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(54) PERSONAL VIDEOCONFERENCING SYSTEM HAVING DISTRIBUTED PROCESSING ARCHITECTURE

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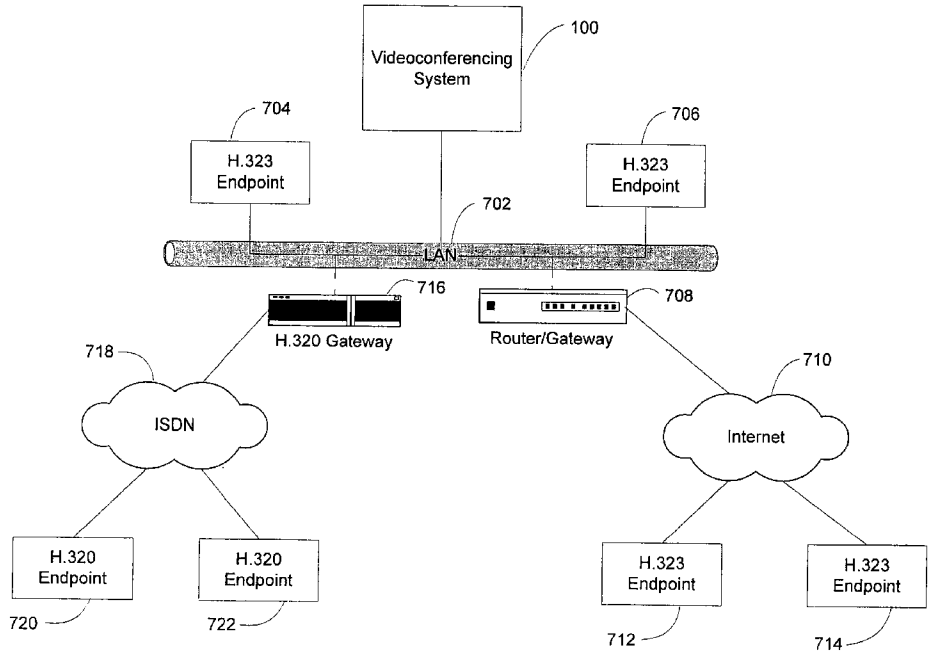
(57) **ABSTRACT**

A personal videoconferencing system includes a videoconferencing appliance connected to a personal computer through a Universal Serial Bus (USB) or similar connection. The appliance is provided with a video camera and microphone for generating local video and audio streams. The local video and audio streams are compressed by a video and audio encoder residing at the appliance, and the compressed video and audio streams are conveyed to the personal computer over the USB connection. The appliance may be further provided with an audio decoder for decompressing a remote audio stream received by the personal computer through a network interface and conveyed to the appliance via the USB connection. A video decoder, located on the personal computer, is configured to decompress the local video stream (received through the USB connection) as well as a remote video stream received through the network interface. The decompressed video streams are then sent to a monitor for display to a user. The decompressed audio stream may be played either at a loudspeaker coupled to the audio decoder or at the personal computer.



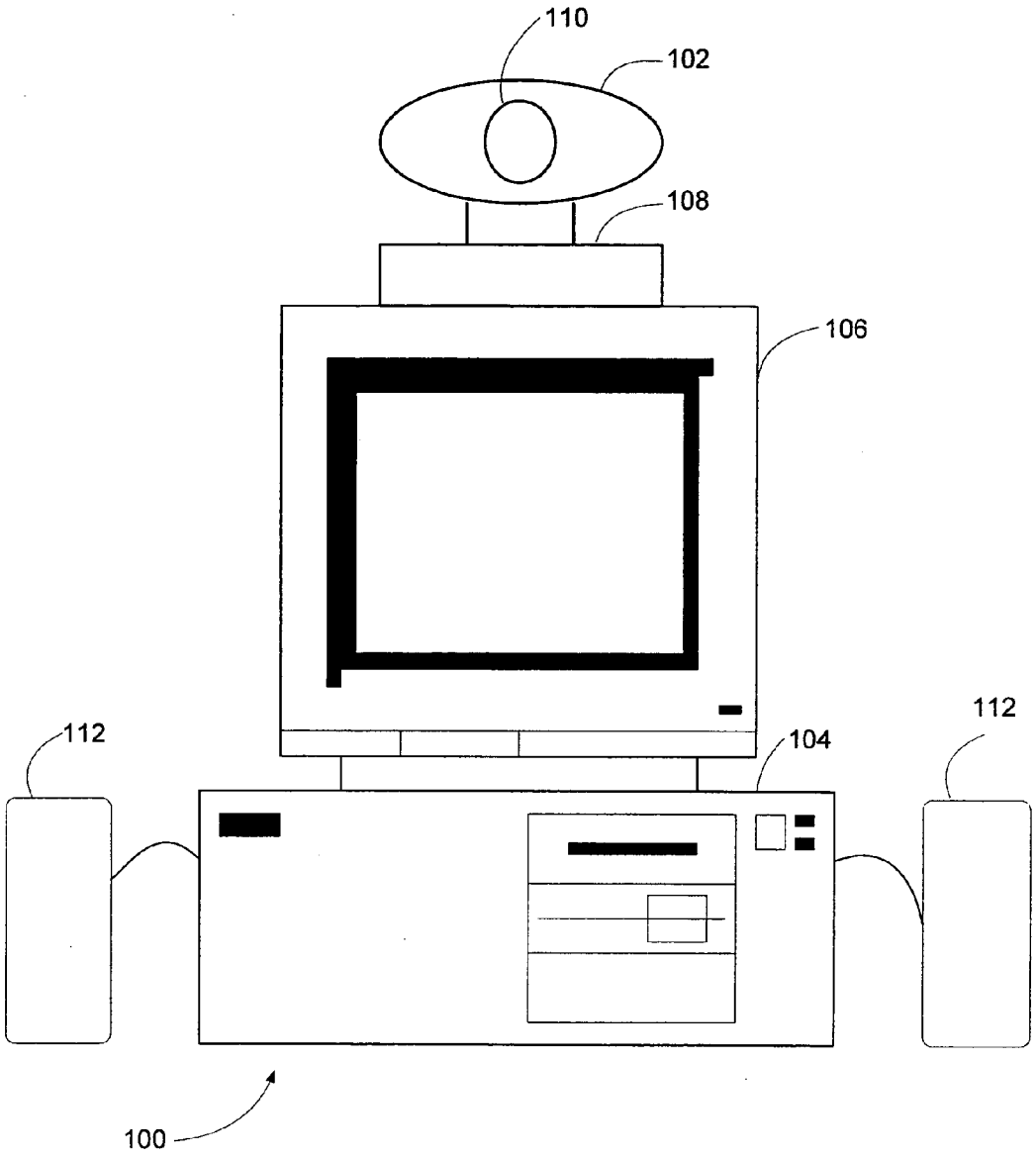


Fig. 1

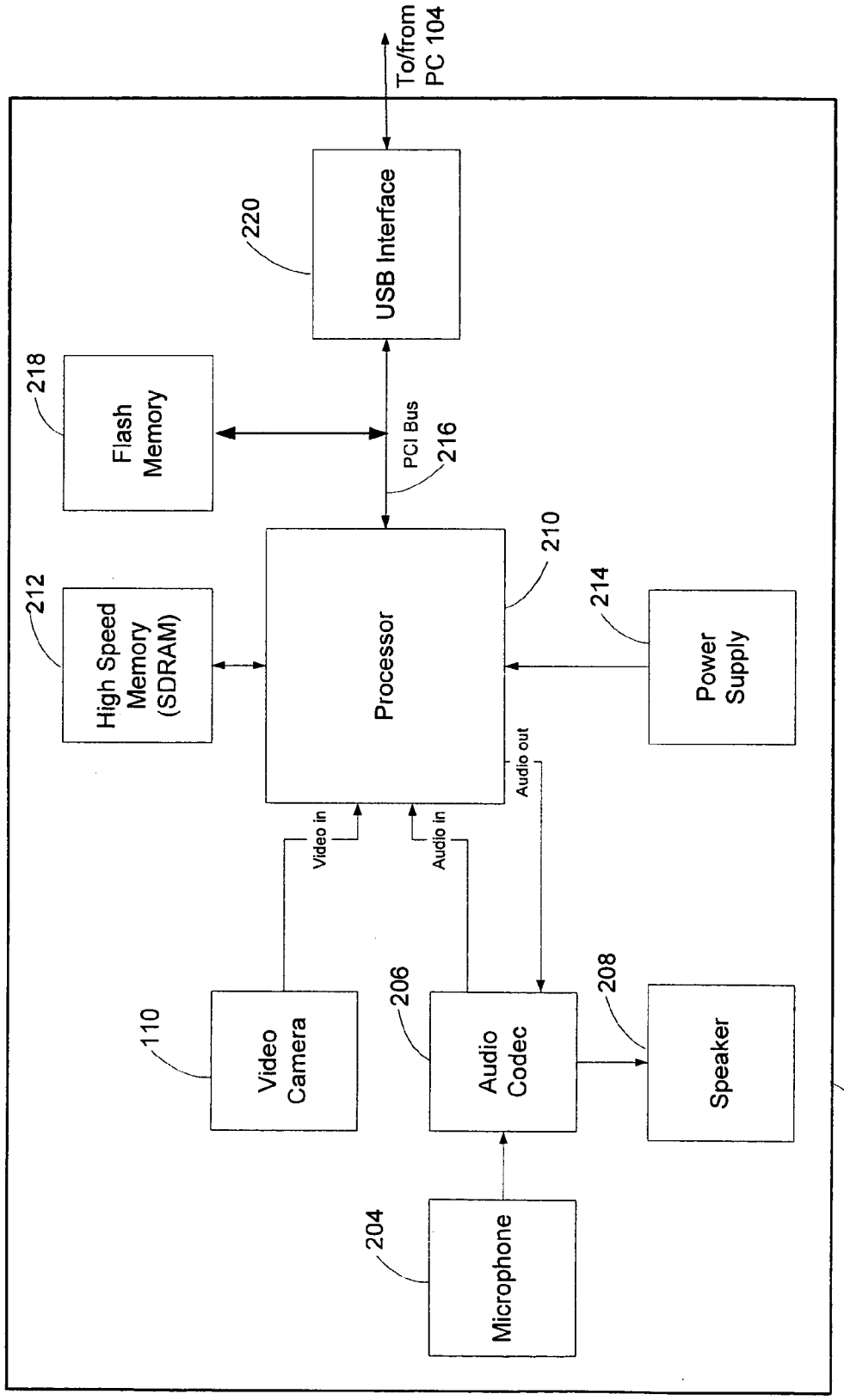

To/from PC 104
USB Interface
220
Flash Memory
218
PCI Bus
216
Processor
210
High Speed Memory (SDRAM)
212
Power Supply
214
Video in
Audio in
Audio out
Video Camera
110
Audio Codec
206
Speaker
208
Microphone
204
102

Fig. 2

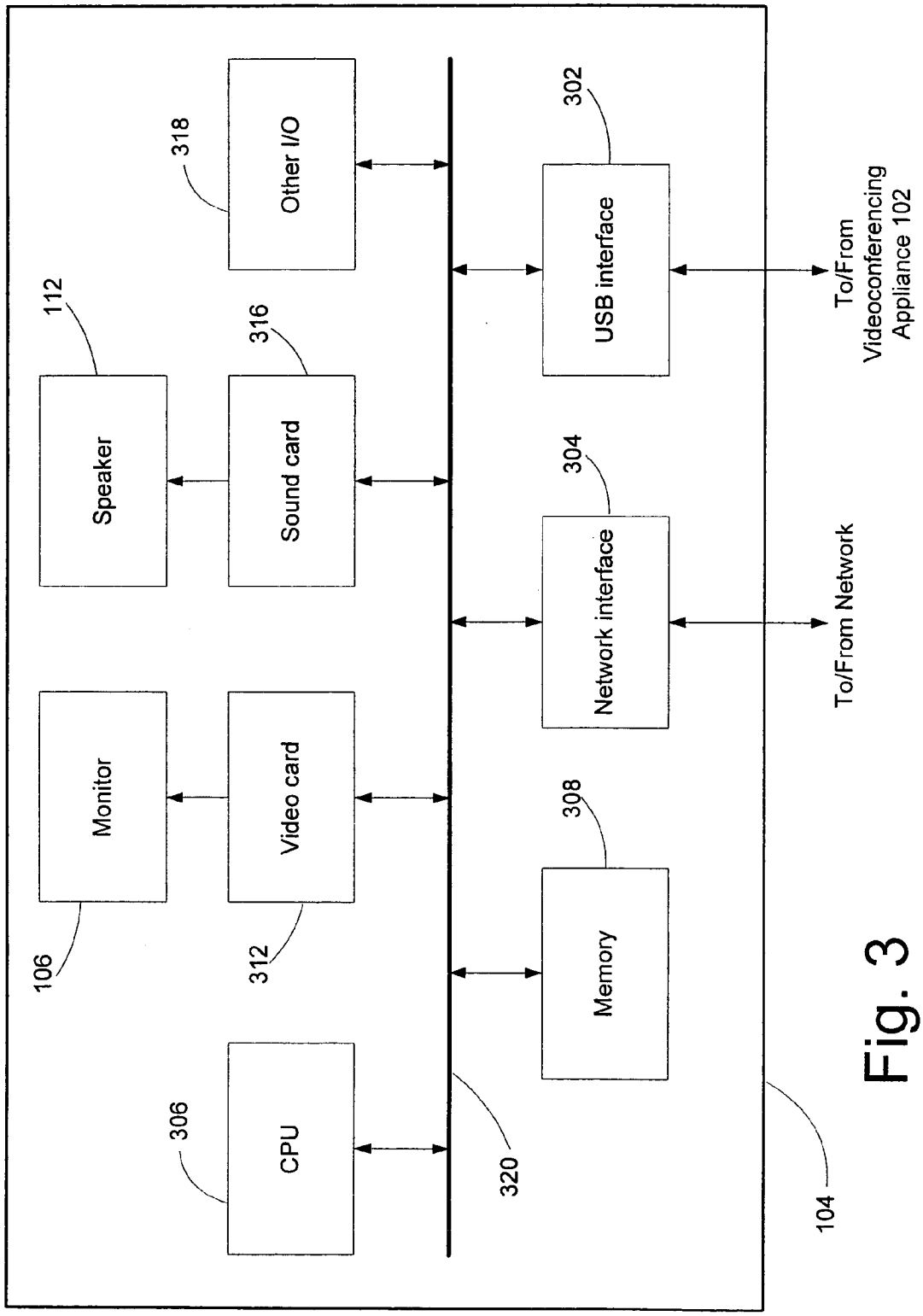

Other I/O
318
302
USB interface
To/From Videoconferencing Appliance 102
112
Speaker
316
Sound card
304
Network interface
To/From Network
Monitor
106
Video card
312
308
Memory
CPU
306
320
104

Fig. 3

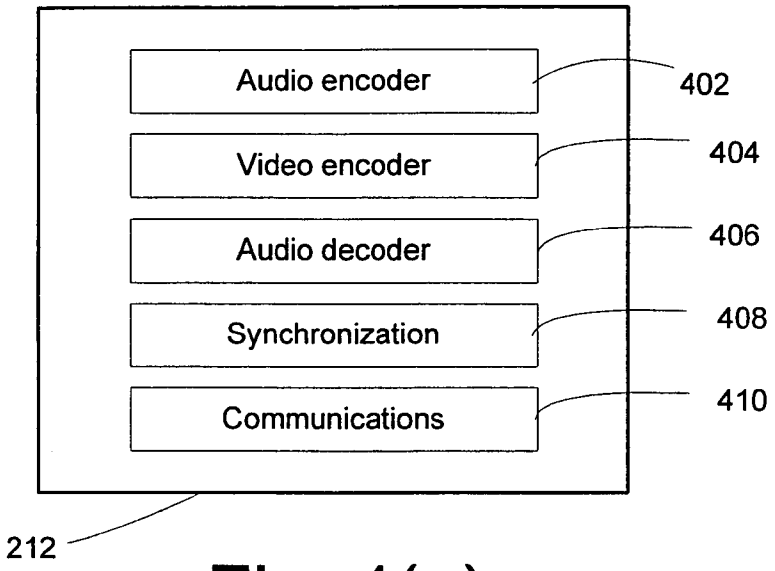

Audio encoder
Video encoder
Audio decoder
Synchronization
Communications
402
404
406
408
410
212

Fig. 4(a)

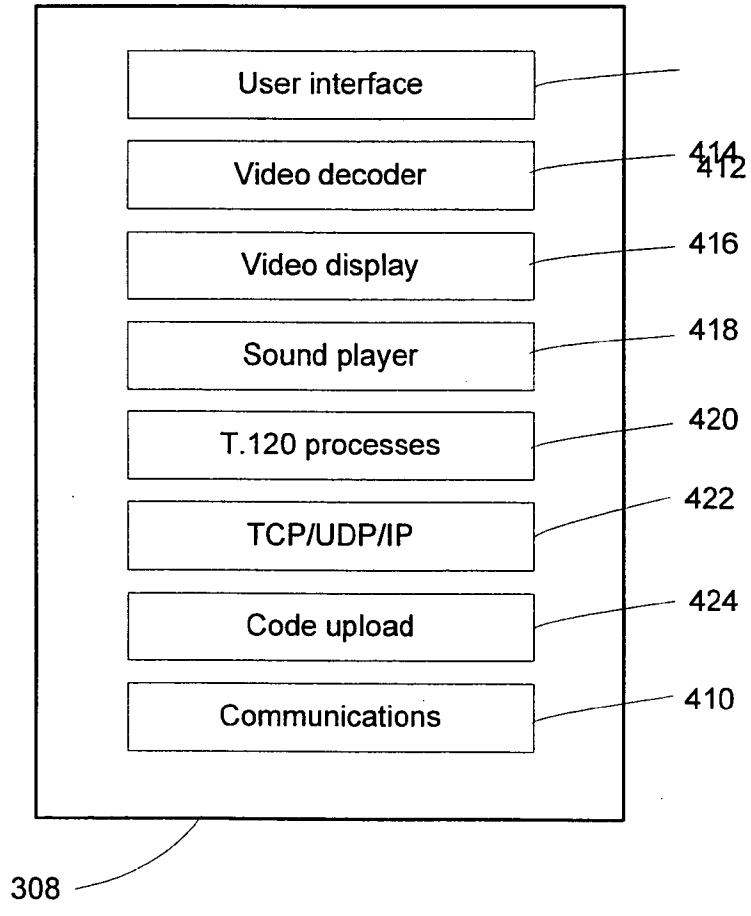

User interface
Video decoder
Video display
Sound player
T.120 processes
TCP/UDP/IP
Code upload
Communications
414
412
416
418
420
422
424
410
308

Fig. 4(b)

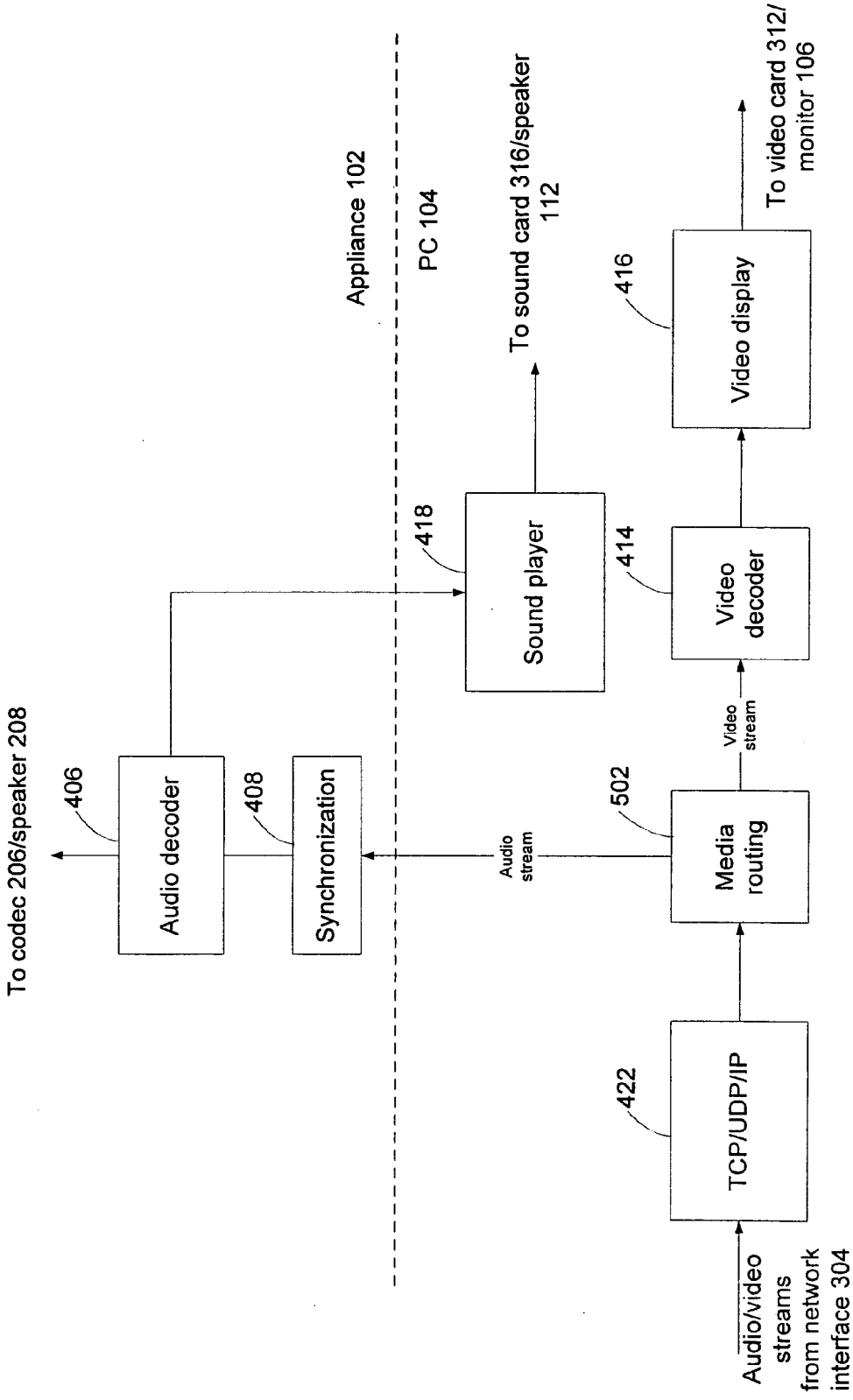

Audio/video streams from network interface 304
TCP/UDP/IP
422
Media routing
502
Video stream
Audio stream
Video decoder
414
Video display
416
To video card 312/ monitor 106
Sound player
418
To sound card 316/speaker 112
Appliance 102
PC 104
Audio decoder
406
Synchronization
408
To codec 206/speaker 208

Fig. 5

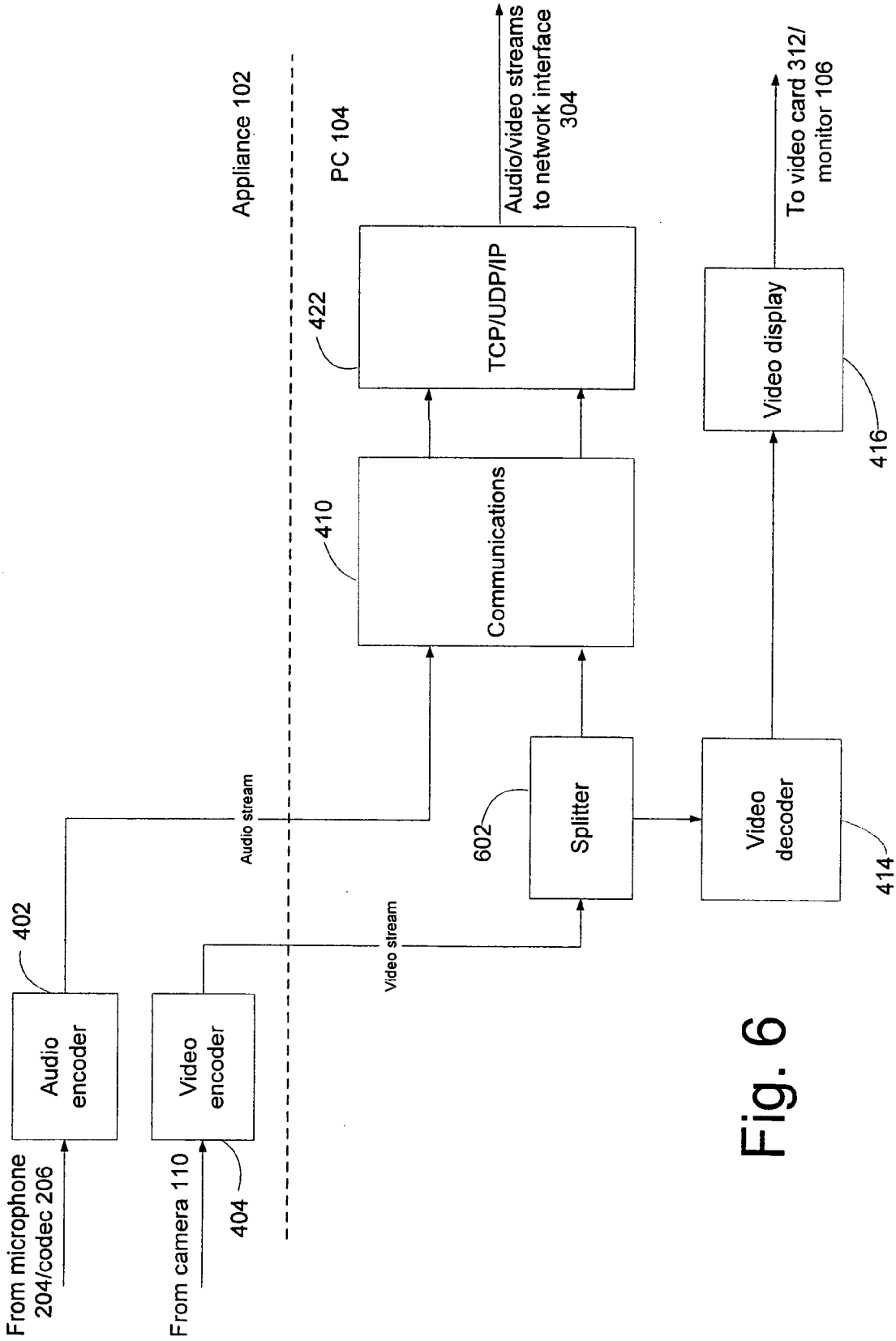

From microphone 204/codec 206
From camera 110
Audio encoder
Video encoder
402
404
Appliance 102
PC 104
Audio stream
Video stream
602
Splitter
Communications
410
TCP/UDP/IP
422
Audio/video streams to network interface 304
Video decoder
414
Video display
416
To video card 312/ monitor 106

Fig. 6

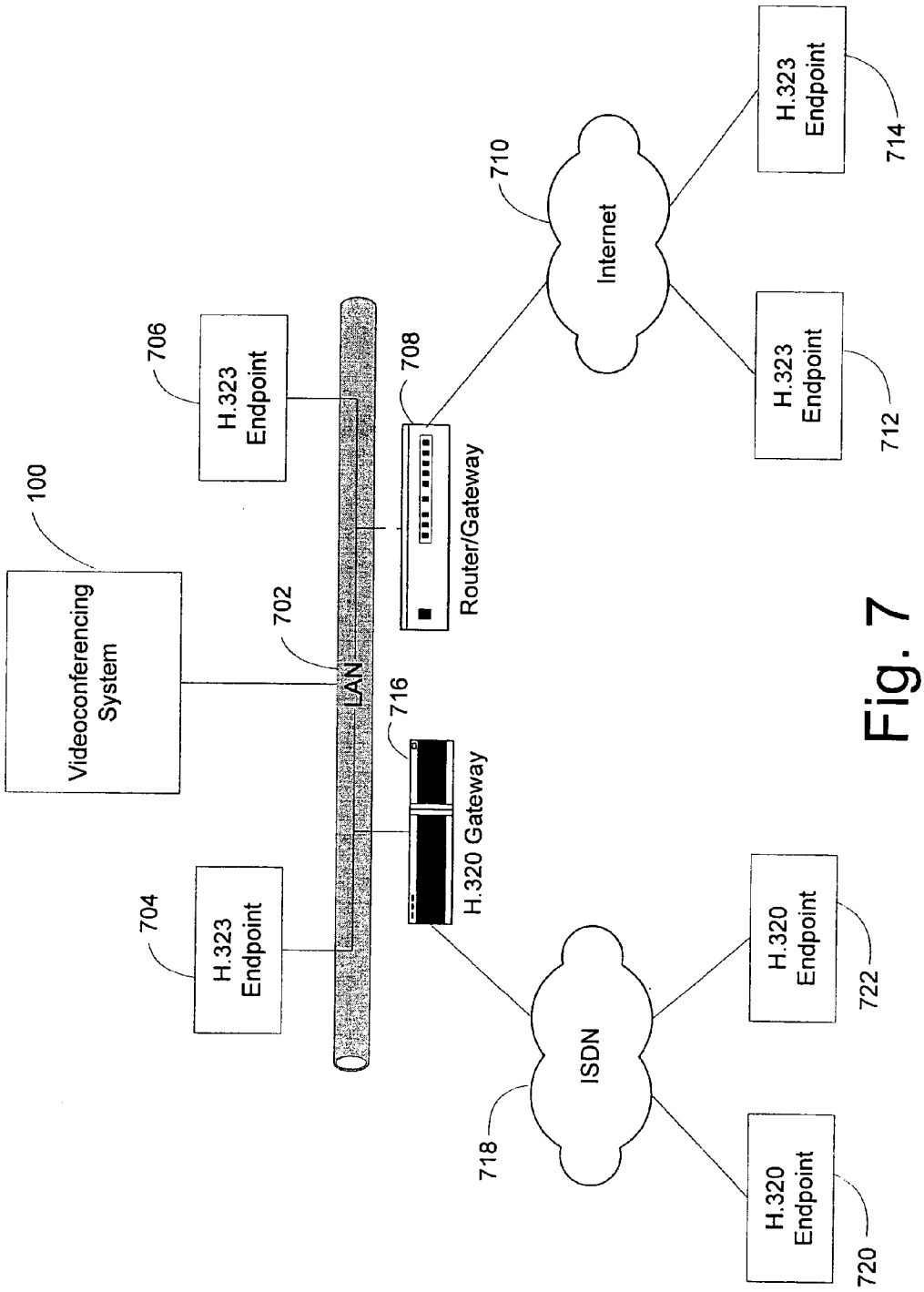

100
Videoconferencing System
702
LAN
704
H.323 Endpoint
706
H.323 Endpoint
708
Router/Gateway
710
Internet
712
H.323 Endpoint
714
H.323 Endpoint
716
H.320 Gateway
718
ISDN
720
H.320 Endpoint
722
H.320 Endpoint

Fig. 7

PERSONAL VIDEOCONFERENCING SYSTEM HAVING DISTRIBUTED PROCESSING ARCHITECTURE

FIELD OF THE INVENTION

[0001] The invention relates generally to telecommunications equipment, and more particularly to a personal videoconferencing system.

DESCRIPTION OF THE PRIOR ART

[0002] Businesses are making increasing use of videoconferencing systems to enable geographically remote individuals groups to communicate with each other from their respective locations. By offering the ability to communicate graphic information and to view the facial expressions and gestures of the conference participant(s) located at a remote site, videoconferencing facilitates richer and more natural communication between conference participants when compared to traditional audio-only conferencing. Regular use of videoconferencing avoids or significantly reduces the need for expensive and time-consuming business travel.

[0003] Several commercial vendors are presently manufacturing and selling high-quality videoconferencing systems for business use. Such systems tend to be expensive to purchase and maintain, bulky in size, and difficult to configure and operate. Due to the expense and size of business videoconferencing systems, as well as the necessity to connect each system to multiple digital telephone lines, businesses desiring to utilize videoconferencing often purchase a relatively small number of videoconferencing systems for common use of the employees and install each system within a conference room or area, rather than in individual employee's offices. Persons wishing to use a videoconferencing system must typically reserve the associated conference room in advance, and may need to secure the assistance of a system administrator or other IT professional to set up the video call to the remote conferencing site and to configure and operate the videoconferencing system prior to and during the conference. The need to arrange aspects of the videoconference in advance and to travel to the conference room in which the videoconferencing system is situated may dissuade certain persons from availing themselves of the benefits of videoconferencing.

[0004] A number of personal videoconferencing devices have been developed and are presently commercially available. These devices typically comprise low resolution video cameras connected to a desktop personal computer through a USB port or similar interface. Raw (unencoded) video generated by the video camera (representative of a user's image), together with raw audio generated by a microphone (representative of the user's speech) are sent to the desktop computer to be encoded prior to transmission of the encoded audio and video data to a remote site through a network interface or modem. The desktop computer also handles decoding of incoming audio and video data received from the remote site, as well as echo cancellation, media stream packetization and call establishment and control.

[0005] Because the audio/video encoding and decoding processes tend to be computationally expensive, most desktop computers are limited to low bit-rate videoconferencing. This limitation results in poor image quality and jerky motion (as well as poor speech reproduction), which may distract the user and substantially reduce the videoconferencing device's effectiveness as a communication tool, particularly in a business setting. Video and audio quality may be improved by installing a video capture and processing board in the desktop computer, which handles various processing tasks associated with the audio and video streams. However, many persons, particularly those having limited technical sophistication, may be dissuaded from purchasing and using board-based systems because of the need to open up the desktop case and physically install the board in an appropriate slot on the motherboard. Further, board-based systems may require the user to perform non-trivial configuration of the associated desktop computer to ensure that the board is properly configured and hardware conflicts do not arise.

[0006] Thus, a need remains for a personal videoconferencing system which is compact, easy to set up and configure, and which provides business-quality audio and video.

SUMMARY

[0007] In accordance with one aspect of the invention, a personal videoconferencing system includes a videoconferencing appliance connected to a personal computer (PC) via a Universal Serial Bus (USB) or comparable communication interface. Processing tasks for implementing videoconferencing services are distributed between an onboard processor located within the appliance and the central processing unit (CPU) of the PC. In particular, the onboard processor handles compression of a locally generated audio stream (typically representative of the speech of the local user), compression of a locally generated video stream (typically representative of an image of the local user), and echo cancellation and decompression of at least one remotely generated audio stream (typically representative of the speech of a remote user).

[0008] The compressed local audio and video streams, and the decompressed and echo cancelled remote audio stream, are conveyed to the PC through the USB interface. The compressed local audio and video streams are directed to a network interface for transmission over a network to a remote conference endpoint. The PC also receives compressed remote audio and video streams. The PC is configured to handle decompression of the compressed remote and local video streams, display of the local and remote video streams, and (optionally) playing of the audio stream. The PC additionally handles execution of a user interface, packetization of media streams, call establishment and control operations, and low-level network connectivity tasks.

[0009] In preferred embodiments, the videoconferencing appliance and PC perform audio and video compression/decompression and media stream packetization, and call establishment/control operations in accordance with the requirements set forth in the ITU H.323 Recommendation. By utilizing the H.323 protocols, the personal videoconferencing system may intercommunicate with any other H.323-compliant conference endpoints, as well as with (via a gateway) with H.320- and H.321-compliant endpoints.

[0010] Use of the distributed processing architecture advantageously enables high quality videoconferencing services to be achieved on a PC or similar platform. Further, by compressing local audio and video streams at the videocon-

ferencing appliance, high quality audio and video may be sent over a standard USB connection without exceeding the connection's bandwidth.

BRIEF DESCRIPTION OF THE FIGURES

[0011] In the accompanying drawings:

[0012] **FIG. 1** is a front view of an embodiment of a personal videoconferencing system, in accordance with the present invention;

[0013] **FIG. 2** is a block diagram showing hardware components of a videoconferencing appliance of the **FIG. 1** embodiment;

[0014] **FIG. 3** is a block diagram showing hardware components of a personal computer of the **FIG. 1** embodiment;

[0015] **FIG. 4**(*a*) is a block diagram showing software components of the videoconferencing system stored in the appliance memory;

[0016] **FIG. 4**(*b*) is a block diagram showing software components of the videoconferencing system stored in the personal computer memory;

[0017] **FIG. 5** is a block diagram showing the flow of outgoing (local) audio and video streams through various software components;

[0018] **FIG. 6** is a block diagram showing the flow of incoming (remote) audio and video streams through various software components; and

[0019] **FIG. 7** is a diagram showing an exemplary network environment of the personal videoconferencing system.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0020] **FIG. 1** shows a front view of a personal videoconferencing system **100** in accordance with an embodiment of the invention. Videoconferencing system **100** generally includes a videoconferencing appliance **102** coupled to a personal computer (hereinafter "PC") **104** via a universal serial bus (USB) or comparable connection. PC **104** is provided with a conventional monitor **106** for displaying images, text and other graphical information to a user. In the FIG.1 embodiment, videoconferencing appliance **102** (hereinafter "appliance") has a base **108** shaped to rest on a top surface of monitor **106**. In other embodiments, appliance **102** may be formed integrally with monitor **106**.

[0021] Appliance **102** is provided with a video camera **110** for continuously capturing an image of a user positioned in front of videoconferencing system **100**. In one embodiment, video camera **110** may be manually swiveled and tilted relative to base **108** to properly frame the user's image. Videoconferencing appliance **102** may alternatively be equipped with a conventional camera tracking system (including an electromechanical apparatus for adjusting the pan and tilt angle and zoom setting of video camera **110**) for automatically aiming the camera at the user based on acoustic localization, video image analysis, or other well-known technique. Video camera **110** may have a fixed-focus lens, or may alternatively include a manual or automatic focus mechanism to ensure that the user's image is in focus. Appliance **102** is further provided with a microphone and an interface for an external loudspeaker (not shown in **FIG. 1**) for, respectively, generating audio signals representative of the user's speech and for reproducing the speech of one or more remote conference participants. The remote conference participant's speech may alternatively be reproduced at loudspeakers **112** or a headset (not shown) connected to PC **104** through a sound card, or at speakers integrated within PC **104**.

[0022] Videoconferencing system **100** is generally operative to generate and encode local audio and video streams for transmission to a remote conference endpoint over a packet switched network, and to decode and present remote audio and video streams received from the remote conference endpoint over the network. In accordance with preferred embodiments, videoconferencing system **100** implements the audio/video encoding, media stream packetization, and other related protocols set forth in Recommendation H.323 ("Packet-Based Multimedia Communications Systems") of the International Telecommunication Union (ITU), which is incorporated herein by reference. The components and operation of videoconferencing system **100** are discussed in further detail below in connection with FIGS. **2-6**.

[0023] **FIG. 2** is a block diagram showing interconnected hardware components of appliance **102**. Video camera **110** conventionally includes a sensor and associated optics for continuously capturing the image of the user and generating signals representative of the image. The sensor may comprise a CCD or CMOS sensor, and may be a single sensor having multiple layers, each for sensing a different color channel, or may alternatively comprise multiple individual sensors combined with means (such as a prism or filters) for splitting the incoming light into separate channels. In a preferred embodiment, video camera **110** includes conventional CCIR656-compliant controller circuitry coupled to the sensor for outputting a video data stream in an 8-bit parallel, 4:2:2 YUV time multiplexed format. The resolution of images captured by video camera **110** will typically be 640 by 480 pixels, although other image resolutions may be used. As alluded to above, video camera **110** is preferably provided with conventional positioning and focusing mechanisms adjustable by the user to ensure that the user's image in properly framed and focussed.

[0024] Appliance **102** further includes a conventional microphone **204** for sensing the speech of the local user and generating audio signals representative of the speech. Microphone **204** may be integrated within the housing of videoconferencing appliance **102**, or may comprise an external microphone or microphone array coupled to videoconferencing appliance **102** by a jack or other suitable interface. Microphone **204** communicates with an audio codec **206**, which comprises circuitry or instructions for converting the analog signals produced by microphone **204** to a digitized audio stream. Audio codec **206** is also configured to perform digital-to-analog conversion in connection with an incoming audio data stream so that the speech of the remote user may be reproduced at conventional loudspeaker **208**. Audio codec **206** may also perform various other low-level processing of the incoming and outgoing audio signals, such as gain control.

[0025] Locally generated audio and video streams from audio codec **206** and video camera **110** are output to a

processor **210**, which is programmed to encode (compress) the audio and video streams for subsequent delivery to the remote conference endpoint(s) over the packet-switched network. Processor **210** may comprise, for example, the Trimedia™ TM-1300 programmable media processor available from Philips Semiconductors of Sunnyvale, Calif. Processor **210** is generally configured to read in audio and video data from codec **206** and video camera **110**, to compress and perform other processing operations on the audio and video data, and to output compressed audio and video streams to a PCI bus **216**. Processor **210** is additionally configured to receive as input through PCI bus **216** an incoming (remote) compressed audio stream representative of the speech of a remote conference participant, to decompress and otherwise process the incoming audio stream and to direct the decompressed audio stream to audio codec **206**/speaker **208** so that the remote speech may be reproduced at appliance **102**. Processor **210** is powered by a conventional power supply **214**, which may also power various other hardware components. Processing of the outgoing audio and video streams and incoming audio stream will be discussed in more detail in connection with FIGS. **4-6**.

[**0026**] Processor **210** is coupled to high-speed memory **212**, which stores (during operation of appliance **102**) data and instructions for carrying out processing of the outgoing and incoming audio and video streams. In one embodiment, high-speed memory **212** comprises 16 MB of synchronous DRAM (SDRAM) doupled to processor **210** by a 32-bit bus. Compressed local audio and video streams are output from processor **210** to a PCI bus **216** through an internal bus interface, which also receives the incoming compressed audio stream transmitted over PCI bus **216**.

[**0027**] Appliance **102** may be further provided with non-volatile memory **218** coupled to PCI bus **216**. Non-volatile memory **218**, which may comprise flash memory or programmable ROM, stores low-level operating and boot code for uploading program instructions from PC **104** during system start-up and/or upon the occurrence of other predetermined events. A universal serial bus (USB) interface **220**, which includes an external connector attachable to a cable extending between interface **220** and a corresponding interface located at PC **104**, is coupled to PCI bus **216** to enable bi-directional communication between appliance **102** and PC **104**. Use of a USB connection advantageously allows appliance **102** to be "hot-plugged", thereby avoiding the need to restart PC **104**.

[**0028**] **FIG. 3** is a block diagram showing hardware components of PC **104**. A USB interface **302**, coupled to corresponding USB interface **220** of appliance **102**, sends and receives audio and video streams and related control information to and from appliance **102**. PC **104** is further provided with a network interface **304** to enable communication between videoconferencing system **100** and other network-connected devices, such as another remote videoconferencing endpoint. Network interface **304** will typically comprise an Ethernet card which is connected to a local area network (LAN), cable modem, digital subscriber line (PSL) modem, or other suitable network access device.

[**0029**] CPU **306**, which may comprise an Intel® Pentium®-class or other suitable processor, is generally operative to execute program instructions and manage hardware resources. In accordance with the distributed processing architecture of videoconferencing system **100**, CPU **306** handles decoding of locally and remotely generated video streams, display of the decoded video streams on monitor **106**, media stream packetization, call establishment and control, network connectivity operations, data conferencing tasks, and execution of a user interface (whereas processor **210** of appliance **102** handles encoding of locally generated audio and video streams and decoding of the remotely generated audio stream(s)).

[**0030**] Memory **308** stores program instructions and data for execution and processing by CPU **306**. Memory **308** may variously comprise any suitable one or combination of volatile memory such as DRAM, non-volatile memory such as ROM, and-storage devices such as hard drives and CD-ROMs. CPU **306** may also be provided with high-speed cache memory to reduce memory read operations and thereby accelerate program execution.

[**0031**] Decompressed video streams are-directed to monitor **106** to be displayed to the user. Monitor **106**, which may comprise a conventional CRT or LCD monitor, is coupled to a video card **312**, which performs frame buffering, color space conversion, and other low-level video processing operations necessary to drive monitor **106**. Alternatively, functions of video card **312** may be performed by CPU **306**. PC **104** may optionally be provided with loudspeakers **112** or a headset, coupled to a sound card **316**, for playing the decoded remote audio stream such that the speech of the user of a remote conference endpoint is reproduced at PC **104**. Sound card **316** may additionally receive and digitize input from an external microphone (not shown.). Finally, PC **104** is typically provided with other input/output devices **318**, such as a keyboard, mouse, printer and the like for entering user input and/or presenting or recording output. The various hardware components of PC **104** are interconnected by at least one system bus **320**.

[**0032**] FIGS. **4**(*a*) and **4**(*b*) depict software components of videoconferencing system **100** residing, respectively, in high-speed memory **212** of appliance **102** and memory **308** of PC **104**. Those skilled in the art will recognize that the software components of videoconferencing system **100** will be designed to run in a particular video software environment, such as Video for Windows from Microsoft Corporation, or QuickTime from Apple Computer. However, videoconferencing system **100** should not be construed as being limited to a particular video environment, operating system, or platform.

[**0033**] Referring initially to **FIG. 4**(*a*), software components residing (during operation of videoconferencing system **100**) at appliance **102** include audio encoder **402**, video encoder **404**, audio decoder **406**, synchronization routines **408**, and communications processes **410**. In a preferred embodiment, software components residing at appliance **102** are configured as drivers which are stored in non-volatile memory **308** (typically as files stored on a hard drive) of PC **104** and uploaded to memory **202** of appliance **100** at system start-up or upon occurrence of certain events. This arrangement obviates the need to install high-capacity non-volatile memory in appliance **104** and facilitates software updates.

[**0034**] The software components residing at appliance **102** are generally configured to implement the various functions set forth in the H.323 Recommendation, so as to enable interoperability with any other H.323-compliant remote

conference endpoint. Video encoder **404** comprises instructions for encoding quarter common intermediate format (QCIF) images in the local video stream supplied by video camera **110** in accordance with Recommendation H.261 ("Video Codec for Audiovisual Services at px64 kbit/s", incorporated herein by reference) of the ITU. As is known in the art, H.261 utilizes a discrete cosine transform-based predictive encoding scheme to achieve compression of the video stream. Video encoder **404** may be additionally configured to support alternative video encoding protocols, such as H.261 common intermediate format (CIF), H.263, or proprietary formats.

[**0035**] Audio encoder **402** comprises instructions for applying the encoding protocol of ITU Recommendation G.711 ("Pulse Code Modulation (PCM) of Voice Frequencies") to the local audio stream generated by microphone **204**/audio codec **206**. The G.711 protocol utilizes a PCM scheme to compress the local audio stream. Audio encoder **402** may be configured to support additional audio encoding algorithms, such as MPEG-1 audio and ITU Recommendations G.722, G.728, G.729 and G.723.1 or other proprietary or non-proprietary algorithms.

[**0036**] Audio decoder **406** comprises program instructions for decoding one or more incoming compressed audio streams received from remote conference endpoints. Audio decoder **406** is configured to decode audio streams encoded in accordance with the G.711 protocol, and may additionally be configured to decode audio streams encoded using other protocols, such as G.722, G.728, G.729, G.723.1, and MPEG-1 audio. Synchronization routines **408** comprise program instructions for delaying the decoded audio stream output by audio decoder **406** to maintain lip synchronization of the speech and images received from the remote conference endpoint(s).

[**0037**] In accordance with preferred embodiments of videoconferencing system **100**, audio decoder **406** is additionally configured to apply an echo cancellation algorithm to the incoming audio stream to remove components of the incoming audio signal attributable to acoustic feedback between the loudspeaker and microphone located at the remote conferencing terminal. Since echo cancellation techniques are well known in the art, they need not be discussed in detail herein. Generally, echo cancellation involves the use of an adaptive filter that generates an approximation of the acoustic feedback (comprising a delayed and weighted version of the locally generated audio stream), which is in turn subtracted from the remote audio stream. The filter's tap weights may be updated using any one of a number of existing algorithms.

[**0038**] Audio encoder **402** and audio decoder.**406** may be configured to apply other well-known processes to the incoming and outgoing audio streams in order to improve audio quality. By way of non-limiting examples, these processes may include automatic gain control and dynamic noise reduction.

[**0039**] Communications processes **410** include instructions for implementing the media stream packetization functions of ITU Recommendations H.225.0 ("Call Signalling Protocols and Media Stream Packetization for Packet-Based Multimedia Communication Systems") and H.245 ("Control Protocol for Multimedia Communications") which are incorporated by reference. The protocols set forth in the H.225.0 and H.245 Recommendations are well known in the art, and hence a detailed description of the functions implemented by communications processes **410** is not included. Generally, communications processes **410** handles packetization of encoded audio and video streams in accordance with Real-Time Protocol (RTP), capability exchange, opening/closing of audio and video channels, mode changes, flow control, and general commands and indications. As discussed below, communications processes **410** may alternatively reside in memory **308** of PC **104**.

[**0040**] It should be noted that, although the various software components **402-410** are depicted in **FIG. 4**(*a*) as being separate entities, the functionality embodied by any two or more components may be integrated into a single component without departing from the scope of the invention.

[**0041**] **FIG. 4**(*b*) depicts software components of videoconferencing system **100** residing in memory **308** of PC **104**. A user interface **412**, the details of which are outside the scope of the invention, is provided to present information to the user and to allow the user to control various aspects of a video conference. Exemplary user controls may include volume and mute controls for the audio portion of the conference, window size and configuration controls for the video portion of the conference, and call establishment/termination controls for initiating and breaking down calls to selected remote conference endpoints.

[**0042**] Video decoder **414** includes instructions for decoding local and remote video streams encoded in accordance with the H.261 QCIF protocol. Video decoder **414** may additionally comprise instructions for decoding video streams encoded using alternative protocols, such as H.261 CIF, H.263, or proprietary protocols.

[**0043**] Video display module **416** and sound player **418** comprise instructions for, respectively, displaying decoded local and remote video streams on monitor **106**, and playing decoded remote audio streams via speaker **314**. In a typical video environment (such as Video for Windows), video display module **416** and sound player **418**, will be embedded within an operating system running on PC **104** and will be accessible through an API.

[**0044**] PC **104** may additionally be provided with T.120 processes **420** comprising instructions for implementing data sharing with remote conference endpoints in accordance with the protocols-set forth in ITU Recommendation T.120 ("Data Protocols for Multimedia Processing"), which is incorporated by reference. In brief, T.120 processes enable the exchange of file-specific data (file transfers, application sharing, etc.) over a standard-compliant channel.

[**0045**] A conventional network layer, such as TCP/UDP/IP stack **422**, handles low-level network connectivity tasks including establishment and tear-down of reliable (e.g., TCP) and unreliable (e.g., UDP) channels for communication of control information and audio and video streams with remote conference endpoints. TCP/UDP/IP stack **422**, which will typically be embedded in an operating system executing on PC **104**, may also handle error checking and control and addressing functions in connection with communications received and transmitted through network interface **304**.

[**0046**] Code upload module **424** comprises instructions for uploading audio encoder **402**, video decoder **404**, audio

decoder **406**, synchronization routines **408** and communications processes **410** to high-speed memory **212** via the USB connection coupling USB interfaces **220** and **302**. As discussed above, uploading of the software components from memory **308** to high-speed memory **212** will typically be effected upon system start-up or upon the occurrence of certain pre-specified events.

[**0047**] Finally, communications processes **410**, described above in connection with **FIG. 4**(*a*), may alternatively or additionally reside in memory **308** for execution by CPU **306**.

[**0048**] **FIG. 5** is a block diagram depicting the path of incoming (remote) audio and video streams through various software components residing in PC **104** and appliance **102**. The incoming audio and video streams, which are representative of the speech and images transmitted by one or more remote conference endpoints, are received through network interface **304** and initially-processed by TCP/UDP/IP stack **422** which performs (inter alia) error checking functions and strips header information from the incoming media streams. The audio and video streams are then directed to a media routing filter **502**, which sends (via the USB connection) the audio stream(s) to synchronization routines **408** and audio decoder **406** located at appliance **102**. If multiple incoming audio streams are received (indicative of a multi-point conference), audio decoder **406** may also perform mixing or switching of the audio streams. As discussed above, audio decoder **406** may also apply an echo cancellation algorithm to the incoming audio stream to remove components of the stream attributable to acoustic coupling between the microphone and loudspeaker at the remote conference endpoint.

[**0049**] The decoded audio stream(s) is then directed to audio codec **206** for conversion to an analog signal, which is in turn applied to loudspeaker **208**, which reproduces the speech of the user(s) of the remote conference endpoint(s). Audio decoder **406** may also direct through the USB connection a copy of the decoded audio stream to sound player **418**, which causes the remote speech to be reproduced at PC **104** via sound card **316** and loudspeaker **112**.

[**0050**] The incoming video stream(s) is sent to video decoder **414**, which decodes the video stream, and may additionally perform mixing or switching services in the case of multiple video streams. The decoded video stream is subsequently passed to video display module **416**, which causes the images embodied in the decoded video stream to be displayed in a window on monitor **106**.

[**0051**] **FIG. 6** is a block diagram showing the path of the local (outgoing) audio and video streams through various software components. The local audio stream generated by microphone **204** and digitized by audio codec **206** is encoded by audio encoder **402** (alternatively, the local audio stream may be generated by an external microphone coupled to sound card **316** and then passed on to audio encoder **402**). Similarly, the local video stream generated by video camera **110** is passed to video encoder **404**, which encodes the video stream in accordance with the appropriate protocol.

[**0052**] The encoded audio stream is then sent over the USB connection to communications processes **410**. The encoded video stream is conveyed to a splitter **602** over the USB connection. Splitter **602** directs one copy of the video stream to communications processes **410**. A second copy of the local video stream is directed by splitter **702** to video decoder **414**, which decodes the video stream and passes the decoded video stream to video display module **416**. Video display module **416** in turn causes the images embodied in the local video stream to be displayed in a window on monitor **106**.

[**0053**] Communications processes **410** packetizes the audio and video streams and passes them to TCP/UDP/IP stack **422**, which attaches header information to the audio and video streams, and places the streams on network interface **304** for transmission to one or more remote conference endpoints over the network.

[**0054**] It is to be appreciated that the distributed software and hardware architecture of videoconferencing system **100**, which implements compression of the local (outgoing) audio and video streams at appliance **102**, enables high-quality video and audio streams to be transmitted over a (relatively low bandwidth) USB connection. Further, by locating audio and video encoding and video decoding operations at appliance **100**, the resources of CPU **306** are not unduly taxed.

[**0055**] **FIG. 7** depicts an exemplary network environment of videoconferencing system **100**. Videoconferencing system **100** is coupled to LAN **702**, which may typically comprise an Ethernet-based network, through network interface **304**. H.323-compliant endpoints **704** and **706** are located at other nodes of LAN **702**. H.323 endpoints **704** and **706** may comprise other personal videoconferencing systems according to the present invention, or may alternatively comprise any suitable H.323 compliant group or personal videoconferencing system.

[**0056**] Router or gateway **708** is located at a node of LAN **702** and is configured to enable communication over Internet **710** (or a wide area network) between LAN connected devices, such as videoconferencing system **100**, and devices located outside of LAN **702**, such as H.323 endpoints **712** and **714**. To allow videoconferencing system **100** to communicate with conventional H.320-compliant conference endpoints **720** and **722** (which receive and transmit multiplexed audio/video streams over circuit switched ISDN lines **718**), an H.320 gateway **716** may be provided and connected to packet-switched LAN **316**. As is known in the art, H.320 gateway **718** provides protocol conversion services required to implement real-time bi-directional communication between H.320 and H.323 compliant endpoints.

[**0057**] Videoconferencing system **100** is preferably configured to receive and process audio and video streams from a plurality of remote conference endpoints (e.g., H.323 endpoints **704**, **706**, **712**, **714** and/or H.320 endpoints **720**, **722**) to thereby enable multi-point conferencing. The total number of separate audio/video streams which may be concurrently received and processed by videoconferencing system **100** will depend, at least in part, on considerations of bandwidth and processor (onboard processor **210** and CPU capabilities. One or more multi-point control units (MCUs) may be employed to combine or switch multiple audio/video streams and thus expand the number of conference endpoints which may participate in a conference.

[**0058**] While reference is made throughout the foregoing description to an H.323-compliant videoconferencing system, it should be appreciated that the invention should not be construed to be limited thereto. Those skilled in the art will

recognize that videoconferencing system **100** may be adapted to implement any number of packet-based protocols. Further, videoconferencing system **100** may also be easily configured to support video telephony employing the standard Session Initiation/Media Gateway Control (SIP/MGCP) protocols.

[**0059**] It will also be recognized by those skilled in the art that, while the invention has been described above in terms of preferred embodiments, it is not limited thereto. Various features and aspects of the above-described invention may be used individually or jointly. Further, although the invention has been described in the context of its implementation in a particular environment and for particular applications, those skilled in the art will recognize that its usefulness is not limited thereto and that the present invention can be utilized in any number of environments and implementations.

What is claimed is:

1. A videoconferencing appliance, comprising;

a microphone for generating a local audio stream;

a video camera for generating a local video stream;

an audio encoder, coupled to the microphone, for compressing the local audio stream;

a video encoder, coupled, to the camera, for compressing the local video stream;

a communication interface, coupled to the audio and video encoders, for conveying the compressed local audio and video streams to a personal computer; and

an audio decoder for decompressing a compressed remote audio stream received from the personal computer through the communication interface.

2. The videoconferencing appliance of claim 1, wherein the audio decoder is configured to echo cancel the remote audio stream.

3. The videoconferencing appliance of claim 1, wherein the audio encoder, video encoder, and audio decoder comprise program instructions executed by an onboard processor.

4. The videoconferencing appliance of claim 1, wherein at least a portion of the program instructions normally reside on the personal computer, and are uploaded to the videoconferencing appliance through the communication interface upon the occurrence of a predetermined event.

5. The videoconferencing appliance of claim 1 further comprising a communications process for packetizing the compressed audio and video streams and for establishing and controlling calls.

6. The videoconferencing appliance of claim 1 further comprising a loudspeaker, coupled to the audio decoder, for playing the decompressed remote audio stream.

7. The videoconferencing appliance of claim 1, wherein the communication interface comprises a Universal Serial Bus (USB) interface.

8. The videoconferencing appliance of claim 1, wherein the audio decoder is configured to transfer the decompressed remote audio stream to the personal computer to be played thereby.

9. The videoconferencing appliance of claim 3, wherein the program instructions implement H.323 protocols.

10. A videoconferencing system, comprising:

a personal computer including:

a network interface for receiving compressed remote audio and video streams from a remote conference endpoint and for transmitting compressed local audio and video streams to the remote endpoint;

a video decoder for decompressing the compressed remote video stream;

a monitor, coupled to the video decoder, for displaying the decompressed remote video stream; and,

a first communication interface for conveying the compressed remote audio stream to a videoconferencing appliance;

the videoconferencing appliance including:

a microphone for generating a local audio stream;

a video camera for generating a local video stream;

an audio encoder, coupled to the microphone, for compressing the local audio stream;

a video encoder, coupled to the camera, for compressing the local video stream;

a second communication interface, coupled to the audio and video encoders and to the first communication interface, for conveying the compressed local audio and video streams to the personal computer; and

an audio decoder for decompressing a compressed remote audio stream received from the personal computer through the second communication interface.

11. The videoconferencing system of claim 10, wherein the audio decoder sends the decompressed remote audio stream to the personal computer through the first and second communication interfaces.

12. The videoconferencing system of claim 10, wherein the first and second communication interfaces comprise Universal Serial Bus (USB) interfaces.

13. The videoconferencing system of claim 10, wherein the audio encoder, video encoder, and audio decoder comprise program instructions executed by a processor disposed at the videoconferencing appliance.

14. The videoconferencing system of claim 10, wherein the video decoder comprises program instructions executed by a processor disposed at the personal computer.

15. The videoconferencing system of claim 10, wherein the videoconferencing appliance further comprises a communications process for packetizing the compressed audio and video streams and for establishing and controlling calls.

16. The videoconferencing system-of claim 15, wherein the audio and video encoders, audio decoder, and communications process are configured to implement H.323 protocols.

17. The videoconferencing system of claim 13, wherein at least a portion of the program instructions normally reside on the personal computer, and are uploaded to the videoconferencing appliance through the first and second communication interfaces upon the occurrence of a predetermined event.

18. The videoconferencing system of claim 11, wherein the personal computer is coupled to a loudspeaker for playing the remote audio stream.

19. The videoconferencing system of claim 10, wherein the audio decoder is configured to echo cancel the remote audio stream.

20. The videoconferencing system of claim 10, wherein the personal computer includes a user interface having a set of user controls.

21. The videoconferencing system of claim 10, wherein the personal computer includes a TCP/UDP/IP stack for managing communications with a remote conference endpoint over the network.

22. The,videoconferencing appliance of claim 1, wherein the microphone is external to a housing of the appliance and is removably coupleable to the audio encoder via a microphone interface.

23. The videoconferencing system of claim 10, wherein the microphone is external to a housing of the appliance and is removably coupleable to the audio encoder via a microphone interface.

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