(54) Title: DIFFUSION EN CONTINU DE VIDEOS NUMERIQUES ENTRE DES DISPOSITIFS VIDEO AU MOYEN D'UN SYSTEME DE TELEVISION PAR CABLE

(57) Abstract:
Systems and methods are presented that permit an individual to share digital video between video devices using a cable television system. A first video device streams digital video to a cable headend, which transcodes it and stitches it with other video content,
(57) Abstract (continued):
such as a menuing system. The headend then transmits the digital video to a second video device, such as a set top box, for display. The data stream may be controlled using a standard set top box remote control, and the system may be used without purchasing additional hardware or software, or configuring a wireless local area network.
Title: STREAMING DIGITAL VIDEO BETWEEN VIDEO DEVICES USING A CABLE TELEVISION SYSTEM

Abstract: Systems and methods are presented that permit an individual to share digital video between video devices using a cable television system. A first video device streams digital video to a cable headend, which transcodes it and stitches it with other video content, such as a menuing system. The headend then transmits the digital video to a second video device, such as a set top box, for display. The data stream may be controlled using a standard set top box remote control, and the system may be used without purchasing additional hardware or software, or configuring a wireless local area network.
Streaming Digital Video Between Video Devices Using A Cable Television System

Cross-Reference To Related Application

[0001] This application claims the benefit of U.S. Provisional Application No. 61/393,262, filed October 14, 2010, the contents of which are incorporated by reference in their entirety.

Technical Field

[0002] The present invention relates to sharing digital video between electronic devices, and more particularly to using a television system to establish a private, bidirectional data channel to stream personalized digital video for the enjoyment of subscribers.

Background Art

[0003] Digital video forms an integral part of modern life. Private digital video devices allow us to record our life experiences for later review and enjoyment. Professional digital video, in the form of movies and television, allows us to see life through the eyes of others, and to benefit from their wisdom and their follies. As social creatures, we often wish to share these experiences with others, and we relish the opportunity to invite others into our homes for viewing sessions.

[0004] Digital media may be downloaded for viewing using a video player, or viewed on web sites such as YouTube using a web browser that supports streaming media. Digital media also may be recorded using video devices ranging from smartphones, to professional and amateur video cameras, to webcams on personal computers. There are many different and incompatible methods and locations for storing this media. As a result, there are many different and incompatible methods for later viewing: on a phone display, on a television screen, on a computer display (using one of several incompatible viewers). As a result, people who wish to later view this digital video must learn many different display and control interfaces, and educate themselves as to the intricacies of the different media formats.
It would be simpler to view all digital media using a single video device, as the viewer would only have to learn how to use that single device.

[0005] It is known in the art to share video between computers and televisions, although methods for doing so are cumbersome or expensive. Some computers, including laptops, have video outputs that may be connected directly to a television video input using special cables. Setting up such systems is often difficult, as the process entails several steps of varying technical skill: analyzing the computer and the television to determine which kind of cable or cables are required; connecting the components properly; directing the computer to transmit video to the television, often through a non-intuitive sequence or combination of keystrokes or by running a custom application; tuning the television to the appropriate channel; adjusting the video resolution, size and position of the viewable area, brightness and color balance, and so on. Many of these steps are beyond the capabilities of the average person, and even if they are performed correctly, the video quality is often poor, and control of the television display must be performed awkwardly from the computer. Furthermore, for cable television subscribers, this arrangement often bypasses a cable set top box that controls ordinary cable television reception. Thus, a subscriber must learn how to change back and forth between ordinary cable television and the direct connection to the computer having the digital video.

[0006] One solution to this problem has been the use of an intermediate computer that interfaces to both the personal computer and the television. Commercial embodiments of this solution include the Apple TV® digital media extender from Apple, Inc. of Cupertino, California. However, this solution requires the user to purchase an additional computer and learn how to configure it, which some individuals may be unwilling or unable to do. Also, this solution requires the user to set up a wireless local network on the premises to allow the intermediate computer to connect to the personal computer, which a non-skilled person may find difficult. A different solution, in which the television itself has wireless networking and the personal computer connections with the television wirelessly, suffers from the same problem. Yet another solution is to convert the personal computer into a cable set top box, or “media center,” using purchased or downloaded software. An advantage of using this approach is that other, more general applications found on the computer may be used on the television, such as web browsers, email clients and so on. Examples of this solution are the
MythTV home entertainment application developed by Mr. Isaac Richards, and the Boxee system, from Boxee, Inc. However, these solutions do not solve the problem of avoiding complex and unfamiliar user interfaces, as they typically have custom menus and require the use of a keyboard and mouse to control the web browser, email client, and other added features that appear on the television. These solutions may also require the user to set up a wireless local area network, although some do permit direct cable connections from a set top box to the personal computer (with the aforementioned disadvantages).

**Summary of Illustrated Embodiments**

**[0007]** In accordance with various embodiments of the present invention, systems and methods are presented that overcome these difficulties by using existing cable television infrastructure to share digital video on smartphones, personal computers, and other devices with a set top box. These systems and methods do not require connecting a computer to a television with a cable, purchasing additional computers and configuring them, or setting up a local, wireless data connection on the premises. Furthermore, these systems are controlled using a standard set top box remote control, permitting cable subscribers to use a standard cable system menu, without being forced to use a keyboard and mouse to control the image displayed on the television or to learn a new menuing interface.

**[0008]** In a first embodiment there is provided a method of streaming digital video between a first video device and a second video device. The digital video may include audio data, moving image data, still image data, or any combination of these, and may be encoded according to an MPEG specification. The first video device, which may be a personal computer or a smartphone for example, is connected to a public data network, such as the Internet. The second video device may be a television or a TV set top box, and is connected to a cable television system having a cable network and a cable headend. The cable headend is also connected to the public data network. The second video device may be controlled by a video device controller, such as a remote control.

**[0009]** The method includes establishing a first bidirectional data channel from the first video device to the cable headend and establishing a second bidirectional data channel over the cable network from the second video device to the cable headend. Doing so permits bidirectional data communication between the first video device and the second video device
through the cable headend. Once the data communication has been established, the method further includes receiving a first data stream that includes the digital video at the cable headend from the first video device using the first data channel. Next, the method includes forming a second data stream that includes a second video that is based on the received digital video. The second video may be the received digital video, or it may comprise a transcoding of the received digital video into a format that is decodable by the second video device. Furthermore, the second video may include a plurality of video frames, each video frame having a frame of the digital video stitched together with another image, such as a navigation button, an advertisement, information associated with the first video device, information associated with the digital video. The method further includes transmitting the second data stream from the cable headend to the second video device using the second data channel. The data stream is controlled by sending commands from the video device controller to the first video device over the first and second data channels. Finally, the second video may be displayed on a television.

[0010] In some related embodiments, the first and second video devices are located within the premises of an individual. In such cases, it may be the case that no bidirectional data channel between the first and second video devices exists entirely within the premises. In other related embodiments, establishing the first data channel includes receiving, from the first video device, a first request to establish the first data channel, the first request having request parameters that include a unique identifier; and authorizing the establishment of the first data channel based on the request parameters. The first request may be received over either the public data network or over the cable network. The unique identifier may be a media access control (MAC) address that is uniquely associated with the first video device. And establishing the second data channel may include receiving, from the second video device, a second request to establish the second data channel, the second request having request parameters that include the unique identifier; identifying the first video device using the received unique identifier; and associating the second video device with the identified first video device.

[0011] These methods may be implemented using the systems described below, or similar systems. Further, the methods may be implemented in computer hardware or
software, or a combination of these. Computer software may be provided as a computer program product having program code stored thereon.

**Brief Description of the Drawings**

[0012] The foregoing features of the invention will be more readily understood by reference to the following detailed description, taken with reference to the accompanying drawings, in which:

[0013] Fig. 1 is a depiction of an example embodiment of the invention in which an individual streams video data from a smartphone into a cable television system for display on a television;

[0014] Fig. 2 is a depiction of a second example embodiment in which an individual streams video data from a personal computer to a television located on the same premises;

[0015] Fig. 3 is a block diagram showing the functional components of the embodiment of Fig. 2;

[0016] Fig. 4 is a timing diagram showing example processes that may be used to share digital video between a first video device and a second video device in accordance with an embodiment of the invention; and

[0017] Fig. 5 is a flowchart showing these processes from the perspective of a cable television operator at a cable television headend.

**Detailed Description of Specific Embodiments**

[0018] Definitions. As used in this description and the accompanying claims, the following terms shall have the meanings indicated, unless the context otherwise requires:

[0019] **Digital video** refers to encoded digital data pertaining to a plurality of images, sounds, or both images and sounds. The plurality of images may include moving images, different images presented sequentially with a perceptible delay, or repetitions of a still image. The data may be encoded using any encoding format known in the art, especially a format according to an MPEG specification.

[0020] A **video device** refers to any electronic device capable of capturing, encoding, or displaying digital video, including without limitation smartphones, personal computers, video cameras, television set top boxes, and smart televisions.
[0021] A cable network is a network of physical cables that is used for distributing electrical or optical signals, including digital video. For example, a television system uses a network of coaxial or optical fiber cables to distribute television signals to subscribers.

[0022] Cable television system refers to a television system that delivers television signals to viewers using a cable network, be it electrical, optical, or a combination of these. While specific reference is made in various places to components of an electrical cable television system for ease of explanation, the corresponding components in a fiber optic television system are expressly contemplated.

[0023] A bidirectional data channel is a data channel that sends digital video from a first video device to a second video device in a first direction, and commands for controlling the first video device from the second video device to the first video device in the opposite direction. In embodiments of the invention, the second video device does not share video with the first video device, so the channel in the first direction may use a much higher data rate than the channel in the opposite direction.

[0024] Fig. 1 is a depiction of a typical embodiment of the invention. In accordance with this embodiment, an individual is able to take video of an interesting scene and stream it back to a television for viewing by someone else. The individual 100 possesses a video device, such as smartphone 110. The individual 100 uses smartphone 110 to capture streaming video (and perhaps audio) of an interesting scene, in this case a building 120. The smartphone 110 encodes the captured audiovisual data into digital video, and streams the digital video to a communications tower 130, for example using the smartphone’s cellular network connection. Communications tower 130 transmits the digital video across a public data network 140, such as the Internet, to a cable television headend 150. The headend 150 forwards the digital video through a private cable network 160 to a subscriber premises 170. Inside the premises 170 is a typical cable television apparatus, including a cable set top box 172, a television 174, and a remote control 176. The cable set top box 172 receives the digital video and decodes it for display on the television 174. The remote control 176 is used to tune the set top box 172 to an appropriate channel for such display. In an alternate embodiment (not shown), the television 174 incorporates the decoding and tuning functions of the set top box 172, in which case the remote control 176 may directly control those functions inside the television.
[0025] As described in more detail below, cable television headend 150 performs any necessary reformatting and transcoding of the digital video stream to allow it to be viewed optimally on television 174. Such reformatting may include resizing the video, altering the video's resolution, mixing in other video such as advertisements, and other reformatting as is known in the art. Transcoding may include converting the digital video from a source format to a format that is decodable by the set top box 172.

[0026] Fig. 2 is a depiction of a second example embodiment in which an individual streams video data from a personal computer to a television located on the same premises. In this embodiment the individual 100 accesses the digital video on a personal computer, such as laptop 200. For example, the individual 100 may have transferred to laptop 200 the video previously shot using the smartphone 110 from Fig. 1, and now wishes to relive a memory associated with the experience. Or, laptop 200 may contain digital video from another source, such as a DVD or Blu-Ray disc or a stored video file, and the individual wishes to watch the video on television 174 using the remote control 176 to control playback. This latter use case is advantageous in that the individual 100 need not possess a standalone player to be able to watch video discs.

[0027] In Fig. 2, the connection 210 to the public data network 140 may be accomplished using wires or cables, or it may be wireless. In a particularly advantageous embodiment, individual 100 is a cable television subscriber and cable television headend 150 provides Internet access. In this embodiment, connection 210, which is used to stream the digital video upstream, uses the same cables as connections 220, 222, which are used to stream appropriately encoded television signals to set top box 172 from the cable television headend 150. In this way, no additional cables are required to connect laptop 200 to set top box 172 or television 174.

[0028] However, it should be emphasized that, while the connection between laptop 200 and public data network 140 and the connection between headend 150 and set top box 172 may travel over the same physical cables, they comprise separate logical networks. For example, a cable television provider typically transmits data between headend 150 and premises 170 using signals having a frequency spectrum, and allocates different frequency windows to each connection. Frequencies belonging to the first connection may be selected using a signal filter in a cable modem. Thus, the laptop 200 does not have access to the
television signals transmitted to set top box 172, and likewise set top box 172 does not have access to digital data on frequencies selected by the cable modem.

[0029] The arrangement of Fig. 2 is advantageous, because the set top box 172 integrates into the cable television system directly, so it is not necessary for subscriber 100 to separately purchase a second device (such as a second set top box) to share the digital video between devices. This arrangement may be used when there is no bidirectional data channel that connects the laptop 200 and the set top box 172, such as a wireless LAN, contained entirely within the premises.

[0030] Details of these embodiments now follow. Fig. 3 is a block diagram showing the functional components of the embodiment of Fig. 2. Cable television headend 150 and personal computer 200 are shown in greater detail. In accordance with the embodiment shown in Fig. 3, the subscriber obtains internet access through cable television headend 150 so connection 210 is omitted for clarity. However, other embodiments are contemplated in which the subscriber obtains internet access through other means, such as the cellular network as shown in Fig. 1, so the embodiment shown in Fig. 3 should not be construed to limit the scope of the invention. Further, while reference will be made to personal computer 200, it will be understood that other video devices may be employed, such as the smartphone 110 shown in Fig. 1, provided that they have installed on them the appropriate hardware or software applications as now described. In addition, while the various components are described as software, it is contemplated that particularly computationally expensive operations such as video and audio capture or video encoding may be performed in hardware.

[0031] Referring to Fig. 3, the functions of personal computer 200 are explained in more detail. Personal computer 200 includes a video application 310. This video application 310 may be, by way of illustration: a web browser that displays web pages having embedded videos in Java, Flash, HTML 5, or other web video format; a proprietary video disc player application such as the CyberLink PowerDVD player; an application that plays digital video from a file or a URL, such as the Microsoft Windows Media Player or the Apple QuickTime Player; screen capture software, such as that found in remote desktop applications like Windows Terminal Server, VNC Server from RealVNC Limited, or any of several applications from Citrix Systems, Inc.; or any other application that provides digital video
and may be controlled programmatically through an application programming interface 312. For concreteness, and not by way of limitation, video application 310 will be treated as a web browser having open a web page having embedded digital video 350.

[0032] Personal computer 200 also includes video capture software 320 and audio capture software 322. Capture software 320, 322 may be embodied in a single software package, or they may be separate, and perform video and audio capture according to techniques known in the art. Although both video and audio capture are shown in Fig. 3, audio capture may be omitted in various contemplated embodiments. For example, if video application 310 does not provide any audio, then cable television headend 150 will not receive any audio from personal computer 200. In such cases, headend 150 may optionally mix audio into the video to provide a more enjoyable subscriber experience. Such audio may be selectable by the subscriber from an audio library using a remote control, or it may be of the television operator’s choosing. Also, in some embodiments video capture and audio capture are performed using hardware instead of software.

[0033] Captured video (and audio, if present) are sent to encoder 330, which encodes the video and audio into encoded digital video data according to an encoding format known in the art, such as MPEG. Encoder 330 presents the encoded digital video to streamer 332. Streamer 332 streams the encoded digital video to cable television headend 150 over a bidirectional data channel using techniques known in the art. In such a configuration, streamer 332 acts as a server, and headend 150 acts as a video client that requests the digital video after a connection with the second video device has been established.

[0034] Control software 340 is provided to control and monitor streamer 332, and to provide feedback to a user of personal computer 200. Control software 340 is executed by the user to launch the streaming components, and communicates with streamer 332 using a local network (TCP) connection. Control software 340, upon launch, establishes a service connection with headend 150, and obtains a list of authorized IP addresses that are permitted to access the streaming video data. When a client attempts to connect to the streamer 332 and request streaming video, streamer 332 requests authorization from control software 340. Control software determines whether the IP address is authorized, and responds to streamer 332 so that streamer 332 may accept or deny the connection as appropriate. Control software 340 may also direct streamer 332 to terminate execution at the request of a subscriber.
Conversely, streamer 332 may provide status updates to control software 340, such as whether streamer 332 is awaiting a connection with the headend 150, that such a connection has been established or torn down, or that streamer 332 is currently streaming digital video. Control software 340 may display these status updates on a display of personal computer 200. Encoder 330, streamer 332, and control software 340 may be provided by the cable television system operator as a single downloadable software application for the convenience of a subscriber.

The functions of cable television headend 150 are now explained in greater detail. Headend 150 includes several computing modules connected by a local area network 360. These modules include a cable network interface 370 for communicating with the cable network 160. Interface 370 may include, for example, a cable modem termination system (CMTS) that provides high speed data services, such as Internet access and digital video streaming, to subscribers. Interface 370, when employed to provide the Internet access required by web browser 310, forwards requests to a public network interface 372, such as a network router, that acts as a gateway to public data network 140. Other hardware and software used in this process is omitted for clarity, but can include various modules that provide data security such as encryption, virus detection and removal, and so on. Thus, for example, requests for digital video 350 from browser 310 are passed through the cable network 160, cable network interface 370, local area network 360, and public network interface 372 on their way to the public data network 140. This data path is comparable to data path 210 of Fig. 2.

In addition to these data components, cable television headend 150 also includes transcoders 374 and stitchers 376. As is known in the art, transcoders convert data encoded in one format into a different format. In this connection, digital video that is not displayable using cable set top box 172 is transcoded into the appropriate format. In one embodiment, to reduce latency between the video application and display of its content on the television 174, encoder 330 may encode captured video and audio data using a simple encoding scheme. Such simple encoding schemes may be desired in some embodiments if personal computer 200 is not computationally powerful. In an alternate embodiment, digital video 350 may be directly downloaded from the public data network 140 via the public network interface 372. In this embodiment, the digital video 350 is saved at the headend for
later streaming playback, but its format may be different from what set top box 172 supports. In either case, transcoders 374 re-encode the data into an appropriate format that is decodable by set top box 172. One or more transcoders may be employed to accommodate the demand of many subscribers.

[0038] Stitchers 376 take the transcoded content, along with other audiovisual content such as interactive menus, advertisements, and the like, and stitch them together to make a final television signal for display on television 174. Stitchers 376 may also contain other logic, for example logic that determines what other content should be stitched together with the transcoded digital video, logic for processing control messages from a remote control 176 (such as menu item selection or movement commands, start / stop stream commands, and the like), and logic to perform other functions. As with the transcoders, several stitchers 376 may be employed within cable television headend 150 to meet subscriber demand. Cable network interface 370, public networking interface 372, transcoders 374, and stitchers 376 may be hardware, software, or a combination of these.

[0039] It should be appreciated that cable television headend 150 may be part of a cable television system comprising several such headends, each headend serving a different cable network in a different geographic area. Further, multiple cable television systems may be grouped together under the administrative control of a single multiple system operator (MSO), as is known in the art. In such larger systems, each headend may or may not include the functional units shown in Fig. 3. For example, transcoders 374 and stitchers 376 servicing headend 150 may be located at a different headend of the MSO, or at a data center remote from the headend 150. These remote transcoders and stitchers may be connected to headend 150 using a private data network of the MSO (not shown). The low latency added by such a physical arrangement of components, coupled with the ease of administration gained by placing multiple pieces of equipment having similar functions in the same physical location, provides advantages over prior art systems.

[0040] The processes for establishing data channels between the personal computer 200 and the set top box 172, and for streaming digital video over those channels, are now described. These data channels are bidirectional. In a first direction, the personal computer 200 streams digital video to cable television headend 150, which forwards the video (after transcoding and stitching) to set top box 172 for eventual display. In the opposite direction,
set top box 172 receives keystrokes from a remote control. These keystrokes may include commands to establish the channel, tear down the channel, and to start and stop playback of video, or select a different digital video source. In some more generalized embodiments, keystrokes are sent from the remote control to control the personal computer 200 in ways unrelated to streaming the digital video. For example, the remote control may be used to select a computer shut down function, or to launch an application such as an email client that will then display on the television connected to set top box 172. Other ways in which a remote control may fully utilize the bidirectional data channel between the set top box 172 and personal computer 200 in accordance with these embodiments may be envisioned by persons having skill in the art.

[0041] Fig. 4 is a timing diagram that illustrates the relevant processes. The first video device includes control software 410 and encoder / streamer 420, which appear in the example embodiment of Fig. 3 as control software 340, encoder 330, and streamer 332 respectively. The cable television headend includes transcoder 374 and stitcher 376, one or more rendezvous servers 430, and a streaming application 440, described in more detail below. The second video device in this example figure is a set top box 172. It will be appreciated that the only functionality required of set top box 172 is the ability to receive video data, change channels, and pass keystrokes upstream to a headend. No more complex hardware or software is required in the set top box 172, although some commercial embodiments may include them. It will be also appreciated that these processes are applicable not just to personal computers and set top boxes as described in the following, but may be generalized to operate on any video devices that are configured to play the roles of producer and consumer, respectively, of digital video.

[0042] In order to establish a bidirectional connection between the personal computer 200 and the set top box 172, two bidirectional data channels must be set up: one between the personal computer 200 and the cable television headend 150, and one between the headend 150 and the set top box 172. However, there is no pre-established association between a subscriber’s set top box and her personal computer. Rendezvous servers 430 are provided at the headend to make this association, and to permit these two video devices to ‘find each other’, and to ensure authentication of the subscriber and authorization of the connection based on subscription and service parameters. Rendezvous may be facilitated using the fact
that both video devices are associated with the subscriber. Rendezvous servers 430 accept offers to stream digital video and requests for the streamed digital video, and pair these offers and requests based on a unique subscriber identifier. The number of servers 430 used by any given headend may be determined by demand. In an alternate embodiment, a multiple system operator may house such rendezvous servers 430 at a data center or other location away from the cable headend that services the subscriber participating in these processes, and may share servers between headends depending on relative demand. Such an arrangement provides advantages when the MSO services several time zones, where demand for rendezvous services peaks and ebbs in different time zones at the same local time in each time zone.

[0043] In general, the cable television provider may wish to provide television signals to the subscriber at all times in order to avoid “dead air.” Practically speaking, this means that the connection between the headend 150 and the set top box 172 should be made only after a digital video stream is already available; in other words, after the connection between the headend 150 and the personal computer 200 has already been established and is pending on a rendezvous server 430. Other embodiments are contemplated; for example, if the connection between the set top box 172 and the headend 150 is made first, headend 150 may give the subscriber a “Waiting” screen, advertisements, or otherwise fill the “dead air” with meaningful television signals of the television operator’s choosing.

[0044] Streaming application 440 provides two functions. First, it communicates with rendezvous servers 430 on behalf of the set top box 172 to establish one of the two bidirectional data channels. Second, it receives commands from a remote control 176 (shown in Figs. 1 and 2) via the set top box 172, and forwards them to the first video device. In some embodiments, the streaming application 440 runs on a computer processor located at the headend. In other embodiments, the processor may be located elsewhere, such as another headend, or an MSO data center in close proximity to the rendezvous servers 430.

[0045] To begin the process, control software 410 connects to encoder / streamer 420 and verifies that these modules are functioning correctly. Next, control software 410 requests authorization to establish a first data channel to stream video data by sending a request to a rendezvous server 430. This request includes parameters that identify the subscriber. Rendezvous server 430 determines whether to permit the establishment of the
data channel based on the subscriber identification, and may include, in some embodiments, determining whether the subscriber has paid for this feature. If authorization is granted, the rendezvous server 430 transmits service information to control software 410. This service information includes, among other data, a list of authorized IP addresses belonging to transcoders 374 that are employed by the cable television operator. Control software 410 stores this service information, and notifies the rendezvous server 430 that it stands ready to stream digital video.

[0046] Next, the subscriber uses remote control 176 to direct the set top box 172 to tune to a special channel. The headend receives a channel designation for the special channel, and instructs stitcher 376, which is responsible for providing the final, stitched video to the set top box, to launch streaming application 440. Application 440, under the assumption that a streaming peer has already been established, immediately requests that peer’s information from rendezvous server 430. This second request to establish a data channel includes parameters that uniquely identify the subscriber, similar to the first request to establish a data channel. Thus, for example, the application 440 may request a web page URL using an HTTP GET request that includes this information.

[0047] If the subscriber is not authorized to receive this service, an error message may be returned by rendezvous server 430, allowing the set top box 172 to send an error message to the television. Otherwise, server 430 returns a detailed response to this request. As several personal computers, smartphones, or other video devices may be providing streaming digital video and have established connections, rendezvous server 430 returns peer information pertaining to one or more peers that are available for viewing selection by identifying the video devices using the unique identifier and associating the set top box with these devices. The peer information may include, for example, a list of connected set top boxes at the subscriber premises, a list of disconnected set top boxes that are available to stream video, a list of set top boxes that are not available to stream video, and other useful information, such as Internet Protocol (IP) addresses, media access control (MAC) addresses, timestamps, and the like. Typically, this information is returned in an XML format, but other formats known in the art may be used. Application 440 may use the returned information to display a menu of choices to the subscriber on set top box 172. Once a selection of which digital video to view, application 440 requests the digital video from rendezvous server 430.
[0048] Now that both bidirectional data channels have been established, rendezvous server 430 announces the completed connection to control software 410 on the first video device. The announcement includes an address of a transcoder 374. Control software 410 then instructs encoder / streamer 420 to connect begin encoding and streaming the digital video as a server. At the same time, control software contacts the transcoder 374 from the announcement, instructing it to request the streamed digital video from the encoder / streamer 420 as a client. Transcoder 374 requests the video stream from encoder / streamer 420, which, as noted above, requests authorization to stream from control software 410.

[0049] The video data stream itself includes the digital video, as well as other data. As is known in the art, header information may be added to the digital video data, such as real time streaming protocol (RTSP) headers, transmission control protocol (TCP) or user datagram protocol (UDP) headers, internet protocol (IP) headers, Ethernet frame headers, and so on. The digital video data is encoded using an encoding format known in the art, or in the case of live capture, unformatted data may be streamed.

[0050] As transcoder 374 receives the video stream, it transcodes it into a format that is decodable by the set top box 172. Next, this transcoded video stream is passed to stitcher 376, which performs stitching, scaling, and other video manipulation. Stitcher 376 forms a second video stream for display, by optionally stitching the digital video with another image, such as context help information, one or more navigation buttons, a menuing interface, an advertisement, information associated with the first video device, or information associated with the digital video. This stitched digital video is then passed as a second data stream from the headend to the set top box 172, and from there to the television.

[0051] A subscriber can control the video stream from the remote control 176, and need not return to the personal computer 200 or other first video device to do so, because the data channels are bidirectional. In particular, the subscriber may use the remote control 176 to send keystroke commands to the streaming application 440, as shown. In this case, the streaming application 440 receives the keystrokes and determines what interactive feature the subscriber wishes to access. If the feature is relevant to the streaming of digital video, application 440 forwards this information to stitcher 376. For example, if the subscriber clicks a “stop” or “disconnect” button in the set top graphical interface, presses a channel up or channel down key, or navigates away from the special channel, the stitcher will be notified.
that new television signals are required. In this case, the stitcher will notify the encoder / streamer 420 that a change to the stream (i.e., a tear down) is required. If necessary, the encoder / streamer 420 will notify control software 410 of the change.

[0052] However, in some embodiments, the subscriber may perform other actions using the remote control. It is contemplated that a subscriber may use a graphical user interface, provided by stitcher 376 or streaming application 440 to set top box 172, to alter other stream parameters. These other parameters include, for example: audio and video encoding parameters, a video resolution, a new file name or URL to stream, and the like. Control software may then present these changes to the video application 310 using an application programming interface (API). The use of such APIs is known in the art for this purpose. It is contemplated that any parameter that may be altered using an API of a video application 310 may be accessed and changed using a set top box remote control.

[0053] Further, in some additional embodiments, the remote control 176 may be used to control other aspects of the function of the first video device. For instance, if the first video device is obtaining the digital video from a web site, the remote control 176 may be used to cause the first video device to navigate to a new URL to obtain new digital video. Or, the remote control 176 can be used to send real-time text message data to the first video device. This embodiment is particularly useful in the environment of Fig. 1 to request that the individual 100 use smartphone 110 to film a different interesting scene, or to provide feedback on the quality of the streamed video, for example. In alternate embodiments, such as that of Fig. 2, the remote control 176 may be used to control a personal computer 200 in other ways, such as launching and using an email client or other software application, directing the computer to shut down, or performing some other useful action. A person skilled in the art may envision other useful applications of the control channel.

[0054] Fig. 5 is a flowchart showing the processes in Fig. 4 from the perspective of a cable television operator at a cable television headend, such as headend 150. In step 510 the headend establishes a first bidirectional data channel with a first video device, such as smartphone 110 or personal computer 200. Typically, the headend will employ a rendezvous server for this purpose, and includes authorizing the establishment of the first data channel based on parameters sent to the rendezvous server. In step 520 the headend establishes a second bidirectional data channel with a second video device, such as set top box 172. This
step is typically performed when the headend receives information that the set top box has
tuned to a special channel devoted to this purpose. Once both connections have been
established, the headend may display a menu on the special channel, informing the
subscriber what devices are currently available to stream digital video for viewing, and
permitting the subscriber to choose a device using a remote control. Once the subscriber
makes a selection, the headend directs the first video device to begin streaming digital video
in a first data stream. This first data stream is received by the headend using the first data
channel in step 530, and may be requested by a transcoder located at the headend. In step
540, the headend forms a second data stream including second video that is based on the
received digital video. For example, the transcoder may transcode the received digital video
into a format that is decodable by the second video device, if necessary. The properly
formatted video may then be stitched together with other video images, such as a menu that
permits the subscriber to start and stop playback or otherwise control the video stream from
the remote control. If the other video images should not be mixed with or overlaid onto the
digital video, the digital video may also be scaled at this time to provide empty space in each
video frame in which to stitch the other video images. The second data stream includes the
final transcoded, stitched video. In step 550, the headend transmits the second data stream to
the second video device using the second data channel. The second video device may then
send the video to a viewing device, such as a television 174, for the subscriber’s enjoyment.

[0055] It should be noted that this logic flow diagram is used herein to demonstrate
various aspects of the invention, and should not be construed to limit the present invention to
any particular logic flow or logic implementation. The described logic may be partitioned
into different logic blocks (e.g., programs, modules, functions, or subroutines) without
changing the overall results or otherwise departing from the true scope of the invention.
Often times, logic elements may be added, modified, omitted, performed in a different order,
or implemented using different logic constructs (e.g., logic gates, looping primitives,
conditional logic, and other logic constructs) without changing the overall results or
otherwise departing from the true scope of the invention.

[0056] The present invention may be embodied in many different forms, including,
but in no way limited to, computer program logic for use with a processor (e.g., a
microprocessor, microcontroller, digital signal processor, or general purpose computer),
programmable logic for use with a programmable logic device (e.g., a Field Programmable Gate Array (FPGA) or other PLD), discrete components, integrated circuitry (e.g., an Application Specific Integrated Circuit (ASIC)), or any other means including any combination thereof.

[0057] Computer program logic implementing all or part of the functionality previously described herein may be embodied in various forms, including, but in no way limited to, a source code form, a computer executable form, and various intermediate forms (e.g., forms generated by an assembler, compiler, linker, or locator). Source code may include a series of computer program instructions implemented in any of various programming languages (e.g., an object code, an assembly language, or a high-level language such as Fortran, C, C++, JAVA, or HTML) for use with various operating systems or operating environments. The source code may define and use various data structures and communication messages. The source code may be in a computer executable form (e.g., via an interpreter), or the source code may be converted (e.g., via a translator, assembler, or compiler) into a computer executable form.

[0058] The computer program may be fixed in any form (e.g., source code form, computer executable form, or an intermediate form) either permanently or transitorily in a tangible storage medium, such as a semiconductor memory device (e.g., a RAM, ROM, PROM, EEPROM, or Flash-Programmable RAM), a magnetic memory device (e.g., a diskette or fixed disk), an optical memory device (e.g., a CD-ROM), a PC card (e.g., PCMCIA card), or other memory device. The computer program may be distributed in any form as a removable storage medium with accompanying printed or electronic documentation (e.g., shrink wrapped software), preloaded with a computer system (e.g., on system ROM or fixed disk), or distributed from a server or electronic bulletin board over the communication system (e.g., the Internet or World Wide Web).

[0059] Hardware logic (including programmable logic for use with a programmable logic device) implementing all or part of the functionality previously described herein may be designed using traditional manual methods, or may be designed, captured, simulated, or documented electronically using various tools, such as Computer Aided Design (CAD), a hardware description language (e.g., VHDL or AHDL), or a PLD programming language (e.g., PALASM, ABEL, or CUPL).
[0060] Programmable logic may be fixed either permanently or transitori­ly in a tangible storage medium, such as a semiconductor memory device (e.g., a RAM, ROM, PROM, EEPROM, or Flash-Programmable RAM), a magnetic memory device (e.g., a diskette or fixed disk), an optical memory device (e.g., a CD-ROM), or other memory device. The programmable logic may be distributed as a removable storage medium with accompanying printed or electronic documentation (e.g., shrink wrapped software), pre­loaded with a computer system (e.g., on system ROM or fixed disk), or distributed from a server or electronic bulletin board over the communication system (e.g., the Internet or World Wide Web).

[0061] The embodiments of the invention described above are intended to be merely exemplary; numerous variations and modifications will be apparent to those skilled in the art. All such variations and modifications are intended to be within the scope of the present invention as defined in any appended claims.
What is claimed is:

1. A method of streaming digital video between a first video device and a second video device, the first video device being connected to a public data network, wherein the second video device is connected to a cable television system having a cable network and a cable headend, the cable headend also being connected to the public data network, the second video device being controlled by a video device controller, the method comprising:
   establishing a first bidirectional data channel from the first video device to the cable headend;
   establishing a second bidirectional data channel over the cable network from the second video device to the cable headend, thereby permitting bidirectional data communication between the first video device and the second video device through the cable headend;
   receiving a first data stream that includes the digital video at the cable headend from the first video device using the first data channel;
   forming a second data stream that includes a second video that is based on the received digital video; and
   transmitting the second data stream from the cable headend to the second video device using the second data channel, wherein the data stream is controlled by sending commands from the video device controller to the first video device over the first and second data channels.

2. The method of claim 1, wherein the digital video includes audio data, moving image data, still image data, or any combination of these.

3. The method of claim 1, wherein the digital video is encoded according to an MPEG specification.

4. The method of claim 1, wherein the first video device is a personal computer or a smartphone.

5. The method of claim 1, wherein the second video device is a television or a set top box connected to a television, and the device controller is a remote control.

6. The method of claim 5, further comprising displaying the second video on the television.
7. The method of claim 1, wherein the second video comprises the received digital video.

8. The method of claim 1, wherein the second video comprises a transcoding of the received digital video into a format that is decodable by the second video device.

9. The method of claim 1, wherein the second video comprises a plurality of video frames, each video frame comprising a frame of the digital video stitched together with another image.

10. The method of claim 9, wherein the other image comprises an advertisement, information associated with the first video device, or information associated with the digital video.

11. The method of claim 1, wherein the public data network is the Internet.

12. The method of claim 1, wherein the first and second video devices are located within the premises of an individual.

13. The method of claim 12, wherein no bidirectional data channel between the first and second video devices exists entirely within the premises.

14. The method of claim 1, wherein establishing the first data channel comprises:
   receiving, from the first video device, a first request to establish the first data channel, the first request having request parameters that include a unique identifier; and
   authorizing the establishment of the first data channel based on the request parameters.

15. The method of claim 14, wherein the first request is received over either the public data network or over the cable network.

16. The method of claim 14, wherein the unique identifier is a media access control (MAC) address that is uniquely associated with the first video device.

17. The method of claim 14, wherein establishing the second data channel comprises:
   receiving, from the second video device, a second request to establish the second data channel, the second request having request parameters that include the unique identifier;
   identifying the first video device using the received unique identifier; and
   associating the second video device with the identified first video device.

18. A tangible, non-transitory, data storage medium in which is stored computer program code for streaming digital video between a first video device and a second video device, the
first video device being connected to a public data network, wherein the second video device is connected to a cable television system having a cable network and a cable headend, the cable headend also being connected to the public data network, the second video device being controlled by a video device controller, the storage medium comprising:

program code for establishing a first bidirectional data channel from the first video device to the cable headend;

program code for establishing a second bidirectional data channel over the cable network from the second video device to the cable headend, thereby permitting bidirectional data communication between the first video device and the second video device through the cable headend;

program code for receiving a first data stream that includes the digital video at the cable headend from the first video device using the first data channel;

program code for forming a second data stream that includes a second video that is based on the received digital video; and

program code for transmitting the second data stream from the cable headend to the second video device using the second data channel, wherein the data stream is controlled by sending commands from the video device controller to the first video device over the first and second data channels.
Establish a first bidirectional data channel with a first video device

Establish a second bidirectional data channel with a second video device

Receive a first data stream having digital video from the first video device using the first data channel

Form a second data stream including second video that is based on the digital video

Transmit the second data stream to the second video device using the second data channel

FIG. 5