US006732183B1

(12) **United States Patent**
**Graham**

(10) **Patent No.: US 6,732,183 B1**
(45) **Date of Patent: May 4, 2004**

(54) **VIDEO AND AUDIO STREAMING FOR MULTIPLE USERS**

(75) Inventor: **John J. Graham**, Saratoga, CA (US)

(73) Assignee: **BroadWare Technologies, Inc.**, Cupertino, CA (US)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/565,563**

(22) Filed: **May 4, 2000**

**Related U.S. Application Data**

(63) Continuation-in-part of application No. 09/001,850, filed on Dec. 31, 1997.
(60) Provisional application No. 60/034,128, filed on Dec. 31, 1996.

(51) **Int. Cl.**[7] ..... **G06F 15/16**
(52) **U.S. Cl.** ..... **709/231**; 348/722
(58) **Field of Search** ..... 709/245, 203, 709/231; 370/401, 352, 395, 229; 348/722; 345/327

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,228,859 A 7/1993 Rowe
5,247,670 A 9/1993 Matsunaga
5,390,240 A 2/1995 Sensney
5,512,938 A 4/1996 Ohno
5,528,282 A 6/1996 Voeten et al.
5,602,992 A 2/1997 Daneels
5,606,693 A 2/1997 Nilsen et al.
5,668,986 A 9/1997 Nilsen et al.
5,668,996 A 9/1997 Radinsky
5,724,355 A * 3/1998 Bruno et al. ..... 370/401
5,751,280 A 5/1998 Abbott et al.
5,764,750 A * 6/1998 Chau et al. ..... 379/229
5,764,916 A 6/1998 Busey et al.
5,778,181 A 7/1998 Hidary et al.
5,802,526 A 9/1998 Fawcett et al.
5,815,662 A 9/1998 Ong
5,828,839 A 10/1998 Moncreiff
5,842,015 A 11/1998 Cunniff et al.
5,844,553 A 12/1998 Hao et al.
5,861,881 A * 1/1999 Freeman et al. ..... 345/302
5,864,555 A * 1/1999 Mathur et al. ..... 370/395
5,880,792 A * 3/1999 Ward et al. ..... 348/722
5,884,032 A 3/1999 Bateman et al.
5,889,506 A 3/1999 Lopresti et al.
5,889,942 A 3/1999 Orenshteyn
5,898,780 A 4/1999 Liu et al.
5,905,524 A 5/1999 Sauer
5,905,872 A * 5/1999 DeSimone et al. ..... 709/245
5,922,054 A 7/1999 Bibayan
5,928,327 A 7/1999 Wang et al.
5,928,330 A 7/1999 Goetz et al.

(List continued on next page.)

OTHER PUBLICATIONS

Paek et al, Video Server Retrieval Scheduling for Variable Bit Rate Scalable Video, IEEE 1996.*

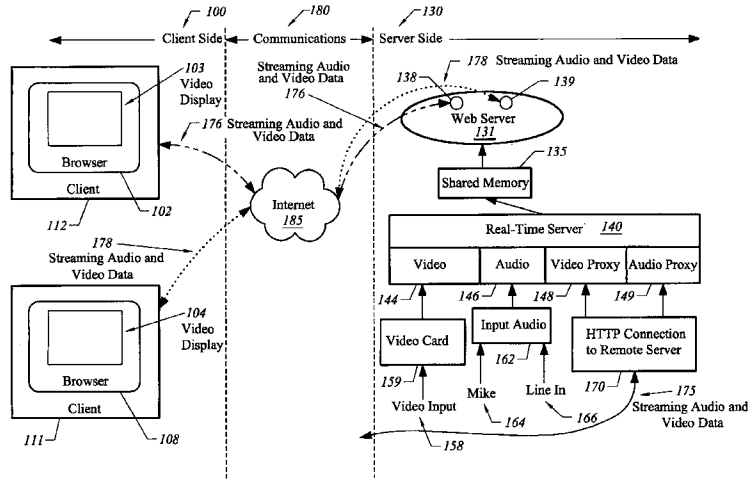
(List continued on next page.)

*Primary Examiner*—Marc D. Thompson
*Assistant Examiner*—Thong Vu
(74) *Attorney, Agent, or Firm*—Cooley & Godward LLP

(57) **ABSTRACT**

A computer system provides streaming media to a plurality of clients over a network. The system includes a proxy module that forwards streaming media from a first streaming media source to a network server module that is communicating to the plurality of client terminals. The proxy module is comunicatable with the network server module to be signaled a switch request. In response to the switch request, the proxy module forwards streaming media from a second streaming media source to the network server module while the network server module is signaling streaming media from the first streaming media source to the plurality of client terminals.

**7 Claims, 7 Drawing Sheets**



U.S. PATENT DOCUMENTS

| | | | | | |
|---|---|---|---|---|---|
| 5,930,493 | A | | 7/1999 | Ottesen et al. | |
| 5,953,005 | A | | 9/1999 | Liu | |
| 5,956,716 | A | | 9/1999 | Kenner et al. | |
| 5,960,173 | A | | 9/1999 | Tang et al. | |
| 6,006,241 | A | | 12/1999 | Purnaveja et al. | |
| 6,009,410 | A | | 12/1999 | LeMole et al. | |
| 6,018,768 | A | | 1/2000 | Ullman et al. | |
| 6,020,931 | A | * | 2/2000 | Bilbrey et al. | 348/584 |
| 6,025,837 | A | | 2/2000 | Matthews, III et al. | |
| 6,055,522 | A | | 4/2000 | Krishna et al. | |
| 6,091,407 | A | * | 7/2000 | Boetje et al. | 345/327 |
| 6,151,609 | A | | 11/2000 | Truong | |
| 6,222,843 | B1 | * | 4/2001 | Mauger | 370/397 |
| 6,298,120 | B1 | | 10/2001 | Civinlar et al. | |
| 6,452,933 | B1 | | 9/2002 | Duffield et al. | |

OTHER PUBLICATIONS

Huang et al, The Mercuri Multimedia Laboratory at Honeywell, IEEE 1996.*

Liu et al, Perfomance of a Storage System for Supporting Different Video Types and Qualities, IEEE 1996.*

Server Products User's Guide, Graham Technology Solutions, Inc. www.graham.com/products/manual. 1998.*

Paek et al. "Video Server Retrieval Scheduling for Variable Bit Rate Scalable Video", IEEE 1996, ps. 108–112.

Huang et al., "The Mercuri Multimedia Laboratory at Honeywell", IEEE 1996, pp. 72–77.

Liu et al., Performance of a Storage System for Supporting Different Video Types and Qualities, IEEE 1996, pp. 1314–1331.

Instructions for using Netscape Navigator, downloaded from Netscape website/.../NetHelp/netscape/navigator/nav.html, printed on Dec. 14, 1997, 67 pages.

Video Server Architectures: Performance and Scalability.. – Bernhardt, et al. (1994) ffp.eurecom.fr/ATM/papersEURECOM/PAPERS/brestBernhardt.ps.g2.

* cited by examiner

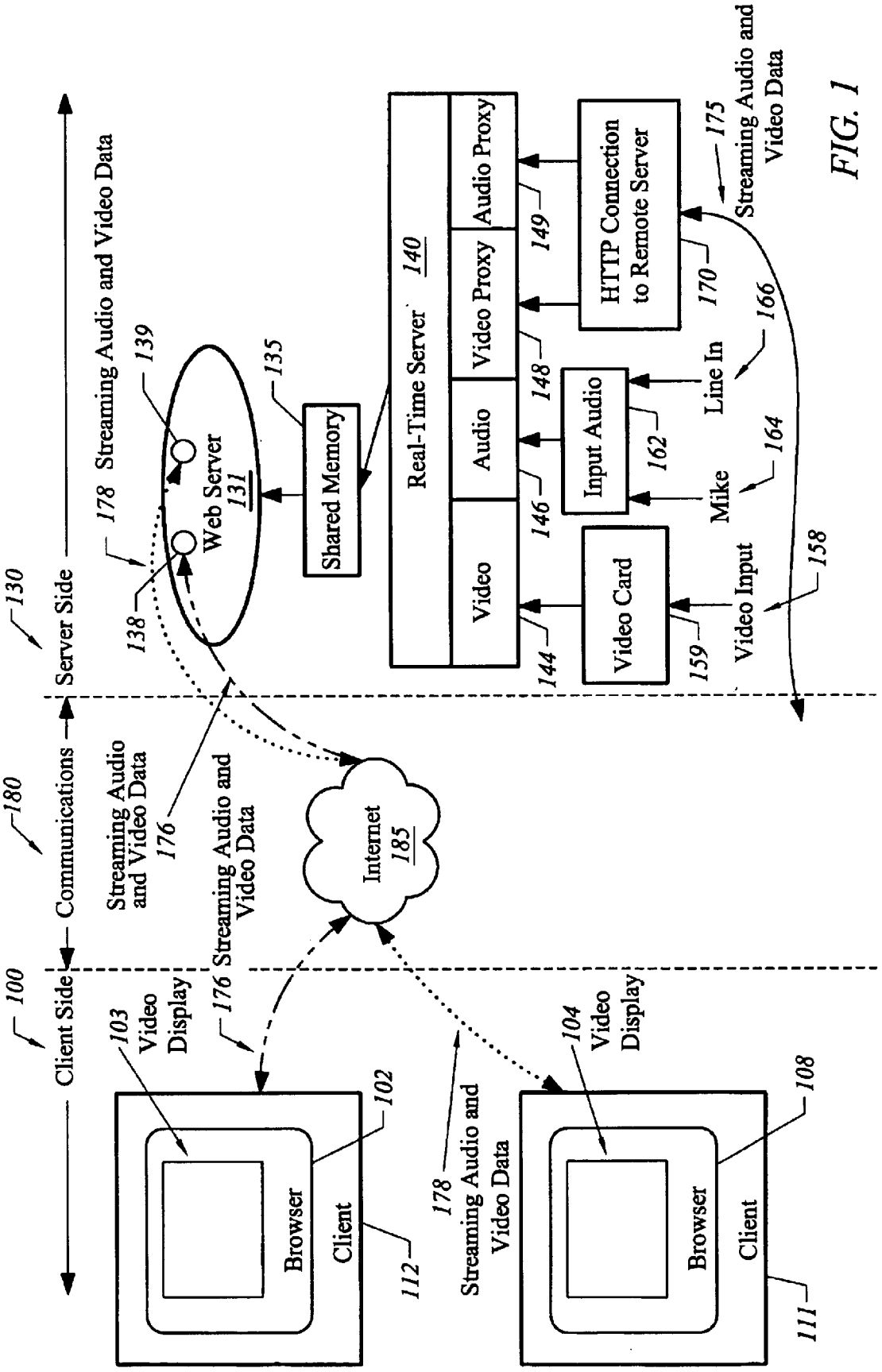

Server Side
130
Communications
180
Client Side
100
Streaming Audio and Video Data
178
139
138
Web Server
131
135
Shared Memory
Real-Time Server
140
Video
Audio
Video Proxy
Audio Proxy
144
146
148
149
Video Card
Input Audio
HTTP Connection to Remote Server
159
162
170
Video Input
Mike
Line In
158
164
166
175
Streaming Audio and Video Data
Streaming Audio and Video Data
176
Internet
185
Streaming Audio and Video Data
176
103
Video Display
102
Browser
Client
112
178
Streaming Audio and Video Data
104
Video Display
108
Browser
Client
111

FIG. 1

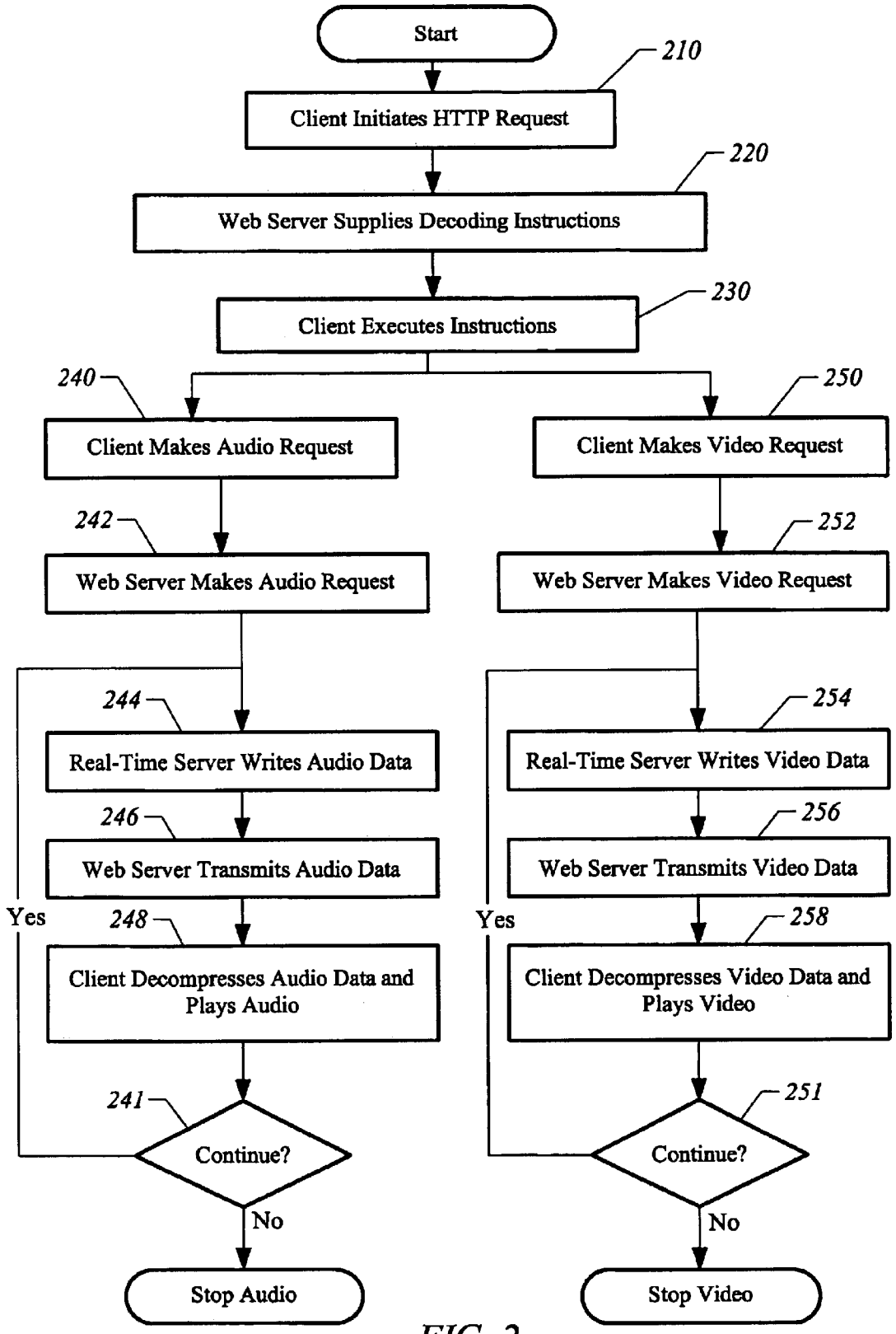

Start
210
Client Initiates HTTP Request
220
Web Server Supplies Decoding Instructions
230
Client Executes Instructions
240
Client Makes Audio Request
250
Client Makes Video Request
242
Web Server Makes Audio Request
252
Web Server Makes Video Request
244
Real-Time Server Writes Audio Data
254
Real-Time Server Writes Video Data
246
Web Server Transmits Audio Data
256
Web Server Transmits Video Data
Yes
248
Client Decompresses Audio Data and Plays Audio
Yes
258
Client Decompresses Video Data and Plays Video
241
Continue?
251
Continue?
No
No
Stop Audio
Stop Video

FIG. 2

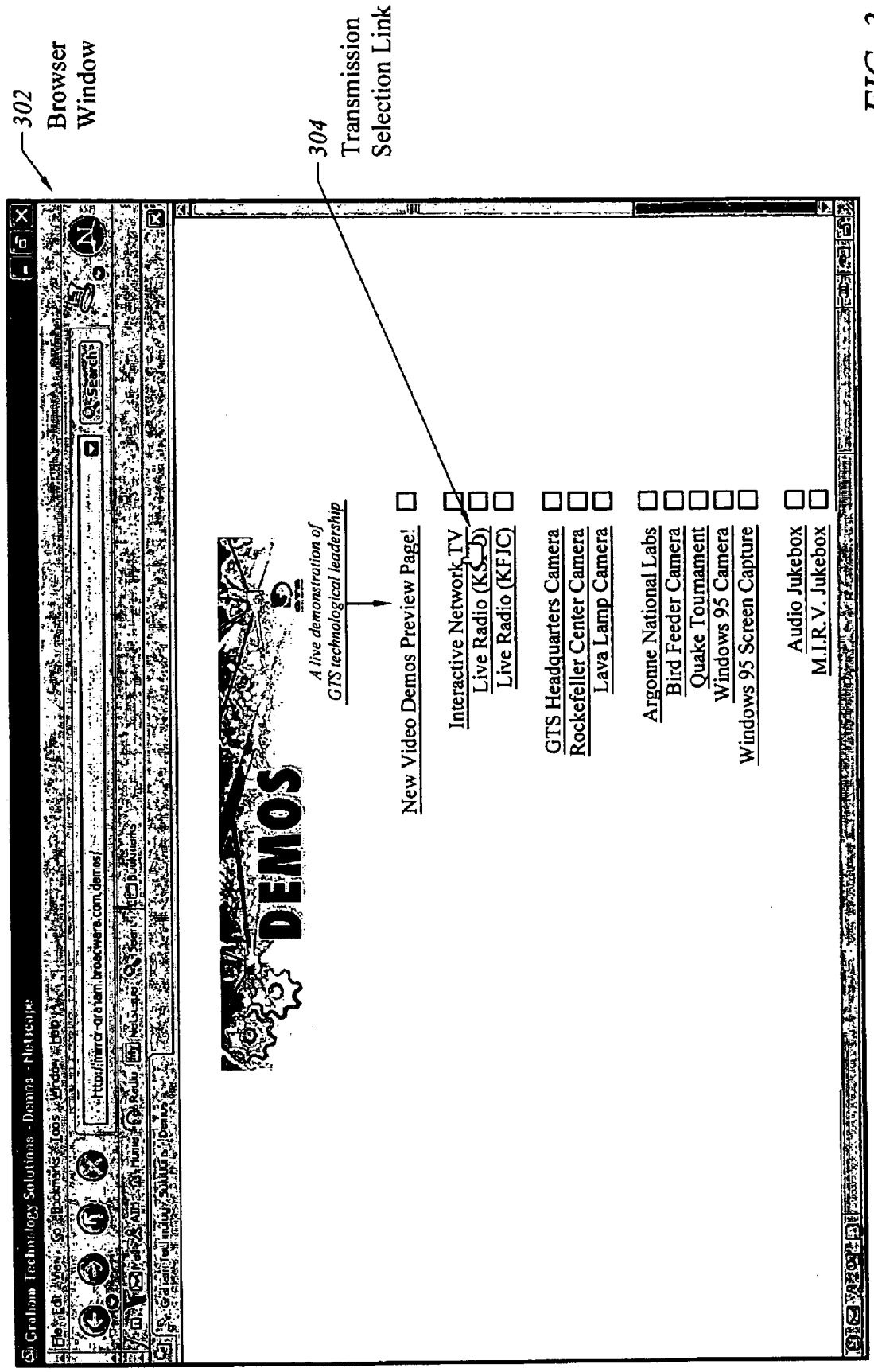

302
Browser Window
304
Transmission Selection Link
Graham Technology Solutions - Demos - Netscape
DEMOS
A live demonstration of GTS technological leadership
New Video Demos Preview Page!
Interactive Network TV
Live Radio (KSJD)
Live Radio (KFJC)
GTS Headquarters Camera
Rockefeller Center Camera
Lava Lamp Camera
Argonne National Labs
Bird Feeder Camera
Quake Tournament
Windows 95 Camera
Windows 95 Screen Capture
Audio Jukebox
M.I.R.V. Jukebox

FIG. 3

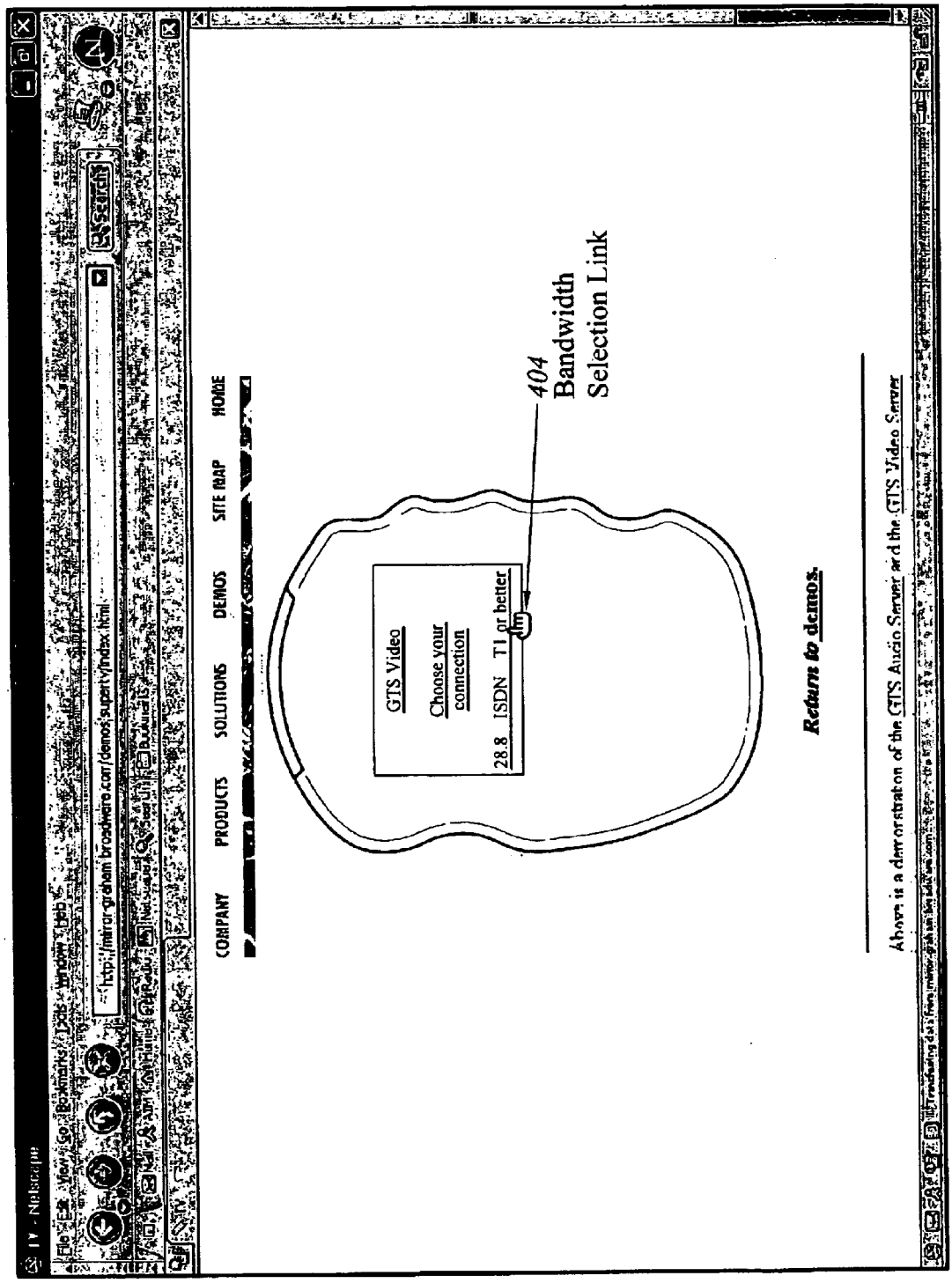

302
Browser Window
COMPANY
PRODUCTS
SOLUTIONS
DEMOS
SITE MAP
HOME
GTS Video
Choose your connection
28.8 ISDN T1 or better
404
Bandwidth Selection Link
Return to demos.
Above is a demonstration of the GTS Audio Server and the GTS Video Server

FIG. 4

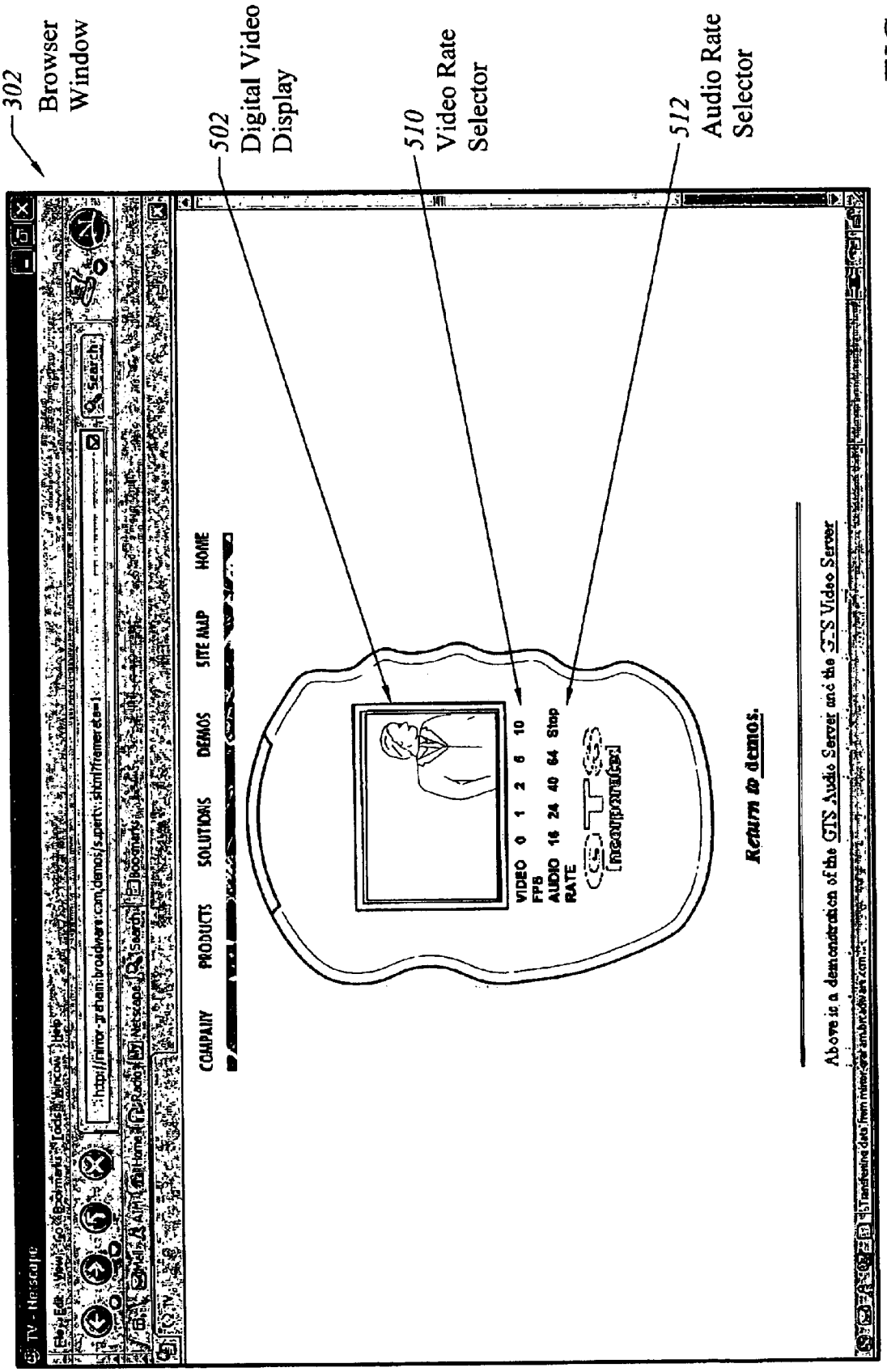

302
Browser Window
502
Digital Video Display
510
Video Rate Selector
512
Audio Rate Selector
COMPANY
PRODUCTS
SOLUTIONS
DEMOS
SITE MAP
HOME
VIDEO 0 1 2 6 10
FPS
AUDIO 16 24 40 64 Stop
RATE
Return to demos.
Above is a demonstration of the GTS Audio Server and the GTS Video Server

FIG. 5

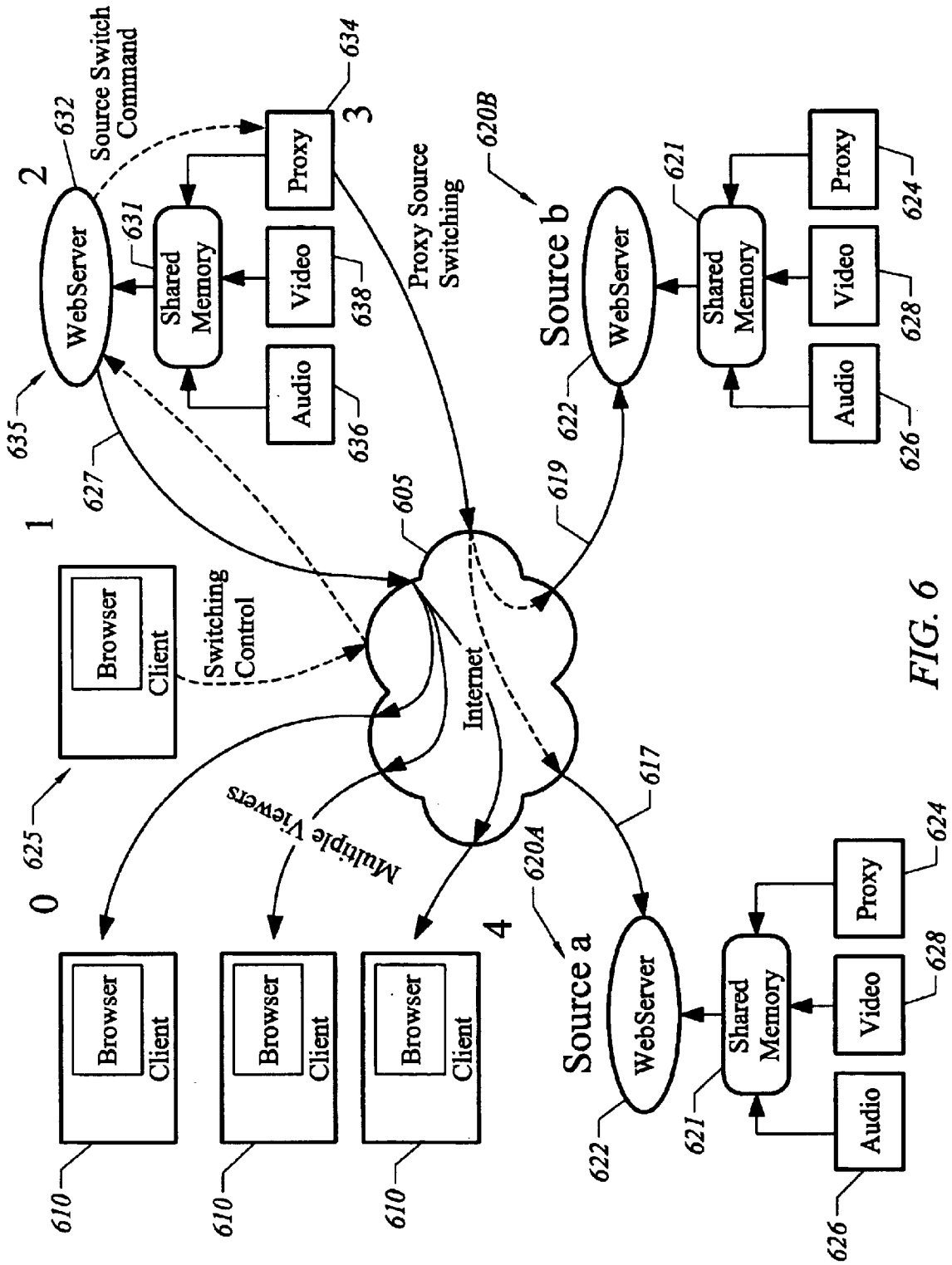

Source Switch Command
WebServer
Shared Memory
Proxy
Video
Audio
Proxy Source Switching
Source b
Source a
Browser Client
Switching Control
Internet
Multiple Viewers
0
1
2
3
4
610
605
617
619
620A
620B
621
622
624
625
626
627
628
631
632
634
635
636
638

FIG. 6

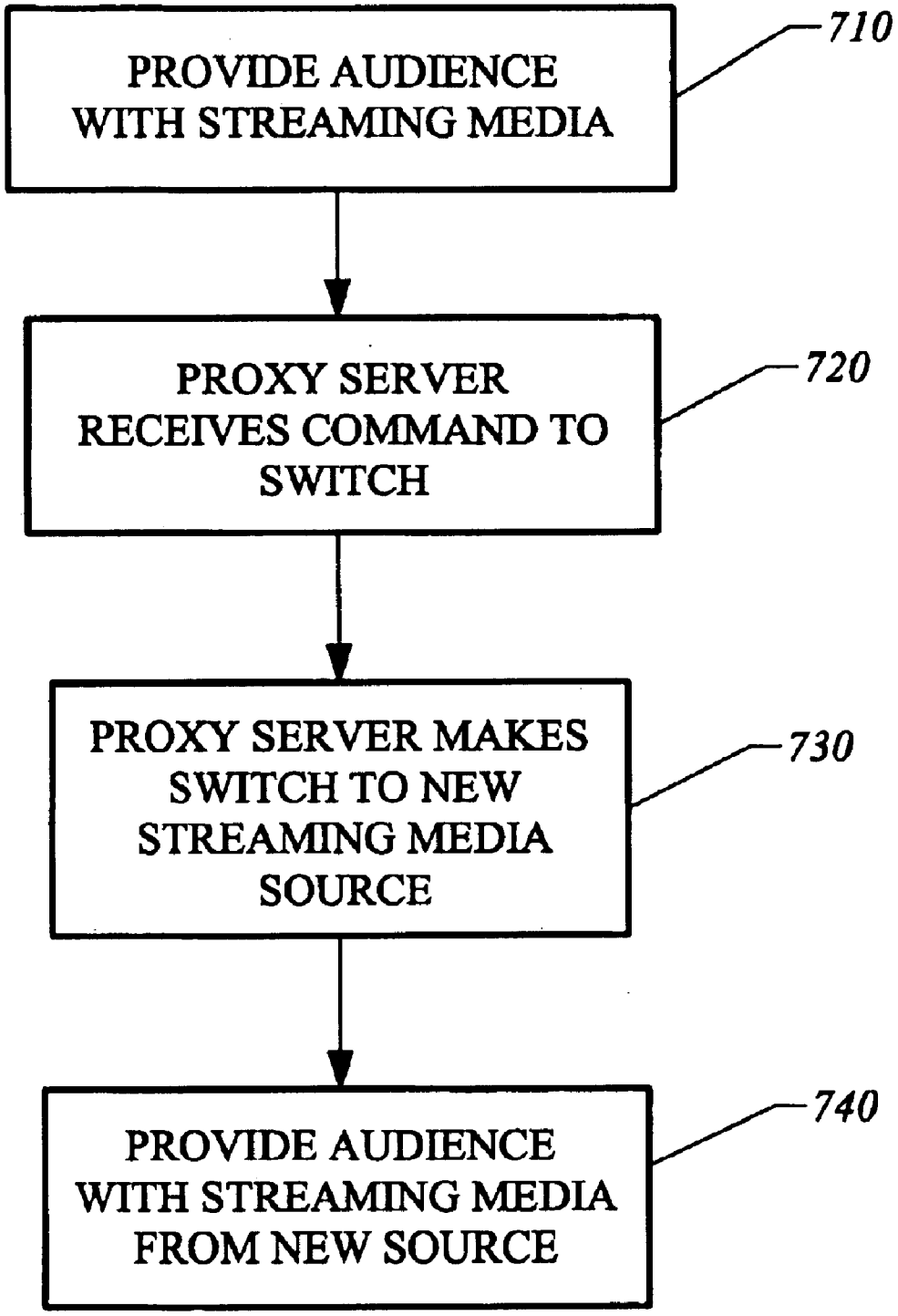

PROVIDE AUDIENCE WITH STREAMING MEDIA
710
PROXY SERVER RECEIVES COMMAND TO SWITCH
720
PROXY SERVER MAKES SWITCH TO NEW STREAMING MEDIA SOURCE
730
PROVIDE AUDIENCE WITH STREAMING MEDIA FROM NEW SOURCE
740

*FIG. 7*

# VIDEO AND AUDIO STREAMING FOR MULTIPLE USERS

## CROSS REFERENCE TO RELATED APPLICATIONS

This continuation-in-part appliction claims priority from the U.S. patent application Ser. No. 09/001,850, filed Dec. 31, 1997, entitled Video And Audio Streaming For Multiple Users, which claims priority to U.S. Provisional Patent Application No. 60/034,128, filed Dec. 31, 1996, both of the aforementioned applications are herein incorporated by reference.

## BACKGROUND OF THE INVENTION

1.Field of the Invention

This invention relates to the field of network delivery of audio and video information. In particular, the invention relates to a system for delivering audio and video information to multiple users.

2. Background Information

The Internet enables many different ways of communicating. Originally, the Internet was used for the exchange of files and electronic mail. As the capabilities of the Internet expand, other types of communications are enabled.

Audio and video transmissions are an important area of the communications that the Internet enables. For example, many technologies support the transmission of digital video and/or audio signals over the Internet. An example of such a technology is Quicktime™, available from Apple Computer, Inc., of Cupertino Calif. Quicktime movies are files that can be transmitted across the Internet. Quicktime provides both audio and video displays. Many other file formats allow audio and video to be displayed on people's computers.

This paragraph describes an example use of a the Quicktime technology. A user will have a browser application that resides on his/her computer. The computer, acting as a client under the direction of the browser application, will connect to various World Wide Web (web) servers. Each web server will typically serve hypertext markup language (HTML) files to the clients. The files may include text, graphics references, and references to specialized files. Some of these specialized files can include audio and video information in Quicktime form. The clients can then play these audio and video files once they are downloaded using a Quicktime plug-in, a helper application, or Quicktime capabilities built into the browser application. A plug-in and a helper application are described in greater detail below.

Streaming audio and video, as a subset of all the types of audio and video that can be transmitted over the Internet, allow people to broadcast long and/or live video and audio transmissions across the Internet. Streaming video and audio is video and audio digital data that is transmitted on a continuous basis. A client can access the data stream and regenerate the video images and audio signal as they are being transmitted. Streaming technology is particularly helpful where the events are live, or where the files would be so large as to be a burden on the end users. Examples of where streaming technology is particularly useful are for the display of conferences, sporting events, radio broadcasts, television broadcasts, and the like.

RealNetworks, Inc. of Seattle, Wash., provides a system for transmitting streaming audio and video signals to users over the Internet. RealNetworks supplies a server that allows multiple users to simultaneously receive streaming audio and video.



The real audio system requires that not only the client have additional software, but that the content provider have a separate server from their normal web server. For a client to receive a real audio broadcast, the client typically connects through their browser to a Web page with a reference to a real audio server. The client then accesses its separate real audio player program. The real audio player program then connects to the referenced real audio server. A significant drawback to such an arrangement is that the user must download the real audio player program. This program must then be installed on the user's computer. This may cause a number of problems for the user. For example, if the user is behind a firewall, or some security program, the client may not be able to receive the broadcast from the server. Additionally, the installation of any program may have conflicts with other programs. The program has the disadvantage of being platform specific. This means that a different program must be developed and downloaded for each type of computer that is to be used to access RealNetworks broadcasts. Additionally, the broadcasters of the streaming audio and video need to use the RealNetworks server, which is separate from the broadcasters' World Wide Web server (also referred to as the web server). This increases the broadcasters' security problems because now the broadcasters must be concerned with two separate servers.

Another example of a video and audio system that uses Internet like communications is the MBone. The MBone is a specialized communication network that allows for the distribution of streaming video and audio signals to multiple users. A specialized network is set up specifically to transmit MBone communications. A significant drawback of this system is that users must be connected to the specialized network. Additionally, users will be required to have specialized software on their computers to listen to and watch MBone transmissions.

A streaming video system, not requiring a user to download a separate program, was developed for a single user by John Graham of California. This single user broadcast technology allowed a web server to serve a single streaming video signal to a single client. Although the user did not need to download a plug-in to see the video, only one user was allowed to access the video stream at a time. In this system, video information was captured from a video camera and digitized. The digital video information was then encapsulated in a MIME encoded multipart data stream. The client received this data stream and reconstructed frames of the digital video.

Therefore, what is desired is a platform independent video and audio streaming system that does not require the user to download additional programs beyond the functionalities found in a browser.

## 1. A SUMMARY OF THE INVENTION

A system and method of providing streaming audio and video data to multiple users is described. In one embodiment, the system comprises a first client, a second client and a server. The first and second clients are executing browsers. The server can communicate with the two clients. The server concurrently provides streaming audio and video data to both of the clients. Importantly, the server does not require the two browsers to use a plug-in or a helper application to receive and use the streaming audio and video data.

In some embodiments of the invention, a browser causes a client to request an HTML file from a web server. The client receives the HTML file. The HTML file includes an

HTML tag that directs the browser to load one or more applets from the server. The browser executes the applets causing the browser to request streaming audio and video from the web server. That request may or may not include parameters giving information about the type of request being made. The web server associates a server process with the request, given the parameters in the request. The web server notifies real-time audio and video process that streaming audio and video information is needed. In response to the notification, the real-time audio and video process stores encoded audio and video data in a shared memory location. The server process accesses the shared memory and inserts the audio and video data into one or more data streams. The client receives the data streams and reconstructs the audio and video signals using only the capabilities of the browser. In some embodiments, a separate stream and server process is used for each of the audio and video data. These embodiments allow multiple clients to simultaneously receive the same audio and video data.

Other embodiments of the invention include a web server that can serve streaming audio and video information as well as perform more usual web server functions (such as, serving web pages, performing file transfers, supporting secure communications). These embodiments have the advantage of allowing the broadcasters and the users to set up their security configurations for one web server, rather than two servers (a web server and a streaming audio and video server).

Although many details have been included in the description and the figures, the invention is defined by the scope of the claims. Only limitations found in those claims apply to the invention.

## 2. A BRIEF DESCRIPTION OF THE DRAWINGS

The figures illustrate the invention by way of example, and not limitation. Like references indicate similar elements.

FIG. **1** illustrates a system including one embodiment of a streaming audio and video system for multiple users where client computers do not need plug-ins or helper programs.

FIG. **2** illustrates an example method of streaming audio and video for multiple users.

FIG. **3** illustrates a web page that a user can use to access a streaming audio and video broadcast.

FIG. **4** illustrates a web page for selecting the bandwidth of the user's Internet connection.

FIG. **5** illustrates a web page having streaming audio and video.

FIG. **6** is a block diagram under another embodiment of the invention, illustrating a proxy switching system

FIG. **7** is a flow chart for a process to use proxy switching for providing streaming media to client terminals, under an embodiment of the invention.

## 3. THE DESCRIPTION

The following sections describe embodiments of the invention. The first section provides definitions that will help in the understanding of the remaining sections. The second section shows an example system that supports various embodiments of the invention. The third section describes an example method of using the invention. The fourth section illustrates an actual use of the streaming audio and video used in some embodiments of the invention. The last section reviews additional alternative embodiments of the invention.

### (a) Definitions

The following definitions will help in the understanding of the following description.

Client: a computer, process, program, or combination of computers, processes or programs, that can communicate with a server.

Server: a computer, process, program, or combination of computers, processes or programs, that can communicate with a client. The server and the client can be executing on the same computer(s).

Web server: a server for serving at least Internet related requests. Example web servers can serve HTML pages in response to HTTP requests from clients. Some web servers can serve many different kinds of requests, e.g., HTTPS, and/or FTP.

Browser: an application, program, process, or combination of applications, programs or processes, that allow a client to make a request of a web server and process the results of the request. The browser may be part of a stand alone application or a set of programs that are integrated into the operating system of the client.

Plug-in: plug-ins are external software programs that extend the capabilities of the browser in a specific way. For example, a plug-in can be used to give the browser the ability to play audio samples or view video movies from within the browser.

Helper application: like plug-ins, helper applications are external software programs. The browser redirects some types of file to the helper applications. The helper applications allow clients to process many different types of files on the Internet. When the browser encounters a sound, image, or video file, the browser hands off the data to the helper applications to run or display the file.

JavaScript: a stand-alone programming language built into many browsers. Primarily an extension to the Internet standard HTML language.

Java: a programming language whose programs (called applets) can travel over the Internet for use by clients. Whereas plug-ins and helper applications are tailored for a particular type of client, Java applets generally work across the Internet regardless of the type of client. Many browsers include Java capabilities so Java applets require no installation. Except where noted, Java and JavaScript are interchangeable.

### (b) System

FIG. **1** illustrates a system including one embodiment of the invention where audio and video is supplied over the Internet to multiple users. The following paragraphs first list the elements of FIG. **1**, describe their interconnections, and then describe the various elements in greater detail.

This paragraph lists the elements of FIG. **1**. FIG. **1** includes a system having three parts: a client side **100**, a communications interface **180**, and a server side **130**. The client side **100** includes a client **112** and a client **111**. The client **112** includes a browser **102** having a video display area **103**. The client **111** includes a browser **108** and a video display area **104**. The communications interface **180** includes the Internet **185**. The server side **130** includes a web server **131**, a shared memory **135**, and a real-time server **140**. The web server **131** includes two processes, a process **138** and a process **139**. The real-time server **140** includes a video module **144**, an audio module **146**, a video proxy **148**, and an audio proxy **149**. The real-time server **140** interfaces with a number of other elements. These elements include a video card **159**, an input audio interface **162**, and an HTTP connection to remote server **170**. Various elements of FIG. **1** have now been listed.

The following paragraphs describe the interconnections between the elements of FIG. **1**. Beginning on the server side **130**, the video card **159** receives a video input **158** outputs a digital video signal to the video module **144**. Similarly, an input audio interface **162** receives a mike input **164** and/or a line input **166** and outputs a digital audio signal to the audio module **146**. The HTTP connection to remote server **170** receives a streaming audio and video data **175**. The HTTP connection to remote server **170** outputs the video data to the video proxy module **148** and the audio data to the audio proxy module **149**. The real-time server **140** uses the data received by the various modules and stores portions of that data in the shared memory **135**, after some manipulation of the data. The shared memory **135** is accessed by the web server **131**. The process **138** and the process **139** transmit and receive data to the communications interface **180**. Thus, the couplings of the server side **130** have been described. In some embodiments, the process **138** and the process **139** correspond to HTTPD processes.

The communications interface **180** allows the client side **100** to communicate with the server side **130**. The communications interface, and the Internet **185** in particular, support many different types of connections by the client side **100** and the server side **130**. In the example communications interface **180**, the communications interface **180** includes the Internet **185**. In particular, in this example, the process **138** is communicating streaming audio and video data **176** to the Internet **185**. Similarly, the process **139** is communicating the streaming audio and video data **178** to the Internet **185**.

On the client side **100**, the client **112** is communicating the streaming audio and video data **176** with the Internet **185**. Similarly, the client **111** is communicating with the Internet **185** to receive and manage the streaming audio and video data **178**. The clients then communicate the information to their respective browser applications. The browser applications the generate video images in their respective video display areas.

Thus, the connections between the various elements of FIG. **1** have been described. Now the various elements will be described in greater detail in the following paragraphs. An example method of using these elements is described below in relation to FIG. **2**.

The server side **130** will be described first.

The video input **158** represents a video signal that a user of such a system wishes to broadcast to the clients on the client side **100**. The video input **158** can include analog signals representing video information. The video card **159** digitizes the video input **158** to produce a digital video image. Various embodiments of the invention include Sun video cards available from Sun Microsystems, of Mountain View, Calif., and Parallax XVideo Xtra™ video cards, available from Parallax Graphics, Inc., of Santa Clara, Calif. However, what is important is that the real-time server **140**, and in particular the video module **144**, receives some sort of digitized video signal. The video module **144** is responsible for providing the real-time server **140** with the video information that will be broadcast to the client side **100**. The video module **144** can convert the digitized video signals to be of better use to the rest of the system. For example, the video module **144** may, if not done by the video card **159**, convert digital video data into a sequence of JPEG digital video frames. In any case, what is important is that the real-time server **140** receives digital video information in a format that it can use (example formats include, JPEG, MPEG, GIF, and AVI).

Similarly, the input audio interface **162** allows for the input of analog audio signals and converts this input to digital audio signals. What is important is that the audio module **146** receives a digitized audio signal that can be used by the real-time server **140**. The audio module **146** may convert the digitized audio signal into any of a number of formats, corresponding to any of a number of audio transmission rates (examples include G.711 and G.723 audio compression formats).

The HTTP connection to remote server **170** represents an important advantage of one embodiment of the invention. In this embodiment, the HTTP connection to remote server **170** allows the server side **130** to forward broadcasts of audio and video signals from other streaming audio and video servers. In these uses, the server side **130** acts as a client to another server. The HTTP connection to remote server **170** can receive video and audio signals being broadcast through the Internet **185** from another server. The HTTP connection to remote server **170** provides the digital video information from the other server to the video proxy module **148**. Similarly, the HTTP connection to remote server **170** provides the audio data to the audio proxy module **149**. The video proxy module **148** and the audio proxy module **149** then supply the respective video and audio data to the real-time server **140**.

The real-time server **140** represents an application, or set of applications, executing on one or more computers, that prepares audio and video data for broadcasting to multiple users through the web server **131**. The real-time server **140** takes the data from the various modules, processes the data, and stores the processed data in the shared memory **135**. The real-time server **140** can perform compression, and other manipulations of the data, to reduce the processing burden on the web server **131**. For example, in some embodiments of the invention, the real-time server **140** receives digitized video data and compresses that data into JPEG images. These JPEG images are sequenced digital frames of video. Similarly, for the audio data, the real-time server **140** breaks the audio information into one-half second time periods of audio data (other embodiments use other time periods). These one-half second time periods of data are stored in the shared memory **135**. The real-time server **140** can also compress the audio information into one of a number of various compressed audio signals (e.g., G.711 and/or G.723 audio compression formats). In some embodiments of the invention, the real-time server can broadcast audio and video from multiple sources to multiple clients.

The shared memory **135** represents a shared storage area for use by the real-time server to store audio and video data for access by the web server **131**. In one embodiment the shared memory **135** has a locking and semaphore usage scheme to ensure that the real-time server **140** is not writing data into the shared memory **135** while the web server **131** is accessing that data. In some embodiments, the semaphores act as notifiers to indicate that new data in the shared memory **135** is available for use by the web server **131**. In some embodiments, the video data and the audio data are stored in different shared memory locations.

The web server **131** communicates data over the Internet **185** using one or more communications protocols. In some embodiments of the invention, these protocols include HTTP (Hypertext Transfer Protocol), TCP (Transmission Control Protocol) and UDP (User Datagram Protocol). The web server **131** represents an application, including one or more processes, for communicating over the Internet **185**. In one embodiment, the web server **131** includes an Apache web server. Each of the processes in the web server **131**

represents one or more processes for serving streaming audio and video data to the client side **100**. In some embodiments, the web server **131** transmits the video data as a multipart MIME (multi-purpose Internet mail extensions) encoded file for decoding directly by the browser or as compressed video information for decoding by an applet run in the browser. The web server **131** transmits the audio data as compressed audio data for decoding by an applet run in the browser.

In some embodiments, the web server **131** initiates a separate process for each audio and video connection made from client side **100**. Thus, for one client receiving streaming audio and video data, two processes would be started within the web server **131**. The first process would supply video data and the second process would supply audio data. The processes access the shared memory **135** and serve the data across the Internet to the respective client.

In some embodiments, the web server **131** initiates at least one process for each client. This provides important advantages in some embodiments of the invention. In particular, because the web server **131** is serving the data directly through processes it created, server side **130** users need not worry about security issues beyond those already faced with their web server **131**. Thus, these embodiments of the invention have a lower chance of interfering with client side **100** fire walls and have a lower chance of having a server side **130** security problem.

Other embodiments of the invention include separate Common Gateway Interface (CGI) programs for audio and video. These CGI programs are used by the web server **131** to serve the streaming audio and video data. These CGI programs are not necessarily integrated as tightly to the web server **131** as the process **138** and the process **139**. However, a CGI program allows for the easy extension of many different types of web servers.

The communications interface **180** permits communications between the server side **130** and the client side **100**. In this example, the Internet **185** supports the communications. Other embodiments of the invention support other communications interfaces. For example, the Internet **185** can be replaced by a local area network, a wide are network, a proprietary telecommunications and networking infrastructure, or some other communications interface. What is important is that the server side **130** can communicate with the client side **100**. The communications interface **180** can also include combinations of the above described technologies. For example, the Internet **185** can include a web server to which the clients on the client side communicate through to access the Internet **185**. The client side **100** can be on a local area network that is connected through a server, or router, to the Internet **185**.

The client side **100** represents the consumers of the streaming audio and video data. In this example, the two clients are receiving separated streaming audio and video data signals. Other embodiments of the invention support many more clients.

The client **112** represents a computer, such as a PC compatible computer, running a browser application **102**. For video display, the browser application **102** can include a Netscape Navigator™ or Communicator™ program for "multipart/xmixed-replace MIME type video," or a Microsoft Internet Explorer™ 3.0 or later for a Java based video transmission. In some embodiments, the Java based video transmission applet parses the multipart/x-mixed-replace MIME type video. For audio, the browser application **102** can include any browser that supports Java and/or JavaScript.

The browser application **102** is responsible for receiving the streaming audio and video data **176** and reconstructing an audio and video signal suitable for the end user. In this example, the video display area **103** displays the reconstructed video information received from the video input **158** at the real-time server **140**. Similarly, the client **111** is executing the browser **108**. The browser **108** is displaying the same video signal in the video display area **104**. The client **111** represents another computer executing a browser application.

Various embodiments of the invention have modifications to the system shown in FIG. **1**. Some of these variations are described in this paragraph. For example, the client **111** and the client **112** can be the same computer or be different computers. The clients can be on the same local area network or be on completely different local area networks. There can be many more clients receiving the information from the client side **100**. Additionally, as shown with the HTTP connection to remote server **170**, a real-time server **140** can appear on the client side **100** to distribute data to other clients.

Note that portions of the system, and embodiments of the invention, are sets of computer programs or computer that can be stored on computer usable media such as floppy disks, hard drives, CD ROMs, Zip disks, etc.

Thus, an example system supporting streaming audio and video data for multiple users has been described.

(c) Example Method

FIG. **2** illustrates one example of a method of broadcasting streaming audio and video data to multiple users. This example method could be executed on the system of FIG. **1**. In this example, the client **112** will initiate a request to receive streaming audio and video data **176** from the server side **130**. The client **112** will display the video data in the video display area **103** and will play the audio data for the user. Importantly, the client **112** can play audio and video without the need of a plug-in or helper application. As will be shown, the audio and video play as part of a transparent process of the client **112** loading a web page from the server **131**.

At block **210**, the client **112** initiates an HTTP request from the web server **131**. This could be the result of the browser **102** receiving and displaying an HTML (hypertext markup language) page including a link that will initiate streaming audio and video. The user would have selected this link which will then result in the browser **102** making the connection to the web server **131**.

As a result of the connection, at block **220**, the web server **131** supplies a Java applet for decoding audio data and that will help in the display of video information. These instructions could be supplied as two separate Java applets or one combined Java applet.

At block **230**, the client executes the Java applets. The video display portion of the applet initiates a request of the web server **131** for a HTTP transmission of a multipart/mixed replace MIME encoded video (or in other embodiments, video data for Java decoding). Also at block **230**, the audio Java applet makes a similar request of the web server **131**. The requests can include optional information such as desired video frame rates or audio rates. The requests include the URI (universal resource indicator) indicating the particular audio or video streaming information to be served.

The following will describe the audio serving by the web server **131** and eventual decoding by the client **112**. The video serving will be described after the audio.

At block **240**, in response to executing the Java applet, the client makes an audio request of the web server **131**. This is done through the Java applet which supplies a universal resource indicator to the web server **131**. The universal resource indicator can indicate the audio stream that is being requested. This request looks, to the client **112**, like a file download request. The web server **131** responds accordingly to this request by beginning to transfer the streaming audio information. Importantly, the client **112** does not need to know that the file is a streaming audio or video signal that is essentially never ending.

In response to the client request, the web server **131**, and in particular the process **138**, makes an audio data request of the shared memory **135**. Note, if the process **138** had not been created, the web server **131** creates the process (in some embodiments, the web server **131** creates a separate process for each of the audio and video data streams). The audio data request of the shared memory is done by the web server **131**, and in particular by the process **138**, by notifying the real-time server **140** that audio information is requested. In subsequent iterations, the web server **131** need not make the explicit request for the audio information. Once requested, the real-time server **140** will continue to provide audio information, in these embodiments, until it is told to stop.

In any case, the real-time server **140**, in response to the request, prepares audio information and writes this information into the shared memory **135**. In various embodiments of the invention, the real-time server **140** prepares the audio data by breaking the audio information into time periods. This audio information is also compressed into various sets of compressed data corresponding to different audio rates. Higher audio rates correspond to better quality audio signals. In these embodiments of the invention, the real-time server **140** writes the data for the various audio rates to the shared memory **135**, thereby reducing the work load of the web server **131**. Different web server **131** processes will require different audio rates depending on their connections to their respective clients. By storing the information corresponding to the different audio rates into the shared memory **135**, each process can access the desired audio rate data from the shared memory **135**. Thus, the web server **131** need not calculate the compressed audio data for each process within the web server **131**.

The process **138**, through the web server **131**, now transmits the data accessed from the shared memory **135**. This corresponds to block **246**.

At block **248**, the client **112** receives the compressed audio data. The client decompresses the audio data as commanded by Java audio applet, and plays the audio information through the audio system of the client **112**.

At block **241**, a test is made to determine whether the web server **131** should continue broadcasting the streaming audio information to the client **112**. This test is made by determining whether the client **112** has broken the connection to the web server **131**.

The web server will continue serving the data as long as the client **112** is connected to the web server **131** through the Java audio applet.

Note, importantly, the user at the client **112** has not had to download any additional plug-ins or helper programs to play the streaming audio information.

Turning to the video broadcasting, at block **252**, the web server **131** makes a video information request to the real-time server **140**. The real-time server **140** takes each video frame from the video module **144**, or the video proxy module **148**, and compresses that information into a JPEG image. In some embodiments of the invention, the video card **159** provides the images as JPEGs. The requesting procedure is similar to that followed in the audio request block **240**.

The real-time server **140**, at block **254**, writes one JPEG frame into the shared memory **135**. The process **138** accesses the shared memory **135** to retrieve the JPEG frame and transmit that frame to the client **112**. At block **256**, the process also formats the JPEG as part of a multipart MIME encoded file.

At block **258**, the client **112**, using the capabilities of the browser **102**, decompresses the video data from the MIME encoded format, and the JPEG encoded form, and creates the video display **103**.

At block **251**, the web server **131** determines whether the video Java applet is still requesting video frames. Block **254** through block **251** are then repeated. The result of these blocks is that multiple frames of video information is displayed in the video display **103**. Thus, the user has the perception of a video display at the client **112**.

Note, by the time the audio information is played from the previous audio transmission, a new audio transmission has been received and decompressed. Thus, the client **112** will have a continuous audio signal being presented to the user.

If it is the case that the audio, or the video, information is not being received by the client **112** at a sufficient data rate, the corresponding Java applet, in some embodiments of the invention, can request a different rate of transmission. The Java applet can request a lower rate corresponding to a lower audio or video signal, that will more appropriately match the bandwidth availability of the client **112**.

One advantage of the system of FIG. **1** is that if the web server **131** becomes heavily loaded, the video frame rate is automatically reduced. This is done by ensuring that the audio processes take priority over the video processes. If a video process cannot access the shared memory **135** in sufficient time, that video frame will simply not be transmitted to the client **112**. However, the corresponding audio process should have an opportunity to transmit the audio information.

As has been seen by the above discussion, the user has not been required to download any plug-ins or use any helper applications in the receiving of the streaming audio and video data. Additionally, the web server **131** is able to execute this example method for multiple clients. Each client would have a corresponding set of processes in the web server **131**. The number of processes is only limited to the number of connections that can be supported by the web server **131**. As has been noted, some of the work that would normally be performed by the web server **131** has been moved into the real-time server **140** to reduce the load on the web server **131**.

(d) Example Video Display

FIG. **3** through FIG. **5** represent the interface presented to a user using a browser **102** on a client **112**. In this example, the user is using a standard PC with a standard Netscape Communicator™ 4.0 browser application. FIG. **3** includes a browser window **302** with a cursor positioned over a transmission selection link **304**. The transmission selection link **304** corresponds to a request for transmission of streaming audio and video data. FIG. **4** illustrates the result of the selection of the transmission selection link **304**. The user is presented with a number of connection speeds to select from. The user selects the speed associated with his or her

connection speed to the Internet **185**. In this example, the user is selecting a T1 or better connection speed. In one embodiment of the invention, the Java applets are controlling the presentation of the various selection speeds. This is shown as a bandwidth selection link **404**.

FIG. **5** illustrates the result of the "T1 or higher" bandwidth selection link being chosen. A digital video display **502** is shown in the browser window **302**. The client computer executing, the Netscape Communicator browser, is playing an audio signal corresponding to the digital video display **502**. In this example, a user is allowed to modify the video rate, shown in frames per second, by selecting one of the video rate selectors **510**. A result of selecting one of the various video rate selectors **510** would be that the corresponding video Java applet will communicate with its corresponding process in the web server **131**. The Java applet would request a change in the video frame per second rate being supplied by the process in the web server **131**. Similarly, a set of audio rate selectors **512** allow the user to select a higher or lower quality audio signal. The corresponding Java audio applet would communicate with its corresponding process in the web server **131** to request the change in the audio rate.

(e) Additional Embodiments

Thus a system for broadcasting streaming video and audio information to multiple users has been described. However, various embodiments of the invention include modifications and optional additions to the system.

It is possible for the real-time server **140** to be receiving and transmitting multiple different video and audio signals through the web server **131**. Additionally, multiple web servers could be accessing the information from the real-time server **140**. Additionally, multiple real-time servers **140** could be providing information for the web server **131**.

In some embodiments of the invention, users can select either the audio stream, the video stream, or both the audio and video stream from a server. Similarly, some users can select one of these sets of streams while other users select other sets of streams. Additionally, some users can select different rates for audio or video information than other users. In such systems, the real-time server **140** supplies the data corresponding to the requested rates to the shared memory **135**. For example, if one user is requesting a first audio rate and a second user is requesting a second audio rate, the shared memory **135** would store audio data for both audio rates of compression. In some embodiments, the web server **131** notifies the real-time server **140** when a particular audio rate is not required by any of the processes anymore.

(f) Proxy Switching

FIG. **6** illustrates a system **600** under another embodiment of the invention. The system **600** enables viewers on client terminals **610** to experience streaming media broadcast from multiple sources **620**A on a network such as the Internet. With system **600**, client terminals **610** may be switched seamlessly between media sources. Specifically, users of client terminals **610** can be switched between sources of streaming media without experiencing an interruption that would otherwise result from breaking a connection with one streaming media source **620**A to receive streaming media from another source **620**B.

In an embodiment, system **600** includes administrator **625** coupled to proxy switching source **635** across the Internet **605**. The proxy switching source **635** communicates over the Internet **605** with other streaming media sources **620**A and **620**B.

The proxy switching source **635** includes a web server **632** to communicate with client terminals and other servers over the Internet. The proxy switching source **635** may also function as a streaming media source for client terminals **610**. To this end, proxy switching source **635** may include an audio module **636** to receive and digitize audio input for broadcasting streaming audio media to client terminals **610**. The proxy switching source **635** may also include a video module **638** to receive and digitize video input for broadcasting streaming video media to the client terminals **610**. The proxy switching source **635** also includes proxy switching module **634**. The proxy switching module **634** communicates with other servers to receive streaming audio and/or video media. In particular, the proxy switching module **634** communicates with web servers **622** of the streaming media sources **620**A and **620**B to receive streaming media via the Internet **605**. For proxy switching source **635**, shared memory **631** stores streaming media received from video module **638**, audio module **636**, or through media source **620**A and **620**B via proxy switching module **634**. The web server **632** of proxy switching source **635** transmits streaming media that is first stored in shared memory **631**.

The streaming media sources **620**A and **620**B each include web server **622**. Each streaming media source **620**A, **620**B is assumed to include a video module **628**, an audio module **626**, and a proxy switching module **624**. As with proxy switching source **635**, the audio module **626** receives and digitizes audio input. The video module **628** receives and digitizes video input.

The proxy switching module **624** enables sources **620**A, **620**B to each receive streaming audio and video media from other sources (not shown). A shared memory **621** stores streaming media data for web server **622**. In this way, an embodiment may provide for each source **620**A, **620**B to alternatively function as proxy switching source **635**.

In an embodiment, administrator **625** is a client terminal having browser **628**. The administrator **625** may also include a display area to view streaming media from the selected source **620**. In an embodiment, administrator **625** includes an editor interface to select one of the streaming media sources **620**A, **620**B for broadcast to client terminals **610**. For example, the editor interface may display streaming audio and video media from each source **620**A and **620**B. The editor interface may also include a selection feature, such as a point-and-click mechanism or selection icon, to enable the editor of administrator **625** to select one of the streaming media sources **620**A, **620**B for broadcast to client terminals **610**.

Initially, the administrator **625** selects, for example, media source **620**A. The selection is passed to proxy switching source **635**. The proxy switching source **635** establishes communications with the selected media source **620**A. When media source **620**A is selected by administrator **625**, the proxy switching source **635** couples to a channel **617** for receiving streaming media from media source **620**A. The shared memory **631** stores the streaming media from source **620**A. The streaming media stored in shared memory **631** is subsequently signaled by web server **632** to client terminals **610** (and administrator **625**). The web server **632** signals the streaming media from the media source **620**A to the client terminals **610** on a communication channel **627** available through the Internet **605**.

The administrator **625** may subsequently select source **620**B. A switching control signal is transmitted to web server **632** via Internet **605** to signal the switch. The switch control causes proxy switching module switches to channel **619** to

receive streaming media from source **620**B. The shared memory **631** then receives streaming media from source **620**B. The web server module **632** accesses the streaming media from shared memory **631**. The web server **632** then signals the streaming media from source **620**B to client terminals **610** on the communication channel **627**, once streaming media from source **620**A that remaining in shared memory **631** is transmitted to client terminals **610**. The web server **632** does not disconnect or break the connection of communication channel **627** while proxy server module **634** makes the switch from source **620**A to **620**B. The web server **632** seamlessly transmits the streaming media from source **620**B. The client terminals **610** maintain their connections with web server **632**, and the web server **632** is not interrupted in signaling streaming media after switching to source **620**B. Thus, once administrator **625** switches from source **620**A to source **620**B, clients **610** are all seamlessly switched together from source **620**A to source **620**B. The communication channel **627** between client terminals **610** and web server **632** remains intact. The effect is that all of the client terminals **610** switch streaming media sources **620**A and **620**B nearly simultaneously, without an interruption or break in experiencing streaming media.

While system **600** illustrates administrator **625** as signaling a switch to occur from source **620**A to source **620**B, other embodiments may provide that one or more of the client terminals **610** can signal the switch to proxy switching source **635**. In these embodiments, web server module **632** of proxy switching source **635** receives the switch request from one of the clients **610**. That client terminal **610** making the switch request may be treated as an administrator, in which case all of the other clients are switched to the requested source together. Alternatively, the client terminal **610** making the switch request may be switched to a new source individually. As still another alternative, one or more of the client terminals **610** may make the request to switch media sources to administrator **625**. The administrator **625** then chooses the response to the request.

In an embodiment shown by FIG, **6**, the streaming media sources **620**A and **620**B are provided to alternatively function as proxy sources for other streaming media sources. Thus, in the example shown, each source **620**A, **620**B may route streaming media from one or more other sources. Further, each of the steaming media sources **620**A, **620**B may act as proxy switching sources, so as to switch between other sources (not shown) feeding media to the proxy modules **624** of the respective sources **620**A, **620**B. The administrator **625** may access the web servers **622** of the sources **620**A and **620**B to cause streaming media received from one source (not shown) by respective proxy modules **624** to be switch to another source (not shown). One of the advantages provided by this embodiment is that system **600** is scalable, allowing both proxy streaming media delivery and switching on a large scale.

FIG. **7** illustrates a flow process for operating proxy switching, using a system such as shown by FIG. **6**. In step **710**, an audience is provided streaming media from a first source. The audience may comprise client terminals **610**. The streaming media may include audio media and/or video media. The streaming media may originate from proxy switching source **635**, or from one of the other sources **620**A and **620**B.

In step **720**, a command is provided to proxy switching source **635** to switch sources from, for example, source **620**A to source **620**B. The command may alternatively request to switch from proxy switching source **635** to either source **620**A or source **620**B. The command may be provided from either administrator **625**, or from one of the client terminals **610**. The command is received by the server **632** of the proxy switching source **635**.

The web server **632** of the proxy switching source **635** communicates the command to switch media sources to the proxy module **634**. The command may be in the form of a uniform resource locator (URL), which instructs the web server **632** to cause the proxy module **634** to switch to the new media source **620**B. The URL signaled as the command may include parameters to specify the switch. One format for a URL having parameters to cause the switch to a new media resource is as follows:

www.<hostingserver>.com/<file type>? server =<viewing channe number>% source=<sourcelocation>: <portnumber>-<channel number>

In the URL illustration, the new media source is provided as a new channel to clients **610**.

In step **730**, the proxy module switches to a different streaming media source. For example, the proxy module switches to receive streaming media from source **620**B, rather than **620**A.

In step **740**, one or more of the participants in the audience experience streaming media from the new source. If, for example, administrator **625** makes the request, then all of the audience experiences streaming media from the new source. Alternatively, one of the participants may make an individual command, in which case only that client terminal **610** is coupled to receive streaming media from the new source **620**B.

As an alternative mentioned with FIG. **6**, proxy switching source **635** may be switched to one of the sources **620**A or **620**B. A command to cause a new host for streaming media delivery may be provided as a URL with parameters such as:

www.<hostingserver>.com/<file type>? server =<viewing channel number>% source=www.<newhost>.com: <portnumber>-<channelnumber>

(g) Examples of Proxy Switching

As one example, system **600** may provide a virtual seminar or symposium for an audience of users operating individual client terminals **610**. The speakers of the seminar may be recorded in real-time through audio and video digitizers located on terminals or servers, forming streaming media sources **620**A and **620**B. For this example, it is assumed that system **600** is operated over the Internet. Since each speaker may be located in a different location, the media stream resulting from a broadcast by each speaker may be directed to proxy switching source **635**. When a presentation by one speaker is completed, an administrator **625** can switch the audience to a new speaker. The switch may be made seamlessly from the audience's point of view, even though each client terminal comprising the audience is located remote from the rest of the audience. The administrator **625** may also use the seamless switching to enable a discussion to occur between speakers. For example, a speaker can indicate to administrator **625** a desire to respond to a statement by another speaker. The administrator **625** may then cause the switch to occur, so that the new speaker can address the audience, before switching back to the old speaker. The administrator **625** can make the switch without breaking the connection (communication channel **627**) with the audience. As a result, the audience does not experience a broadcast interruption when a switch is made to a new speaker. In this manner, the virtual seminar can be made to simulate a real seminar, or a closed network analog broadcast of a seminar. However, system **600** enables the Internet

to be used in a manner that enables the audience and speakers to be located remote from one another.

As another example, a classroom may use system **600** as an educational tool. The client terminals may be operated by students. The administrator **625** may be a teacher, providing the students with an educational streaming media content. The system **600** allows the teacher to use client terminals **610** to show each student the same streaming media content. The teacher may then switch the whole classroom to a new streaming media source, rather than require the students to make the switch independently.

(h) Conclusion

The foregoing description of various embodiments of the invention has been presented for purposes of illustration and description. It is not intended to limit the invention to the precise forms disclosed. Many modifications and equivalent arrangements will be apparent.

What is claimed is:

**1**. A system for providing streaming media to a plurality of clients over a network, the system comprising:

a plurality of streaming media sources coupled to the network;

a network server module that couples to the plurality of clients to signal streaming media from at least a first streaming media source in the plurality of streaming media sources to each of the plurality of clients using a first channel;

a switching terminal to signal a switch request to the network server module, the switch request requesting streaming media from a second streaming media source in the plurality of streaming media sources; and

a proxy module that forwards streaming media from the first streaming media source to the network server module, the proxy module being communicatable with the network server module to be signaled the switch request, and in response to the switch request, the proxy module forwarding streaming media from the second streaming media source to the network server module to facilitate seamless transition on the first channel from the first streaming media source to the second streaming media source.

**2**. The system of claim **1**, wherein the proxy module forwards the streaming media from the second streaming media source to the network server module while the network server module signals streaming media from the first streaming media source to the plurality of client terminals.

**3**. The system of claim **1**, further comprising a memory that stores streaming media forwarded from the proxy module for the network server module, the network server module accessing the memory to receive the streaming media forwarded from the proxy module.

**4**. The system of claim **3**, wherein the proxy module forwards the streaming media from the second streaming media source to the network server module while the network server module is accessing the streaming media from the first streaming media source from the memory.

**5**. The system of claim **1**, wherein the plurality of streaming media sources coupled to the network each include a proxy module to receive streaming media from other streaming media sources to facilitate large scale proxy streaming media delivery.

**6**. The system of claim **1**, wherein the switching terminal is an administrator for the plurality of client terminals.

**7**. The system of claim **1**, wherein the switching terminal is one of the plurality of client terminals that receives streaming media from the network server module.

* * * * *