United States Patent Application Publication	20250265031
Kind Code	A1
Publication Date	August 21, 2025
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SYSTEMS AND METHODS OF DISTRIBUTING AUDIO TO ONE OR MORE PLAYBACK DEVICES

Abstract

An example method includes receiving data indicating a configuration of one or more playback devices. The one or more playback devices may include one or more transducers. The method further includes, based on the received data, associating each of one or more audio streams respectively with at least one transducer of the one or more transducers. The method further includes generating the one or more audio streams and sending at least one of the generated one or more audio streams to each of the one or more playback devices. An example non-transitory computer readable medium and an example computing device related to the example method are also disclosed herein.

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Family ID:	**1000008586774**
Appl. No.:	**19/030560**
Filed:	**January 17, 2025**

Related U.S. Application Data

parent US continuation 18479498 20231002 parent-grant-document US 12271656 child US 19030560
parent US continuation 18063887 20221209 parent-grant-document US 11782675 child US 18479498
parent US continuation 17543055 20211206 parent-grant-document US 11526326 child US 18063887
parent US continuation 16782962 20200205 parent-grant-document US 11194541 child US 17543055
parent US continuation 16416714 20190520 parent-grant-document US 10592200 child US 16782962

Publication Classification

Int. Cl.: **G06F3/16** (20060101); **H03G3/30** (20060101); **H03G5/16** (20060101); **H03G7/00** (20060101); **H03G9/02** (20060101); **H04R3/04** (20060101); **H04R3/12** (20060101); **H04R27/00** (20060101)

U.S. Cl.:

CPC   **G06F3/165** (20130101); **H03G3/3005** (20130101); **H04R3/04** (20130101); **H04R3/12** (20130101); **H04R27/00** (20130101); H03G5/165 (20130101); H03G7/002 (20130101); H03G9/025 (20130101); H04R2227/003 (20130101); H04R2227/005 (20130101)

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is a continuation of U.S. patent application Ser. No. 18/479,498, filed Oct. 2, 2023, which is a continuation of U.S. patent application Ser. No. 18/063,887, filed Dec. 9, 2022, now U.S. Pat. No. 11,782,675, which is a continuation of U.S. patent application Ser. No. 17/543,055, filed Dec. 6, 2021, now U.S. Pat. No. 11,526,326, which is a continuation of U.S. patent application Ser. No. 16/782,962, Feb. 5, 2020, now U.S. Pat. No. 11,194,541, which is a continuation of U.S. patent application Ser. No. 16/416,714, filed May 20, 2019, now U.S. Pat. No. 10,592,200, which is a continuation of U.S. patent application Ser. No. 15/888,789, filed Feb. 5, 2018, now U.S. Pat. No. 10,296,288, which is a continuation of U.S. patent application Ser. No. 15/009,319, filed Jan. 28, 2016, now U.S. Pat. No. 9,886,234, each of which is incorporated herein by reference in its entirety.

FIELD OF THE DISCLOSURE
[0002] The disclosure is related to consumer goods and, more particularly, to methods, systems, products, features, services, and other elements directed to media playback or some aspect thereof.
BACKGROUND
[0003] Options for accessing and listening to digital audio in an out-loud setting were limited until in 2003, when SONOS, Inc. filed for one of its first patent applications, entitled "Method for Synchronizing Audio Playback between Multiple Networked Devices," and began offering a media playback system for sale in 2005. The Sonos Wireless HiFi System enables people to experience music from many sources via one or more networked playback devices. Through a software control application installed on a smartphone, tablet, or computer, one can play what he or she wants in any room that has a networked playback device. Additionally, using the controller, for example, different songs can be streamed to each room with a playback device, rooms can be grouped together for synchronous playback, or the same song can be heard in all rooms synchronously.
[0004] Given the ever growing interest in digital media, there continues to be a need to develop consumer-accessible technologies to further enhance the listening experience.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] Features, aspects, and advantages of the presently disclosed technology may be better understood with regard to the following description, appended claims, and accompanying drawings where:

[0006] FIG. **1** shows an example media playback system configuration in which certain embodiments may be practiced;

[0007] FIG. **2** shows a functional block diagram of an example playback device;

[0008] FIG. **3** shows a functional block diagram of an example control device;

[0009] FIG. **4** shows an example controller interface;

[0010] FIG. **5** shows a flow diagram of an example method;

[0011] FIG. **6** shows a computing device, a control device, and multiple playback devices, according to an example embodiment; and

[0012] FIG. **7** shows a computing device, a control device, and two playback devices, according to another example embodiment.

[0013] The drawings are for the purpose of illustrating example embodiments, but it is understood that the inventions are not limited to the arrangements and instrumentality shown in the drawings.

DETAILED DESCRIPTION

I. Overview

[0014] In some examples, one or more playback devices may stream and play audio content according to audio processing algorithms that may be customized for each playback device, or even customized for each transducer of each playback device. For instance, a playback device may include a first woofer, a second woofer, and a tweeter. As such, the playback device may use the audio content to generate a first audio stream for the first woofer, a second audio stream for the second woofer, and a third audio stream for the tweeter. This may further involve operations such as file format conversion, sample rate conversion, bit depth conversion, frequency-dependent amplification or attenuation, volume limiting, phase correction, and the like.

[0015] Depending on the capabilities of the playback devices, such audio processing performed by the playback devices may cause undesirable delay time between receiving audio content and playing the audio content, especially in cases where multiple playback devices are playing the audio content in synchrony. This may render the playback devices somewhat unsuited for applications such as lip-syncing audio content with video content, studio recording, and public address and stage monitoring for live performances. One way to alleviate this problem is to process audio using a computing device that is not designated to play the audio content. This may be especially helpful if the computing device has processing capacity superior to that of the playback devices.

[0016] In this example, the computing device may receive information about each of the playback devices such as specifications or model designations, frequency or phase response for transducers, volume limits, information regarding the environment or room in which the playback devices are located, or locations of the playback devices relative to each other. Such information may be received via a user-interface of the computing device, from a server associated with the playback devices, or from the one or more playback devices themselves.

[0017] The computing device may use this information to determine parameters of the audio processing algorithms. Alternatively, the one or more playback devices may determine the parameters of the audio processing algorithms and provide the parameters to the computing device. In either case, the computing device may generate audio streams according to the respective audio processing algorithms. Lastly, the computing device may send the audio streams to the corresponding playback devices.

[0018] When the audio streams are received by the one or more playback devices, the only task remaining might be to convert the received audio streams from digital to analog so that the audio

streams may be provided to the respective transducers. In the live audio context, this may reduce the amount of processing time between production of the live audio content and playback of the audio content by the one or more playback devices. Ideally, the processing time might be imperceptible to listeners.

[0019] Accordingly, some examples described herein include, among other things, a computing device using information about how one or more playback devices are configured to generate audio streams to be sent to various transducers of the one or more playback devices. Other aspects of the examples will be made apparent in the remainder of the description herein.

[0020] In one example, a non-transitory computer readable medium stores instructions that, when executed by a computing device, cause the computing device to perform functions. The functions include receiving data indicating a configuration of one or more playback devices. The one or more playback devices may include one or more transducers. The functions further include, based on the received data, associating each of one or more audio streams respectively with at least one transducer of the one or more transducers. The functions further include generating the one or more audio streams and sending at least one of the generated one or more audio streams to each of the one or more playback devices.

[0021] In another example, a method includes receiving data indicating a configuration of one or more playback devices. The one or more playback devices may include one or more transducers. The method further includes, based on the received data, associating each of one or more audio streams respectively with at least one transducer of the one or more transducers. The method further includes generating the one or more audio streams and sending at least one of the generated one or more audio streams to each of the one or more playback devices.

[0022] In yet another example, a computing device includes one or more processors and a non-transitory computer readable medium storing instructions that, when executed by the one or more processors, cause the computing device to perform functions. The functions include receiving data indicating a configuration of one or more playback devices. The one or more playback devices may include one or more transducers. The functions further include, based on the received data, associating each of one or more audio streams respectively with at least one transducer of the one or more transducers. The functions further include generating the one or more audio streams and sending at least one of the generated one or more audio streams to each of the one or more playback devices.

[0023] It will be understood by one of ordinary skill in the art that this disclosure includes numerous other embodiments. While some examples described herein may refer to functions performed by given actors such as "users" and/or other entities, it should be understood that this is for purposes of explanation only. The claims should not be interpreted to require action by any such example actor unless explicitly required by the language of the claims themselves.

II. Example Operating Environment

[0024] FIG. **1** shows an example configuration of a media playback system **100** in which one or more embodiments disclosed herein may be practiced or implemented. The media playback system **100** as shown is associated with an example home environment having several rooms and spaces, such as for example, a master bedroom, an office, a dining room, and a living room. As shown in the example of FIG. **1**, the media playback system **100** includes playback devices **102**, **104**, **106**, **108**, **110**, **112**, **114**, **116**, **118**, **120**, **122**, and **124**, control devices **126** and **128**, and a wired or wireless network router **130**.

[0025] Further discussions relating to the different components of the example media playback system **100** and how the different components may interact to provide a user with a media experience may be found in the following sections. While discussions herein may generally refer to the example media playback system **100**, technologies described herein are not limited to applications within, among other things, the home environment as shown in FIG. **1**. For instance, the technologies described herein may be useful in environments where multi-zone audio may be

desired, such as, for example, a commercial setting like a restaurant, mall or airport, a vehicle like a sports utility vehicle (SUV), bus or car, a ship or boat, an airplane, and so on.

a. Example Playback Devices

[0026] FIG. **2** shows a functional block diagram of an example playback device **200** that may be configured to be one or more of the playback devices **102-124** of the media playback system **100** of FIG. **1**. The playback device **200** may include a processor **202**, software components **204**, memory **206**, audio processing components **208**, audio amplifier(s) **210**, speaker(s) **212**, and a network interface **214** including wireless interface(s) **216** and wired interface(s) **218**. In one case, the playback device **200** might not include the speaker(s) **212**, but rather a speaker interface for connecting the playback device **200** to external speakers. In another case, the playback device **200** may include neither the speaker(s) **212** nor the audio amplifier(s) **210**, but rather an audio interface for connecting the playback device **200** to an external audio amplifier or audio-visual receiver.

[0027] In one example, the processor **202** may be a clock-driven computing component configured to process input data according to instructions stored in the memory **206**. The memory **206** may be a tangible computer readable medium configured to store instructions executable by the processor **202**. For instance, the memory **206** may be data storage that can be loaded with one or more of the software components **204** executable by the processor **202** to achieve certain functions. In one example, the functions may involve the playback device **200** retrieving audio data from an audio source or another playback device. In another example, the functions may involve the playback device **200** sending audio data to another device or playback device on a network. In yet another example, the functions may involve pairing of the playback device **200** with one or more playback devices to create a multi-channel audio environment.

[0028] Certain functions may involve the playback device **200** synchronizing playback of audio content with one or more other playback devices. During synchronous playback, a listener will preferably not be able to perceive time-delay differences between playback of the audio content by the playback device **200** and the one or more other playback devices. U.S. Pat. No. 8,234,395 entitled, "System and method for synchronizing operations among a plurality of independently clocked digital data processing devices," which is hereby incorporated by reference, provides in more detail some examples for audio playback synchronization among playback devices.

[0029] The memory **206** may further be configured to store data associated with the playback device **200**, such as one or more zones and/or zone groups the playback device **200** is a part of, audio sources accessible by the playback device **200**, or a playback queue that the playback device **200** (or some other playback device) may be associated with. The data may be stored as one or more state variables that are periodically updated and used to describe the state of the playback device **200**. The memory **206** may also include the data associated with the state of the other devices of the media system, and shared from time to time among the devices so that one or more of the devices have the most recent data associated with the system. Other embodiments are also possible.

[0030] The audio processing components **208** may include one or more digital-to-analog converters (DAC), an audio preprocessing component, an audio enhancement component or a digital signal processor (DSP), and so on. In one embodiment, one or more of the audio processing components **208** may be a subcomponent of the processor **202**. In one example, audio content may be processed and/or intentionally altered by the audio processing components **208** to produce audio signals. The produced audio signals may then be provided to the audio amplifier(s) **210** for amplification and playback through speaker(s) **212**. Particularly, the audio amplifier(s) **210** may include devices configured to amplify audio signals to a level for driving one or more of the speakers **212**. The speaker(s) **212** may include an individual transducer (e.g., a "driver") or a complete speaker system involving an enclosure with one or more drivers. A particular driver of the speaker(s) **212** may include, for example, a subwoofer (e.g., for low frequencies), a mid-range driver (e.g., for middle frequencies), and/or a tweeter (e.g., for high frequencies). In some cases, each transducer in the one

or more speakers **212** may be driven by an individual corresponding audio amplifier of the audio amplifier(s) **210**. In addition to producing analog signals for playback by the playback device **200**, the audio processing components **208** may be configured to process audio content to be sent to one or more other playback devices for playback.

[0031] Audio content to be processed and/or played back by the playback device **200** may be received from an external source, such as via an audio line-in input connection (e.g., an auto-detecting 3.5 mm audio line-in connection) or the network interface **214**.

[0032] The microphone(s) **220** may include an audio sensor configured to convert detected sounds into electrical signals. The electrical signal may be processed by the audio processing components **208** and/or the processor **202**. The microphone(s) **220** may be positioned in one or more orientations at one or more locations on the playback device **200**. The microphone(s) **220** may be configured to detect sound within one or more frequency ranges. In one case, one or more of the microphone(s) **220** may be configured to detect sound within a frequency range of audio that the playback device **200** is capable or rendering. In another case, one or more of the microphone(s) **220** may be configured to detect sound within a frequency range audible to humans. Other examples are also possible.

[0033] The network interface **214** may be configured to facilitate a data flow between the playback device **200** and one or more other devices on a data network. As such, the playback device **200** may be configured to receive audio content over the data network from one or more other playback devices in communication with the playback device **200**, network devices within a local area network, or audio content sources over a wide area network such as the Internet. In one example, the audio content and other signals transmitted and received by the playback device **200** may be transmitted in the form of digital packet data containing an Internet Protocol (IP)-based source address and IP-based destination addresses. In such a case, the network interface **214** may be configured to parse the digital packet data such that the data destined for the playback device **200** is properly received and processed by the playback device **200**.

[0034] As shown, the network interface **214** may include wireless interface(s) **216** and wired interface(s) **218**. The wireless interface(s) **216** may provide network interface functions for the playback device **200** to wirelessly communicate with other devices (e.g., other playback device(s), speaker(s), receiver(s), network device(s), control device(s) within a data network the playback device **200** is associated with) in accordance with a communication protocol (e.g., any wireless standard including IEEE 802.11a, 802.11b, 802.11g, 802.11n, 802.11ac, 802.15, 4G mobile communication standard, and so on). The wired interface(s) **218** may provide network interface functions for the playback device **200** to communicate over a wired connection with other devices in accordance with a communication protocol (e.g., IEEE 802.3). While the network interface **214** shown in FIG. **2** includes both wireless interface(s) **216** and wired interface(s) **218**, the network interface **214** may in some embodiments include only wireless interface(s) or only wired interface(s).

[0035] In one example, the playback device **200** and one other playback device may be paired to play two separate audio components of audio content. For instance, playback device **200** may be configured to play a left channel audio component, while the other playback device may be configured to play a right channel audio component, thereby producing or enhancing a stereo effect of the audio content. The paired playback devices (also referred to as "bonded playback devices") may further play audio content in synchrony with other playback devices.

[0036] In another example, the playback device **200** may be sonically consolidated with one or more other playback devices to form a single, consolidated playback device. A consolidated playback device may be configured to process and reproduce sound differently than an unconsolidated playback device or playback devices that are paired, because a consolidated playback device may have additional speaker drivers through which audio content may be rendered. For instance, if the playback device **200** is a playback device designed to render low

frequency range audio content (i.e. a subwoofer), the playback device **200** may be consolidated with a playback device designed to render full frequency range audio content. In such a case, the full frequency range playback device, when consolidated with the low frequency playback device **200**, may be configured to render only the mid and high frequency components of audio content, while the low frequency range playback device **200** renders the low frequency component of the audio content. The consolidated playback device may further be paired with a single playback device or yet another consolidated playback device.

[0037] By way of illustration, SONOS, Inc. presently offers (or has offered) for sale certain playback devices including a "PLAY:1," "PLAY:3," "PLAY:5," "PLAYBAR," "CONNECT:AMP," "CONNECT," and "SUB." Any other past, present, and/or future playback devices may additionally or alternatively be used to implement the playback devices of example embodiments disclosed herein. Additionally, it is understood that a playback device is not limited to the example illustrated in FIG. **2** or to the SONOS product offerings. For example, a playback device may include a wired or wireless headphone. In another example, a playback device may include or interact with a docking station for personal mobile media playback devices. In yet another example, a playback device may be integral to another device or component such as a television, a lighting fixture, or some other device for indoor or outdoor use.

b. Example Playback Zone Configurations

[0038] Referring back to the media playback system **100** of FIG. **1**, the environment may have one or more playback zones, each with one or more playback devices. The media playback system **100** may be established with one or more playback zones, after which one or more zones may be added, or removed to arrive at the example configuration shown in FIG. **1**. Each zone may be given a name according to a different room or space such as an office, bathroom, master bedroom, bedroom, kitchen, dining room, living room, and/or balcony. In one case, a single playback zone may include multiple rooms or spaces. In another case, a single room or space may include multiple playback zones.

[0039] As shown in FIG. **1**, the balcony, dining room, kitchen, bathroom, office, and bedroom zones each have one playback device, while the living room and master bedroom zones each have multiple playback devices. In the living room zone, playback devices **104**, **106**, **108**, and **110** may be configured to play audio content in synchrony as individual playback devices, as one or more bonded playback devices, as one or more consolidated playback devices, or any combination thereof. Similarly, in the case of the master bedroom, playback devices **122** and **124** may be configured to play audio content in synchrony as individual playback devices, as a bonded playback device, or as a consolidated playback device.

[0040] In one example, one or more playback zones in the environment of FIG. **1** may each be playing different audio content. For instance, the user may be grilling in the balcony zone and listening to hip hop music being played by the playback device **102** while another user may be preparing food in the kitchen zone and listening to classical music being played by the playback device **114**. In another example, a playback zone may play the same audio content in synchrony with another playback zone. For instance, the user may be in the office zone where the playback device **118** is playing the same rock music that is being played by playback device **102** in the balcony zone. In such a case, playback devices **102** and **118** may be playing the rock music in synchrony such that the user may seamlessly (or at least substantially seamlessly) enjoy the audio content that is being played out-loud while moving between different playback zones. Synchronization among playback zones may be achieved in a manner similar to that of synchronization among playback devices, as described in previously referenced U.S. Pat. No. 8,234,395.

[0041] As suggested above, the zone configurations of the media playback system **100** may be dynamically modified, and in some embodiments, the media playback system **100** supports numerous configurations. For instance, if a user physically moves one or more playback devices to

or from a zone, the media playback system **100** may be reconfigured to accommodate the change(s). For instance, if the user physically moves the playback device **102** from the balcony zone to the office zone, the office zone may now include both the playback device **118** and the playback device **102**. The playback device **102** may be paired or grouped with the office zone and/or renamed if so desired via a control device such as the control devices **126** and **128**. On the other hand, if the one or more playback devices are moved to a particular area in the home environment that is not already a playback zone, a new playback zone may be created for the particular area.

[0042] Further, different playback zones of the media playback system **100** may be dynamically combined into zone groups or split up into individual playback zones. For instance, the dining room zone and the kitchen zone **114** may be combined into a zone group for a dinner party such that playback devices **112** and **114** may render audio content in synchrony. On the other hand, the living room zone may be split into a television zone including playback device **104**, and a listening zone including playback devices **106**, **108**, and **110**, if the user wishes to listen to music in the living room space while another user wishes to watch television.

c. Example Control Devices

[0043] FIG. **3** shows a functional block diagram of an example control device **300** that may be configured to be one or both of the control devices **126** and **128** of the media playback system **100**. As shown, the control device **300** may include a processor **302**, memory **304**, a network interface **306**, and a user interface **308**. In one example, the control device **300** may be a dedicated controller for the media playback system **100**. In another example, the control device **300** may be a network device on which media playback system controller application software may be installed, such as for example, an iPhone™, iPad™ or any other smart phone, tablet or network device (e.g., a networked computer such as a PC or Mac™).

[0044] The processor **302** may be configured to perform functions relevant to facilitating user access, control, and configuration of the media playback system **100**. The memory **304** may be configured to store instructions executable by the processor **302** to perform those functions. The memory **304** may also be configured to store the media playback system controller application software and other data associated with the media playback system **100** and the user.

[0045] The microphone(s) **310** may include an audio sensor configured to convert detected sounds into electrical signals. The electrical signal may be processed by the processor **302**. In one case, if the control device **300** is a device that may also be used as a means for voice communication or voice recording, one or more of the microphone(s) **310** may be a microphone for facilitating those functions. For instance, the one or more of the microphone(s) **310** may be configured to detect sound within a frequency range that a human is capable of producing and/or a frequency range audible to humans. Other examples are also possible.

[0046] In one example, the network interface **306** may be based on an industry standard (e.g., infrared, radio, wired standards including IEEE 802.3, wireless standards including IEEE 802.11a, 802.11b, 802.11g, 802.11n, 802.11ac, 802.15, 4G mobile communication standard, and so on). The network interface **306** may provide a means for the control device **300** to communicate with other devices in the media playback system **100**. In one example, data and information (e.g., such as a state variable) may be communicated between control device **300** and other devices via the network interface **306**. For instance, playback zone and zone group configurations in the media playback system **100** may be received by the control device **300** from a playback device or another network device, or transmitted by the control device **300** to another playback device or network device via the network interface **306**. In some cases, the other network device may be another control device.

[0047] Playback device control commands such as volume control and audio playback control may also be communicated from the control device **300** to a playback device via the network interface **306**. As suggested above, changes to configurations of the media playback system **100** may also be performed by a user using the control device **300**. The configuration changes may include

adding/removing one or more playback devices to/from a zone, adding/removing one or more zones to/from a zone group, forming a bonded or consolidated player, separating one or more playback devices from a bonded or consolidated player, among others. Accordingly, the control device **300** may sometimes be referred to as a controller, whether the control device **300** is a dedicated controller or a network device on which media playback system controller application software is installed.

[0048] The user interface **308** of the control device **300** may be configured to facilitate user access and control of the media playback system **100**, by providing a controller interface such as the controller interface **400** shown in FIG. **4**. The controller interface **400** includes a playback control region **410**, a playback zone region **420**, a playback status region **430**, a playback queue region **440**, and an audio content sources region **450**. The user interface **400** as shown is just one example of a user interface that may be provided on a network device such as the control device **300** of FIG. **3** (and/or the control devices **126** and **128** of FIG. **1**) and accessed by users to control a media playback system such as the media playback system **100**. Other user interfaces of varying formats, styles, and interactive sequences may alternatively be implemented on one or more network devices to provide comparable control access to a media playback system.

[0049] The playback control region **410** may include selectable (e.g., by way of touch or by using a cursor) icons to cause playback devices in a selected playback zone or zone group to play or pause, fast forward, rewind, skip to next, skip to previous, enter/exit shuffle mode, enter/exit repeat mode, enter/exit cross fade mode. The playback control region **410** may also include selectable icons to modify equalization settings, and playback volume, among other possibilities.

[0050] The playback zone region **420** may include representations of playback zones within the media playback system **100**. In some embodiments, the graphical representations of playback zones may be selectable to bring up additional selectable icons to manage or configure the playback zones in the media playback system, such as a creation of bonded zones, creation of zone groups, separation of zone groups, and renaming of zone groups, among other possibilities.

[0051] For example, as shown, a "group" icon may be provided within each of the graphical representations of playback zones. The "group" icon provided within a graphical representation of a particular zone may be selectable to bring up options to select one or more other zones in the media playback system to be grouped with the particular zone. Once grouped, playback devices in the zones that have been grouped with the particular zone will be configured to play audio content in synchrony with the playback device(s) in the particular zone. Analogously, a "group" icon may be provided within a graphical representation of a zone group. In this case, the "group" icon may be selectable to bring up options to deselect one or more zones in the zone group to be removed from the zone group. Other interactions and implementations for grouping and ungrouping zones via a user interface such as the user interface **400** are also possible. The representations of playback zones in the playback zone region **420** may be dynamically updated as playback zone or zone group configurations are modified.

[0052] The playback status region **430** may include graphical representations of audio content that is presently being played, previously played, or scheduled to play next in the selected playback zone or zone group. The selected playback zone or zone group may be visually distinguished on the user interface, such as within the playback zone region **420** and/or the playback status region **430**. The graphical representations may include track title, artist name, album name, album year, track length, and other relevant information that may be useful for the user to know when controlling the media playback system via the user interface **400**.

[0053] The playback queue region **440** may include graphical representations of audio content in a playback queue associated with the selected playback zone or zone group. In some embodiments, each playback zone or zone group may be associated with a playback queue containing information corresponding to zero or more audio items for playback by the playback zone or zone group. For instance, each audio item in the playback queue may comprise a uniform resource identifier (URI),

a uniform resource locator (URL) or some other identifier that may be used by a playback device in the playback zone or zone group to find and/or retrieve the audio item from a local audio content source or a networked audio content source, possibly for playback by the playback device.

[0054] In one example, a playlist may be added to a playback queue, in which case information corresponding to each audio item in the playlist may be added to the playback queue. In another example, audio items in a playback queue may be saved as a playlist. In a further example, a playback queue may be empty, or populated but "not in use" when the playback zone or zone group is playing continuously streaming audio content, such as Internet radio that may continue to play until otherwise stopped, rather than discrete audio items that have playback durations. In an alternative embodiment, a playback queue can include Internet radio and/or other streaming audio content items and be "in use" when the playback zone or zone group is playing those items. Other examples are also possible.

[0055] When playback zones or zone groups are "grouped" or "ungrouped," playback queues associated with the affected playback zones or zone groups may be cleared or re-associated. For example, if a first playback zone including a first playback queue is grouped with a second playback zone including a second playback queue, the established zone group may have an associated playback queue that is initially empty, that contains audio items from the first playback queue (such as if the second playback zone was added to the first playback zone), that contains audio items from the second playback queue (such as if the first playback zone was added to the second playback zone), or a combination of audio items from both the first and second playback queues. Subsequently, if the established zone group is ungrouped, the resulting first playback zone may be re-associated with the previous first playback queue, or be associated with a new playback queue that is empty or contains audio items from the playback queue associated with the established zone group before the established zone group was ungrouped. Similarly, the resulting second playback zone may be re-associated with the previous second playback queue, or be associated with a new playback queue that is empty, or contains audio items from the playback queue associated with the established zone group before the established zone group was ungrouped. Other examples are also possible.

[0056] Referring back to the user interface **400** of FIG. **4**, the graphical representations of audio content in the playback queue region **440** may include track titles, artist names, track lengths, and other relevant information associated with the audio content in the playback queue. In one example, graphical representations of audio content may be selectable to bring up additional selectable icons to manage and/or manipulate the playback queue and/or audio content represented in the playback queue. For instance, a represented audio content may be removed from the playback queue, moved to a different position within the playback queue, or selected to be played immediately, or after any currently playing audio content, among other possibilities. A playback queue associated with a playback zone or zone group may be stored in a memory on one or more playback devices in the playback zone or zone group, on a playback device that is not in the playback zone or zone group, and/or some other designated device.

[0057] The audio content sources region **450** may include graphical representations of selectable audio content sources from which audio content may be retrieved and played by the selected playback zone or zone group. Discussions pertaining to audio content sources may be found in the following section.

d. Example Audio Content Sources

[0058] As indicated previously, one or more playback devices in a zone or zone group may be configured to retrieve for playback audio content (e.g. according to a corresponding URI or URL for the audio content) from a variety of available audio content sources. In one example, audio content may be retrieved by a playback device directly from a corresponding audio content source (e.g., a line-in connection). In another example, audio content may be provided to a playback device over a network via one or more other playback devices or network devices.

[0059] Example audio content sources may include a memory of one or more playback devices in a media playback system such as the media playback system **100** of FIG. **1**, local music libraries on one or more network devices (such as a control device, a network-enabled personal computer, or a networked-attached storage (NAS), for example), streaming audio services providing audio content via the Internet (e.g., the cloud), or audio sources connected to the media playback system via a line-in input connection on a playback device or network devise, among other possibilities.

[0060] In some embodiments, audio content sources may be regularly added or removed from a media playback system such as the media playback system **100** of FIG. **1**. In one example, an indexing of audio items may be performed whenever one or more audio content sources are added, removed or updated. Indexing of audio items may involve scanning for identifiable audio items in all folders/directory shared over a network accessible by playback devices in the media playback system, and generating or updating an audio content database containing metadata (e.g., title, artist, album, track length, among others) and other associated information, such as a URI or URL for each identifiable audio item found. Other examples for managing and maintaining audio content sources may also be possible.

[0061] The above discussions relating to playback devices, controller devices, playback zone configurations, and media content sources provide only some examples of operating environments within which functions and methods described below may be implemented. Other operating environments and configurations of media playback systems, playback devices, and network devices not explicitly described herein may also be applicable and suitable for implementation of the functions and methods.

III. Example Methods and Systems Related to Centralized Audio Processing

[0062] As discussed above, some examples described herein include, among other things, a computing device using information about how one or more playback devices are configured to generate audio streams to be sent to various transducers of the one or more playback devices. Other aspects of the examples will be made apparent in the remainder of the description herein.

[0063] The method **500** shown in FIG. **5** presents an example method that can be implemented within an operating environment including, for example, one or more of the media playback system **100** of FIG. **1**, one or more of the playback device **200** of FIG. **2**, and one or more of the control device **300** of FIG. **3**. The method **500** may involve other devices as well. The method **500** may include one or more operations, functions, or actions as illustrated by one or more of blocks **502**, **504**, **506**, and **508**. Although the blocks are illustrated in sequential order, these blocks may also be performed in parallel, and/or in a different order than those described herein. Also, the various blocks may be combined into fewer blocks, divided into additional blocks, and/or removed based upon the desired implementation.

[0064] In addition, for the method **500** and other processes and methods disclosed herein, the flowcharts show functionality and operation of one possible implementation of present embodiments. In this regard, each block may represent a module, a segment, or a portion of program code, which includes one or more instructions executable by a processor for implementing specific logical functions or steps in the process. The program code may be stored on any type of computer readable medium, for example, such as a storage device including a disk(s) or hard drive(s). In some embodiments, the program code may be stored in memory (e.g., disks or disk arrays) associated with and/or connected to a server system that makes the program code available for download (e.g., an application store or other type of server system) to desktop/laptop computers, smart phones, tablet computers, or other types of computing devices. The computer readable medium may include non-transitory computer readable media, for example, such as computer readable media that stores data for short periods of time like register memory, processor cache, and Random Access Memory (RAM). The computer readable medium may also include non-transitory media, such as secondary or persistent long-term storage, like read-only memory (ROM), optical or magnetic disks, compact-disc read-only memory (CD-ROM), for example. The

computer readable media may also be any other volatile or non-volatile storage systems. The computer readable medium may be considered a computer readable storage medium, for example, or a tangible storage device. In addition, for the method **500** and other processes and methods disclosed herein, each block in FIG. **5** may represent circuitry that is wired to perform the specific logical functions in the process.

[0065] FIG. **6** depicts various devices that are related to the method **500**. The playback device **605** includes transducers **601**A, **602**A, **603**A, **601**B, **602**B, **603**B, **601**C, **602**C, and **603**C. The transducers **601**A-C and **603**A-C may be woofers and the transducers **602**A-C may be tweeters. The playback device **606** may include a subwoofer **604**. The playback device **607** may include woofers **601**D and **603**D, and a tweeter **602**D. The playback device **608** may include woofers **601**E and **603**E, and a tweeter **602**E. Other configurations of the playback devices **605-608** are possible.

[0066] The computing device **609** may be an instance of the playback device **200** or the control device **300**, however the computing device **609** may also include any general-purpose computing device or specific-purpose computing device that is configured to communicate with the playback devices **605-608** and/or the control device **623** via a wired or wireless connection. The computing device **609** may be a desktop or laptop computer, for example.

[0067] Herein, any reference to the computing device **609** may include any peripheral device connected to the computing device **609** via a wired or wireless connection. That is, any function described as performed by the computing device **609** herein may, in some examples, be performed in concert with, or independently by, a peripheral device connected to the computing device **609**.

[0068] The control device **623** may be an instance of the control device **300** that is configured to control the playback devices **605-608**.

[0069] Referring to FIG. **5**, at block **502** the method **500** includes receiving data indicating a configuration of one or more playback devices. For instance, the computing device **609** may receive data **621** indicating a configuration of the playback devices **605-608**.

[0070] The data **621** may be received via a user-interface (e.g., keyboard, keypad, and/or mouse) of the computing device **609**, from any of the playback devices **605-608**, from the control device **623**, or from a server (not shown), among other possibilities. In some cases, the computing device **609** may, from time to time, receive new data reflecting changes to user-selected frequency equalization settings of the playback devices **605-608** and/or changes within the environment of the playback devices **605-608** detected by one or more of the playback devices **605-608**.

[0071] At block **504**, the method **500** includes, based on the received data, associating each of one or more audio streams respectively with at least one transducer of the one or more playback devices. For instance, the computing device **609** may associate the audio streams depicted in FIG. **6** with the transducers of the playback devices **605-608** as shown in Table 1. In the example below, the audio streams may be generated by processing and/or mixing four-channel audio content (e.g., 3.1 surround sound) retrieved by the computing device **609**. However, other forms of audio content may be used to generate the audio streams as well.

TABLE-US-00001 TABLE 1

Channel of Content	Generated Audio Stream	Associated Transducer(s)
1	611A	601A, 603A
1	612A	602A
2	611B	601B, 603B
2	612B	602B
3	611C	601C, 603C
3	612C	602C
1/2	611D	601D, 603D
1/2	612D	602D
2/3	611E	601E, 603E
2/3	612E	602E
4	617	604

[0072] Table 1 indicates that the computing device **609** may use a first channel (e.g., left) of the audio content to generate the audio streams **611**A and **612**A, a second channel (e.g., center) of the audio content to generate the audio streams **611**B and **612**B, and a third channel (e.g., right) of the audio content to generate the audio streams **611**C and **612**C. Table 1 further indicates that the computing device **609** may mix the first channel and the second channel to generate the audio streams **611**D and **612**D. Table 1 further indicates that the computing device **609** may mix the second channel and the third channel to generate the audio streams **611**E and **612**E. Table 1 further indicates that the computing device may use a fourth channel of the audio content to generate the

audio stream **617**.

[0073] In some examples, the data **621** may include the associations between channels of audio content, audio streams, and transducers as shown in Table 1. The data **621** may also include sets of one or more parameters of audio processing algorithms that correspond respectively to the audio streams **611**A, **612**A, **611**B, **612**B, **611**C, **612**C, **611**D, **612**D, **611**E, **612**E, and **617**. In this context, the data **621** may also map the audio processing algorithms to the respective transducers of the playback devices **605-608**. For example, the data **621** may map parameters of a particular audio processing algorithm to the transducers **601**A and **603**A, and the computing device **609** may analyze the data **621** and responsively generate the audio stream **611**A by using the particular audio processing algorithm to process the audio content. The computing device **609** may send the generated audio stream **611**A to the playback device **605** to be routed to the transducers **601**A and **603**A by the playback device **605**.

[0074] In other examples, the computing device **609** may associate the audio streams with the transducers without receiving explicit information regarding the associations. For instance, the data **621** may include information such as model designation or specifications of the respective playback devices **605-608**. In addition, the data **621** may include information regarding how many transducers and which type of transducers (e.g., tweeter, woofer, subwoofer) the respective playback devices **605-608** include. The data **621** may further include frequency response, phase response, and/or volume limits for each of the transducers of the playback devices **605-608**. Further, the data **621** may include information regarding the locations of the respective playback devices **605-608** within an environment (e.g., a room), or information characterizing the environment. The computing device **609** may use this information to determine a quantity of audio streams to be generated and to associate the audio streams with the transducers as shown in Table 1, for example.

[0075] For instance, the data **621** may indicate that the playback device **605** (e.g., a "soundbar") is located near a front end of a room and that the playback device **605** is configurable to play three channels of audio content via respective sets of transducers **601**A-**603**A, **601**B-**603**B, and **601**C-**603**C. The data **621** may also indicate that transducers **601**A-C and **603**A-C are woofers configured to play mid-range audio frequencies (e.g., 120 Hz-2 kHz). The data **621** may also indicate that the transducers **602**A-C are tweeters configured to play high-range frequencies (e.g., 2 kHz-20 kHz). The data **621** may indicate any information about the playback device **605** implicitly or explicitly. For instance, the computing device **609** might infer the quantity and type transducers included in the playback device **605** based on the model designation of the playback device **605** represented by the data **621**.

[0076] By further example, the data **621** may indicate that the transducer **604** of the playback device **606** is configured to play low-range frequencies (e.g., <120 Hz). The data **621** may indicate any information about the playback device **606** implicitly or explicitly.

[0077] In addition, the data **621** may indicate that the playback device **607** is located near a rear left portion of the room and that the playback device **607** is configured to play one or two channels of audio content via the transducers **601**D-**603**D. The data **621** may also indicate that transducers **601**D and **603**D are woofers configured to play mid-range audio frequencies (e.g., 120 Hz-2 kHz). The data **621** may also indicate that the transducer **602**D is a tweeter configured to play high-range frequencies (e.g., 2 kHz-20 kHz). The data **621** may indicate any information about the playback device **607** implicitly or explicitly.

[0078] In addition, the data **621** may indicate that the playback device **608** is located near a rear right portion of the room and that the playback device **608** is configured to play one or two channels of audio content via the transducers **601**E-**603**E. The data **621** may also indicate that transducers **601**E and **603**E are woofers configured to play mid-range audio frequencies (e.g., 120 Hz-2 kHz). The data **621** may also indicate that the transducer **602**E is a tweeter configured to play high-range frequencies (e.g., 2 kHz-20 kHz). The data **621** may indicate any information about the

playback device **608** implicitly or explicitly.

[0079] In some examples, the computing device **609** may, based on the data **621**, determine a quantity of audio streams to be generated by the computing device **609**. For instance, the data **621** may indicate the quantity and types of transducers included in each of the playback devices **605-608**. As described below, the computing device **609** may determine that four-channel audio content (e.g., **3.1** channel surround) is to be played by the playback devices **605-608** in the form of eleven audio streams **611**A, **612**A, **611**B, **612**B, **611**C, **612**C, **611**D, **612**D, **611**E, **612**E, and **617**.

[0080] The computing device **609** may associate the audio streams with the transducers as shown in Table 1 based on the data **621** characterizing the playback devices **605-608** as described above. For example, the computing device **609** may recognize that, based on the configuration of the playback devices **605-608**, the first channel of audio content may be provided to the transducers **601**A-**603**A (e.g., because the transducers **601**A-**603**A may be located at the front left portion of the room and the first channel may be a left channel). Furthermore, the computing device **609** may recognize that the first channel of the audio content may be processed using low pass filtering and/or high pass filtering and provided to the transducers **601**A and **603**A as the audio stream **611**A (e.g., because the transducers **601**A and **603**A may be mid-range woofers). Additionally, the computing device **609** may recognize that the first channel of the audio content may be processed using high pass filtering and provided to the transducer **602**A as the audio stream **612**A (e.g., because the transducer **602**A may be a high-range tweeter.)

[0081] By further example, the computing device **609** may recognize that, based on the configuration of the playback devices **605-608**, the second channel of audio content may be provided to the transducers **601**B-**603**B (e.g., because the transducers **601**B-**603**B may be located at the front center portion of the room and the second channel may be a center channel). Furthermore, the computing device **609** may recognize that the second channel of the audio content may be processed using low pass filtering and/or high pass filtering and provided to the transducers **601**B and **603**B as the audio stream **611**B (e.g., because the transducers **601**B and **603**B may be mid-range woofers). Additionally, the computing device **609** may recognize that the second channel of the audio content may be processed using high pass filtering and provided to the transducer **602**B as the audio stream **612**B (e.g., because the transducer **602**B may be a high-range tweeter.)

[0082] In addition, the computing device **609** may recognize that, based on the configuration of the playback devices **605-608**, the third channel of audio content may be provided to the transducers **601**C-**603**C (e.g., because the transducers **601**C-**603**C may be located at the front right portion of the room and the third channel may be a right channel). Furthermore, the computing device **609** may recognize that the third channel of the audio content may be processed using low pass filtering and/or high pass filtering and provided to the transducers **601**C and **603**C as the audio stream **611**C (e.g., because the transducers **601**C and **603**C may be mid-range woofers). Additionally, the computing device **609** may recognize that the third channel of the audio content may be processed using high pass filtering and provided to the transducer **602**C as the audio stream **612**C (e.g., because the transducer **602**C may be a high-range tweeter.)

[0083] Also, the computing device **609** may recognize that, based on the configuration of the playback devices **605-608**, the first and second channels of audio content may be mixed and provided to the transducers **601**D-**603**D (e.g., because the transducers **601**D-**603**D may be located at the rear left portion of the room and there might not be a playback device corresponding to the rear center of the room). Furthermore, the computing device **609** may recognize that the first and second channels of the audio content may be mixed and processed using low pass filtering and/or high pass filtering and provided to the transducers **601**D and **603**D as the audio stream **611**D (e.g., because the transducers **601**D and **603**D may be mid-range woofers). Additionally, the computing device **609** may recognize that the first and second channels of the audio content may be mixed and processed using high pass filtering and provided to the transducer **602**D as the audio stream **612**D (e.g., because the transducer **602**D may be a high-range tweeter.)

[0084] Additionally, the computing device **609** may recognize that, based on the configuration of the playback devices **605-608**, the second and third channels of audio content may be mixed and provided to the transducers **601**E-**603**E (e.g., because the transducers **601**E-**603**E may be located at the rear right portion of the room and there might not be a playback device corresponding to the rear center of the room). Furthermore, the computing device **609** may recognize that the second and third channels of the audio content may be mixed and processed using low pass filtering and/or high pass filtering and provided to the transducers **601**E and **603**E as the audio stream **611**E (e.g., because the transducers **601**E and **603**E may be mid-range woofers). Additionally, the computing device **609** may recognize that the second and third channels of the audio content may be mixed and processed using high pass filtering and provided to the transducer **602**E as the audio stream **612**E (e.g., because the transducer **602**E may be a high-range tweeter.)

[0085] Lastly, the computing device **609** may recognize that, based on the configuration of the playback devices **605-608**, the fourth channel of audio content may be provided to the transducer **604** (e.g., because the transducer **604** is a subwoofer and the fourth channel might not correspond to a particular location of a room). Furthermore, the computing device **609** may recognize that the fourth channel of the audio content may be processed using low pass filtering and provided to the transducer **604** as the audio stream **617**.

[0086] In some cases, there may be a one-to-one relationship between the audio streams and the transducers of the playback devices **605-608**, but in other cases, the same audio stream may be provided to multiple transducers of the playback devices **605-608**. By further example, the same audio stream may be provided to multiple transducers of the same playback device. Additionally, there may be a one-to-one relationship between channels of audio content retrieved by the computing device **609** and the audio streams, or the computing device **609** might generate more or less audio streams than there are channels of the retrieved audio content. Generation of audio streams by the computing device **609** is described in more detail below with regard to block **506**.

[0087] At block **506**, the method **500** includes, based on the data, generating the one or more audio streams. For example, the computing device **609** may, based on the data **621**, generate the audio streams **611**A, **612**A, **611**B, **612**B, **611**C, **612**C, **611**D, **612**D, **611**E, **612**E, and **617**. In some examples in which the computing device **609** is a playback device, the computing device **609** may generate its own audio stream(s) for playback by its own transducers.

[0088] In some examples, the computing device **609** may receive, from any of the playback devices **605-608** or the control device **623**, a command to generate the audio streams. For instance, any of the playback devices **605-608** or the control device **623** may receive input via a user-interface and responsively send the command to generate the audio streams to the computing device **609**. In this context, the computing device **609** may generate the audio streams in response to receiving the command.

[0089] By further example, the computing device **609** may retrieve digital audio content from memory accessible by the computing device **609** or from another computing device such as a server. The command to generate the audio streams received by the computing device **609** may include a uniform resource locator (URL), a uniform resource indicator (URI), or some other indication of a network location from which the digital audio content is available. The URL or URI may be received by the computing device **609** from another device as well. In this context, the computing device **609** may use the retrieved digital audio content to generate the one or more audio streams.

[0090] In another example, the computing device **609** may receive analog audio content via an input port (e.g., line-in port) of the computing device **609** and convert the analog audio content to digital audio content using an analog-to-digital converter. The command received by the computing device **609** may specify that the computing device **609** is to generate audio streams using the analog audio content received by the input port. In this context, the computing device **609** may use the converted digital audio content to generate the one or more audio streams.

[0091] In one example, the computing device **609** determines (e.g., calculates), based on the data **621**, parameters of audio processing algorithms that correspond respectively to one or more of the transducers of the playback devices **605-608**. The computing device **609** may then use the audio processing algorithms to generate audio streams that correspond respectively to one or more of the transducers. In another example, the computing device **609** instead receives (i.e., does not determine) parameters of the audio processing algorithms that correspond respectively to one or more of the transducers of the playback devices **605-608**. In this case, the computing device **609** may use the received parameters to generate the audio streams.

[0092] Whether the computing device **609** receives or determines parameters of the audio processing algorithms, the computing device **609** may process, for each of the one or more audio streams, audio content according to the respective audio processing algorithms. As an example, the computing device **609** may first translate the retrieved audio content from one file format to another (e.g., mp3 to pulse code modulation (PCM) format). In some examples, the computing device **609** may "downconvert" a sample rate of the retrieved audio content, for example, from 96 kHz to 44.1 kHz. The computing device **609** may also downconvert the bit depth of the retrieved audio content. Generally, the computing device **609** may perform file format conversion, sample rate conversion, and bit depth conversion prior to performing transducer-specific audio processing, but other examples are possible.

[0093] Next, the computing device **609** may perform one or more of the following to the audio content in order to generate each of the audio streams: frequency-dependent amplification, frequency-dependent attenuation (e.g., low-pass or high-pass filtering), volume limiting, phase delay, mixing one or more channels of the retrieved audio content, or adding a reverberation effect.

[0094] For instance, for a given audio stream, the computing device **609** might boost low-end frequencies and/or attenuate high-end frequencies. The computing device **609** might "clip" the retrieved audio content such that no portion of the given audio stream exceeds a given level of volume. Further, the computing device **609** might add a delay effect to a particular frequency range with respect to another frequency range of the audio content. Any or all of these processes, if applicable, might be applied by the computing device **609** uniquely for each of the audio streams generated by the computing device **609**. Any of the above processes may be related to user-selected equalization settings and/or compensating an otherwise undesirable response that would be heard by a listener due to particularities of the environment and/or positioning of the playback devices **605-608**.

[0095] By further example, the computing device **609** may again perform file format conversion upon the audio streams (e.g., PCM to mp3), before the audio streams are sent to the playback devices **605-608**.

[0096] At block **508**, the method **500** includes sending at least one of the generated one or more audio streams to each of the one or more playback devices. For example, the computing device **609** may send the audio streams **611**A-E, **612**A-E, and **617** to the corresponding playback devices **605-608**.

[0097] In the example depicted in FIG. **6**, the computing device **609** may send the audio streams **611**A-C and **612**A-C directly to the playback device **605**, the audio stream **617** directly to the playback device **606**, the audio streams **611**D and **612**D directly to the playback device **607**, and the audio streams **611**E and **612**E to the playback device **608**. The audio streams may include a universally unique identifier (UUID) of an application that generates the audio streams so that the playback devices may verify that the audio streams are indeed the audio streams and not some other unrelated data.

[0098] In various examples, the computing device **609** may "unicast" or "multicast" the audio streams to the playback devices **605-608**. In the "unicast" example, the computing device **609** may send, with the audio stream **611**A, a network address of the playback device **605**. Accordingly, if the playback device **606** were to receive the audio stream **611**A, the playback device **606** may

forward the audio stream **611**A to the playback device **605** based on the network address.

[0099] In a "multicast" example, each of the playback devices **605-608** might receive all of the audio streams sent by the computing device **609**, but the audio streams might each include an indication of which playback devices are to play that particular audio stream. In this way, each playback device may use the indications included in each audio stream to parse the audio streams and play the audio streams that are intended for that particular playback device.

[0100] In another example, any or all of the audio streams may be sent to corresponding playback devices using one of the playback devices **605-608** (e.g., a group coordinator device) or the control device **632** as an intermediary. For instance, the computing device **609** may send the audio streams **611**A-**611**E, **612**A-**612**E, and **617** to the playback device **607**, and the playback device **607** may send the audio streams **611**A-**611**C and **612**A-**612**C to the playback device **605**, send the audio stream **617** to the playback device **606**, send the audio streams **611**E and **612**E to the playback device **608**, and play the audio streams **611**D and **612**D.

[0101] In addition, the computing device **609** may send timing data to one or more of the playback devices **605-608** so that one or more of the playback devices **605-608** may play the audio streams in synchrony. Furthermore, the timing data may allow the playback devices **605-608** to play audio content in synchrony with video content played by a video playback device (not shown).

[0102] The computing device **609** may also send, to the playback devices **605-608**, data mapping the audio streams **611**A-**611**E, **612**A-**612**E, and **617** to one or more respective transducers of the playback devices **605-608**. For instance, along with the audio streams **611**A and **612**A, the computing device **609** may send, to the playback device **605**, information indicating that the audio stream **611**A is to be played by the transducers **601**A and **603**A and information indicating that the audio stream **612**A is to be played by the transducer **602**A.

[0103] In some examples, the computing device **609** may process audio for the playback devices **605-608** after the playback devices **605-608** are reconfigured. Also, the computing device **609** may process audio for other playback devices in addition to or instead of the playback devices **605-608**. For example, the playback devices **605-608** may be reconfigured so that all of the woofers **601**A-E and **603**A-E receive identical (e.g., monaural) mid-range audio streams and all of the tweeters **602**A-E receive identical (e.g., monaural) high-range audio streams. As such, the computing device **609** may receive new data reflecting changes to the configuration of the playback devices **605-608** and/or reflecting the configuration of additional playback devices.

[0104] Referring to FIG. **7** for example, the computing device **609** may receive the data **721** in any manner in which the data **621** is received as described above. The data **721** may indicate that the playback devices **605** and **606** (not shown in FIG. **7**) have been removed from the room or are otherwise no longer associated with the playback devices **607** and **608** in a common playback group. In another example, the playback devices **607** and **608** as shown in FIG. **7** may represent additional playback devices that are not shown in FIG. **6**.

[0105] The computing device **609** may, based on the received data **721**, associate audio streams **711**D, **712**D, **711**E, and **712**E respectively with at least one transducer of the transducers **601**D, **602**D, **603**D, **601**E, **602**E, or **603**E. More specifically, the computing device **609** may associate audio streams with transducers as shown below in Table 2.

TABLE-US-00002 TABLE 2 Channel Generated of Audio Audio Associated Content Stream Transducer(s) 1/2/4 711D 601D, 603D 1/2   712D 602D 2/3/4 711E 601E, 603E 2/3   712E 602E

[0106] In the example depicted in Table 2, the audio content may be four-channel audio content (e.g., 3.1 surround sound) retrieved by the computing device **609**. For example, the audio content might include a first (e.g., left) channel, a second (e.g., center) channel, a third (e.g., right) channel, and a fourth (e.g., subwoofer) channel. However, based on the data **721** indicating that only the playback devices **607** and **608** might be available for playing audio content, the computing device **609** may determine that the audio stream **711**D may be generated by mixing the first, second, and fourth channels. The computing device **609** may generate the audio stream **711**D and provide the

audio stream **711**D to the playback device **607**, which may provide the audio stream **711**D to the transducers **601**D and **603**D. The computing device **609** may also, as shown by Table 2, generate the audio stream **712**D by mixing the first and second channels, and provide the audio stream **712**D to the playback device **607** so that the playback device **607** may provide the audio stream **712**D to the transducer **602**D. The computing device **609** may also generate the audio stream **711**E by mixing the second, third, and fourth channels, and provide the audio stream **711**E to the playback device **608** so that the playback device **608** may provide the audio stream **711**E to the transducers **601**E and **603**E. The computing device **609** may also generate the audio stream **712**E by mixing the second and third channels, and provide the audio stream **712**E to the playback device **608** so that the playback device **608** may provide the audio stream **712**E to the transducer **602**E.

Iv. Conclusion

[0107] The description above discloses, among other things, various example systems, methods, apparatus, and articles of manufacture including, among other components, firmware and/or software executed on hardware. It is understood that such examples are merely illustrative and should not be considered as limiting. For example, it is contemplated that any or all of the firmware, hardware, and/or software aspects or components can be embodied exclusively in hardware, exclusively in software, exclusively in firmware, or in any combination of hardware, software, and/or firmware. Accordingly, the examples provided are not the only way(s) to implement such systems, methods, apparatus, and/or articles of manufacture.

[0108] Additionally, references herein to "embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment can be included in at least one example embodiment of an invention. The appearances of this phrase in various places in the specification are not necessarily all referring to the same embodiment, nor are separate or alternative embodiments mutually exclusive of other embodiments. As such, the embodiments described herein, explicitly and implicitly understood by one skilled in the art, can be combined with other embodiments.

[0109] The Specification is presented largely in terms of illustrative environments, systems, procedures, steps, logic blocks, processing, and other symbolic representations that directly or indirectly resemble the operations of data processing devices coupled to networks. These process descriptions and representations are typically used by those skilled in the art to most effectively convey the substance of their work to others skilled in the art. Numerous specific details are set forth to provide a thorough understanding of the present disclosure. However, it is understood to those skilled in the art that certain embodiments of the present disclosure can be practiced without certain, specific details. In other instances, well known methods, procedures, components, and circuitry have not been described in detail to avoid unnecessarily obscuring aspects of the embodiments. Accordingly, the scope of the present disclosure is defined by the appended claims rather than the forgoing description of embodiments.

[0110] When any of the appended claims are read to cover a purely software and/or firmware implementation, at least one of the elements in at least one example is hereby expressly defined to include a tangible, non-transitory medium such as a memory, DVD, CD, Blu-ray, and so on, storing the software and/or firmware.

Claims

1. At least one non-transitory computer-readable medium comprising program instructions that are executable by at least one processor such that a first playback device is configured to: receive, via a network interface of the first playback device comprising a first audio transducer, configuration data corresponding to a configuration of a second playback device, wherein the configuration data indicates a second audio transducer and a third audio transducer of the second playback device; determine, with respect to a first location corresponding to the first playback device, a second

location corresponding to the second playback device; receive audio content comprising first audio channels and second audio channels; assign the first audio channels based on (i) channel assignments of the first channels and (ii) respective positioning of the first location and the second location; map, based on (i) the configuration data, (ii) the first location, and (iii) the second location, parameters of an audio processing algorithm to the second audio transducer and the third audio transducer, wherein the program instructions that are executable by the at least one processor such that the first playback device is configured to map the parameters of the audio processing algorithm comprise program instructions that are executable by the at least one processor such that the first playback device is configured to: determine a mix of one or more of the second audio channels based on relative positioning of the first location and the second location; generate audio data based on the mapped parameters and the second audio channels, wherein the generated audio data comprises a first audio stream, a second audio stream, and a third audio stream; and cause, via the network interface, playback of the second audio stream and the third audio stream via the second playback device while the first playback device plays back the first audio stream, wherein the second playback device plays back the second audio stream via the second audio transducer and the third audio stream via the third audio transducer.

2. The at least one non-transitory computer-readable medium of claim 1, wherein the program instructions that are executable by the at least one processor such that the first playback device is configured to determine the mix of one or more of the second audio channels comprise program instructions that are executable by the at least one processor such that the first playback device is configured to: configure multiple second channels to be mixed into the second audio stream; and assign the second audio stream to the second audio transducer based on the second position.

3. The at least one non-transitory computer-readable medium of claim 1, wherein the program instructions that are executable by the at least one processor such that the first playback device is configured to determine the mix of one or more of the second audio channels comprise program instructions that are executable by the at least one processor such that the first playback device is configured to: configure generation of the second audio stream and the third audio stream from a particular second audio channel; and assign the second audio stream to the first audio transducer and the third audio stream to the second audio transducer.

4. The at least one non-transitory computer-readable medium of claim 1, wherein the program instructions that are executable by the at least one processor such that the first playback device is configured to map the parameters of the audio processing algorithm comprise program instructions that are executable by the at least one processor such that the first playback device is configured to: determine frequency-dependent filtering for the second audio channels based on the relative positioning of the first location and the second location.

5. The at least one non-transitory computer-readable medium of claim 1, wherein the program instructions that are executable by the at least one processor such that the first playback device is configured to map the parameters of the audio processing algorithm comprise program instructions that are executable by the at least one processor such that the first playback device is configured to: determine frequency-dependent filtering based on the relative positioning of the first location and the second location.

6. The at least one non-transitory computer-readable medium of claim 5, wherein the program instructions that are executable by the at least one processor such that the first playback device is configured to determine the frequency-dependent filtering based on the relative positioning of the first location and the second location comprise program instructions that are executable by the at least one processor such that the first playback device is configured to: apply high pass filtering for portions of the second audio channels.

7. The at least one non-transitory computer-readable medium of claim 1, wherein the program instructions that are executable by the at least one processor such that the first playback device is configured to map the parameters of the audio processing algorithm comprise program instructions

that are executable by the at least one processor such that the first playback device is configured to: configure the mix of one or more of the second audio channels based on a type of the second audio transducer and a type of the third audio transducer indicated by the configuration data, wherein the type of the second audio transducer is a tweeter and the type of the third audio transducer is a woofer.

8. The at least one non-transitory computer-readable medium of claim 1, wherein the program instructions that are executable by the at least one processor such that the first playback device is configured to map the parameters of the audio processing algorithm comprise program instructions that are executable by the at least one processor such that the first playback device is configured to: when the mix adapts based on the parameters, adjust the mapping to apply phase correction.

9. The at least one non-transitory computer-readable medium of claim 1, wherein the program instructions that are executable by the at least one processor such that the first playback device is configured to map the parameters of the audio processing algorithm comprise program instructions that are executable by the at least one processor such that the first playback device is configured to: configure volume limiting based on the parameters.

10. Circuitry for integration into a first playback device comprising a first audio transducer, the circuitry comprising: at least one circuit board; a communication integrated circuit (IC) attached to the at least one circuit board; at least one processor attached to the at least one circuit board; and at least one non-transitory computer-readable medium attached to the at least one circuit board, the at least one non-transitory computer-readable medium comprising program instructions that are executable by the at least one processor such that, when the circuitry is integrated into the first playback device, the first playback device is configured to: receive, via the communication IC, configuration data corresponding to a configuration of a second playback device, wherein the configuration data indicates a second audio transducer and a third audio transducer of the second playback device; determine, with respect to a first location corresponding to the first playback device, a second location corresponding to the second playback device; receive audio content comprising first audio channels and second audio channels; assign the first audio channels based on (i) channel assignments of the first channels and (ii) respective positioning of the first location and the second location; map, based on (i) the configuration data, (ii) the first location, and (iii) the second location, parameters of an audio processing algorithm to the second audio transducer and the third audio transducer, wherein the program instructions that are executable by the at least one processor such that the first playback device is configured to map the parameters of the audio processing algorithm comprise program instructions that are executable by the at least one processor such that the first playback device is configured to: determine a mix of one or more of the second audio channels based on relative positioning of the first location and the second location; generate audio data based on the mapped parameters and the second audio channels, wherein the generated audio data comprises a first audio stream, a second audio stream, and a third audio stream; and cause, via the communication IC, playback of the second audio stream and the third audio stream via the second playback device while the first playback device plays back the first audio stream, wherein the second playback device plays back the second audio stream via the second audio transducer and the third audio stream via the third audio transducer.

11. The circuitry of claim 10, wherein the program instructions that are executable by the at least one processor such that the first playback device is configured to determine the mix of one or more of the second audio channels comprise program instructions that are executable by the at least one processor such that the first playback device is configured to: configure multiple second channels to be mixed into the second audio stream; and assign the second audio stream to the second audio transducer based on the second position.

12. The circuitry of claim 10, wherein the program instructions that are executable by the at least one processor such that the first playback device is configured to determine the mix of one or more of the second audio channels comprise program instructions that are executable by the at least one

processor such that the first playback device is configured to: configure generation of the second audio stream and the third audio stream from a particular second audio channel; and assign the second audio stream to the first audio transducer and the third audio stream to the second audio transducer.

13. The circuitry of claim 10, wherein the program instructions that are executable by the at least one processor such that the first playback device is configured to map the parameters of the audio processing algorithm comprise program instructions that are executable by the at least one processor such that the first playback device is configured to: determine frequency-dependent filtering for the second audio channels based on the relative positioning of the first location and the second location.

14. The circuitry of claim 10, wherein the program instructions that are executable by the at least one processor such that the first playback device is configured to map the parameters of the audio processing algorithm comprise program instructions that are executable by the at least one processor such that the first playback device is configured to: determine frequency-dependent filtering based on the relative positioning of the first location and the second location.

15. The circuitry of claim 14, wherein the program instructions that are executable by the at least one processor such that the first playback device is configured to determine the frequency-dependent filtering based on the relative positioning of the first location and the second location comprise program instructions that are executable by the at least one processor such that the first playback device is configured to: apply high pass filtering for portions of the second audio channels.

16. The circuitry of claim 10, wherein the program instructions that are executable by the at least one processor such that the first playback device is configured to map the parameters of the audio processing algorithm comprise program instructions that are executable by the at least one processor such that the first playback device is configured to: configure the mix of one or more of the second audio channels based on a type of the second audio transducer and a type of the third audio transducer indicated by the configuration data, wherein the type of the second audio transducer is a tweeter and the type of the third audio transducer is a woofer.

17. The circuitry of claim 10, wherein the program instructions that are executable by the at least one processor such that the first playback device is configured to map the parameters of the audio processing algorithm comprise program instructions that are executable by the at least one processor such that the first playback device is configured to: when the mix adapts based on the parameters, adjust the mapping to apply phase correction.

18. The circuitry of claim 10, wherein the program instructions that are executable by the at least one processor such that the first playback device is configured to map the parameters of the audio processing algorithm comprise program instructions that are executable by the at least one processor such that the first playback device is configured to: configure volume limiting based on the parameters.

19. A method to be performed via a first playback device comprising a first audio transducer, the method comprising: receiving, via a network interface, configuration data corresponding to a configuration of a second playback device, wherein the configuration data indicates a second audio transducer and a third audio transducer of the second playback device; determining, with respect to a first location corresponding to the first playback device, a second location corresponding to the second playback device; receiving audio content comprising first audio channels and second audio channels; assigning the first audio channels based on (i) channel assignments of the first channels and (ii) respective positioning of the first location and the second location; mapping, based on (i) the configuration data, (ii) the first location, and (iii) the second location, parameters of an audio processing algorithm to the second audio transducer and the third audio transducer, wherein mapping the parameters of the audio processing algorithm comprises: determining a mix of one or more of the second audio channels based on relative positioning of the first location and the second

location; generating audio data based on the mapped parameters and the second audio channels, wherein the generated audio data comprises a first audio stream, a second audio stream, and a third audio stream; and causing, via the network interface, playback of the second audio stream and the third audio stream via the second playback device while the first playback device plays back the first audio stream, wherein the second playback device plays back the second audio stream via the second audio transducer and the third audio stream via the third audio transducer.

20. The method of claim 19, wherein determining the mix of one or more of the second audio channels comprises: configuring multiple second channels to be mixed into the second audio stream; and assigning the second audio stream to the second audio transducer based on the second position.

21. The method of claim 19, wherein determining the mix of one or more of the second audio channels comprises: configuring generation of the second audio stream and the third audio stream from a particular second audio channel; and assigning the second audio stream to the first audio transducer and the third audio stream to the second audio transducer.