations at WinHEC 2000" May 2000, 138 pages.	☐
	44	"Written Opinion of the International Searching Authority. issued by the International Searching Authority in connection with PCT Application No. PCT/US2013/046386, on September 30, 2013, 6 pages.".	☐

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	Attorney Docket Number	04-0401-CON1014D

	45	"Yamaha DME 32 manual: copyright 2001".	☐
	46	"Yamaha DME Designer software manual: Copyright 2004, 482 pages".	☐

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	Examiner Name	SURVILLO, OLEG
	Attorney Docket Number	04-0401-CON1014D

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☐ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Michael P. Boyea/	Date (YYYY-MM-DD)	2014-11-14
Name/Print	Michael P. Boyea	Registration Number	70248

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Electronic Acknowledgement Receipt	
EFS ID:	20704220
Application Number:	14516867
International Application Number:	
Confirmation Number:	9318
Title of Invention:	Obtaining Content from Remote Source for Playback
First Named Inventor/Applicant Name:	Nicholas A.J. Millington
Customer Number:	107361
Filer:	Michael Paul Boyea
Filer Authorized By:	
Attorney Docket Number:	04-0401-CON1014D
Receipt Date:	14-NOV-2014
Filing Date:	17-OCT-2014
Time Stamp:	16:36:34
Application Type:	Utility under 35 USC 111(a)

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	Non Patent Literature	Maniactools_2010.pdf	287375 61babf16b81c514a1120bfd0913483a1794523f8	no	2

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Information:

2	Non Patent Literature	Mills_1992.pdf	20150 e4433f36b224603612efffe98427c19a9de1d315	no	7
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3	Non Patent Literature	Mills_1994.pdf	264103 e346019be653f77afab569c335911df4fcf4d135	no	16
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4	Non Patent Literature	Motorola_2001.pdf	5767492 3f2c32fdb050b38c23a1978faa65a0f938d9ef6f	no	111
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5	Non Patent Literature	13619237_Non-Final_OA_4-10-13.pdf	329715 29e4c915f6e0cdc22f63f1be82b2b404ac6906ac	no	10
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6	Non Patent Literature	14184522_Non-Final_OA_5-1-14.pdf	1042059 3e0d22e91cd5d85ad3f946ad4a7897db11c7df09	no	31
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7	Non Patent Literature	13827653_Non-Final_OA_12-5-13.pdf	956362 48d14b60b6340041f85ab471b4fb37ca7b17a051	no	28
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8	Non Patent Literature	13298090_Non-Final_OA_01-05-12.pdf	1401752 5401dd4b7d75aa6308908e34179cab7252ea3a73	no	40
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10	Non Patent Literature	14184528_Non-Final_OA_5-12-14.pdf	784767 cedc7adc69fbf2021f105c90f100487cc3feb203	no	23

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11	Non Patent Literature	13848932_Non-Final_OA_5-14-14.pdf	461919 e2e7f62a13e4121e1416e89a9fd5fc441e0196d4	no	14
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43	Non Patent Literature	Palm_Handbook_for_Palm_VII_May2000.pdf	13845892 f215b74616fd7598ac30202c2892bc084fdc328c	no	311
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44	Non Patent Literature	Park_2003.pdf	4261812 9408664cb1b116fbcdb0f9f7f66efca31263e75e	no	5
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53	Non Patent Literature	AppleTV_SetupGuide_3rdGeneration_3-16-12.pdf	1323810 a761cdb34a8a8882f256a7dd181e835416d22903	no	36
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55	Other Reference-Patent/App/Search documents	PCTUS2013046386_Written_Opinion_9-30-13.pdf	232837 6aa1639ae8799b1400f1fda0fec57d72587c8eaa	no	6
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58	Non Patent Literature	Yamaha_2004-482_pages_Part2.pdf	15906586 27a80c5d77e4a91dd0b1c04322e76749f327fe0e	no	237
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59	Information Disclosure Statement (IDS) Form (SB08)	MPB__Sonos_04-0401-CON1014D_MBHB_14-1800-CON2_IDS_2of2.pdf	708546 a5b7219846e5fc813066dc7b8291bbea5c1135e8	no	8
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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.

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:
JASPER JOSEPH T.

HANLEY, FLIGHT & ZIMMERMAN, LLC 150 S.
WACKER DRIVE, SUITE 2100 CHICAGO IL 60606 USA

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43bis.1)

Date of mailing *(day/month/year)*	**30 September 2013 (30.09.2013)**
Applicant's or agent's file reference 12-0402-PCT	**FOR FURTHER ACTION** See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2013/046386	**18 June 2013 (18.06.2013)**	26 June 2012 (26.06.2012)

International Patent Classification (IPC) or both national classification and IPC
G06Q 50/10(2012.01)i

Applicant
SONOS, INC.

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1bis(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.
For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/KR	Date of completion of this opinion	Authorized officer
Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea Facsimile No. +82-42-472-7140	27 September 2013 (27.09.2013)	KIM Sung Gon Telephone No. +82-42-481-8746

Form PCT/ISA/237 (cover sheet) (July 2011)

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2013/046386

Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of :

   ☒ the international application in the language in which it was filed

   ☐ a translation of the international application into _____ , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of:

   a. a sequence listing filed or furnished
      ☐ on paper
      ☐ in electronic form

   b. time of filing or furnishing
      ☐ contained in the international application as filed.
      ☐ filed together with the international application in electronic form.
      ☐ furnished subsequently to this Authority for the purposes of search.

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additioanl copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2013/046386

Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-21	YES
	Claims	NONE	NO
Inventive step (IS)	Claims	NONE	YES
	Claims	1-21	NO
Industrial applicability (IA)	Claims	1-21	YES
	Claims	NONE	NO

2. Citations and explanations :

Reference is made to the following documents:

D1: US 7483958 B1 (TAREK Z. ELABBADY et al.) 27 January 2009
D2: US 2010-0228740 A1 (ALAN CANNISTRARO et al.) 09 September 2010

1. Novelty and Inventive Step

1.1 Claims 1-10

1.1.1 Independent claim 1

D1, which is considered to be the closest prior art to the subject matter of claim 1, discloses a method comprising: presenting media content information (e.g., music file, a play list) to the user, determining whether an original media playing license associated with the particular media contents file is available, generating a temporary media playing license from the original media playing license, the temporary media playing license specifying restrictions relating to playback of the particular media content file via the home network device; and sending the temporary media playing license to the home network device (See abstract, column 11, lines 1-20, claim 1, figure 4 in D1). Claim 1 differs from D1 in facilitating addition of content to the playlist by at least one participating user; and playback of content from the playlist in the restricted playback mode. However, D2 discloses a method comprising: receiving from at least one of the plurality of user devices a vote on a media item; and organizing the playlist based on the received votes (See abstract, paragraphs [0047]-[0057], claim 1, figure 4 in D2). Accordingly, claim 1 would have been obvious over D1 and D2. Therefore, claim 1 lacks an inventive step under PCT Article 33(3).

Continued on Supplemental Box

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of : Box No. V

1.1.2 Dependent claims 2-10

The additional feature of claim 2 is identical to the feature of D1 in that media items in the playlist are automatically chosen and added to the playlist by a program on the playlist host device (See claim 6 in D1). Accordingly, claim 2 would have been obvious over D1 and D2. Therefore, claim 2 lacks an inventive step under PCT Article 33(3).

Claim 3 further specifies authenticating the at least one participating user to enable the at least one participating user to add content to the playlist in the restricted playback mode. However, the additional feature of claim 3 is virtually suggested by the feature of D2 considering that the host receives an opt-in command from an authorized user and the opt-in command instructs the host to allow remote access to the playlist (See abstract, paragraphs [0047]-[0057], figure 4 in D2). Accordingly, claim 3 would have been obvious over D1 and D2. Therefore, claim 3 lacks an inventive step under PCT Article 33(3).

The additional feature of claim 4 is identical to the feature of D2 in receiving from at least one of the plurality of user devices a vote on a media item; and organizing the playlist based on the received votes (See abstract, paragraphs [0047]-[0057], claim 1, figure 4 in D2). Accordingly, claim 4 would have been obvious over D1 and D2. Therefore, claim 4 lacks an inventive step under PCT Article 33(3).

Claims 5, 6 further specify that facilitating addition of content comprises accepting user selection of the content from a list of available content via a graphical user interface, and the list of available content includes a library of shared music available via a network. However, the additional features of claims 5, 6 are virtually suggested by the feature of D1 considering presenting media content information (e.g., metadata from the media library) to the user through a display screen, and selecting one or more music files, a play list, or other grouping of music files by the user (See abstract, column 11, lines 1-20, claim 1, figure 4 in D1). And D2 discloses a step of sending a playlist on a host device to a plurality of portable devices for display on a graphical user interface (See paragraph [0009] in D2). Accordingly, claims 5, 6 would have been obvious over D1 and D2. Therefore, claims 5, 6 lack an inventive step under PCT Article 33(3).

Claim 7 further comprises that the restricted playback mode is initiated and ended by a host user according to user authorization. However, the additional feature of claim 7 is merely a

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Supplemental Box

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Continuation of : Previous Page

matter of design option when the general knowledge in relevant field of the art is used. Accordingly, claim 7 would have been obvious over D1 and D2. Therefore, claim 7 lacks an inventive step under PCT Article 33(3).

Claim 8 further specifies configuring the restricted playback mode for a fixed time interval. However, the additional feature of claim 8 is virtually suggested by the feature of D2 considering ordering changes can be postponed until the interval since the last touch event has exceeded 2 seconds (See paragraph [0089] in D2). Accordingly, claim 8 would have been obvious over D1 and D2. Therefore, claim 8 lacks an inventive step under PCT Article 33(3).

Claim 9 further specifies that a restricted playback mode includes a specified configuration of zones. However, the additional feature of claim 9 is virtually suggested by the feature of D1 considering that the media content license may be associated with a specific entity or with multiple entities (e.g., groups) (See column 7, lines 61-66 in D1). Accordingly, claim 9 would have been obvious over D1 and D2. Therefore, claim 9 lacks an inventive step under PCT Article 33(3).

Claim 10 further comprises that the subset of playback functions includes limited user interaction with at least one of zone configuration and content playback parameters. However, the additional feature of claim 10 is merely a matter of design option when the general knowledge in relevant field of the art is used. Accordingly, claim 10 would have been obvious over D1 and D2. Therefore, claim 10 lacks an inventive step under PCT Article 33(3).

1.2 Claims 11-20

1.2.1 Independent claim 11

Claim 11 relates to a tangible computer readable storage medium including instructions which, when executed by a processor, are to implement at least a method. But it shares similar technical features with claim 1. Accordingly, the same reasoning applies to claim 11. Therefore, claim 11 lacks an inventive step under PCT Article 33(3).

1.2.2 Dependent claims 12-20

Claims 12-20 share the same technical features with claims 2-10, respectively. Accordingly, the

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In case **the space in any of the preceding boxes is not sufficient.**
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same reasoning applies to claims 12-20. Therefore, claims 12-20 lack an inventive step under PCT Article 33(3).

1.3 Independent claim 21

Claim 21 relates to a media playback system, but it shares similar technical features with claim 1. Accordingly, the same reasoning applies to claim 21. Therefore, claim 21 lacks an inventive step under PCT Article 33(3).

2. Industrial Applicability

Claims 1-21 are industrially applicable under PCT Article 33(4).

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MCDONNELL BOEHNEN HULBERT & BERGHOFF LLP
SONOS, INC.
300 SOUTH WACKER DRIVE
CHICAGO IL 60606

MAILED
NOV 03 2014
OFFICE OF PETITIONS

Doc Code: TRACK1.GRANT

Decision Granting Request for Prioritized Examination (Track I or After RCE)	Application No.: 14/516,867

1. THE REQUEST FILED October 17, 2014 IS **GRANTED.**

The above-identified application has met the requirements for prioritized examination
- A. ☒ for an original nonprovisional application (Track I).
- B. ☐ for an application undergoing continued examination (RCE).

2. **The above-identified application will undergo prioritized examination.** The application will be accorded special status throughout its entire course of prosecution until one of the following occurs:

- A. filing a **petition for extension of time** to extend the time period for filing a reply;
- B. filing an **amendment to amend the application to contain more than four independent claims, more than thirty total claims**, or a multiple dependent claim;
- C. filing a **request for continued examination**;
- D. filing a notice of appeal;
- E. filing a request for suspension of action;
- F. mailing of a notice of allowance;
- G. mailing of a final Office action;
- H. completion of examination as defined in 37 CFR 41.102; or
- I. abandonment of the application.

Telephone inquiries with regard to this decision should be directed to Irvin Dingle at (571)272-3210, Office of Petitions.

Irvin Dingle
/Irvin Dingle/
[*Signature*]

Paralegal Specialist
(Title)

UNITED STATES PATENT AND TRADEMARK OFFICE

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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
14/516,867	10/17/2014	2447	1740	04-0401-CON1014D	20	3

CONFIRMATION NO. 9318

107361
McDonnell Boehnen Hulbert & Berghoff LLP
Sonos, Inc.
300 South Wacker Drive
Chicago, IL 60606

FILING RECEIPT



Date Mailed: 10/27/2014

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

Nicholas A.J. Millington, Santa Barbara, CA;

Applicant(s)

Sonos, Inc., Santa Barbara, CA

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a CON of 13/297,000 11/15/2011
which is a CON of 10/816,217 04/01/2004 PAT 8234395
which claims benefit of 60/490,768 07/28/2003

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

If Required, Foreign Filing License Granted: 10/24/2014

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 14/516,867**

Projected Publication Date: 02/05/2015

Non-Publication Request: No

Early Publication Request: No

Title

Obtaining Content from Remote Source for Playback

Preliminary Class

709

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

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No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 14/516,867

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	280
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	600
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	720
TOTAL CLAIMS (37 CFR 1.16(i))	20 minus 20 =	*			OR	x 80 =	0.00
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*				x 420 =	0.00
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).						0.00
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	1600

APPLICATION AS AMENDED - PART II

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

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE($)	ADDITIONAL FEE($)		RATE($)	ADDITIONAL FEE($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	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 found in the appropriate box in column 1.

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
14/516,867	10/17/2014	Nicholas A.J. Millington	04-0401-CON1014D

CONFIRMATION NO. 9318

107361
McDonnell Boehnen Hulbert & Berghoff LLP
Sonos, Inc.
300 South Wacker Drive
Chicago, IL 60606

NOTICE

OC000000071535128

Date Mailed: 10/27/2014

INFORMATIONAL NOTICE TO APPLICANT

Applicant is notified that the above-identified application contains the deficiencies noted below. No period for reply is set forth in this notice for correction of these deficiencies. However, if a deficiency relates to the inventor's oath or declaration, the applicant must file an oath or declaration in compliance with 37 CFR 1.63, or a substitute statement in compliance with 37 CFR 1.64, executed by or with respect to each actual inventor no later than the expiration of the time period set in the "Notice of Allowability" to avoid abandonment. See 37 CFR 1.53(f).

The item(s) indicated below are also required and should be submitted with any reply to this notice to avoid further processing delays.

- A properly executed inventor's oath or declaration has not been received for the following inventor(s):
  Nicholas A.J. Millington

Doc Code: TRACK1.REQ
Document Description: TrackOne Request

PTO/AIA/424 (04-14)

CERTIFICATION AND REQUEST FOR PRIORITIZED EXAMINATION UNDER 37 CFR 1.102(e) (Page 1 of 1)

First Named Inventor:	Nicholas A.J. Millington	Nonprovisional Application Number (if known):	
Title of Invention:	Obtaining Content from Remote Source for Playback		

APPLICANT HEREBY CERTIFIES THE FOLLOWING AND REQUESTS PRIORITIZED EXAMINATION FOR THE ABOVE-IDENTIFIED APPLICATION.

1. The processing fee set forth in 37 CFR 1.17(i)(1) and the prioritized examination fee set forth in 37 CFR 1.17(c) have been filed with the request. The publication fee requirement is met because that fee, set forth in 37 CFR 1.18(d), is currently $0. The basic filing fee, search fee, and examination fee are filed with the request or have been already been paid. I understand that any required excess claims fees or application size fee must be paid for the application.

2. I understand that the application may not contain, or be amended to contain, more than four independent claims, more than thirty total claims, or any multiple dependent claims, and that any request for an extension of time will cause an outstanding Track I request to be dismissed.

3. The applicable box is checked below:

I. ☑ Original Application (Track One) - Prioritized Examination under § 1.102(e)(1)

i. (a) The application is an original nonprovisional utility application filed under 35 U.S.C. 111(a). This certification and request is being filed with the utility application via EFS-Web.

---OR---

(b) The application is an original nonprovisional plant application filed under 35 U.S.C. 111(a). This certification and request is being filed with the plant application in paper.

ii. An executed inventor's oath or declaration under 37 CFR 1.63 or 37 CFR 1.64 for each inventor, **or** the application data sheet meeting the conditions specified in 37 CFR 1.53(f)(3)(i) is filed with the application.

II. ☐ Request for Continued Examination - Prioritized Examination under § 1.102(e)(2)

i. A request for continued examination has been filed with, or prior to, this form.
ii. If the application is a utility application, this certification and request is being filed via EFS-Web.
iii. The application is an original nonprovisional utility application filed under 35 U.S.C. 111(a), or is a national stage entry under 35 U.S.C. 371.
iv. This certification and request is being filed prior to the mailing of a first Office action responsive to the request for continued examination.
v. No prior request for continued examination has been granted prioritized examination status under 37 CFR 1.102(e)(2).

Signature /Michael P. Boyea/	Date October 17, 2014
Name (Print/Typed) Michael P. Boyea	Practitioner Registration Number 70,248

Note: *This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. Submit multiple forms if more than one signature is required.**

☐ *Total of _____ forms are submitted.

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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:

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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.

PTO/AIA/14 (12-13)
Approved for use through 01/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	04-0401-CON1014D
	Application Number	
Title of Invention	Obtaining Content from Remote Source for Playback	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Nicholas	A.J.	Millington	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Santa Barbara	State/Province	CA	Country of Residence i	US

Mailing Address of Inventor:

Address 1	Sonos, Inc.		
Address 2	223 East De La Guerra		
City	Santa Barbara	State/Province	CA
Postal Code	93101	Country i	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	107361		
Email Address	docketing@mbhb.com	Add Email	Remove Email

Application Information:

Title of the Invention	Obtaining Content from Remote Source for Playback		
Attorney Docket Number	04-0401-CON1014D	Small Entity Status Claimed	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	5	Suggested Figure for Publication (if any)	

Filing By Reference :

PTO/AIA/14 (12-13)
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	04-0401-CON1014D
	Application Number	
Title of Invention	Obtaining Content from Remote Source for Playback	

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	107361		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the application number blank.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	Continuation of	13297000	2011-11-15
Prior Application Status	Patented		Remove

Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
13297000	Continuation of	10816217	2004-04-01	8234395	2012-07-31
Prior Application Status	Expired				Remove

PTO/AIA/14 (12-13)
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	04-0401-CON1014D
	Application Number	
Title of Invention	Obtaining Content from Remote Source for Playback	

Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
10816217	Claims benefit of provisional	60490768	2003-07-28

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(d). When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX) [i]the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(h)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove

Application Number	Country [i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)

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Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

Authorization to Permit Access:

☐ Authorization to Permit Access to the Instant Application by the Participating Offices

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	04-0401-CON1014D
	Application Number	
Title of Invention	Obtaining Content from Remote Source for Playback	

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In accordance with 37 CFR 1.14(h)(3), access will be provided to a copy of the instant patent application with respect to: 1) the instant patent application-as-filed; 2) any foreign application to which the instant patent application claims priority under 35 U.S.C. 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the instant patent application; and 3) any U.S. application-as-filed from which benefit is sought in the instant patent application.

In accordance with 37 CFR 1.14(c), access may be provided to information concerning the date of filing this Authorization.

Applicant Information:

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Applicant 1 Remove

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Clear

(•) Assignee	( ) Legal Representative under 35 U.S.C. 117	( ) Joint Inventor
( ) Person to whom the inventor is obligated to assign.	( ) Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor :

If the Applicant is an Organization check here. [X]

Organization Name	Sonos, Inc.		
Mailing Address Information:			
Address 1	223 East De La Guerra Street		
Address 2			
City	Santa Barbara	**State/Province**	CA
Country [i]	US	Postal Code	93101
Phone Number		Fax Number	

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	04-0401-CON1014D
	Application Number	
Title of Invention	Obtaining Content from Remote Source for Playback	

Email Address	

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Assignee Information including Non-Applicant Assignee Information:

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Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication . An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

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Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

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Address 1			
Address 2			
City		**State/Province**	
Country i		Postal Code	
Phone Number		Fax Number	
Email Address			

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Signature:

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Signature	/Michael P. Boyea/			Date (YYYY-MM-DD)	2014-10-17
First Name	Michael P.	Last Name	Boyea	Registration Number	70248

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	04-0401-CON1014D
	Application Number	
Title of Invention	Obtaining Content from Remote Source for Playback	

This collection of information is required by 37 CFR 1.76. 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 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet 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.**

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Electronic Patent Application Fee Transmittal	
Application Number:	
Filing Date:	
Title of Invention:	Obtaining Content from Remote Source for Playback
First Named Inventor/Applicant Name:	Nicholas A.J. Millington
Filer:	Michael Paul Boyea
Attorney Docket Number:	04-0401-CON1014D
Filed as Large Entity	

Track I Prioritized Examination - Nonprovisional Application under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Utility application filing	1011	1	280	280
Utility Search Fee	1111	1	600	600
Utility Examination Fee	1311	1	720	720
Request for Prioritized Examination	1817	1	4000	4000
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		5600

Electronic Acknowledgement Receipt	
EFS ID:	20444480
Application Number:	14516867
International Application Number:	
Confirmation Number:	9318
Title of Invention:	Obtaining Content from Remote Source for Playback
First Named Inventor/Applicant Name:	Nicholas A.J. Millington
Customer Number:	107361
Filer:	Michael Paul Boyea
Filer Authorized By:	
Attorney Docket Number:	04-0401-CON1014D
Receipt Date:	17-OCT-2014
Filing Date:	
Time Stamp:	13:09:26
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$5600
RAM confirmation Number	9785
Deposit Account	132490
Authorized User	
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		Sonos_04-0401-CON1014D_MBHB_14-1800-CON2_13297000SpecFiled.pdf	3655852 1d7d2f0c879e9e7117c5d87f317bcbc56c4dde67	yes	62

Multipart Description/PDF files in .zip description

Document Description	Start	End
Specification	1	58
Claims	59	61
Abstract	62	62

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Information:

2	Drawings-only black and white line drawings	Sonos_04-0401-CON1014D_MBHB_14-1800-CON2_13297000FigsFiled.pdf	113795 f1e9aa937e24b0b9e29bd1f55f93121d360d018a	no	5

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Information:

3		Sonos_04-0401-CON1014D_MBHB_14-1800-CON2_Preliminary_Amendment.pdf	112683 9b12c22a4d97c5f9cc90c2d7a4509e188fe7b8d0	yes	10

Multipart Description/PDF files in .zip description

Document Description	Start	End
Preliminary Amendment	1	1
Abstract	2	2
Specification	3	4
Claims	5	9
Applicant Arguments/Remarks Made in an Amendment	10	10

Warnings:					
Information:					
4	Authorization for Extension of Time all replies	Sonos_04-0401-CON1014D_MBHB_14-1800-CON2_General_Authorization.pdf	74878 bd089c1876dd864edc77c9471d5527aef6a24dcc	no	1
Warnings:					
Information:					
5	TrackOne Request	Sonos_04-0401-CON1014D_MBHB_14-1800-CON2_Track1_Req.pdf	126532 15e03289c5e548180b6e056071ff1687fc9d226b	no	2
Warnings:					
Information:					
6	Application Data Sheet	Sonos_04-0401-CON1014D_MBHB_14-1800-CON2_ADS.pdf	1561560 5af57ed093d863bcc5fa21f7de9e0daf2ec40329	no	7
Warnings:					
Information:					
7	Fee Worksheet (SB06)	fee-info.pdf	36579 0671cd07870721603ae11c223325717259bb30cb	no	2
Warnings:					
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			Total Files Size (in bytes):	5681879	

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Electronic Acknowledgement Receipt	
EFS ID:	20444480
Application Number:	14516867
International Application Number:	
Confirmation Number:	9318
Title of Invention:	Obtaining Content from Remote Source for Playback
First Named Inventor/Applicant Name:	Nicholas A.J. Millington
Customer Number:	107361
Filer:	Michael Paul Boyea
Filer Authorized By:	
Attorney Docket Number:	04-0401-CON1014D
Receipt Date:	17-OCT-2014
Filing Date:	
Time Stamp:	13:09:26
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$5600
RAM confirmation Number	9785
Deposit Account	132490
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees) Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)	

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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		Sonos_04-0401-CON1014D_MBHB_14-1800-CON2_13297000SpecFiled.pdf	3655852 1d7d2f0c879e9e7117c5d87f317bcbc56c4dde67	yes	62

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Specification	1	58
	Claims	59	61
	Abstract	62	62

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Information:

2	Drawings-only black and white line drawings	Sonos_04-0401-CON1014D_MBHB_14-1800-CON2_13297000FigsFiled.pdf	113795 f1e9aa937e24b0b9e29bd1f55f93121d360d018a	no	5

Warnings:

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Information:

3		Sonos_04-0401-CON1014D_MBHB_14-1800-CON2_Preliminary_Amendment.pdf	112683 9b12c22a4d97c5f9cc90c2d7a4509e188fe7b8d0	yes	10

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Preliminary Amendment	1	1
	Abstract	2	2
	Specification	3	4
	Claims	5	9
	Applicant Arguments/Remarks Made in an Amendment	10	10

Warnings:					
Information:					
4	Authorization for Extension of Time all replies	Sonos_04-0401-CON1014D_MBHB_14-1800-CON2_General_Authorization.pdf	74878 bd089c1876dd864edc77c9471d5527aef6a24dcc	no	1
Warnings:					
Information:					
5	TrackOne Request	Sonos_04-0401-CON1014D_MBHB_14-1800-CON2_Track1_Req.pdf	126532 15e03289c5e548180b6e056071ff1687fc9d226b	no	2
Warnings:					
Information:					
6	Application Data Sheet	Sonos_04-0401-CON1014D_MBHB_14-1800-CON2_ADS.pdf	1561560 5af57ed093d863bcc5fa21f7de9e0daf2ec40329	no	7
Warnings:					
Information:					
7	Fee Worksheet (SB06)	fee-info.pdf	36579 0671cd07870721603ae11c223325717259bb30cb	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	5681879	

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<u>New Applications Under 35 U.S.C. 111</u>
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<u>National Stage of an International Application under 35 U.S.C. 371</u>
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<u>New International Application Filed with the USPTO as a Receiving Office</u>
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ATTORNEY'S DOCKET NO. 11-0901

PATENTS

UNITED STATES PATENT APPLICATION

OF

NICHOLAS A. J. MILLINGTON

FOR

SYSTEM AND METHOD FOR SYNCHRONIZING OPERATIONS AMONG A PLURALITY OF INDEPENDENTLY CLOCKED DIGITAL DATA PROCESSING DEVICES

INCORPORATION BY REFERENCE

This application claims the benefit of Provisional Patent Application Serial No. 60/490,768, filed on July 28, 2003, entitled "Method for Synchronizing Audio Playback Between Multiple Networked Devices," and Non-provisional Patent Application Serial No. 10/816,217, filed on April 1, 2004, entitled "System and Method for Synchronizing Channel Handoff as Among a Plurality of Independently Clocked Digital Devices," both 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. 2A 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 player11(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. 2A. 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. 2A. With reference to FIG. 2A, that FIG. depicts elements of two synchrony groups, identified by reference numerals 20(1) and 20(2), respectively. For clarity, FIG. 2A 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. 2A 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. 2A 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. 2A 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. 2A 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. 2A, 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. 2A, 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. 2A 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. 2A, 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. 2A 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. 2A, 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 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+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. 2A) 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. 2A) 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 multi-cast 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 multi-cast 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 for providing synchronized audio play back amongst a plurality of audio devices, the method comprising:

retrieving, by a computing device, audio information from any of a locally stored digital audio file, a remotely stored digital audio file via a wide area network, and a streaming digital audio service;

transmitting a plurality of frames to a plurality of audio devices over a local network from the computing device, each frame of the plurality of frames to include the retrieved audio information and timing information inserted at the computing device, wherein the timing information is to be used to play the audio information by the plurality of audio devices in synchrony.

2. The method of claim 1, wherein the computing device comprises a personal computer.

3. The method of claim 2, further comprising transmitting the plurality of frames to the plurality of audio devices responsive to receiving a user command via a user interface of the personal computer.

4. The method of claim 1, wherein the computing device comprises a mobile computing device.

5. The method of claim 4, further comprising transmitting the plurality of frames to the plurality of audio devices responsive to receiving a user command via a user interface of the mobile computing device.

6. The method of claim 1, wherein the computing device is configured to play the audio information in synchrony with the plurality of audio devices.

7. The method of claim 1, wherein the computing device is configured to play different audio information than the plurality of audio devices and at the same time as the plurality of audio devices play the audio information.

8. The method of claim 1, wherein the locally stored digital audio file is stored on a personal computer or a mobile computing device configured to store digital information.

9. The method of claim 1, further comprising wirelessly transmitting the plurality of frames to the plurality of audio devices.

10. The method of claim 1, wherein the computing device comprises a user interface to receive a user command to transmit the plurality of frames.

11. The method of claim 10, wherein the user interface is to enable a user to at least one of select an audio track, display status information, and display an upcoming audio playback selection.

12. The method of claim 10, wherein the user interface is to enable a user to select one or more of the plurality of audio devices for audio playback.

13. A non-transitory computer readable medium having stored therein instructions executable by a processor to perform a method comprising:

retrieving, by a computing device, audio information from any of a locally stored digital audio file, a remotely stored digital audio file via a wide area network, and a streaming digital audio service;

transmitting a plurality of frames to a plurality of audio devices over a local network from the computing device, each frame of the plurality of frames to include the retrieved audio information and timing information inserted at the computing device, wherein the timing information is to be used to play the audio information by the plurality of audio devices in synchrony.

14. A method for providing synchronized audio amongst a plurality of audio devices, the method comprising:

receiving, by an audio device, a plurality of frames over a local network from a computing device, each frame of the plurality of frames to include audio information and timing information, wherein the timing information is to be used to play the audio information by the audio device in synchrony with another receiving audio device; and

converting, by the audio device, the audio information from a digital form into an analog signal to be output based on the timing information via an amplifier and a speaker driver.

15. The method of claim 15, wherein the computing device comprises a mobile computing device.

16. The method of claim 15, wherein the computing device comprises a personal computer.

17. The method of claim 15, wherein the audio information is from any of a locally stored digital audio file, a remotely stored digital audio file via a wide area network, and a streaming digital audio service.

18. The method of claim 15, wherein the local network comprises a wired network.

19. The method of claim 15, wherein the local network comprises a wireless network.

20. A non-transitory computer readable medium having stored therein instructions executable by a processor to perform a method comprising:

receiving, by an audio device, a plurality of frames over a local network from a computing device, each frame of the plurality of frames to include audio information and timing information, wherein the timing information is to be used to play the audio information by the audio device in synchrony with another receiving audio device; and

converting, by the audio device, the audio information from a digital form into an analog signal to be output based on the timing information via an amplifier and a speaker driver.

ABSTRACT OF THE DISCLOSURE

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.

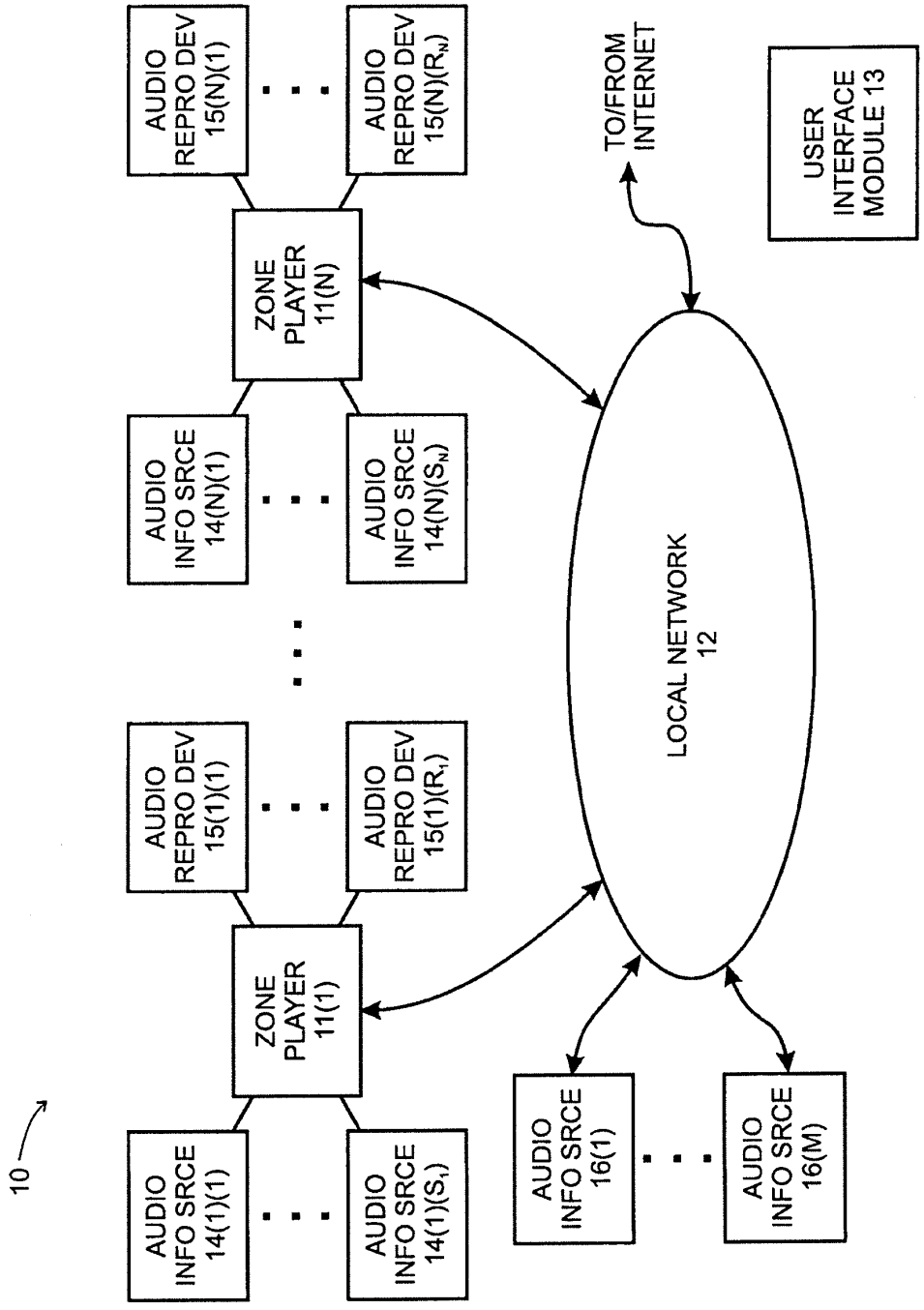

10
AUDIO INFO SRCE 14(1)(1)
AUDIO INFO SRCE 14(1)(S1)
ZONE PLAYER 11(1)
AUDIO REPRO DEV 15(1)(1)
AUDIO REPRO DEV 15(1)(R1)
AUDIO INFO SRCE 14(N)(1)
AUDIO INFO SRCE 14(N)(SN)
ZONE PLAYER 11(N)
AUDIO REPRO DEV 15(N)(1)
AUDIO REPRO DEV 15(N)(RN)
LOCAL NETWORK 12
AUDIO INFO SRCE 16(1)
AUDIO INFO SRCE 16(M)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

FIG. 1

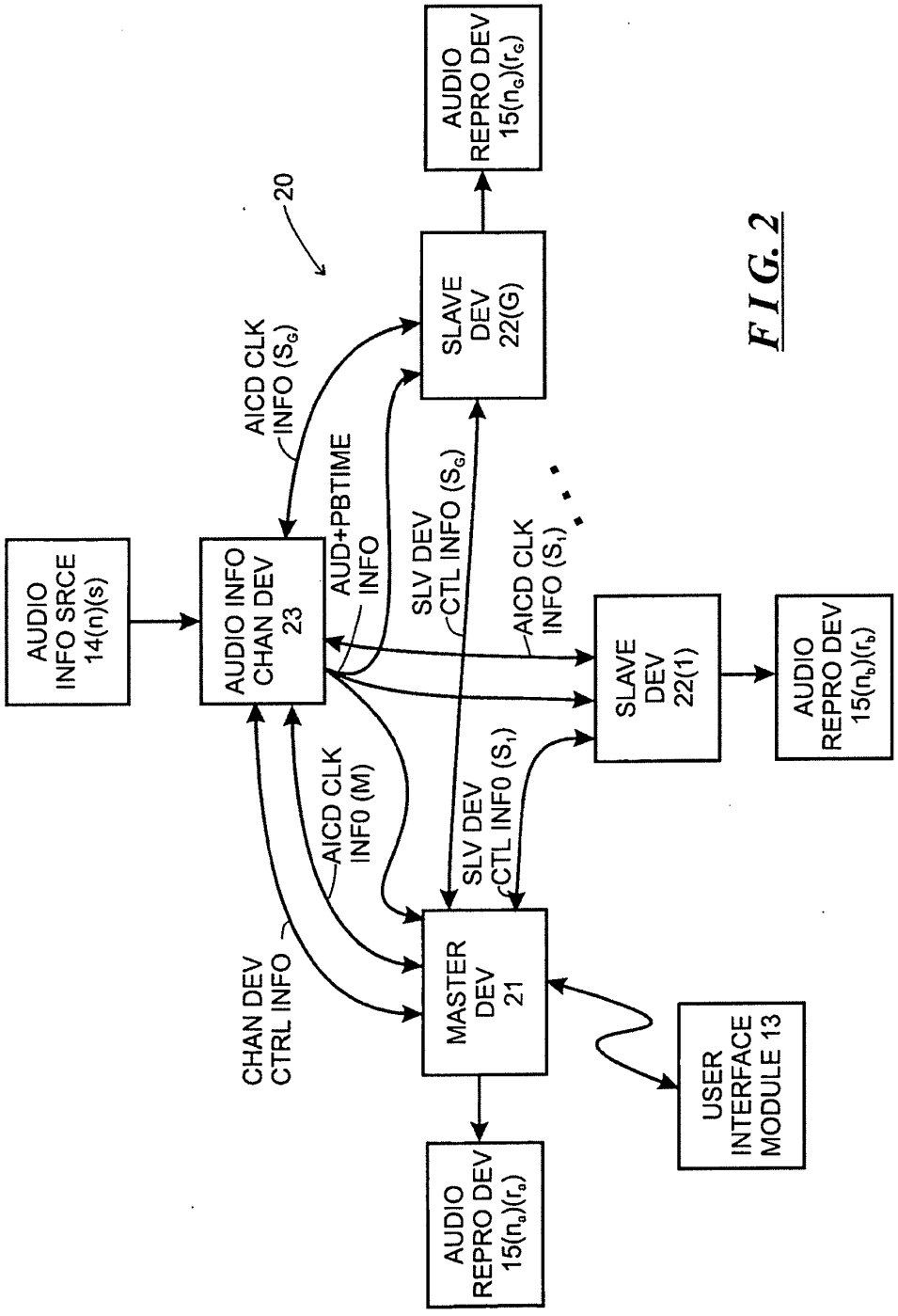

20
AUDIO INFO SRCE 14(n)(s)
AUDIO INFO CHAN DEV 23
AUD+PBTIME INFO
AICD CLK INFO (S_G)
SLAVE DEV 22(G)
AUDIO REPRO DEV 15(n_G)(r_G)
SLV DEV CTL INFO (S_G)
AICD CLK INFO (S_1)
SLAVE DEV 22(1)
AUDIO REPRO DEV 15(n_b)(r_b)
AICD CLK INFO (M)
SLV DEV CTL INFO (S_1)
CHAN DEV CTRL INFO
MASTER DEV 21
USER INTERFACE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

FIG. 2

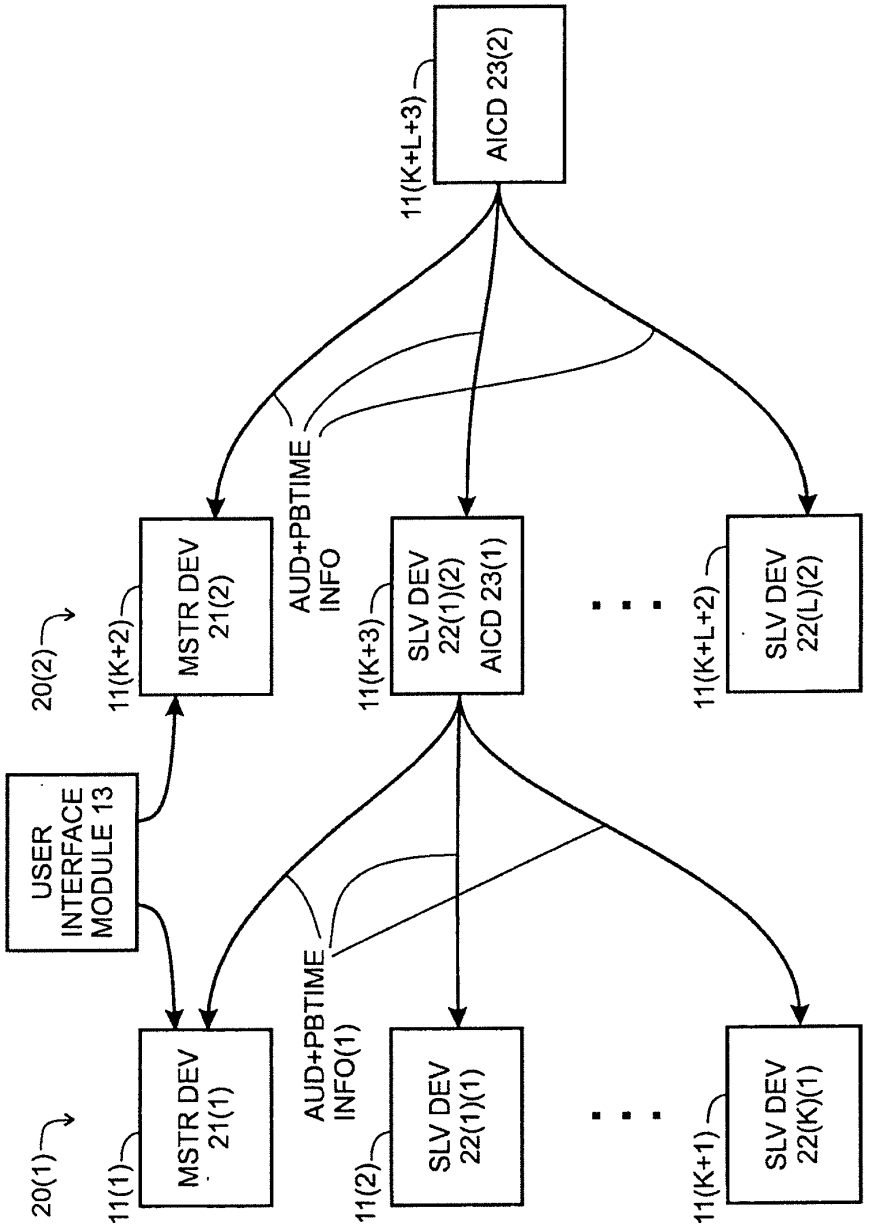

AICD 23(2)
11(K+L+3)
AUD+PBTIME INFO
MSTR DEV 21(2)
11(K+2)
20(2)
SLV DEV 22(1)(2) AICD 23(1)
11(K+3)
SLV DEV 22(L)(2)
11(K+L+2)
USER INTERFACE MODULE 13
AUD+PBTIME INFO(1)
MSTR DEV 21(1)
11(1)
20(1)
SLV DEV 22(1)(1)
11(2)
SLV DEV 22(K)(1)
11(K+1)

FIG. 2A

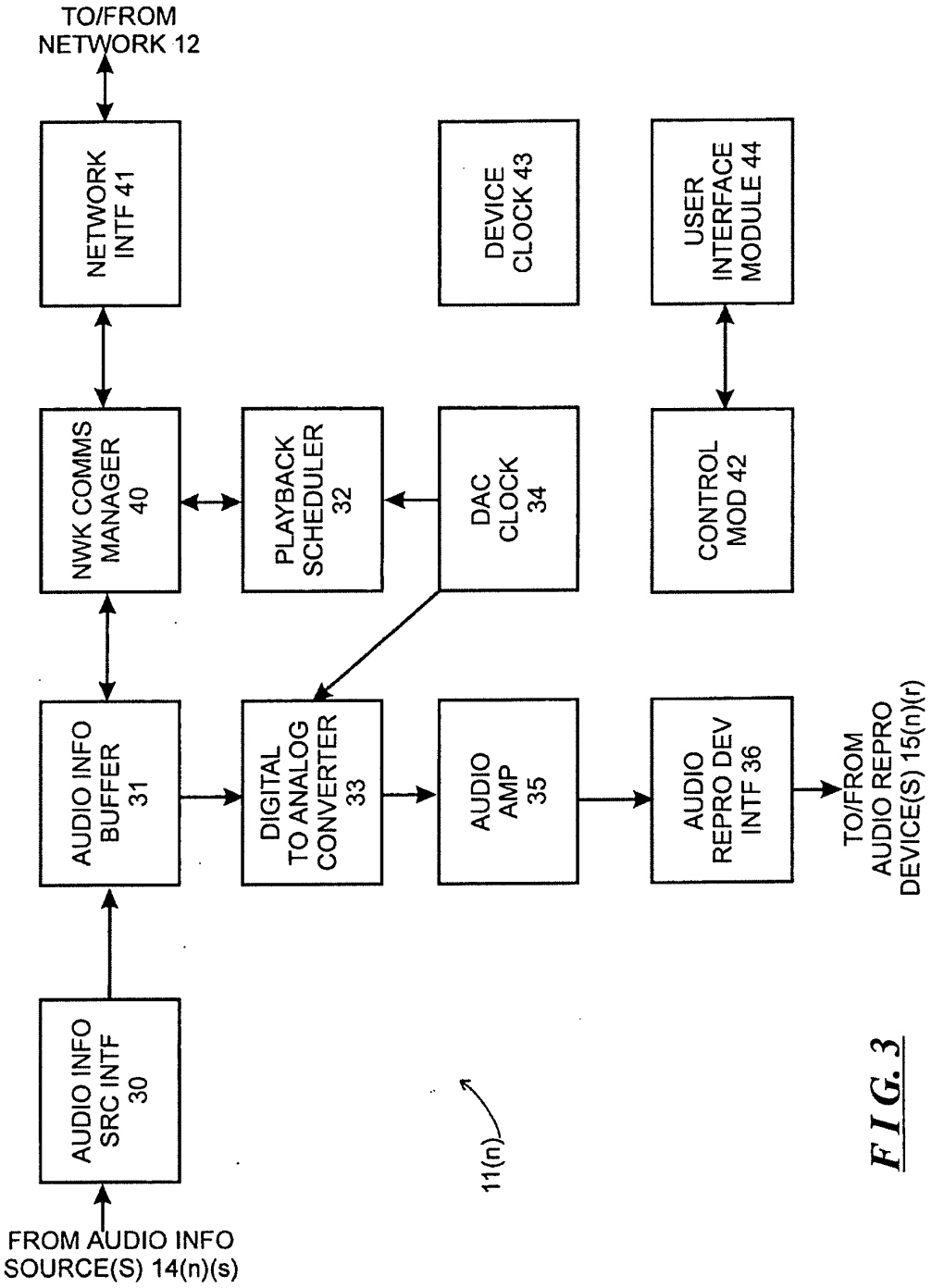

TO/FROM NETWORK 12
NETWORK INTF 41
DEVICE CLOCK 43
USER INTERFACE MODULE 44
NWK COMMS MANAGER 40
PLAYBACK SCHEDULER 32
DAC CLOCK 34
CONTROL MOD 42
AUDIO INFO BUFFER 31
DIGITAL TO ANALOG CONVERTER 33
AUDIO AMP 35
AUDIO REPRO DEV INTF 36
TO/FROM AUDIO REPRO DEVICE(S) 15(n)(r)
AUDIO INFO SRC INTF 30
11(n)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

FIG. 3

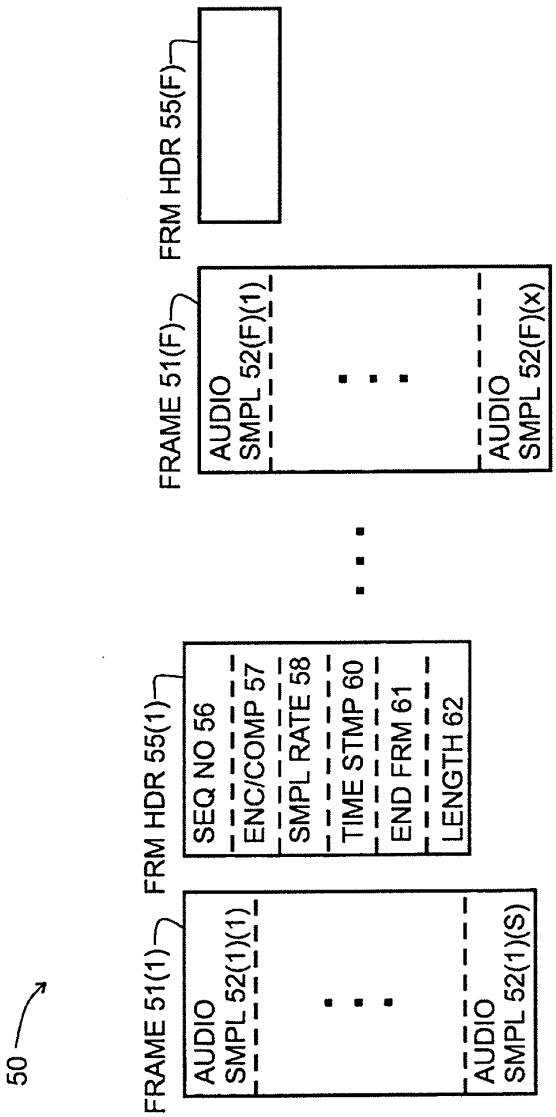

50
FRAME 51(1)
AUDIO SMPL 52(1)(1)
AUDIO SMPL 52(1)(S)
FRM HDR 55(1)
SEQ NO 56
ENC/COMP 57
SMPL RATE 58
TIME STMP 60
END FRM 61
LENGTH 62
FRAME 51(F)
AUDIO SMPL 52(F)(1)
AUDIO SMPL 52(F)(x)
FRM HDR 55(F)

FIG. 4

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
(Case No. 04-0401-CON1014D (MBHB No. 14-1800-CON2))

In re the Application of:	)	
	)	
Nicholas A.J. Millington	)	
	)	
Application No.: TBD	)	**Group Art Unit: TBD**
	)	
Filed: October 17, 2014	)	
	)	**Examiner: TBD**
Confirmation No.: TBD	)	
	)	
For: Obtaining Content from Remote Source for Playback	)	

Mailstop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313

PRELIMINARY AMENDMENT

Prior to examination of the above-referenced application, Applicant respectfully requests entry of the following amendments and consideration of the following remarks.

Amendments to the Abstract begin on page 2 of this paper.

Amendments to the Specification begin on page 3 of this paper.

Amendments to the Claims begin on page 5 of this paper.

Remarks begin on page 10 of this paper.

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AMENDMENTS TO THE ABSTRACT

Please amend the Abstract as follows:

~~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.~~

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.

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AMENDMENTS TO THE SPECIFICATION

Please amend the title of the application as follows:

~~System and Method for Synchronizing Operations Among A Plurality Of Independently Clocked Digital Data Processing Devices~~

Obtaining Content from Remote Source for Playback

Please amend the "Incorporation by Reference" section of the specification starting on page 1 as follows:

INCORPORATION BY REFERENCE

~~This application claims the benefit of Provisional Patent Application Serial No. 60/490,768, filed on July 28, 2003, entitled "Method for Synchronizing Audio Playback Between Multiple Networked Devices," and Non-provisional Patent Application Serial No. 10/816,217, filed on April 1, 2004, entitled "System and Method for Synchronizing Channel Handoff as Among a Plurality of Independently Clocked Digital Devices," both of which are assigned to the assignee of the present application and are incorporated herein by reference.~~

This application claims priority under 35 U.S.C. § 120 to, and is a continuation of, U.S. Non-provisional Patent Application No. 13/297,000, filed on November 15, 20ll, 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 No. 10/816,217, now issued as U.S. Patent No. 8,234,395, filed on April 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 July 28,

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2003 and now expired, 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.

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AMENDMENTS TO THE CLAIMS

1-20 (Cancelled)

21. (New) A first playback device comprising:

a network interface; and

memory comprising program instructions that, when executed by the processor, cause the playback device to:

receive, via the network interface from a network device communicatively coupled to the first playback device over a local area network (LAN), 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;

obtain, via the network interface from the audio information source, the audio information;

transmit, via the network interface to a second playback device, the audio information; and

play back the audio information.

22. (New) The first playback device of claim 21, wherein the program instructions, when executed by the processor, further cause the first playback device to:

generate timing information based on the audio information; and

transmit, to the second playback device, the timing information, and

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wherein causing the first playback device to play back the audio information comprises causing the first playback device to play back the audio information according to the timing information.

23. (New) The first playback device of claim 21, wherein the program instructions, when executed by the processor, further cause the first playback device to:

before transmitting the audio information to the second playback device, receive, from the network device, an instruction to join a synchrony group that includes the second playback device.

24. (New) The first playback device of claim 23, wherein the program instructions, when executed by the processor, further cause the first playback device to:

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

25. (New) The first playback device of claim 24, wherein the status information further comprises an identification of each playback device in the synchrony group.

26. (New) The first playback device of claim 24, wherein the status information further comprises an identification of a master playback device of the synchrony group.

27. (New) The first playback device of claim 26, wherein the first playback device is the master playback device of the synchrony group.

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28. (New) The first playback device of claim 24, wherein the status information further comprises an identification of one or more slave playback devices in the synchrony group.

29. (New) The first playback device of claim 28, wherein the second playback device is one of the one or more slave playback devices in the synchrony group.

30. (New) The playback device of claim 21, wherein the audio information comprises one of audio files or packetized streaming audio information.

31. (New) The playback device of claim 21, wherein obtaining, from the audio information source, the audio information, comprises obtaining, from the audio information source via the Internet, the audio information.

32. (New) The playback device of claim 21, wherein obtaining, from the audio information source, the audio information, comprises sending, to the audio information source, a request for the audio information.

33. (New) A method comprising:

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

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obtaining, by the first playback device from the audio information source, the audio information;

transmitting, by the first playback device to a second playback device, the audio information; and

playing back, by the first playback device, the audio information.

34. (New) The method of claim 33, further comprising:

generating, by the first playback device, timing information based on the audio information; and

transmitting, by the first playback device to the second playback device, the timing information, and

wherein playing back the audio information comprises playing back the audio information according to the timing information.

35. (New) The method of claim 33, further comprising:

before transmitting the audio information to the second playback device, receiving, by the first playback device from the network device, an instruction to join a synchrony group that includes the second playback device.

36. (New) The method of claim 35, further comprising:

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

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37. (New) The method of claim 35, wherein the status information further comprises an identification of each playback device in the synchrony group.

38. (New) The method of claim 37, wherein the status information further comprises an identification of a master playback device of the synchrony group.

39. (New) The method of claim 38, wherein the first playback device is the master playback device of the synchrony group.

40. (New) 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 communicatively coupled to the first playback device over a local area network (LAN), an address identifying a location of audio information available at an audio information source, wherein the audio information source is outside of the LAN;

obtain, from the audio information source, the audio information;

transmit, to a second playback device, the audio information; and

play back the audio information.

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REMARKS

Applicant respectfully requests the Examiner to enter this Preliminary Amendment prior to examination. In this amendment, Applicant updates the Abstract, updates the application title, updates the incorporation by reference section, cancels claims 1-20, and presents new claims 21-40 for examination. Support for these amendments to the specification and claims can be found generally throughout the application.

Applicant respectfully requests entry of these amendments prior to issuance of this application. Should the Examiner wish to further discuss this case with the undersigned, the Examiner is welcome to call the undersigned at (312) 913-3381.

Respectfully submitted,

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Date: October 17, 2014

By: /Michael P. Boyea/
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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
(Case No. 04-0401-CON1014D)

In re Application of:	)	
	)	Confirmation No.: TBD
Nicholas A.J. Millington	)	
	)	Art Unit: TBD
Serial No.: TBD	)	
	)	Examiner: TBD
Filed: October 17, 2014	)	
	)	
Title: Obtaining Content from Remote Source for Playback	)	

Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

GENERAL AUTHORIZATIONS UNDER 37 C.F.R. §§ 1.25(b) and 1.136(a)(3)

In this or any related application filed pursuant to 37 C.F.R. § 1.53, for the entire pendency thereof, and with respect to Deposit Account No. 132490, the Commissioner is hereby generally authorized:

(a) under 37 C.F.R. § 1.25(b), subject to the provisions of 37 C.F.R. § 1.311(b), to charge all fees set forth in 37 C.F.R. §§ 1.16 to 1.18; and

(b) under 37 C.F.R. § 1.136(a)(3) to treat any future reply requiring an extension of time as incorporating a request therefor, and specifically to charge any fee that may be due in connection with such a request.

Respectfully submitted,

Date: October 17, 2014

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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 14/516,867	Filing Date 10/17/2014	☐ 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	10/17/2014	(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".
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LDRC
/PAMELA ROGERS/

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