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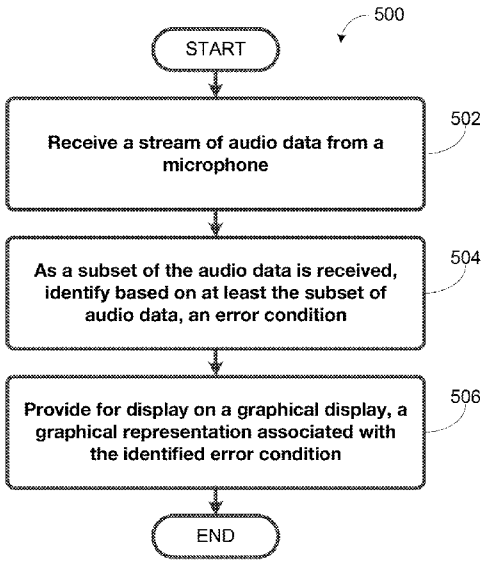

FIGURE 5

(57) Abstract: Examples described herein involve identifying one or more error conditions during calibration of one or more playback devices in a playback environment. A method for calibrating at least one playback device, may comprise receiving, via a microphone, a stream of audio data that includes an audio signal component and a background noise component. As a subset of the stream is received, the method may comprise identifying, based on at least the subset of the stream, an error condition and determining that calibration of the at least one playback device is to be suspended.

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CALIBRATION ERROR CONDITIONS

FIELD OF THE DISCLOSURE

[001] 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

[002] 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 a plethora of 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.

[003] 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.

BRIEF DESCRIPTION OF THE DRAWINGS

[004] 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:

[005] Figure 1 shows an example media playback system configuration in which certain embodiments may be practiced;

[006] Figure 2 shows a functional block diagram of an example playback device;

[007] Figure 3 shows a functional block diagram of an example control device;

[008] Figure 4 shows an example controller interface;

[009] Figure 5 shows a flow diagram of an example method for identifying error conditions;

[010] Figure 6 shows an illustrative playback device calibration user interface; and

[011] Figure 7 shows an illustrative playback device calibration error condition user interface.

[012] 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

[013] In an aspect of the present invention, a method for calibrating at least one playback device is provided. The method comprises receiving, via a microphone, a stream of audio data that includes (i) an audio signal component and (ii) a background noise component, as a subset of the stream is received; identifying, based on at least the subset of the stream, an error condition; and determining that calibration of the at least one playback device is to be suspended.

[014] Identifying the error condition may comprise identifying the error condition from among a plurality of pre-determined error conditions.

[015] Identifying error condition may comprise determining that a variation in a sound pressure level of the audio signal component is less a minimum threshold, and based on determining that the variation in the level of the audio signal component is less than the minimum threshold, identifying the error condition as a movement of a computing device that is less than a threshold speed.

[016] Identifying the error condition may comprise determining that a variation in a sound pressure level of the audio signal component exceeds a maximum threshold, and based on determining that the variation in the level of the audio signal component exceeds the maximum threshold, identifying the error condition as a movement of a computing device that exceeds a threshold speed.

[017] Identifying the error condition may comprise determining that a sound pressure level of the audio signal component has gradually decreased below a minimum threshold, and based on determining that the sound pressure level of the audio signal has gradually decreased below the minimum threshold, identifying the error condition as having exceeded a threshold movement distance.

[018] Identifying the error condition may comprise determining that a sound pressure level of the audio signal component has substantially decreased below a minimum threshold, and based on determining that the sound pressure level of the audio signal

component has substantially decreased below the minimum threshold, identifying the error condition as an improperly orientated computing device.

[019] Identifying the error condition may comprise determining that a sound pressure level of the background noise component exceeds a maximum threshold level, and based on determining that the sound pressure level of the background noise component exceeds the maximum threshold level, identifying the error condition as having background noise that exceeds a threshold level for calibration.

[020] Identifying the error condition may comprise determining that a ratio between the audio signal component and the background noise component is below a minimum threshold, and based on determining that the ratio between the audio signal component and the background noise component is below the minimum threshold, identifying the error condition as having a high background noise to audio signal ratio.

[021] Identifying the error condition may comprise determining that the audio signal component is substantially different from a reference audio signal, and based on determining that the audio signal component is substantially different from the reference audio signal, identifying the error condition as an obstructed microphone.

[022] Identifying the error condition may comprise receiving from a motion sensor, a stream of motion data, and identifying, as a subset of the motion data is received, the error condition further based on at least the subset of motion data.

[023] The method may further comprise, prior to the microphone receiving the stream of audio data, sending to at least one playback device, an instruction that causes the at least one playback device to play a calibration tone, where the audio signal component corresponds to the calibration tone, and responsive to identifying the error condition, sending to the at least one playback device, an instruction that causes the at least one playback device to stop playing the calibration tone. Calibrating the at least one playback device may include a user moving a computing device within a playback environment while the calibration tone is played by the at least one playback device.

[024] The method may further comprise displaying, on a graphical display of a computing device, a graphical representation that indicates the identified error condition and a suggestion for remedying the identified error condition.

[025] In another aspect a non-transitory computer-readable medium is provided. The non-transitory computer-readable medium having stored thereon instructions executable by a computing device to perform the above-described method.

[026] In another aspect, a network device is provided. The network device may be configured to perform the above-described method. The network device may comprise a microphone configured for performing the step of receiving audio data that includes (i) an audio signal component and (ii) a background noise component, and a processor configured for, as a subset of the audio data is received, performing the step of identifying an error condition based on at least the subset of audio data.

[027] The network device may further comprise a graphical display configured for performing the step of displaying a graphical representation associated with the identified error condition.

[028] In examples discussed herein, one or more error conditions during calibration of one or more playback devices may be identified based on audio detected by a microphone of a network device being used for the calibration. Such error conditions may include conditions that affect the calibration of the one or more playback devices. In some cases, such conditions may interfere with the calibration of the one or more playback devices.

[029] After positioning the one or more playback devices at respective positions within a playback environment, calibration of the one or more playback device may be performed to provide a particular audio experience, regardless of the position(s) of the one or more playback devices within the playback environment. The particular audio experience may be an audio experience as intended by artists of audio content when creating the audio content.

[030] In one example, upon positioning the one or more playback devices in a playback environment, a user may use a network device to calibrate the one or more playback devices for the playback environment. The calibration process may involve the one or more playback devices playing a calibration tone, and the user moving the network device within the playback environment while a microphone of the network device detects an audio signal. The detected audio signal may include an audio component associated with the calibration tone played by the one or more playback device. Calibration of the one or more playback devices may then be completed by determining a signal processing algorithm based on the detected audio signal. The signal processing algorithm may be determined such that the particular audio experience is provided by the one or more playback devices when applying the signal processing algorithm during audio playback, as the signal processing algorithm may offset characteristics of the playback environment.

[031] Effectiveness of the calibration may depend on a number of factors. Such factors may include a background noise level, a quality of the audio signal detected by the

microphone, distances between the one or more playback devices and the network device, and a range of movement of the network device, among other possibilities. In some cases, one or more conditions that might negatively affect the effectiveness of the calibration of the one or more playback devices are identified during the calibration process. Such a condition may be referred to herein as an error condition. In some examples, as an audio stream is received via a microphone, the network device may identify error conditions based on the stream of audio data received.

[032] Upon identifying an error condition, the calibration process may be suspended, and the network device may display on a graphical display of the network device, a message indicating that the calibration process has been suspended. The message may additionally or alternatively indicate the identified error condition that triggered the suspension of the calibration process. The message may further additionally or alternatively indicate suggestions for remedying the identified error condition. The network device may further display on the graphical display selectable options for restarting the calibration process or cancelling the calibration process. Other examples are also possible.

[033] As indicated above, the present discussions involve identifying one or more error conditions during calibration of one or more playback devices based on audio detected by a microphone of a network device being used for the calibration. In one aspect, a network device is provided. The network device includes a microphone configured for receiving a stream of audio data that includes (i) an audio signal component and (ii) a background noise component, a processor configured for, as a subset of the stream is received, identifying an error condition based on at least the subset of audio data, and a graphical display configured for displaying a graphical representation that indicates the identified error condition.

[034] In another aspect, a method is provided. The method involves receiving, by a microphone of a network device, a stream of audio data that includes (i) an audio signal component and (ii) a background noise component, as a subset of the stream is received, identifying, by the network device based on at least the subset of audio data, an error condition, and displaying, on a graphical display of the network device, a graphical representation that indicates the identified error condition.

[035] In another aspect, a non-transitory computer-readable medium is provided. The non-transitory computer-readable medium has stored thereon instructions executable by a computing device to perform functions. The functions include receiving, via a microphone,

a stream of audio data that includes (i) an audio signal component and (ii) a background noise component, as a subset of the stream is received, identifying based on at least the subset of audio data, an error condition, and displaying, on a graphical display, a graphical representation that indicates the identified error condition.

[036] 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. It will be understood by one of ordinary skill in the art that this disclosure includes numerous other embodiments.

II. Example Operating Environment

[037] Figure 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 Figure 1, the media playback system 100 includes playback devices 102-124, control devices 126 and 128, and a wired or wireless network router 130.

[038] 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 Figure 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

[039] Figure 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 Figure 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, microphone(s) 220, and a network interface 214 including wireless interface(s) 216 and wired interface(s) 218. In one case, the playback

device 200 may 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.

[040] 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.

[041] 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. Patent 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.

[042] 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.

[043] The audio processing components 208 may include one or more of digital-to-analog converters (DAC), analog-to-digital converters (ADC), audio preprocessing components, audio enhancement components, and a digital signal processor (DSP), among others. 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.

[044] 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 3.5mm audio line-in connection) or the network interface 214.

[045] 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.

[046] 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.

[047] 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 Figure 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).

[048] 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.

[049] 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.

[050] 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 Figure 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

[051] Referring back to the media playback system 100 of Figure 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 Figure 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.

[052] As shown in Figure 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.

[053] In one example, one or more playback zones in the environment of Figure 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 playing 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. Patent No. 8,234,395.

[054] 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.

[055] 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

[056] Figure 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, a user interface 308, and microphone(s) 310. 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™).

[057] 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.

[058] 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.

[059] 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.

[060] 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.

[061] 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 Figure 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 Figure 3 (and/or the control devices 126 and 128 of Figure 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.

[062] 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.

[063] 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.

[064] 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.

[065] 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.

[066] 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.

[067] 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.

[068] 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.

[069] Referring back to the user interface 400 of Figure 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.

[070] 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

[071] 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.

[072] 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 Figure 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.

[073] 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 Figure 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.

[074] The above discussions relating to playback devices, control devices, playback zone configurations, and media item 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 Playback Device Calibration

[075] As previously discussed, one or more playback devices, such as one or more of the playback devices 102-124 of Figure 1, may be configured to provide a particular audio experience, and may be calibrated to provide that audio experience regardless of position(s) of the one or more playback devices within the playback environment.

[076] A calibration interface may be provided on a network device to guide a user through the calibration process. Alternatively, calibration may be performed automatically between the network device and the playback device(s), and may be conducted with or without interaction by a user of the network device. The network device may be a device the user can use to control the one or more playback devices. For instance, the network device may be similar to the control devices 126 and 128 of Figure 1, and 300 of Figure 3. The calibration interface may be a component of a controller interface, such as the controller interface 400 of Figure 4 that is provided on the network device for controlling the one or more playback devices.

[077] Once the one or more playback devices have been positioned within the playback environment, the calibration interface may cause the one or more playback devices to play a calibration tone. The network device may be positioned so as to receive the audio data related to the playback of the calibration tone by the one or more playback devices. In one example, the interface may prompt the user to move the network device within the playback environment while the calibration tone is playing. For example, in one more specific case, the interface may instruct the user to traverse areas within the playback environment where enjoyment of audio playback by the one or more playback devices may typically occurs. In another example, the interface may instruct the user to move the network device as close as possible to opposing border regions of the playback environment, such as walls in a room. In one case, the calibration interface may provide a video demonstrating how a user may traverse a playback environment. The video may be shown to the user via the interface before the calibration tone is played or while the calibration tone is playing.

[078] In one example, the calibration tone may be played for a predetermined duration of time, and the user may be allocated the predetermined duration of time to traverse the areas in the playback environment. In another example, the amount of time that the calibration tone is played back may be modified based on information sensed by the network device regarding the motion or path of the network device. For instance, if the network device determines that that the network device has started to backtrack across a previously traversed path, the network device may determine that no additional measurement of the calibration tone is necessary and may cause playback of the calibration tone by the one or more playback devices to be terminated.

[079] In a further example, the amount of time that the calibration tone is played back may be modified based on the detected audio signal. For instance, if the network device determines that additional samples of the audio signal detected in the playback environment will not improve the determination of the characterization of the playback environment, the network device may determine that no additional measurement of calibration tone is necessary and may cause playback of the calibration tone by the one or more playback devices to be terminated. Other examples are also possible.

[080] The predetermined duration of time may vary depending on a type and/or size of the playback environment. For instance, prior to causing the one or more playback device to play the calibration tone, the calibration interface may prompt the user to indicate a type and/or a size of the playback environment. Based on the user's input, the interface may identify an appropriate predetermined duration of time to play the calibration tone based on the indicated type and/or size of the playback environment. In one case, the provided demonstration video may also vary based on the indicated type and/or size of the playback environment. In another example, the user may be instructed to move between opposing border areas of the playback environment. The approximate size of the playback environment may be determined based on a detected motion and/or path of the network device, so that the playback time of the calibration tone may be adjusted (extended or shortened) based on the detected motion and/or detected path of motion of the user. For example, if it is detected that the user is still moving the network device, the calibration tone playback may be extended. In another example, if it is detected that the user is moving the device in a direction that indicates that the playback environment is larger than previously assumed and that the user needs more time to properly move the device to cover the entire or a substantial portion of the playback environment, the playback time may be extended.

[081] While the one or more playback devices is playing the calibration tone, a microphone of the network device, such as microphone 310 of the control device 300, may detect an audio signal. A processor of the network device, such as the processor 302 of the control device 300, may receive a stream of audio data from the microphone as the audio signal is detected. The processor may then process the received audio data to determine audio characteristics of the playback environment. For instance, a linear frequency response associated with the playback environment may be determined based on the audio data.

[082] A signal processing algorithm may then be determined based on the audio characteristics. For instance, equalization parameters may be determined such that when the equalization parameters are applied by the one or more playback device when playing audio content, a particular audio experience may be created.

IV. Example Methods for Identifying Playback Device-Calibration Error Conditions

[083] As indicated previously, one or more error conditions may negatively affect the effectiveness of the calibration of the one or more playback devices. In one example, the one or more error conditions may be identified during playback of the calibration tone by the one or more playback device and detecting of the audio signal by the microphone of the network device. In one case, calibration of the one or more playback devices may be suspended and/or terminated as soon as an error condition is identified, rather than after completing playback of the calibration tone and detecting of the audio signal for the entire predetermined duration of time.

[084] Figure 5 shows a flow diagram of example method 500 for identifying playback device-calibration error conditions. Method 500 presents example methods that can be implemented within an operating environment involving, for example, the media playback system 100 of Figure 1, one or more of the playback device 200 of Figure 2, and one or more of the control device 300. In one example, the method 500 may be performed in whole or in part by a computing device in communication with a media playback system. For instance, the method 500 may be performed by one or more of the control devices 126 and 128 of Figure 1. In such cases, one or more of the control devices 126 and 128 may have installed thereon a software application that includes instructions executable by a processor of a respective control device to cause the respective control device to perform the functions of method 500.

[085] Method 500 may include one or more operations, functions, or actions as illustrated by one or more of blocks 502-506. Although the respective 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. In addition, for the method 500 and other processes and methods disclosed herein, the flowcharts show functionality and operation of only a few possible implementations 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 or hard drive.

[086] The computer readable medium may include non-transitory computer readable medium, 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 may represent circuitry that is wired to perform the specific logical functions in the process.

[087] As shown in Figure 5, the method 500 involves at block 502, receiving a stream of audio data from a microphone; at block 504, as a subset of the audio data is received, identifying based on at least the subset of audio data, an error condition; and at block 506, providing for display on a graphical display, a graphical representation associated with the identified error condition.

a. Receive a stream of audio data from a microphone

[088] As indicated above, block 502 involves receiving a stream of audio data from a microphone. In one example, the microphone may be a part of a network device providing a calibration interface to guide a user through the process of calibrating one or more playback devices. In another example, the microphone may be a microphone external to

the network device and communicatively coupled to the network device. In discussions herein, physical movement of the network device may involve concurrent physical movement of the microphone.

[089] In one example, the network device, prior to the microphone receiving the stream of audio data, may send to at least one of the one or more playback devices, a message to cause the at least one playback device to play a calibration tone. In one case, the calibration interface may prompt the user to indicate when the user is ready to begin movement of the network device within the playback environment. For instance, the calibration interface may provide on a graphical display of the network device, a selectable icon (i.e. a "start calibration" icon) that the user can select to indicate that the user is ready.

[090] The network device, in response to receiving an input indicating that the user is ready to begin movement of the network device within the playback environment, may accordingly send the message to the at least one of the one or more playback device. In one case, the at least one of the one or more playback device may then coordinate playback of the calibration tone by each of the one or more playback devices.

[091] As the calibration tone is being played by the one or more playback devices, the microphone may detect an audio signal including at least a portion of the calibration tone being played and any ambient noise present in the playback environment. The microphone may then, as the audio signal is detected, sample the detected audio signal and stream the resulting audio data to a processor of the network device.

[092] As such, the stream of audio data may be received while a calibration tone is being played by the one or more playback devices and as the microphone detects and samples the audio signal. The audio data may accordingly include (i) an audio signal component corresponding to the at least a portion of the calibration tone being played, and (ii) a background noise component corresponding to audio elements other than the calibration tone.

[093] Figure 6 shows an illustrative playback device calibration user interface 600. As shown, the user interface 600 includes a graphical representation 602 indicating that one or more playback devices in a "LIVING ROOM" zone is being calibrated. Referring to Figure 1, playback devices, 104, 106, 108, and 110 may be the one or more playback devices that are being calibrated. The user interface 600 further includes a graphical representation 604 that may indicate that detecting of an audio signal for calibration purposes is taking place. The graphical representation 604 may also show a status of the audio signal recording process, such as an amount of the predetermined duration of time

for detecting of the calibration tone that has elapsed and/or that is remaining. The graphical representation 604 may also show a representation of the audio signal that has been detected thus far. Also shown in the user interface 600 is a selectable icon 606 that may be selected to terminate the calibration process. One having ordinary skill in the art will appreciate that the user interface 600 of Figure 6 is for illustration purposes and that other examples are also possible.

b. As a subset of the stream is received, identify based on at least the subset of audio data, an error condition

[094] At block 504, the method 500 involves as a subset of the stream is received, identifying based on at least the subset of audio data, an error condition. In one example, the subset of the audio data may be a single audio data sample. In another example, the subset of the audio data may be a plurality of audio data samples. In one case, identifying the error condition based on at least the subset of the audio data may involve identifying the error condition based on the subset of the audio data and one or more preceding subsets of the audio data in the stream of audio data.

[095] In some cases, an error condition may be statistically insignificant. For instance, if a noise impulse occurs during calibration, the audio data indicating the noise impulse may be automatically discarded as an outlier during processing of the audio data. In such a case, the network device may determine that calibration of the one or more playback devices may continue. In other cases, the error condition may be statistically significant and audio data indicating the error condition may not be discarded as an outlier. In such case, the network device may, responsive to identifying the error condition, determine that calibration of the one or more playback devices is to be suspended, and accordingly send to at least one of the one or more playback devices, a message to cause the at least one playback device to stop playing the calibration tone.

[096] In one example, a plurality of predetermined error conditions and corresponding characteristics of the predetermined error conditions may be defined. In such a case, an identification of the error condition at block 504 may involve identifying the error condition from the plurality of predetermined error conditions based on identifying the corresponding characteristics. In one case, only a single error condition is identified based on the at least a subset of the audio data. In another case, multiple error conditions may be identified based on the at least a subset of audio data.

[097] As indicated above, the calibration interface may prompt the user to move the network device within the playback environment while the calibration tone is playing. The

calibration interface may further prompt the user to move the network device up and down within the network device. Movement of the network device while the microphone of the network device detects the calibration tone may provide a more comprehensive acoustic characteristic of the playback environment to be captured in the stream of audio data. In addition, movement of the network device across areas in the playback environment where enjoyment of audio playback by the one or more playback devices typically occurs while the microphone of the network device detects the calibration tone may further provide an acoustic characteristic of the playback environment that is more pertinent to how the playback environment is used during audio playback by the one or more playback devices in the playback environment.

[098] During the movement of the network device, a level of the audio signal detected by the microphone of the network device may be expected to have a certain degree of variation and a certain rate of variation. As such, if a determination is made that a level of the audio signal component represented in the subset of audio data is less a minimum threshold, an error condition of insufficient movement of the network device may be identified. Alternatively, if a determination is made that a rate of variation in a level of the audio signal component represented in the subset of audio data is above a maximum threshold, an error condition of overly-fast movement of the network device may be identified.

[099] In one example, the network device may further include a motion sensor, such as an accelerometer, among other examples. In such a case, the processor of the network device may further activate the motion sensor during calibration of the one or more playback device, and in particular, while the calibration tone is being played by the one or more playback device and while the network device is expected to be moved within the playback environment. In this instance, the processor of the network device may further be configured to receive a stream of motion data. The motion data may indicate a range of movement and/or a rate of movement of the network device within the playback environment. The range of movement and rate of movement of the network device may involve both lateral movement of the network device within the playback environment and up and down movement of the network device.

[100] As a subset of the motion data is received by the motion sensor, the processor of the network device may identify one or more error conditions based on at least the subset of motion data. As such, the error conditions of insufficient movement or overly-fast movement may alternatively or additionally be identified based on at least a subset of the

motion data from the motion sensor. More specifically, when movement detected by the motion sensor is below a minimum threshold, an error message of insufficient movement is generated, and/or when a rate of movement detected by the motion sensor is above a maximum threshold, an error message of overly fast movement is generated.

[101] In one example, a range of movement that is considered insufficient movement may be determined based on an expected size of the listening environment. In one case, a threshold range of movement of 1.2 meters may be determined for an average listening environment. In this case, if a range of movement detected by the motion sensor is less than 1.2 meters, the error condition of insufficient movement may be identified.

[102] In another example, the expected range of movement may vary depending on an indicated type of listening environment, and accordingly the threshold range of movement may vary based on the indicated type of listening environment. For instance, if a user indicates during the calibration process that the calibration is to be performed for a living room, the threshold range of movement may be 3 meters. The user may indicate that the calibration is performed for a living room by naming the playback zone associated with the playback device(s) being calibrated as "Living Room." On the other hand, if a user indicates during the calibration process that the calibration is to be performed for a bathroom, the threshold range of movement may be 1 meter. Other examples are also possible.

[103] Other examples for determining and/or identifying the threshold range of movement may also be possible. For instance, the network device and/or the playback devices may play an impulse signal and estimate a size of the listening environment based on a detection by the network device and/or playback devices of the reflected signal. Other examples are also possible.

[104] A playback environment may involve one or more playback zones, and accordingly may include one or more playback devices associated with the one or more playback zones. Calibration of the one or more playback devices may be suitably performed within a particular playback zone associated with the one or more playback devices, rather than another playback zone or a playback environment that does not include the particular playback zone. In other words, referring to Figure 1, playback devices 122 and 124 may be suitably calibrated for the master bedroom, and not the dining room.

[105] In one example, if a determination is made that a level of the audio signal component represented in the subset of audio data has gradually decreased below a

minimum threshold, an error condition of exceeding a threshold movement distance may be identified. In other words, the network device may have moved too far from the one or more playback devices, and outside of a suitable playback environment for the one or more playback devices.

[106] Prior to playback of the calibration tone by the one or more playback devices being calibrated and detection of the audio signal by the microphone, the calibration interface may first determine whether a background noise level within the playback environment is suitable for calibration of the one or more playback devices in the playback environment. In one case, the calibration interface may provide a graphical representation of a noise-meter to indicate a noise level in the playback environment. If the noise level is above a suitable level, the calibration interface may prompt the user to attempt to reduce the noise level in the playback environment prior to calibrating the one or more playback devices. If the noise level of the playback environment is within suitable levels, the selectable icon that the user can select to indicate that the user is ready to move the network device within the playback environment may be displayed on the calibration interface. A selection of the selectable icon may then cause the playback of the calibration tone by the one or more playback devices and detection of the audio signal by the microphone of the network device to begin.

[107] During playback of the calibration tone by the one or more playback devices and detection of the audio signal by the microphone of the network device, background noise levels in the playback environment may change. In one example, if a determination is made that a level of the background noise component represented in the subset of audio data is above a maximum threshold level, an error condition of unsuitable background noise may be identified. In one instance, such an error condition may occur if a burst of sound is present in the playback environment during detection of the audio signal by the microphone.

[108] In another example, if a determination is made that a ratio between the audio signal component and the background noise component (signal to noise ratio, or "SNR") represented in the subset of audio data is below a minimum threshold, an error condition of overly high background noise may be identified. In one instance, such an error condition may occur if the background noise in the playback environment has gradually increased beyond a suitable level.

[109] Different network devices may have different microphone configurations. In one example, if the microphone of the network device is on the bottom of the network device

(relative to a standard operating orientation of the network device), the calibration interface may, prior to the playback of the calibration tone by the one or more playback device and detection of the audio signal by the microphone, prompt the user to flip the network device upside-down such that the microphone is on the top of the network device. Such an orientation of the network device, and consequently the microphone may cause the microphone of the network device to be suitably oriented for optimal detection of the audio signal that includes at least a portion of the calibration tone played by the one or more playback devices being calibrated.

[110] In one example, if a determination is made that a level of the audio signal component represented in the subset of audio data has substantially (or drastically) decreased below a minimum threshold, an error condition of having an improperly orientated network device (and microphone) may be identified. For instance, a user may have instinctively and/or accidentally flipped the phone back to standard operating orientation of the network device, in which the microphone may not be optimally oriented for detecting the audio signal that includes at least a portion of the calibration tone played by the one or more playback devices being calibrated. In one case, motion data from the motion sensor may also be used to determine an orientation of the network device. Accordingly, the error conditions of an improperly oriented network device may alternatively or additionally be identified based on at least a subset of the motion data from the motion sensor.

[111] In addition to an improperly orientated network device (and microphone), a microphone that is even partially obstructed may also negatively affect the effectiveness of the calibration of the one or more playback devices using the network device. In one case, a protective and/or decorative case for the network device may obstruct a portion of the microphone. In another case, lint from clothing or other debris from regular use of the network device may also obstruct a portion of the microphone.

[112] In one example, if a determination is made that the audio signal component represented in the subset of audio data is substantially different from a reference audio signal, an error condition of an obstructed microphone may be identified. In one case, the reference audio signal may be representative of the calibration tone. For instance, the reference audio signal may be generated by convoluting the calibration tone audio signal with a frequency response of the microphone. In one case, a substantial difference between the subset of the audio data and the reference audio signal may include a substantially attenuated audio signal represented in the audio data, relative to the reference audio signal.

[113] The network device used for calibration of the one or more playback devices may also be used as a communication device, as such, during playback of the calibration tone by the one or more playback devices and while the microphone of the network device is detecting the audio signal, the network device may receive messages over a local area network and/or cellular network and may generate notifications in the form of audio signal and/or vibrations. The audio and/or vibrational notifications may also negatively affect the effectiveness of the calibration of the one or more playback devices. Accordingly, if a determination is made that the network device generated an audible or physical notification during playback of the calibration tone and detection of the audio signal, a corresponding error state may be identified.

[114] As indicated above, one or more error conditions may be determined based on combinations of the received audio data and motion data. In one example, the network device may be configured to suspend calibration if 1/4 of the received audio data indicates an SNR that is below an SNR threshold. In one case, as discussed previously, may be that the background noise level is too high.

[115] In another case, however, the motion data corresponding to those 1/4 of the received audio data may be further based on to identify the error condition. For instance, if 1/3 of the motion data corresponding to the 1/4 of the received audio data indicates movement above a certain threshold, than an error condition of overly fast movement may be determined. In this case, the below-threshold SNR may result from increased noise from the overly fast movement (wind/draft over the microphone from the movement).

[116] In another instance, if 3/4 of the 1/4 of the received audio data indicates an SNR that is below the SNR threshold despite corresponding motion data indicating an expected, below-threshold rate of movement, an error condition of too much background noise may be determined. Further in this case, if movement of the network device within the playback environment is faster than the threshold rate of movement, but the SNR of the received audio data remains above the SNR threshold, calibration may be allowed to continue and no error conditions may be identified. In other words, in this case, so long as the SNR of the received audio signal is above the SNR threshold, no error condition is identified. However, if the SNR of some of the received audio data (i.e. 1/4, as discussed above) is below the SNR threshold, the motion data may be relied upon to determine whether the error condition relates to background noise or overly fast movement. Other examples are also possible.

[117] Descriptions of the error conditions described above are for illustrative purposes and are not meant to be limiting. One having ordinary skill in the art will appreciate that other examples are also possible. For instance, characteristics may be determined for an error condition involving movement of the network device such that a piece of furniture or the user is between the one or more playback devices and the network device, for example, if the audio data falls below a predetermined threshold for a relatively short amount of time during the calibration procedure. Such an error condition may be identified if the determined characteristics are present in the at least a subset of the audio data.

[118] In addition, while the above examples involve identifying one or more error conditions based on a subset of audio data while the subset of audio data is received, one having ordinary skill in the art will appreciate that an alternative embodiment in which the one or more error conditions is determined after receiving of the audio data is complete, based on all the received audio data, is also possible. Other examples are also possible.

c. Provide for display on a graphical display, a graphical representation associated with the identified error condition

[119] At block 506, the method 500 involves providing for display on a graphical interface, a graphical representation that indicates the identified error condition. Figure 7 shows an illustrative playback device calibration error condition user interface 700 that may be displayed on the graphical interface when an error condition has been identified. As shown, the user interface 700 includes a graphical representation 702 indicating that the displayed content on the interface 700 corresponds to the one or more playback devices in the LIVING ROOM zone.

[120] The user interface 700 further includes a graphical representation 710 that may include a textual message describing an identified error condition and/or suggestions for remedying the error condition. The user interface 700 further includes selectable icons 706 and 708. Selectable icon 706 may be selected to try the calibration process again, and selectable icon 708 may be selected to terminate the calibration process. As shown, the graphical representation 710 may overlay a grayed or dimmed version of some or all of the graphical representation 604 of the user interface 600 of Figure 6.

[121] In one example, each error condition (i.e. in the plurality of predetermined error conditions) may have a corresponding textual message to be provided in the graphical representation 710. For instance, if the identified error condition relates to insufficient movement, an example textual message may be “To get a good measurement, make sure you’re slowly moving your device up and down and walking all throughout your room.

Please try again with more movement." In another instance, if the identified error condition relates to overly-fast movement, an example textual message may be "You were moving a little too fast to get a good measurement for tuning. Please try again, but move slower this time."

[122] In one instance, if the identified error condition relates to background noise being above a threshold level, the example textual message may be "We couldn't get a good measurement for tuning. Please reduce background noise and try again." In such a case, the graphical representation 710 may also include a representation of a noise meter, allowing the user to see if the user sufficiently reduced the background noise level in the playback environment below the threshold level, before selecting the icon 706 to try again.

[123] In another instance, if the identified error condition involves an obstructed microphone, the example textual message may be "If your device has a case, please remove it. Please also make sure your microphone is unobstructed and try again."

[124] The example textual messages discussed herein are for illustrative purposes only and are not meant to be limiting. Further, one having ordinary skill in the art will appreciate that other examples are also possible.

[125] In one example, multiple error conditions may be identified based on the at least a subset of the audio data. In one case, a most severe error condition from the multiple error conditions may be identified and a textual message corresponding to the most severe error condition may be displayed in the graphical representation 710. In another case, a subset of the multiple error conditions may be identified (i.e. top 3 most severe error conditions), and textual messages corresponding to the subset of the multiple error conditions may be displayed in the graphical representation 710. In yet another case, textual messages corresponding to each of the multiple error conditions may be displayed in the graphical representation 710. Other examples are also possible.

V. Conclusion

[126] 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.

[127] 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.

[128] 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.

[129] 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.

[130] (Feature 1) A network device including a microphone configured for receiving audio data that includes (i) an audio signal component and (ii) a background noise component, a processor configured for, as a subset of the stream is received, identifying an error condition based on at least the subset of the stream, and a graphical display configured for displaying a graphical representation that indicates the identified error condition.

[131] (Feature 2) The network device of feature 1, wherein identifying the error condition comprises identifying the error condition from among a plurality of pre-determined error conditions.

[132] (Feature 3) The network device of one of features 1 or 2, wherein identifying the error condition comprises determining that a variation in a sound pressure level of the audio signal component is less a minimum threshold, and based on determining that the variation in the level of the audio signal component is less than the minimum threshold, identifying the error condition as a movement of the computing device that is less than a threshold speed.

[133] (Feature 4) The network device of feature 1 or feature 2 in combination with claim 3, wherein identifying the error condition comprises determining that a variation in a sound pressure level of the audio signal component exceeds a maximum threshold, and based on determining that the variation in the level of the audio signal component exceeds the maximum threshold, identifying the error condition as a movement of the computing device that exceeds a threshold speed.

[134] (Feature 5) The network device of feature 1 or feature 2 in combination with at least one of features 3 to 4, wherein identifying the error condition comprises determining that a sound pressure level of the audio signal component has gradually decreased below a minimum threshold, and based on determining that the sound pressure level of the audio signal has gradually decreased below the minimum threshold, identifying the error condition as having exceeded a threshold movement distance.

[135] (Feature 6) The network device of feature 1 or feature 2 in combination with at least one of features 3 to 5, wherein identifying the error condition comprises determining that a sound pressure level of the audio signal component has substantially decreased below a minimum threshold, and based on determining that the sound pressure level of the audio signal component has substantially decreased below the minimum threshold, identifying the error condition as an improperly orientated computing device.

[136] (Feature 7) The network device of feature 1 or feature 2 in combination with at least one of features 3 to 6, wherein identifying the error condition comprises determining that a sound pressure level of the background noise component exceeds a maximum threshold level, and based determining that the sound pressure level of the background noise component exceeds the maximum threshold level, identifying the error condition as having background noise that exceeds a threshold level for calibration.

[137] (Feature 8) The network device of feature 1 or feature 2 in combination with at least one of features 3 to 7, wherein identifying the error condition comprises determining that a ratio between the audio signal component and the background noise component is below a minimum threshold, and based determining that the ratio between the audio signal

component and the background noise component is below the minimum threshold, identifying the error condition as having a high background noise to audio signal ratio.

[138] (Feature 9) The network device of feature 1 or feature 2 in combination with at least one of features 3 to 8, wherein identifying the error condition comprises determining that the audio signal component is substantially different from a reference audio signal, and identifying the error condition as an obstructed microphone.

[139] (Feature 10) The network device of feature 1 or feature 2 in combination with at least one of features 3 to 9, wherein the functions further comprise prior to the microphone receiving the stream of audio data, sending to at least one playback device, an instruction that causes the at least one playback device to play a calibration tone, wherein the audio signal component corresponds to the calibration tone, and responsive to identifying the error condition, sending to the at least one playback device, an instruction that causes the at least one playback device to stop playing the calibration tone.

[140] (Feature 11) The network device of feature 1, further comprising a motion sensor configured for receiving a stream of motion data, wherein identifying the error condition further comprises, as a subset of the motion data is received by the computing device, identifying the error condition further based on at least the subset of motion data.

[141] (Feature 12) A method comprising receiving, by a microphone of a network device, a stream of audio data that includes (i) an audio signal component and (ii) a background noise component, as a subset of the stream is received, identifying, by the network device based on at least the subset of audio data, an error condition, and displaying, on a graphical display of the network device, a graphical representation that indicates the identified error condition.

[142] (Feature 13) The method of feature 12, wherein identifying the error condition comprises determining, by the network device, that a variation in a sound pressure level of the audio signal component is less a minimum threshold, and based on determining that the variation in the sound pressure level of the audio signal component is less than the minimum threshold, identifying, by the network device, the error condition as a movement of the computing device that is less than a threshold speed.

[143] (Feature 14) The method of feature 12, wherein identifying the error condition comprises determining, by the network device, that a variation in a sound pressure level of the audio signal component exceeds a maximum threshold, and based on determining that the variation in the level of the audio signal component exceeds the maximum threshold,

identifying, by the network device, the error condition as a movement of the computing device that exceeds a threshold speed.

[144] (Feature 15) The method of feature 12, wherein identifying the error condition comprises determining, by the network device, that a sound pressure level of the audio signal component has gradually decreased below a minimum threshold, and based on determining that the sound pressure level of the audio signal has gradually decreased below the minimum threshold, identifying, by the network device, the error condition as having exceeded a threshold movement distance.

[145] (Feature 16) A computer readable medium configured for performing the method of any of features 1 to 15.

(Feature 17) The computer readable medium of feature 16, wherein identifying based on at least the subset of audio data, the error condition comprises determining that a sound pressure level of the background noise component represented in the subset of audio data exceeds a maximum threshold level, and based determining that the sound pressure level of the background noise component exceeds the maximum threshold level, identifying the error condition as having background noise that exceeds a threshold level for calibration.

[146] (Feature 18) The computer readable medium of feature 16, wherein identifying based on at least the subset of audio data, the error condition comprises determining that a ratio between the audio signal component and the background noise component is below a minimum threshold, and based determining that the ratio between the audio signal component and the background noise component is below the minimum threshold, identifying the error condition as having a high background noise to audio signal ratio.

[147] (Feature 19) The computer readable medium of feature 16, wherein identifying based on at least the subset of audio data, the error condition comprises determining that the audio signal component is substantially different from a reference audio signal, and based on determining that the audio signal component is substantially different from the reference audio signal, identifying the error condition as an obstructed microphone.

[148] (Feature 20) The computer readable medium of feature 16, wherein the functions further comprise prior to the microphone receiving the stream of audio data, sending to at least one playback device, an instruction that causes the at least one playback device to play a calibration tone, wherein the audio signal component corresponds to the calibration tone, and responsive to identifying the error condition, sending to the at least one playback device, an instruction that causes the at least one playback device to stop playing the calibration tone.

CLAIMS

1. A method for calibrating at least one playback device, the method comprising:

receiving, via a microphone, a stream of audio data that includes (i) an audio signal component and (ii) a background noise component;

as a subset of the stream is received, identifying, based on at least the subset of the stream, an error condition; and

determining that calibration of the at least one playback device is to be suspended.

2. The method of claim 1, wherein identifying the error condition comprises:

identifying the error condition from among a plurality of pre-determined error conditions.

3. The method of claim 1 or 2, wherein identifying the error condition comprises:

determining that a variation in a sound pressure level of the audio signal component is less a minimum threshold; and

based on determining that the variation in the level of the audio signal component is less than the minimum threshold, identifying the error condition as a movement of a computing device that is less than a threshold speed.

4. The method of claim 1 or 2, wherein identifying the error condition comprises:

determining that a variation in a sound pressure level of the audio signal component exceeds a maximum threshold; and

based on determining that the variation in the level of the audio signal component exceeds the maximum threshold, identifying the error condition as a movement of a computing device that exceeds a threshold speed.

5. The method of claim 1 or 2, wherein identifying the error condition comprises:

determining that a sound pressure level of the audio signal component has gradually decreased below a minimum threshold; and

based on determining that the sound pressure level of the audio signal has gradually decreased below the minimum threshold, identifying the error condition as having exceeded a threshold movement distance.

6. The method of claim 1 or 2, wherein identifying the error condition comprises:

determining that a sound pressure level of the audio signal component has substantially decreased below a minimum threshold; and

based on determining that the sound pressure level of the audio signal component has substantially decreased below the minimum threshold, identifying the error condition as an improperly orientated computing device.

7. The method of claim 1 or 2, wherein identifying the error condition comprises:

determining that a sound pressure level of the background noise component exceeds a maximum threshold level; and

based on determining that the sound pressure level of the background noise component exceeds the maximum threshold level, identifying the error condition as having background noise that exceeds a threshold level for calibration.

8. The method of claim 1 or 2, wherein identifying the error condition comprises:

determining that a ratio between the audio signal component and the background noise component is below a minimum threshold; and

based on determining that the ratio between the audio signal component and the background noise component is below the minimum threshold, identifying the error condition as having a high background noise to audio signal ratio.

9. The method of claim 1 or 2, wherein identifying the error condition comprises:

determining that the audio signal component is substantially different from a reference audio signal; and

based on determining that the audio signal component is substantially different from the reference audio signal, identifying the error condition as an obstructed microphone.

10. The method of any preceding claim, wherein identifying the error condition comprises:

receiving from a motion sensor, a stream of motion data, and

identifying, as a subset of the motion data is received, the error condition further based on at least the subset of motion data.

11. The method of any preceding claim, further comprising:

prior to the microphone receiving the stream of audio data, sending to at least one playback device, an instruction that causes the at least one playback device to play a calibration tone, wherein the audio signal component corresponds to the calibration tone; and

responsive to identifying the error condition, sending to the at least one playback device, an instruction that causes the at least one playback device to stop playing the calibration tone.

12. The method of claim 11, wherein calibrating the at least one playback device includes a user moving a computing device within a playback environment while the calibration tone is played by the at least one playback device.

13. The method of any preceding claim, further comprising displaying, on a graphical display of a computing device, a graphical representation that indicates the identified error condition and a suggestion for remedying the identified error condition.

14. A non-transitory computer-readable medium having stored thereon instructions executable by a computing device to perform a method according to any preceding claim.

15. A network device configured to perform the method of one of claims 1 to 13, the network device comprising:

a microphone configured for performing the step of receiving audio data that includes (i) an audio signal component and (ii) a background noise component; and

a processor configured for, as a subset of the audio data is received, performing the step of identifying an error condition based on at least the subset of audio data.

16. The network device of claim 15 configured to perform the method of claim 13, the network device further comprising:

a graphical display configured for performing the step of displaying a graphical representation associated with the identified error condition.

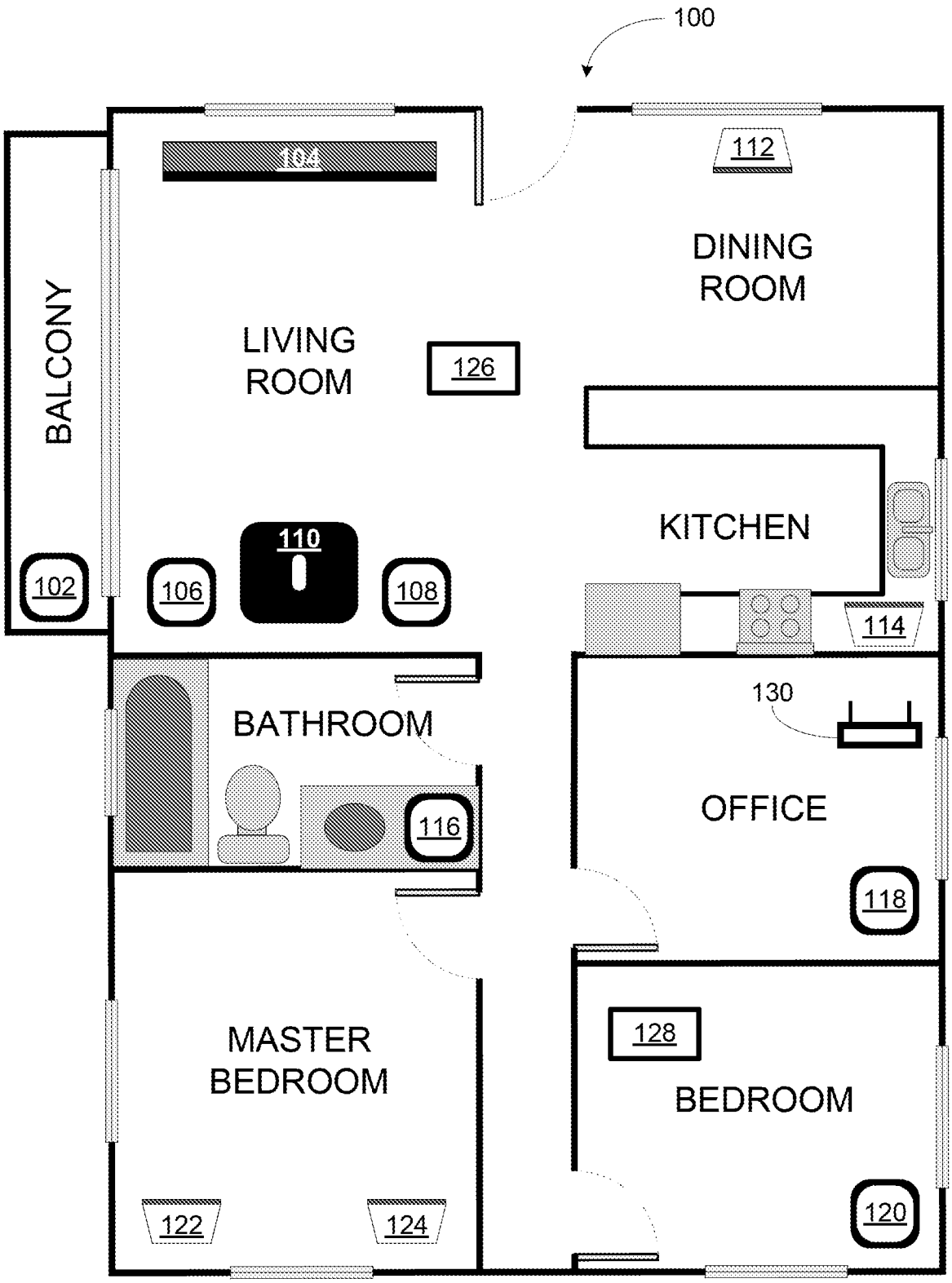
100
104
112
DINING ROOM
BALCONY
LIVING ROOM
126
KITCHEN
110
102
106
108
114
130
BATHROOM
OFFICE
116
118
MASTER BEDROOM
128
BEDROOM
122
124
120

FIGURE 1

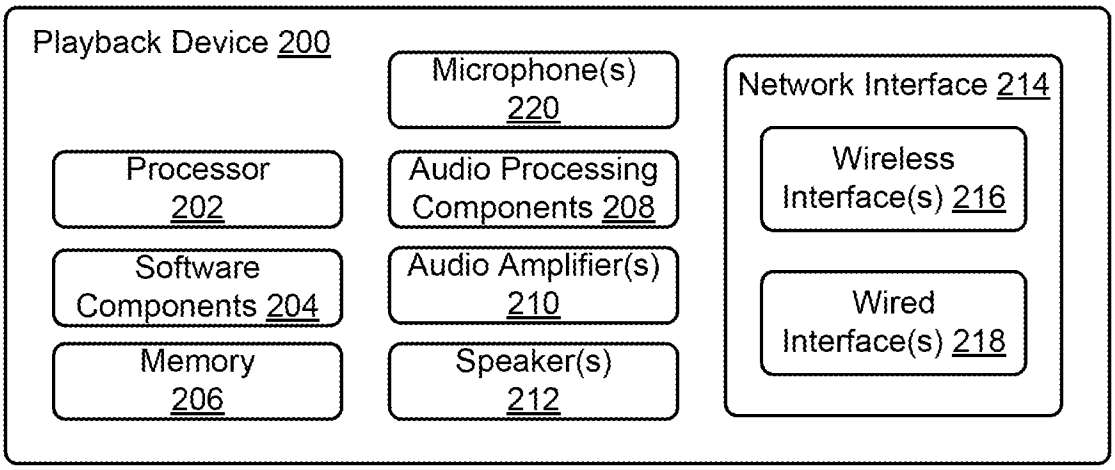

FIGURE 2

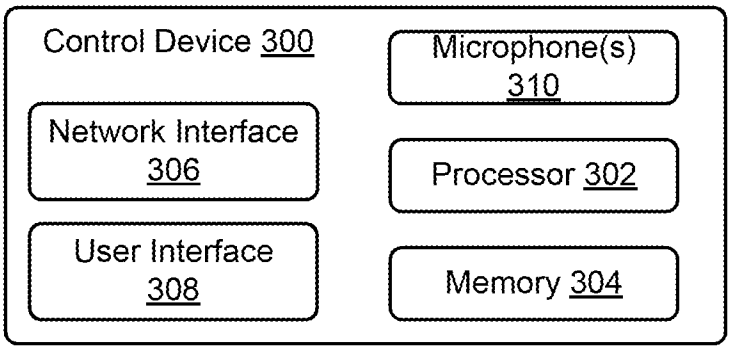

FIGURE 3

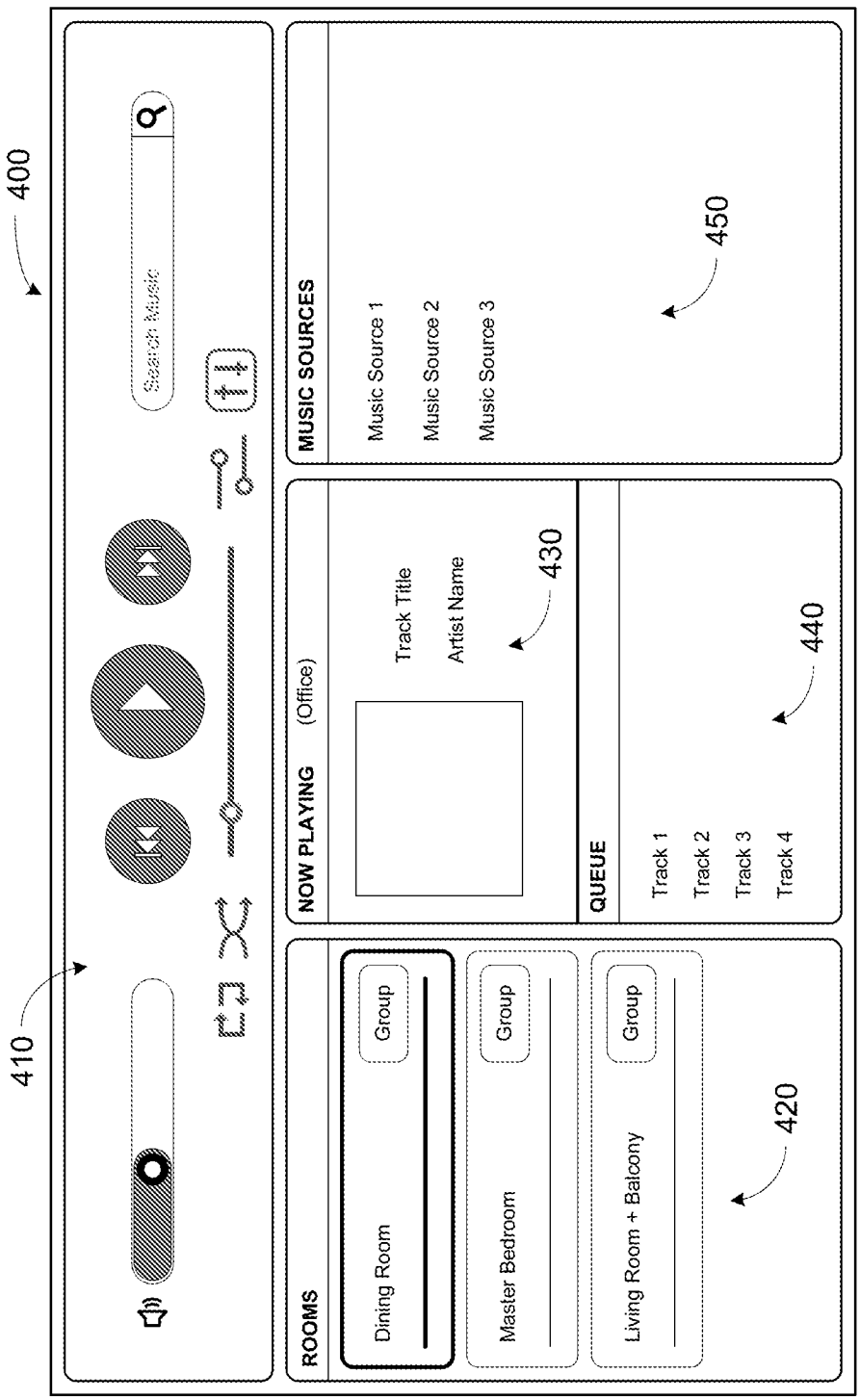
400
410
Search Music
ROOMS
Dining Room
Group
Master Bedroom
Group
Living Room + Balcony
Group
420
NOW PLAYING
(Office)
Track Title
Artist Name
430
QUEUE
Track 1
Track 2
Track 3
Track 4
440
MUSIC SOURCES
Music Source 1
Music Source 2
Music Source 3
450

FIGURE 4

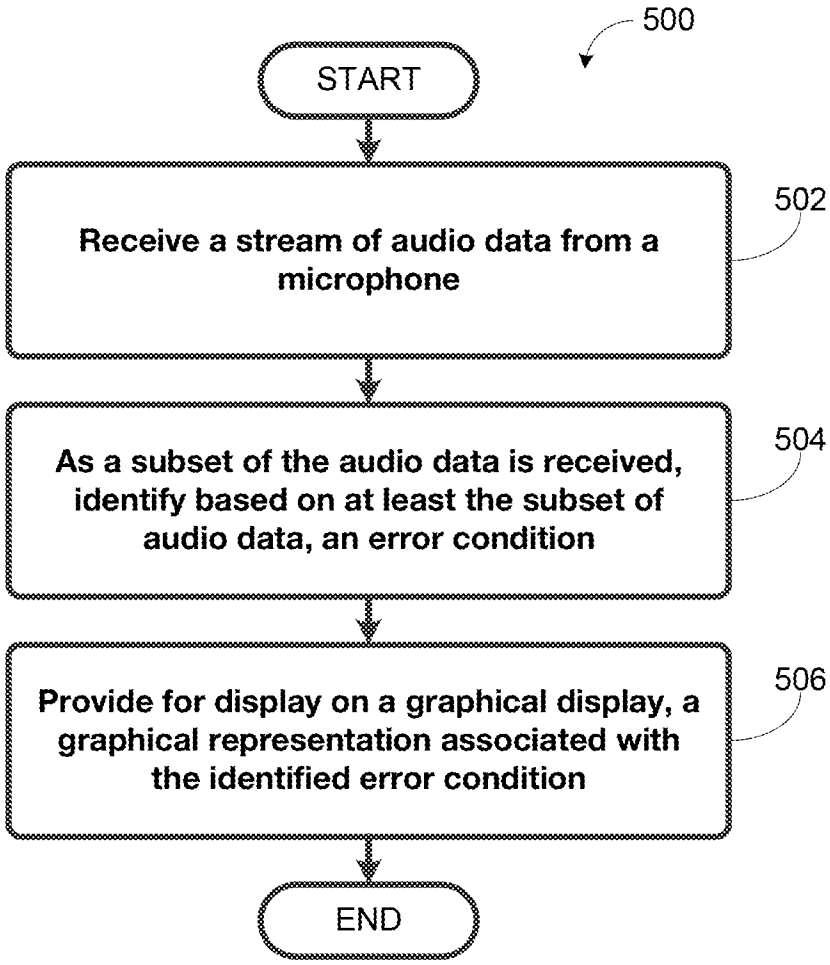
500
START
Receive a stream of audio data from a microphone
502
As a subset of the audio data is received, identify based on at least the subset of audio data, an error condition
504
Provide for display on a graphical display, a graphical representation associated with the identified error condition
506
END

FIGURE 5

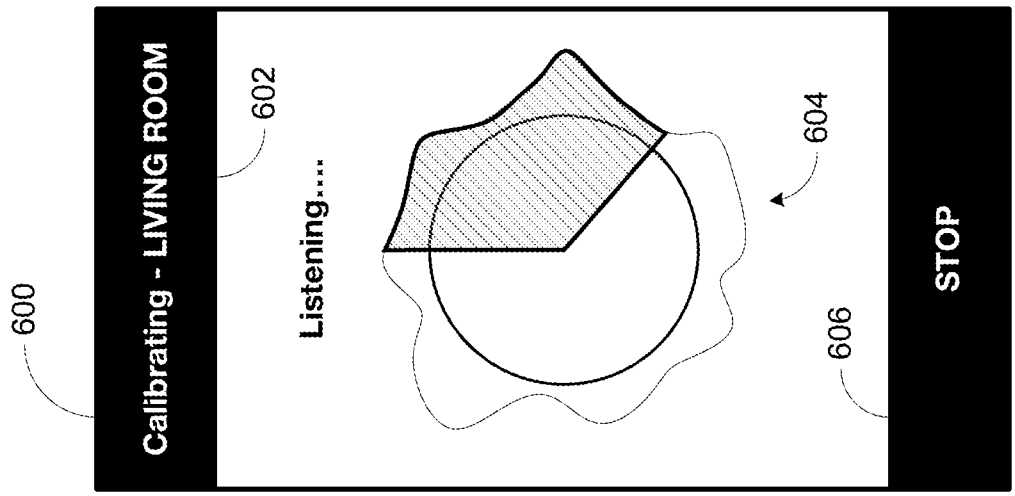

FIGURE 6

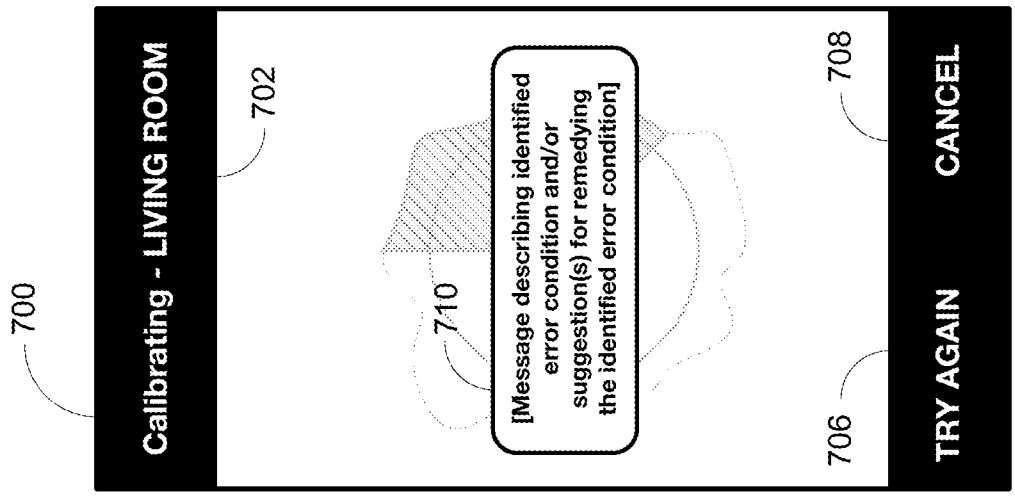

FIGURE 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/043840

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04S7/00 H04R27/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04S

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2015/078596 A1 (SPROGIS KASPARS [LV]) 19 March 2015 (2015-03-19) paragraphs [0074] - [0085]	1-6,10, 12,14,15
X	EP 1 349 427 A2 (BOSE CORP [US]) 1 October 2003 (2003-10-01) paragraphs [0025] - [0026]; figure 4	1,2,7,8, 13-16
X	US 2010/135501 A1 (CORBETT TIM [US] ET AL) 3 June 2010 (2010-06-03) paragraphs [0040] - [0045]	1,9,11, 14,15
X	US 2014/270282 A1 (TAMMI MIKKO TAPIO [FI] ET AL) 18 September 2014 (2014-09-18) paragraphs [0087] - [0091], [0204] - [0210]; figure 6	1,13-16

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 October 2016	18/10/2016

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Fruhmann, Markus

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/043840

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2013/016500 A1 (THOMSON LICENSING [FR]; JOHNSON RONALD DOUGLAS [US]; SCHULTZ MARK ALAN) 31 January 2013 (2013-01-31) paragraph [0020]	1-16

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2016/043840

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		US 2014294201 A1	02-10-2014
		WO 2013016500 A1	31-01-2013