



(51) International Patent Classification:
H04N 21/43 (2011.01) H04N 21/4402 (2011.01)
H04N 21/439 (2011.01)

(21) International Application Number:
PCT/US2019/050316

(22) International Filing Date:
10 September 2019 (10.09.2019)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
16/128,565 12 September 2018 (12.09.2018) US

(71) Applicant: ROKU, INC. [US/US]; 170 Knowles Drive, Los Gatos, California 95032 (US).

(72) Inventor; and

(71) Applicant: WOOD, Anthony John [US/US]; 399 Sherman Avenue #12, Palo Alto, California 94306 (US).

(72) Inventor: ASNIS, Ilya; 1842 Lencar Way, San Jose, California 95124 (US).

(74) Agent: LEE, Michael Q. et al.; STERNE, KESSLER, GOLDSTEIN & FOX P.L.L.C, 1100 New York Avenue, NW, Washington, District of Columbia 20005 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ,

(54) Title: ADAPTIVE SWITCHING IN A WHOLE HOME ENTERTAINMENT SYSTEM

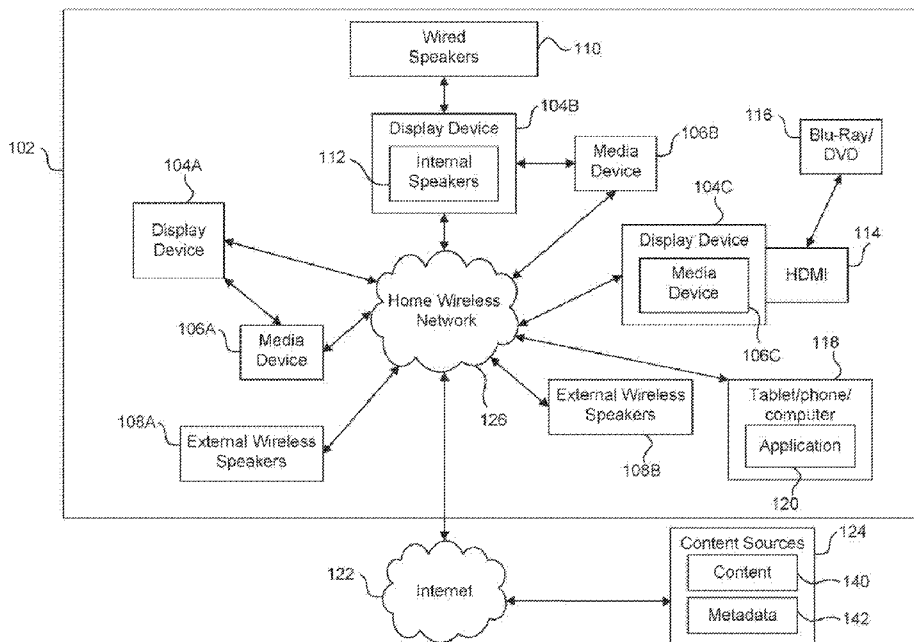


FIG. 1

(57) Abstract: Provided herein are system, apparatus, article of manufacture, method and/or computer program product embodiments, and/or combinations and sub-combinations thereof, for synchronizing playback of audio and video associated with a content, such as a movie or TV show. Also provided herein are system, apparatus, article of manufacture, method and/or computer program product embodiments, and/or combinations and sub-combinations thereof, for coordinating devices in a whole home entertainment system that includes a wireless network, to improve collective utilization of the wireless network and thereby enhance user experience.



UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

ADAPTIVE SWITCHING IN A WHOLE HOME ENTERTAINMENT SYSTEM

BACKGROUND

FIELD

[0001] This disclosure is generally directed to adaptively switching among video encodings in a whole home entertainment system having wireless speakers for playing audio, where the video encodings and audio are associated with content, such as a movie or TV show.

BACKGROUND

[0002] When playing content on a TV, such as a movie or TV show, the playback of audio should be synchronized with the playback of the corresponding video. Otherwise, the user's viewing experience can be greatly diminished.

[0003] But, synchronizing audio and video can be a challenge with whole home entertainment systems where a wireless network is used to provide content to the TV, and the same wireless network is used to transmit audio associated with the content to wireless speakers. In such environments, playback of the audio may not be in sync with the video due to transmission delays caused by the wireless network. This technical problem has been exacerbated by the advent of high definition (HD) video (such as 4K and even higher quality video), since wirelessly transmitting such massive amounts of video data pushes the capabilities of the wireless network.

SUMMARY

[0004] Provided herein are system, apparatus, article of manufacture, method and/or computer program product embodiments, and/or combinations and sub-combinations thereof, for synchronizing playback of audio and video associated with a content, such as a movie or TV show. Accordingly, embodiments described herein endeavor to provide a synchronized, uninterrupted (that is, little or no audio dropouts) playback experience with reduced (or minimum) end-to-end latency between the video playback device (such as a TV) and the audio playback device (such as a speaker).

[0005] Some embodiments operate by: analyzing a wireless network to characterize a current state of the wireless network; based on the analysis, selecting a video encoding

associated with the content; requesting the content from a content source, wherein the requested content comprises the selected video encoding and the audio; receiving the requested content from the content source via the wireless network; buffering the video encoding in a buffer; transmitting the audio to wireless speakers via the wireless network; playing the video encoding on a display device from the buffer; playing the audio on the wireless speakers; and repeating the foregoing to adaptively switch between video encodings of the content based on the current state of the wireless network, to thereby maintain synchronization of playback of the audio and video.

[0006] Also provided herein are system, apparatus, article of manufacture, method and/or computer program product embodiments, and/or combinations and sub-combinations thereof, for coordinating devices in a whole home entertainment system that includes a wireless network, to improve collective utilization of the wireless network and thereby enhance user experience.

[0007] Some embodiments operate by: analyzing a wireless network to characterize a current state of the wireless network; based on the analysis, performing one or more actions to coordinate operation of electronic devices in the whole home entertainment system to thereby improve collective utilization of the wireless network, and causing the electronic devices to operate according to the actions. The actions include any combination of:

- requiring that content be obtained from a source that does not require the wireless network for delivery;
- requiring that a lower resolution video encoding of content be requested, when the content is to be delivered via the wireless network;
- requiring that internal speakers or wired external speakers be used for audio playback; and
- requiring that a lower resolution encoding of audio be used, when the audio is to be transmitted via the wireless network to wireless speakers.

BRIEF DESCRIPTION OF THE FIGURES

[0008] The accompanying drawings are incorporated herein and form a part of the specification.

- [0009] FIG. 1 illustrates a block diagram of a whole home entertainment system, according to some embodiments.
- [0010] FIG. 2 illustrates a block diagram of a display device, according to some embodiments.
- [0011] FIG. 3 illustrates a flowchart for playing video and audio associated with content (such as a movie or TV show) in a whole home entertainment system, where wireless speakers are used to play the audio, according to some embodiments.
- [0012] FIG. 4 illustrates a flowchart for adaptively switching among video encodings in a whole home entertainment system having wireless speakers for playing audio, where the video encodings and audio are associated with content, according to some embodiments.
- [0013] FIG. 5 illustrates a flowchart for coordinating the operation of devices in a whole home entertainment system (such as TVs, media players, wireless speakers, etc.), where at least some of the devices are wirelessly communicating with each other over a wireless network, to improve the collective utilization of the wireless network, according to some embodiments.
- [0014] FIG. 6 illustrates an example computer system useful for implementing various embodiments.
- [0015] In the drawings, like reference numbers generally indicate identical or similar elements. Additionally, generally, the left-most digit(s) of a reference number identifies the drawing in which the reference number first appears.

DETAILED DESCRIPTION

- [0016] FIG. 1 illustrates a block diagram of a whole home entertainment system 102, according to some embodiments. In a non-limiting example, whole home entertainment system 102 is directed to playing content such as movies, TV shows, games, audio books, and music, to name just some examples. System 102 may be located in a user's home or any other location, such as a business, a park, a stadium, a restaurant, a bar, or a government office, to name just some examples.
- [0017] Whole home entertainment system 102 may include one or more display devices 104. Each display device 104 may include a video display (not shown) for playing video associated with content. Also, at least some of the display devices 104 may include internal speakers 112 for playing audio associated with content. Display devices 104 may

be any combination of monitors, televisions (TVs), computers, smart phones, tablets, wearables (such as a watch), appliances, and/or projectors, to name just some examples.

- [0018]** Each display device 104 may be connected to a media device 106. Each media device 106 may be separate from its respective display device 104, or may be part of or integrated with the display device 104.
- [0019]** Each media device 106 may be a streaming media device that may stream content from content sources 124, and may provide such content to its respective display device 104 for playback to users. For example, a given media device 106 may communicate via a home (or local) wireless network 126 to stream content from content sources 124 via the Internet 122. Wireless network 126 may be any wireless network, wireless medium or communication protocol such as WIFI, Bluetooth, infrared, cellular, etc., or any combination thereof.
- [0020]** Each content source 124 may store content 140 and metadata 142. Content 140 may include any combination of music, videos, movies, TV programs, multimedia, images, still pictures, text, graphics, gaming applications, advertisements, programming content, public service content, government content, local community content, software, and/or any other content or data objects in electronic form. Metadata 142 may include data about content 140. For example, metadata 142 may include associated or ancillary information indicating or related to writer, director, producer, composer, artist, actor, summary, chapters, production, history, year, trailers, alternate versions, related content, applications, and/or any other information pertaining or relating to the content 140. Metadata 142 may also or alternatively include links to any such information pertaining or relating to the content 140. Metadata 142 may also or alternatively include one or more indexes of content 140, such as but not limited to a trick mode index.
- [0021]** Each display device 104 may receive content for playback from any number of other devices, such as a Blu-Ray/DVD player 116 connected via a HDMI port 114. Each display device 104 may also or alternatively wirelessly receive content from devices over the home wireless network 126, such as from tablets, computers and/or phones 118.
- [0022]** As noted above, some or all of display devices 104 may include internal speakers 112, and may play audio associated with content using the internal speakers 112. Additionally or alternatively, at least some display devices 104 may play audio using external speakers. In some embodiments, external speakers are wireless speakers 108 that wirelessly communicate with the display devices 104 and/or media devices 106 via the

home wireless network 126. It is noted that, while embodiments are described herein as operating with speakers, this disclosure is not so limited. Instead, embodiments may operate with any electronic device that is enabled for wireless communication (either directly or through another device) and useable for audio playback, such as but not limited to soundbars, TVs, set top boxes, computers, tablets, phones, appliances, internet of things (IOT) devices, wearables, digital assistants, etc.

- [0023]** FIG. 2 illustrates an example media player 106, according to some embodiments. The media player 106 may include one or more video processing modules 202, and one or more audio processing modules 204.
- [0024]** Each video processing module 202 may be configured to decode, encode and/or translate video of one or more video formats, such as but not limited to MP4 (mp4, m4a, m4v, f4v, f4a, m4b, m4r, f4b, mov), 3GP (3gp, 3gp2, 3g2, 3gpp, 3gpp2), OGG (ogg, oga, ogv, ogx), WMV (wmv, wma, asf), WEBM, FLV, AVI, QuickTime, HDV, MXF (OP1a, OP-Atom), MPEG-TS, MPEG-2 PS, MPEG-2 TS, WAV, Broadcast WAV, LXF, GXF, and/or VOB, to name just some examples. Each video processing module 202 may include one or more video codecs, such as but not limited to H.263, H.264, HEV, MPEG1, MPEG2, MPEG-TS, MPEG-4, Theora, 3GP, DV, DVCPRO, DVCPRO, DVCPProHD, IMX, XDCAM HD, XDCAM HD422, and/or XDCAM EX, to name just some examples.
- [0025]** Similarly, each audio processing module 204 may be configured to decode, encode and/or translate audio of one or more audio formats, such as but not limited to AAC, HE-AAC, AC3 (Dolby Digital), EAC3 (Dolby Digital Plus), WMA, WAV, PCM, MP3, OGG GSM, FLAC, AU, AIFF, and/or VOX, to name just some examples.
- [0026]** Media device 106 may also include buffer 206 for buffering video, as well as other types of data. The size of the buffer 206 may be implementation dependent and may depend on the amount of video that is desired to be stored. For example, to buffer one minute of video at 720p at 30 frames per second (FPS), the buffer 206 may be at least 60 megabytes (MB). To buffer one minute of video at 1080p at 30 FPS, the buffer 206 may be at least 130 MB. To buffer one minute of video at 4K at 30 FPS, the buffer 206 may be at least 375 MB.
- [0027]** Media device 106 may also include an adaptive switching module 208. The operation of the adaptive switching module 208 is described below.

- [0028]** In some embodiments, any of display devices 104 may also or alternatively include video processing modules 202, audio processing modules 204, buffers 206, and/or adaptive switching modules 208. Accordingly, any of display device(s) 104 may also or alternatively perform the functions of media device(s) 106 described herein, and the reverse is also true.
- [0029]** As noted above, some display devices 104 may play audio associated with content using wireless speakers 108 by wirelessly transmitting the audio to wireless speakers 108 via the home wireless network 126. In some embodiments, the audio may be wirelessly transmitted via the home wireless network 126 by the corresponding media device 106 rather than the display device 104.
- [0030]** In the whole home entertainment system 102, a technical problem may exist because the wireless speakers 108 may be delayed in receiving the audio due to latencies, delays and/or other issues related to the home wireless network 126. Such delays may result in the playback of the video by a display device 104 being out of sync with the playback of the audio on the wireless speakers 108. That is, playback of the audio may lag playback of the video. Such unsynchronized audio and video playback may greatly degrade the user's viewing experience of the content. This technical problem has been exacerbated by the advent of high definition (HD) video (such as 4K and even higher quality video), since wirelessly transmitting such massive amounts of video data may challenge the capabilities of the home wireless network 126.
- [0031]** In some cases, this technical problem may be addressed by buffering the video at the display device 104 and/or the media device 106 (using buffer 206) prior to playback of the video on the display device 104. Such operation is shown in method 302 of FIG. 3. Method 302 can be performed by processing logic that can comprise hardware (e.g., circuitry, dedicated logic, programmable logic, microcode, etc.), software (e.g., instructions executing on a processing device), or a combination thereof. It is to be appreciated that not all steps may be needed to perform the disclosure provided herein. Further, some of the steps may be performed simultaneously, or in a different order than shown in FIG. 3, as will be understood by a person of ordinary skill in the art. Method 302 shall be described with reference to FIGS. 1 and 2. However, method 302 is not limited to those example embodiments.

- [0032] In 304, a media device 106 (such as, for example purposes, media device 106A) may receive content (that includes both video and audio) via the home wireless network 126 from a source, such as from tablet/computer/phone 118 and/or content source 124.
- [0033] In 306, the media device 106A may decode the video using video processing module(s) 202, and may buffer the decoded video in buffer 206 to compensate for the expected delay in transmitting the audio to wireless speakers 108 (such as, for example purposes, wireless speakers 108A) via the home wireless network 126.
- [0034] In 308, the media device 106A may decode the audio using audio processing module(s) 204, and may transmit the decoded audio to wireless speakers 108A via the home wireless network 126. It is noted that step 308 may be performed before, or simultaneously with, step 306.
- [0035] In some embodiments, the media device 106A may prioritize the transmission of the audio to wireless speakers 108A over home wireless network 126. The media device 106A may utilize any well-known approach or technique to implement such prioritization. For example, if the wireless network 126 is a WIFI network, traffic may be prioritized in a well-known manner based on MAC address or IP address. Also or alternatively, traffic may be prioritized by transmitting the audio without waiting the standard delay(s) associated with WIFI protocols.
- [0036] In 310, the media device 106A may provide the video from the buffer 206 to the associated display device 104A for playback. Also, in 312, the audio may be played by the wireless speakers 108A. Because playback of the video was delayed by buffering in the buffer 206, playback of the audio and video is synchronized. But, this synchronization will be achieved only if the buffering was for an amount equal to (or substantially equal to) the transmission delay caused by the home wireless network 126. This approach may not be possible with HD video such as 1080p and 4K. Because such HD video is composed of a large amount of data, the buffer 206 may not be large enough to store enough video to compensate for the transmission delay caused by the home wireless network 126. (Note that this technical problem does not exist when the content is being obtained from a source that is directly connected to a display device 104, such as Blu-Ray/DVD player 116 connected to display device 104C via HDMI port 114.)
- [0037] Embodiments of this disclosure employ various techniques to address and solve this technical problem. For example, some embodiments dynamically adjust the resolution of the video being requested and received over the home wireless network 126

(from tablet/computer/phone 118 and/or content source 124, for example) based on the current condition of the home wireless network 126. In particular, some embodiments request a lower resolution encoding of the video (such as, for example, 1080p or 720p rather than 4K) based on the current condition of the home wireless network 126. Such operation is depicted in method 402 of FIG. 4.

[0038] Method 402 can be performed by processing logic that can comprise hardware (e.g., circuitry, dedicated logic, programmable logic, microcode, etc.), software (e.g., instructions executing on a processing device), or a combination thereof. It is to be appreciated that not all steps may be needed to perform the disclosure provided herein. Further, some of the steps may be performed simultaneously, or in a different order than shown in FIG. 4, as will be understood by a person of ordinary skill in the art. Method 402 shall be described with reference to FIGS. 1 and 2. However, method 402 is not limited to those example embodiments.

[0039] In 404, the adaptive switching module 208 in a media device 106 (such as, for example purposes, media device 106A) may analyze the home wireless network 126 to determine and characterize the wireless link between its media device 106A (or the corresponding display device 104A) and the wireless speakers 108 being used by the media device 106A to play audio (assume, for example purposes, that the media device 106A is using wireless speakers 108A to play audio). To perform this function, the adaptive switching module 208 may use any well-known techniques, algorithms, services, tools, modules and/or approaches for evaluating the state and condition of a wireless medium, and may take into consideration factors such as bandwidth, traffic, congestion, collisions, latency, utilization, signal strength, the number of devices on a given channel, etc.

[0040] For example, the adaptive switching module 208 may monitor the traffic over the link between the media device 106A and the wireless speakers 108A for the presence or absence of acknowledgements (ACKS) sent by the wireless speakers 108A after successful receipt of frames containing audio data. As will be appreciated by persons skilled in the relevant art(s), the presence or absence of such ACKS can be analyzed by the adaptive switching module 208 to at least partially determine and characterize the wireless link between the media device 106A and the wireless speakers 108A.

[0041] In performing step 404, the adaptive switching module 208 may take into consideration the potential impact on the home wireless network 126 of downloading

various video encodings having different resolutions of the same content, such as 4K versus 1080p versus 720p, etc. As will be appreciated by persons skilled in the relevant art(s), downloading higher definition encodings is more likely to cause transmission delays over the home wireless network 126, relative to downloading lower definition encodings.

[0042] In 406, based on the current state of the wireless link between the media device 106A and the wireless speakers 108 (as determined in step 404), the adaptive switching module 208 may select an encoding of the video to request from the content source (such as content source 124 or tablet/phone/computer 118). The adaptive switching module 208, in step 406, may select a video encoding that would not cause transmission delays over the home wireless network 126 (that is, the link between the media device 106A and the wireless speakers 108A) in excess of the buffering capacity of buffer 206. For example, if the buffer 206 can buffer one second of a particular video encoding (of a given resolution), then the adaptive switching module 208 would select that video encoding only if downloading such encoding over the home wireless network 126 would cause transmission delays between the media device 106A and the wireless speakers 108A of less than one second.

[0043] As will be appreciated by persons skilled in the relevant art(s), audio that is out of sync with video by a small amount (such as 50-100 milliseconds) is not perceivable by most humans. This may be called herein the threshold of non-perception. Thus, in the above example, the adaptive switching module 208 in 406 would select a given encoding of video only if downloading such encoding over the home wireless network 126 would cause transmission delays between the media device 106A and the wireless speakers 108A of less than one second plus the threshold of non-perception (that is, one second plus 50 – 100 milliseconds, in the above example).

[0044] In some cases, buffering may not be available at either the media device 106A or the corresponding display device 104A. In such cases, the adaptive switching module 208 in 406 would select a given encoding of video only if downloading such encoding over the home wireless network 126 would cause transmission delays between the media device 106A and the wireless speakers 108A of less than the threshold of non-perception.

[0045] In 408, the adaptive switching module 208 may request content having the selected video encoding from the content source (such as content source 124 or tablet/phone/computer 118).

- [0046] In 410, the media device 106A may receive the requested content (that includes both video and audio) via the home wireless network 126 from the content source.
- [0047] In 412, the media device 106A may decode the video using video processing module(s) 202, and may buffer the decoded video in buffer 206 to compensate for the expected delay in transmitting the audio to wireless speakers 108A via the home wireless network 126.
- [0048] In 414, the media device 106A may decode the audio using audio processing module(s) 204, and may transmit the decoded audio to wireless speakers 108A via the home wireless network 126. It is noted that step 414 may be performed before, or simultaneously with, step 412. In some embodiments, the media device 106A may prioritize the transmission of the audio to wireless speakers 108A over home wireless network 126, as described above.
- [0049] In 416, the media device 106A may provide the video from the buffer 206 to the associated display device 104A for playback. Also, in 418, the audio may be played by the wireless speakers 108A. Because the video encoding was selected (in steps 406 and 408) based on the current state of the wireless link between its media device 106A and the wireless speakers 108 (and also optionally because the video was buffered in step 412), playback of the audio and video is synchronized.
- [0050] After step 418, control may return to step 404, wherein the condition of the home wireless network 126 may be reevaluated. Then, based on this reevaluated, current condition of the wireless network 126, the video encoding being requested and downloaded from the content source may be adjusted (in steps 406 and 408). In other words, either a lower or higher resolution encoding of the video may be requested from the content source. In this manner, embodiments adaptively and continuously switch between video encodings, so as to maintain synchronization of audio and video playback.
- [0051] In some embodiments, such switching between video encodings may occur at 2 second intervals of the video, since video is typically encoded in 2 second chunks. More generally, such switching between video encodings may occur at the encoding granularity of the video, whether it be 2 second chunks or some other size.
- [0052] This disclosure is directed to other embodiments (in combination with the embodiments discussed herein) for synchronizing the playback of audio and video, such as those described in U.S. Patent Application No. 16/128,624 titled "Dynamically

Adjusting Video To Improve Synchronization With Audio,” filed September 12, 2018, which is herein incorporated by reference in its entirety.

[0053] As shown in the example of FIG. 1, whole home entertainment systems 102 may include more than one display device 104. Some of the display devices 104 may use internal speakers 112 for audio playback (such as display device 104B), and some may use external wireless speakers 108 (such as display devices 104A and 104C). Some display devices 104 may receive content via the home wireless network 126 (such as display devices 104A and 104B), and some may, at times, receive content from wired sources (such as display device 104C connected to Blu-Ray/DVD player 116).

[0054] According to some embodiments, the adaptive switching modules 208 in the media devices 106 may coordinate their operations so as to improve the collective utilization of the wireless network 126. Such operation is shown in method 502 of FIG. 5. Method 502 can be performed by processing logic that can comprise hardware (e.g., circuitry, dedicated logic, programmable logic, microcode, etc.), software (e.g., instructions executing on a processing device), or a combination thereof. It is to be appreciated that not all steps may be needed to perform the disclosure provided herein. Further, some of the steps may be performed simultaneously, or in a different order than shown in FIG. 5, as will be understood by a person of ordinary skill in the art. Method 502 shall be described with reference to FIGS. 1 and 2. However, method 502 is not limited to those example embodiments.

[0055] In 504, the adaptive switching module 208 in a media device 106 may analyze the home wireless network 126 to determine and characterize the home wireless network 126, including for example determining and characterizing any or all of the wireless links between the media devices 106 (or their respective display devices 104) and the wireless speakers 108 in the whole home entertainment system 102. To perform this function, the adaptive switching module 208 may use any well-known techniques, algorithms, services, tools, modules and/or approaches for evaluating the state and condition of a wireless medium, and may take into consideration factors such as bandwidth, traffic, congestion, collisions, latency, utilization, signal strength, the number of devices on a given channel, etc.

[0056] In performing step 504, the adaptive switching module 208 may take into consideration the potential impact on the home wireless network 126 of downloading various video encodings having different resolutions of the same content, such as 4K

versus 1080p versus 720p, etc. As will be appreciated by persons skilled in the relevant art(s), downloading higher definition encodings are more likely to cause delays in transmissions over the home wireless network 126, relative to downloading lower definition encodings.

[0057] The adaptive switching module 208 may also or alternatively take into consideration the potential impact on the home wireless network 126 of using wireless speakers 108 versus internal speakers 112, obtaining content via wired connections (such as from Blu-Ray/DVD 116) versus via the wireless network 126 (such as from content sources 124 or tablet/phone/computer 118), using lower rather than higher resolution audio encodings when wireless speakers 108 are being used to playback audio, etc.

[0058] Step 504 (and also step 506, described below) can be performed by the adaptive switching modules 208 in any or all of the media devices 106, or can be performed by the adaptive switching module 208 in a single one of the media devices 106 (which may be designated as the master adaptive switching module 208). For purposes of illustration and not limitation, assume that the adaptive switching module 208 in media device 106A is performing 504 and 506.

[0059] In 506, based on the analysis of the home wireless network 126 performed in 504, the adaptive switching module 208 in media device 106A may command and coordinate the operation of the other devices in the whole home entertainment systems 102, so as to improve the collective utilization of the wireless network 126 and thereby enhance the viewing experience of the users of whole home entertainment systems 102. Example actions taken by the master adaptive switching module 208 in step 506 may include any combination of:

- Requiring a media device 106 to obtain content from a source that does not require the home wireless network 126 for delivery (such as from Blu-Ray/DVD player 116 that is connected to media device 106B via HDMI port 114) .
- Requiring a media device 126 to request a lower resolution video encoding of content, if the content is being delivered via the home wireless network 126 (from content sources 124 or tablet/phone/computer 118, for example). An embodiment for performing this operation is described above with reference to FIG. 4.
- Requiring a media device 126 to use its internal speakers 112 or wired external speakers 110 for audio playback.

- Requiring a media device 126 to use a lower resolution encoding of audio, if the audio is being transmitted via the home wireless network 126 to wireless speakers 108 for playback. The media device 126 may generate the lower resolution encoding of the audio from the received content using its audio processing module(s) 204, in a well-known manner.

[0060] In 508, the devices in the whole home entertainment systems 102 may operate as commanded (from step 506) when performing user commands. For example, if so commanded, media device 106C in display device 104C will obtain content from Blu-Ray/DVD player 116 rather than from a source over the home wireless network 126. If so commanded, media device 106A will request a 720p video encoding of content, rather than 4k or 1020p. If so commanded, display device 104B will use its internal speakers 112 or wired external speakers 110 for audio playback, rather than access a wireless speaker 108 via the home wireless network 126. If so commanded, tablet/phone/computer 118 will request a lower resolution video encoding and/or use its internal speakers when playing content (in doing so, tablet/phone/computer 118 may operate according to an application 120 which functions as an adaptive switching module 208, and in this context, the tablet/phone/computer 118 may be considered to be a media device 106 and/or a display device 104).

[0061] The master adaptive switching module 208 in media device 106A may allow other devices to download higher resolution video and/or use wireless speakers 108 for playback. In this manner, the master adaptive switching module 208 coordinates the operations of the devices in the whole home entertainment system 102 so as to improve the collective utilization of the wireless network 126, and thereby enhance the experience for all of the users.

[0062] After step 508, control may return to step 504, wherein the condition of the home wireless network 126 may be reevaluated. Then, based on this reevaluated, current condition of the wireless network 126, the master adaptive switching module 208 may modify its commands to the other devices in the whole home entertainment system 102 (in step 506). In this manner, embodiments adaptively and continuously coordinate the operation of the devices in the whole home entertainment system 102, to improve collective utilization of the home wireless network 126 and thereby improvement the user experience.

Example Computer System

- [0063]** Various embodiments and/or components therein can be implemented, for example, using one or more computer systems, such as computer system 600 shown in FIG. 6. Computer system 600 can be any computer or computing device capable of performing the functions described herein. For example, one or more computer systems 600 or portions thereof can be used to implement any embodiments of FIGS. 1-5, and/or any combination or sub-combination thereof.
- [0064]** Computer system 600 includes one or more processors (also called central processing units, or CPUs), such as a processor 604. Processor 604 is connected to a communication infrastructure or bus 606.
- [0065]** One or more processors 604 can each be a graphics processing unit (GPU). In some embodiments, a GPU is a processor that is a specialized electronic circuit designed to process mathematically intensive applications. The GPU can have a parallel structure that is efficient for parallel processing of large blocks of data, such as mathematically intensive data common to computer graphics applications, images, videos, etc.
- [0066]** Computer system 600 also includes user input/output device(s) 603, such as monitors, keyboards, pointing devices, etc., that communicate with communication infrastructure 606 through user input/output interface(s) 602.
- [0067]** Computer system 600 also includes a main or primary memory 608, such as random access memory (RAM). Main memory 608 can include one or more levels of cache. Main memory 608 has stored therein control logic (i.e., computer software) and/or data.
- [0068]** Computer system 600 can also include one or more secondary storage devices or memory 610. Secondary memory 610 can include, for example, a hard disk drive 612 and/or a removable storage device or drive 614. Removable storage drive 614 can be a floppy disk drive, a magnetic tape drive, a compact disk drive, an optical storage device, tape backup device, and/or any other storage device/drive.
- [0069]** Removable storage drive 614 can interact with a removable storage unit 618. Removable storage unit 618 includes a computer usable or readable storage device having stored thereon computer software (control logic) and/or data. Removable storage unit 618 can be a floppy disk, magnetic tape, compact disk, DVD, optical storage disk, and/ any

other computer data storage device. Removable storage drive 614 reads from and/or writes to removable storage unit 618 in a well-known manner.

[0070] According to an exemplary embodiment, secondary memory 610 can include other means, instrumentalities or other approaches for allowing computer programs and/or other instructions and/or data to be accessed by computer system 600. Such means, instrumentalities or other approaches can include, for example, a removable storage unit 622 and an interface 620. Examples of the removable storage unit 622 and the interface 620 can include a program cartridge and cartridge interface (such as that found in video game devices), a removable memory chip (such as an EPROM or PROM) and associated socket, a memory stick and USB port, a memory card and associated memory card slot, and/or any other removable storage unit and associated interface.

[0071] Computer system 600 can further include a communication or network interface 624. Communication interface 624 enables computer system 600 to communicate and interact with any combination of remote devices, remote networks, remote entities, etc. (individually and collectively referenced by reference number 628). For example, communication interface 624 can allow computer system 600 to communicate with remote devices 628 over communications path 626, which can be wired and/or wireless, and which can include any combination of LANs, WANs, the Internet, etc. Control logic and/or data can be transmitted to and from computer system 600 via communication path 626.

[0072] In some embodiments, a non-transitory, tangible apparatus or article of manufacture comprising a tangible computer useable or readable medium having control logic (software) stored thereon is also referred to herein as a computer program product or program storage device. This includes, but is not limited to, computer system 600, main memory 608, secondary memory 610, and removable storage units 618 and 622, as well as tangible articles of manufacture embodying any combination of the foregoing. Such control logic, when executed by one or more data processing devices (such as computer system 600), causes such data processing devices to operate as described herein.

[0073] Based on the teachings contained in this disclosure, it will be apparent to persons skilled in the relevant art(s) how to make and use embodiments of this disclosure using data processing devices, computer systems and/or computer architectures other than that shown in FIG. 6. In particular, embodiments can operate with software, hardware, and/or operating system implementations other than those described herein.

Conclusion

- [0074] It is to be appreciated that the Detailed Description section, and not the Summary and Abstract sections, is intended to be used to interpret the claims. The Summary and Abstract sections can set forth one or more but not all exemplary embodiments as contemplated by the inventors, and thus, are not intended to limit this disclosure or the appended claims in any way.
- [0075] While this disclosure describes exemplary embodiments for exemplary fields and applications, it should be understood that the disclosure is not limited thereto. Other embodiments and modifications thereto are possible, and are within the scope and spirit of this disclosure. For example, and without limiting the generality of this paragraph, embodiments are not limited to the software, hardware, firmware, and/or entities illustrated in the figures and/or described herein. Further, embodiments (whether or not explicitly described herein) have significant utility to fields and applications beyond the examples described herein.
- [0076] Embodiments have been described herein with the aid of functional building blocks illustrating the implementation of specified functions and relationships thereof. The boundaries of these functional building blocks have been arbitrarily defined herein for the convenience of the description. Alternate boundaries can be defined as long as the specified functions and relationships (or equivalents thereof) are appropriately performed. Also, alternative embodiments can perform functional blocks, steps, operations, methods, etc. using orderings different than those described herein.
- [0077] References herein to “one embodiment,” “an embodiment,” “an example embodiment,” or similar phrases, indicate that the embodiment described can include a particular feature, structure, or characteristic, but every embodiment can not necessarily include the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it would be within the knowledge of persons skilled in the relevant art(s) to incorporate such feature, structure, or characteristic into other embodiments whether or not explicitly mentioned or described herein. Additionally, some embodiments can be described using the expression “coupled” and “connected” along with their derivatives. These terms are not necessarily intended as synonyms for each other. For example, some embodiments can be described

using the terms “connected” and/or “coupled” to indicate that two or more elements are in direct physical or electrical contact with each other. The term “coupled,” however, can also mean that two or more elements are not in direct contact with each other, but yet still co-operate or interact with each other.

[0078] The breadth and scope of this disclosure should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims and their equivalents.

WHAT IS CLAIMED IS:

1. A media device for synchronizing playback of audio and video associated with a content, comprising:
 - a buffer; and
 - at least one processor configured to:
 - i. analyze a wireless network to characterize a current state of the wireless network;
 - ii. select a video encoding associated with the content based on the analysis;
 - iii. request the content from a content source, wherein the requested content comprises the selected video encoding and the audio;
 - iv. receive the requested content from the content source via the wireless network;
 - v. buffer the video encoding in the buffer;
 - vi. transmit the audio to wireless speakers via the wireless network;
 - vii. play the video encoding on a display device from the buffer;
 - viii. play the audio on the wireless speakers; and
 - ix. wherein (i)-(viii) are repeated to adaptively switch between video encodings of the content based on the current state of the wireless network, to thereby maintain synchronization of playback of the audio and video.
2. The media device of claim 1, wherein to analyze, the at least one processor is configured to:
 - analyze the wireless network to characterize a wireless link between the display device and the wireless speakers.
3. The media device of claim 1, wherein to analyze, the at least one processor is configured to:
 - analyze the wireless network by taking into consideration potential impact on the wireless network of downloading various video encodings of the content, the video encodings having different resolutions.

4. The media device of claim 1, wherein to select, the at least one processor is configured to:
select a video encoding that would not cause transmission delays over the wireless network in excess of a buffering capacity of the buffer.
5. A method for synchronizing playback of audio and video associated with a content, comprising:
 - a) analyzing a wireless network to characterize a current state of the wireless network;
 - b) selecting a video encoding associated with the content based on the analysis;
 - c) requesting the content from a content source, wherein the requested content comprises the selected video encoding and the audio;
 - d) receiving the requested content from the content source via the wireless network;
 - e) buffering the video encoding in a buffer;
 - f) transmitting the audio to wireless speakers via the wireless network;
 - g) playing the video encoding on a display device from the buffer;
 - h) playing the audio on the wireless speakers; and
 - i) repeating (a)-(h) to adaptively switch between video encodings of the content based on the current state of the wireless network, to thereby maintain synchronization of playback of the audio and video.
6. The method of claim 5, wherein the analyzing comprises:
analyzing the wireless network to characterize a wireless link between the display device and the wireless speakers.
7. The method of claim 5, wherein the analyzing comprises:
analyzing the wireless network by taking into consideration potential impact on the wireless network of downloading various video encodings of the content, the video encodings having different resolutions.

8. The method of claim 5, wherein the selecting comprises:
 - selecting a video encoding that would not cause transmission delays over the wireless network in excess of a buffering capacity of the buffer.

9. A tangible computer-readable device having instructions stored thereon that, when executed by at least one computing device, cause the at least one computing device to perform operations to synchronize playback of audio and video associated with a content, the operations comprising:
 - a) analyzing a wireless network to characterize a current state of the wireless network;
 - b) selecting a video encoding associated with content based on the analysis;
 - c) requesting the content from a content source, wherein the requested content comprises the selected video encoding and audio;
 - d) receiving the requested content from the content source via the wireless network;
 - e) buffering the video encoding in a buffer;
 - f) transmitting the audio to wireless speakers via the wireless network;
 - g) playing the video encoding on a display device from the buffer;
 - h) playing the audio on the wireless speakers; and
 - i) repeating (a)-(h) to adaptively switch between video encodings of the content based on the current state of the wireless network, to thereby maintain synchronization of playback of the audio and video.

10. The tangible computer-readable device of claim 9, wherein the analyzing comprises:
 - analyzing the wireless network to characterize a wireless link between the display device and the wireless speakers.

11. The tangible computer-readable device of claim 9, wherein the analyzing comprises:
 - analyzing the wireless network by taking into consideration potential impact on the wireless network of downloading various video encodings having different resolutions of the content.

12. The tangible computer-readable device of claim 9, wherein the selecting comprises:
selecting a video encoding that would not cause transmission delays over the wireless network in excess of a buffering capacity of the buffer.
13. A method for coordinating devices in a whole home entertainment system comprising a wireless network, to improve collective utilization of the wireless network and thereby enhance user experience, the method comprising:
 - a) analyzing a wireless network to characterize a current state of the wireless network;
 - b) based on the analysis, performing one or more actions to coordinate operation of electronic devices in the whole home entertainment system to thereby improve collective utilization of the wireless network, wherein the actions include any combination of:
 - i. requiring that content be obtained from a source that does not require the wireless network for delivery;
 - ii. requiring that a lower resolution video encoding of content be requested, when the content is to be delivered via the wireless network;
 - iii. requiring that internal speakers or wired external speakers be used for audio playback; and
 - iv. requiring that a lower resolution encoding of audio be used, when the audio is to be transmitted via the wireless network to wireless speakers; and
 - c) causing the electronic devices to operate according to the actions.
14. The method of claim 13, wherein the analyzing comprises:
analyzing the wireless network to characterize wireless links between display devices and wireless speakers.
15. The method of claim 13, wherein the analyzing comprises:
analyzing the wireless network by taking into consideration potential impact on the wireless network of downloading various video encodings having different resolutions of the content.

16. The method of claim 13, wherein a) – c) are repeated to adaptively coordinate the electronic devices to improve collective utilization of the wireless network and thereby enhance user experience.
17. A tangible computer-readable device having instructions stored thereon that, when executed by at least one computing device, cause the at least one computing device to perform operations comprising:
 - a) analyzing a wireless network to characterize a current state of a wireless network;
 - b) based on the analysis, performing one or more actions to coordinate operation of electronic devices in a whole home entertainment system to thereby improve collective utilization of the wireless network, wherein the actions include any combination of:
 - i. requiring that content be obtained from a source that does not require the wireless network for delivery;
 - ii. requiring that a lower resolution video encoding of content be requested, when the content is to be delivered via the wireless network;
 - iii. requiring that internal speakers or wired external speakers be used for audio playback; and
 - iv. requiring that a lower resolution encoding of audio be used, when the audio is to be transmitted via the wireless network to wireless speakers; and
 - c) causing the electronic devices to operate according to the actions.
18. The tangible computer-readable device of claim 17, wherein the analyzing comprises:

analyzing the wireless network to characterize wireless links between display devices and wireless speakers.
19. The tangible computer-readable device of claim 17, wherein the analyzing comprises:

analyzing the wireless network by taking into consideration potential impact on the wireless network of downloading various video encodings having different resolutions of the content.

20. The tangible computer-readable device of claim 17, wherein a) – c) are repeated to adaptively coordinate the electronic devices to improve collective utilization of the wireless network and thereby enhance user experience.

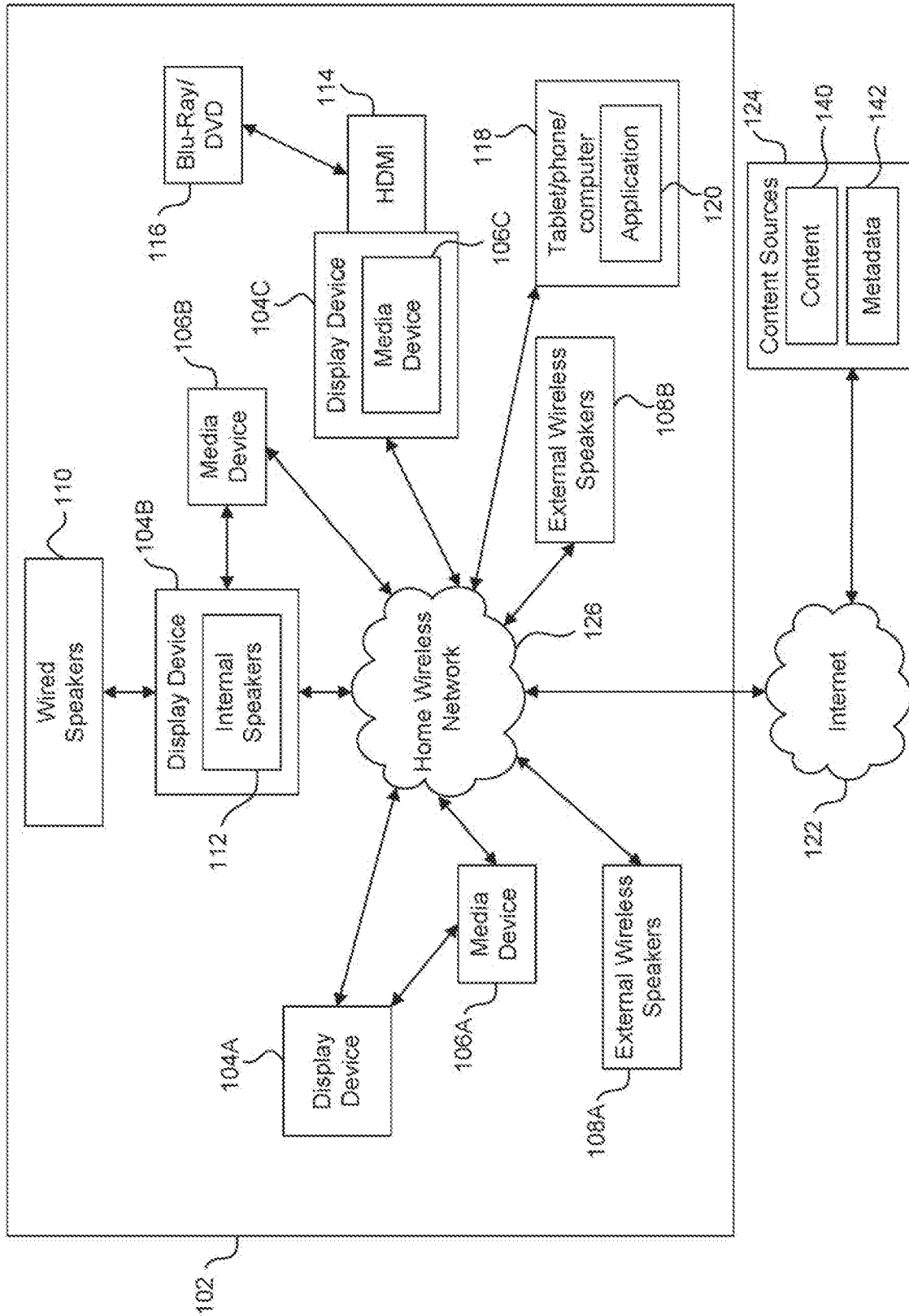


FIG. 1

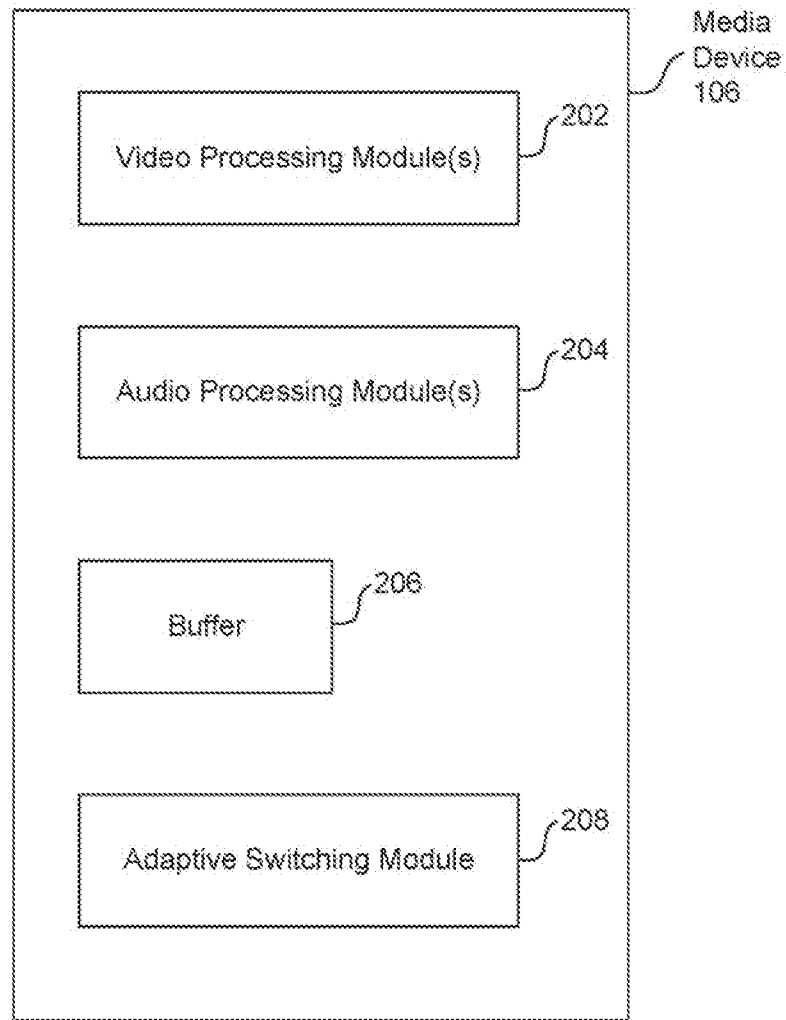


FIG. 2

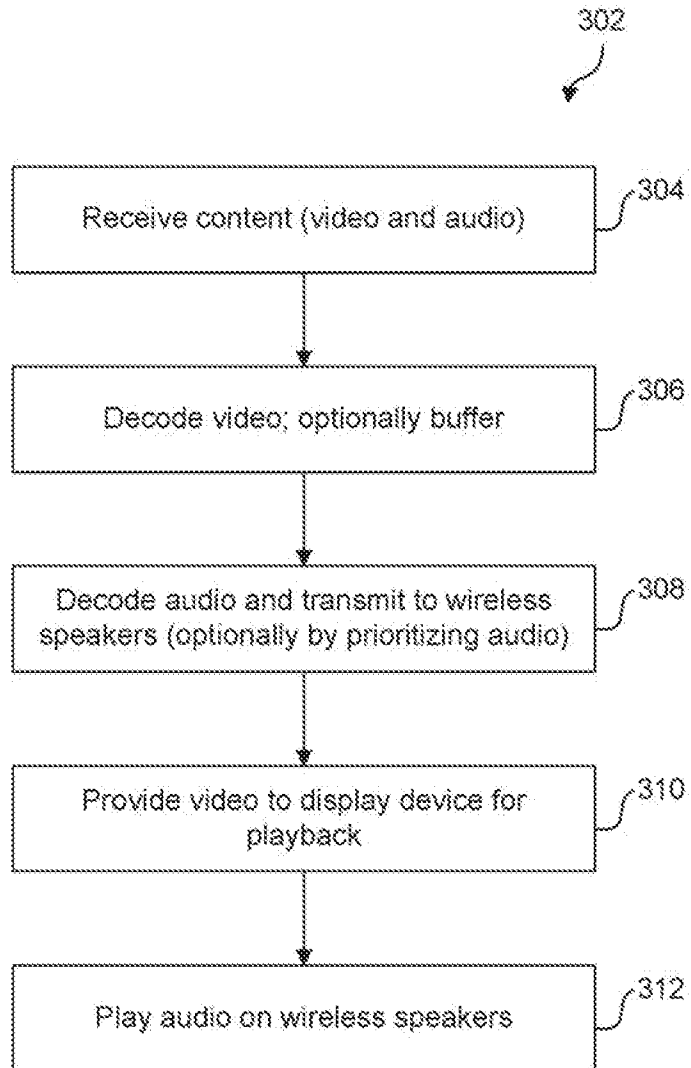


FIG. 3

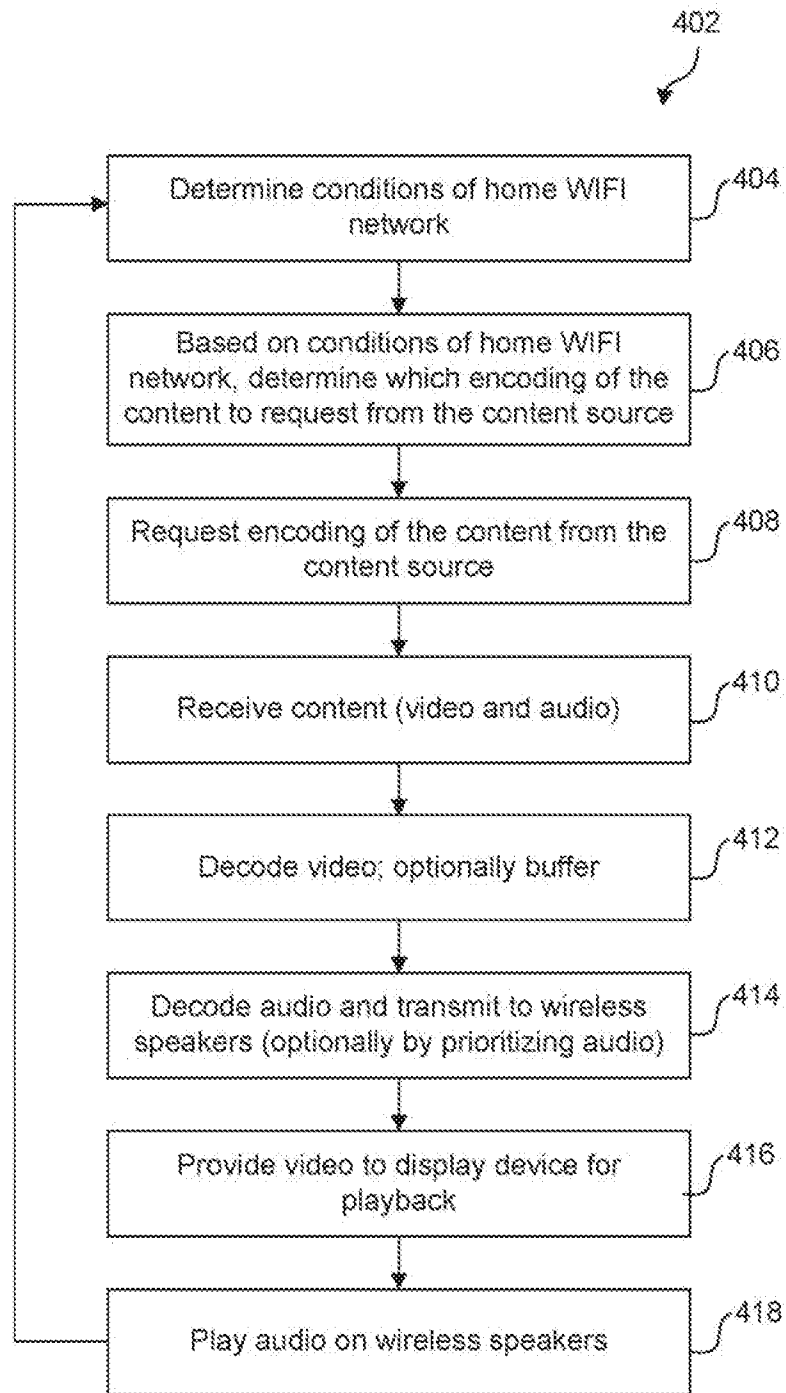


FIG. 4

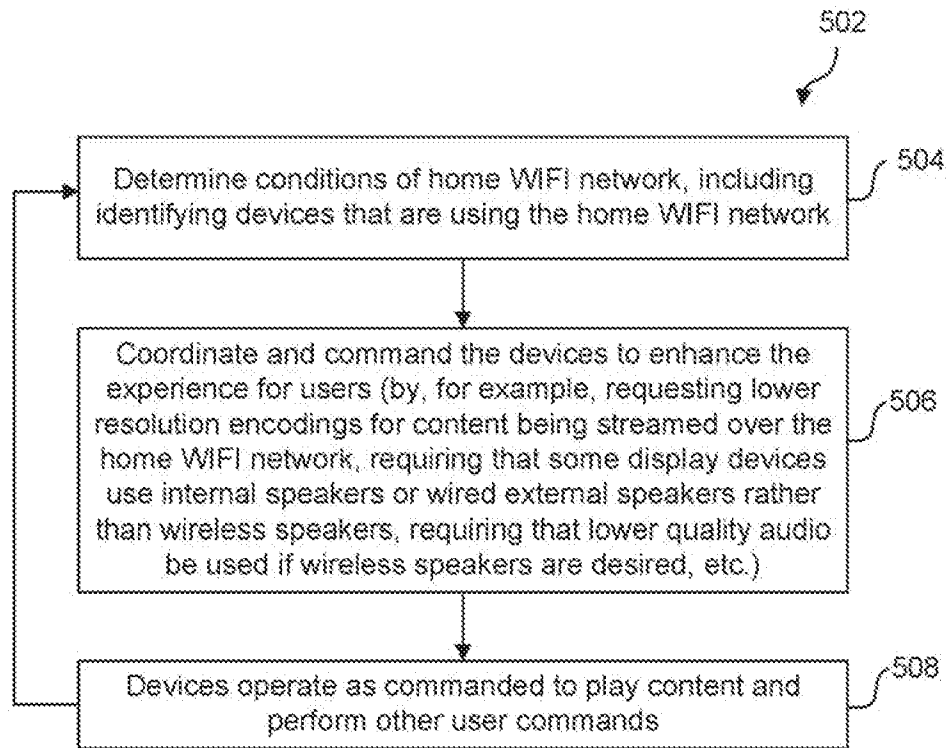


FIG. 5

Computer System 600

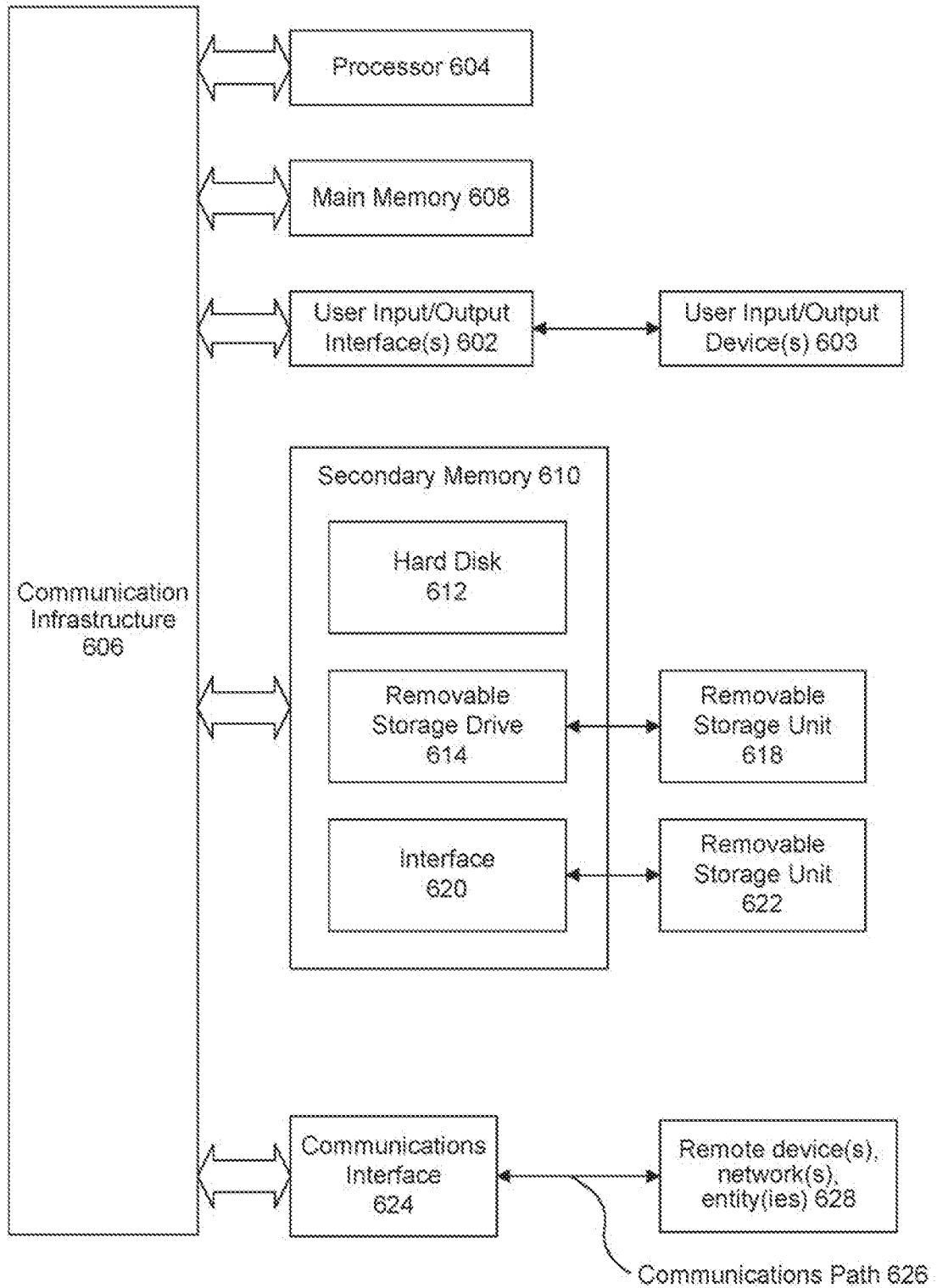


FIG. 6

A. CLASSIFICATION OF SUBJECT MATTER**H04N 21/43(2011.01)i, H04N 21/439(2011.01)i, H04N 21/4402(2011.01)i**

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04N 21/43; H04L 29/06; H04L 29/08; H04L 7/00; H04N 21/2387; H04N 7/15; H04W 48/08; H04W 88/06; H04N 21/439; H04N 21/4402

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

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: content, synchronizing, network, characterize, resolution

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2017-200319 A1 (SK TELECOM CO., LTD.) 23 November 2017 See paragraphs [0001], [0046]-[0047], [0074]-[0081], [0105]; and figures 1-4.	1-2,5-6,9-10
Y		3-4,7-8,11-20
Y	KR 10-1482515 B1 (AIRPLUG INC.) 16 January 2015 See paragraph [0080]; and figure 3.	3,7,11,13-20
Y	KR 10-1535827 B1 (SAMSUNG ELECTRONICS CO., LTD.) 27 July 2015 See claim 4; and figures 1-3.	4,8,12
A	KR 10-1538114 B1 (GACHON UNIVERSITY OF INDUSTRY-ACADEMIC COOPERATION FOUNDATION et al.) 23 July 2015 See paragraphs [0002], [0029]; claim 1; and figure 1.	1-20
A	US 2012-0182383 A1 (TOMMY WING CHAU KEE) 19 July 2012 See paragraphs [0044]-[0052]; and figure 3.	1-20

 Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents:

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

"D" document cited by the applicant in the international application

"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

24 December 2019 (24.12.2019)

Date of mailing of the international search report

24 December 2019 (24.12.2019)

Name and mailing address of the ISA/KR

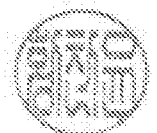
International Application Division
Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea

Facsimile No. +82-42-481-8578

Authorized officer

HWANG, Chan Yoon

Telephone No. +82-42-481-3347



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2019/050316

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2017-200319 A1	23/11/2017	CN 109314793 A	05/02/2019
		KR 10-2000084 B1	15/07/2019
		KR 10-2017-0130253 A	28/11/2017
		KR 10-2017-0130273 A	28/11/2017
		KR 10-2019-0084024 A	15/07/2019
		US 2019-0089761 A1	21/03/2019
KR 10-1482515 B1	16/01/2015	KR 10-2014-0100260 A	14/08/2014
KR 10-1535827 B1	27/07/2015	KR 10-2010-0064532 A	15/06/2010
		US 2010-0142927 A1	10/06/2010
		US 8873928 B2	28/10/2014
KR 10-1538114 B1	23/07/2015	None	
US 2012-0182383 A1	19/07/2012	CN 102710982 A	03/10/2012
		CN 102710982 B	16/03/2016
		EP 2480002 A2	25/07/2012
		EP 2480002 A3	09/10/2013
		EP 2887678 A2	24/06/2015
		EP 2887678 A3	30/09/2015
		HK 1169248 A1	23/12/2016
		KR 10-1355059 B1	24/01/2014
		KR 10-2012-0084686 A	30/07/2012
		TW 201246844 A	16/11/2012
		TW I547123 B	21/08/2016
US 8643696 B2	04/02/2014		