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(54) SYSTEM AND METHOD FOR HOSTING BROWSER-BASED SCREEN SHARING

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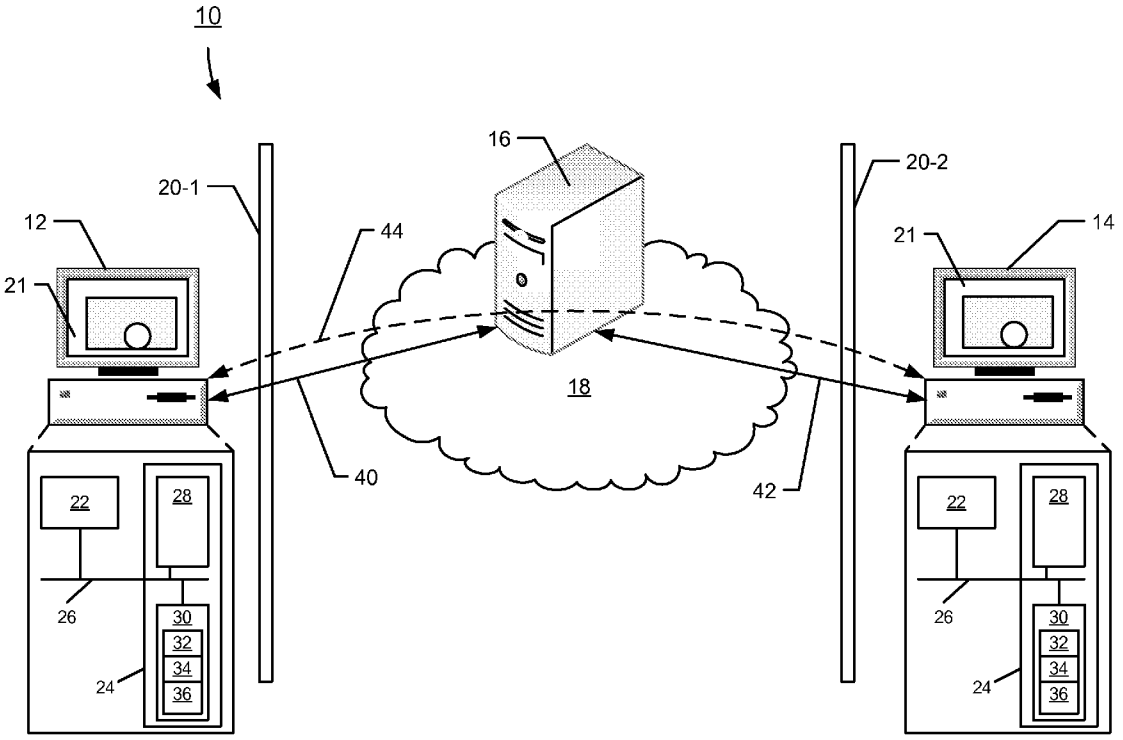
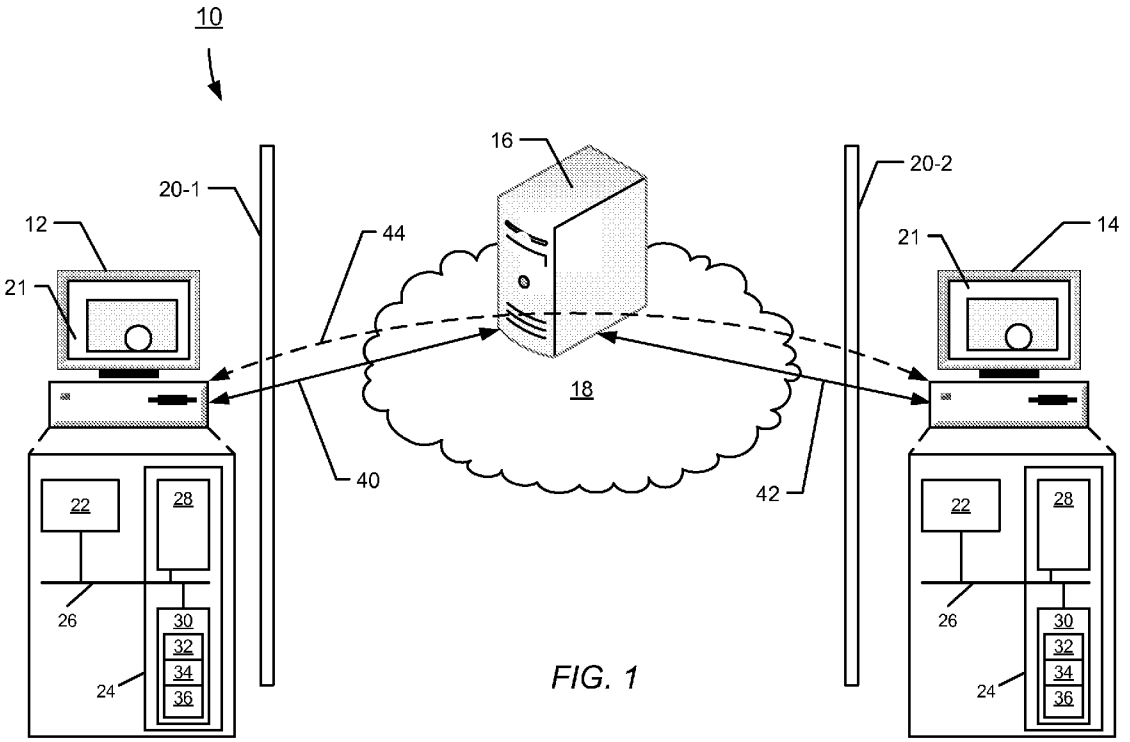
(57) **ABSTRACT**

To host a screen-sharing session during which images displayed on a display screen of a computing system are shared for concurrent display with a guest computing system, a request is sent from a browser program running on the computing system to a server. Received from the server in response to the request is a web page with embedded program code for repeatedly capturing and transmitting image data corresponding to an image displayed on the display screen of the computing system to the server. The screen-sharing session is hosted at the computing system entirely through the browser program by executing the embedded program code to repeatedly capture images displayed over time on the display screen of the computer system and transmit image data corresponding to the captured images to the server.




10
16
20-1
20-2
12
44
21
14
21
18
40
42
22
28
26
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32
34
36
24
22
28
26
30
32
34
36
24

FIG. 1

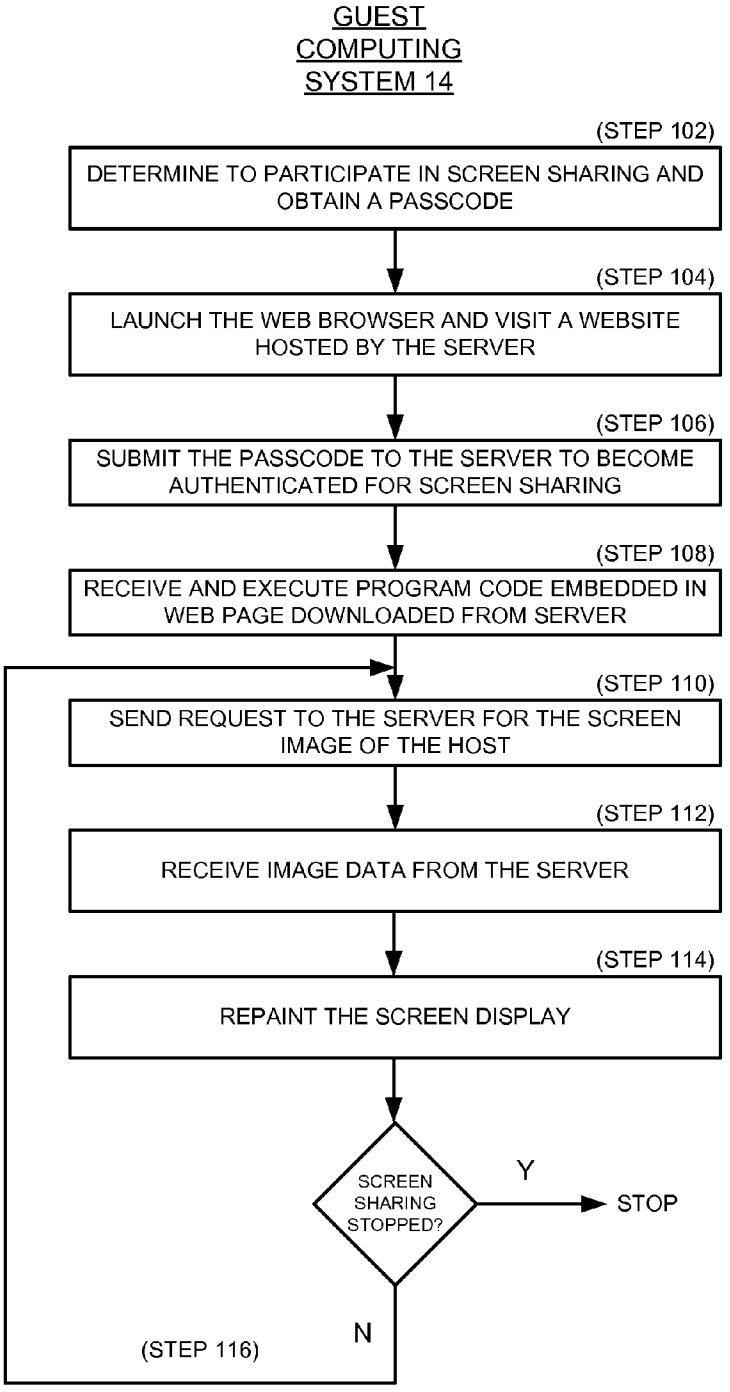
GUEST COMPUTING SYSTEM 14
100
(STEP 102)
DETERMINE TO PARTICIPATE IN SCREEN SHARING AND OBTAIN A PASSCODE
(STEP 104)
LAUNCH THE WEB BROWSER AND VISIT A WEBSITE HOSTED BY THE SERVER
(STEP 106)
SUBMIT THE PASSCODE TO THE SERVER TO BECOME AUTHENTICATED FOR SCREEN SHARING
(STEP 108)
RECEIVE AND EXECUTE PROGRAM CODE EMBEDDED IN WEB PAGE DOWNLOADED FROM SERVER
(STEP 110)
SEND REQUEST TO THE SERVER FOR THE SCREEN IMAGE OF THE HOST
(STEP 112)
RECEIVE IMAGE DATA FROM THE SERVER
(STEP 114)
REPAINT THE SCREEN DISPLAY
SCREEN SHARING STOPPED?
Y
STOP
N
(STEP 116)

FIG. 2

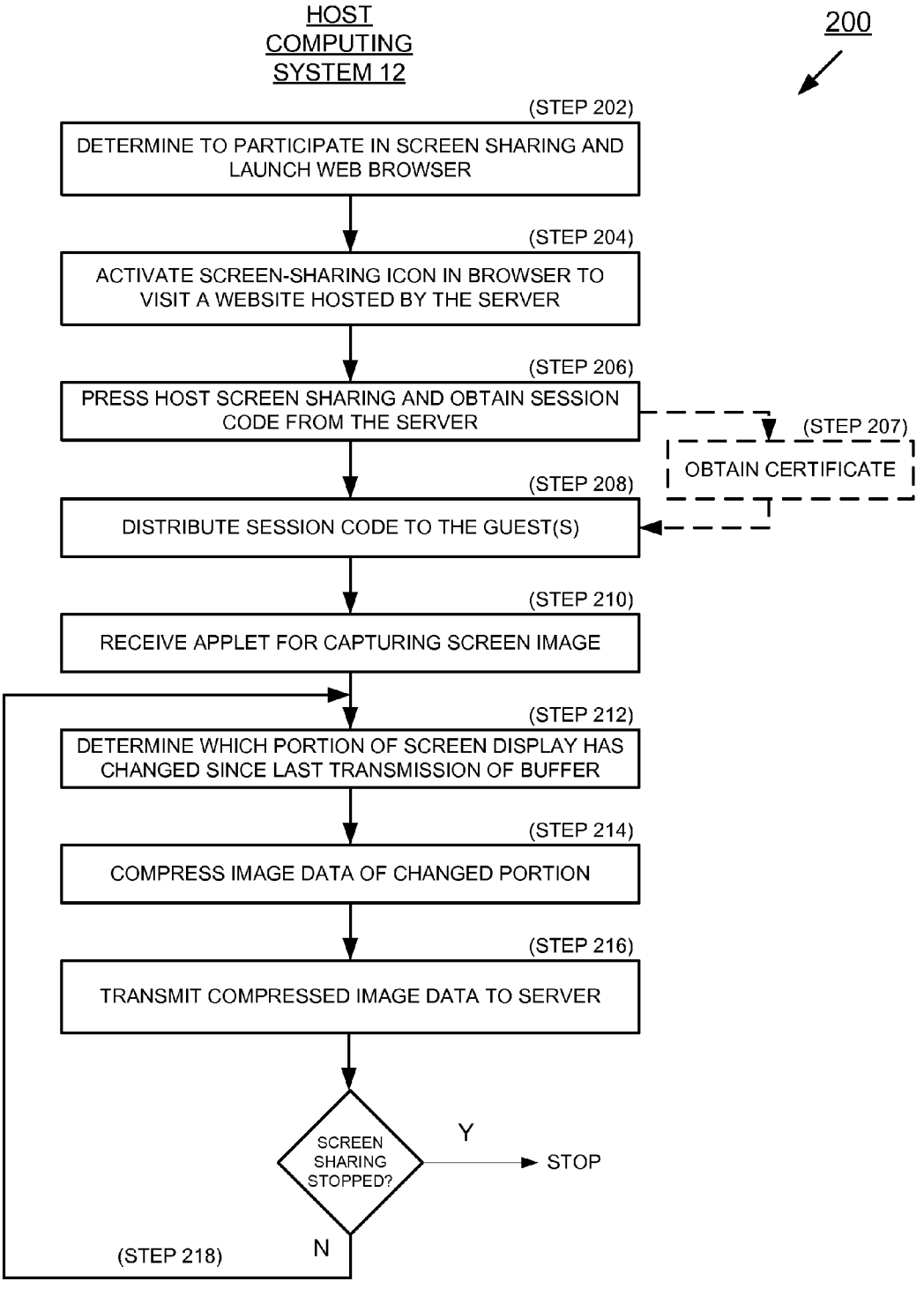
HOST COMPUTING SYSTEM 12
200
(STEP 202)
DETERMINE TO PARTICIPATE IN SCREEN SHARING AND LAUNCH WEB BROWSER
(STEP 204)
ACTIVATE SCREEN-SHARING ICON IN BROWSER TO VISIT A WEBSITE HOSTED BY THE SERVER
(STEP 206)
PRESS HOST SCREEN SHARING AND OBTAIN SESSION CODE FROM THE SERVER
(STEP 207)
OBTAIN CERTIFICATE
(STEP 208)
DISTRIBUTE SESSION CODE TO THE GUEST(S)
(STEP 210)
RECEIVE APPLET FOR CAPTURING SCREEN IMAGE
(STEP 212)
DETERMINE WHICH PORTION OF SCREEN DISPLAY HAS CHANGED SINCE LAST TRANSMISSION OF BUFFER
(STEP 214)
COMPRESS IMAGE DATA OF CHANGED PORTION
(STEP 216)
TRANSMIT COMPRESSED IMAGE DATA TO SERVER
SCREEN SHARING STOPPED?
Y
STOP
N
(STEP 218)

FIG. 3

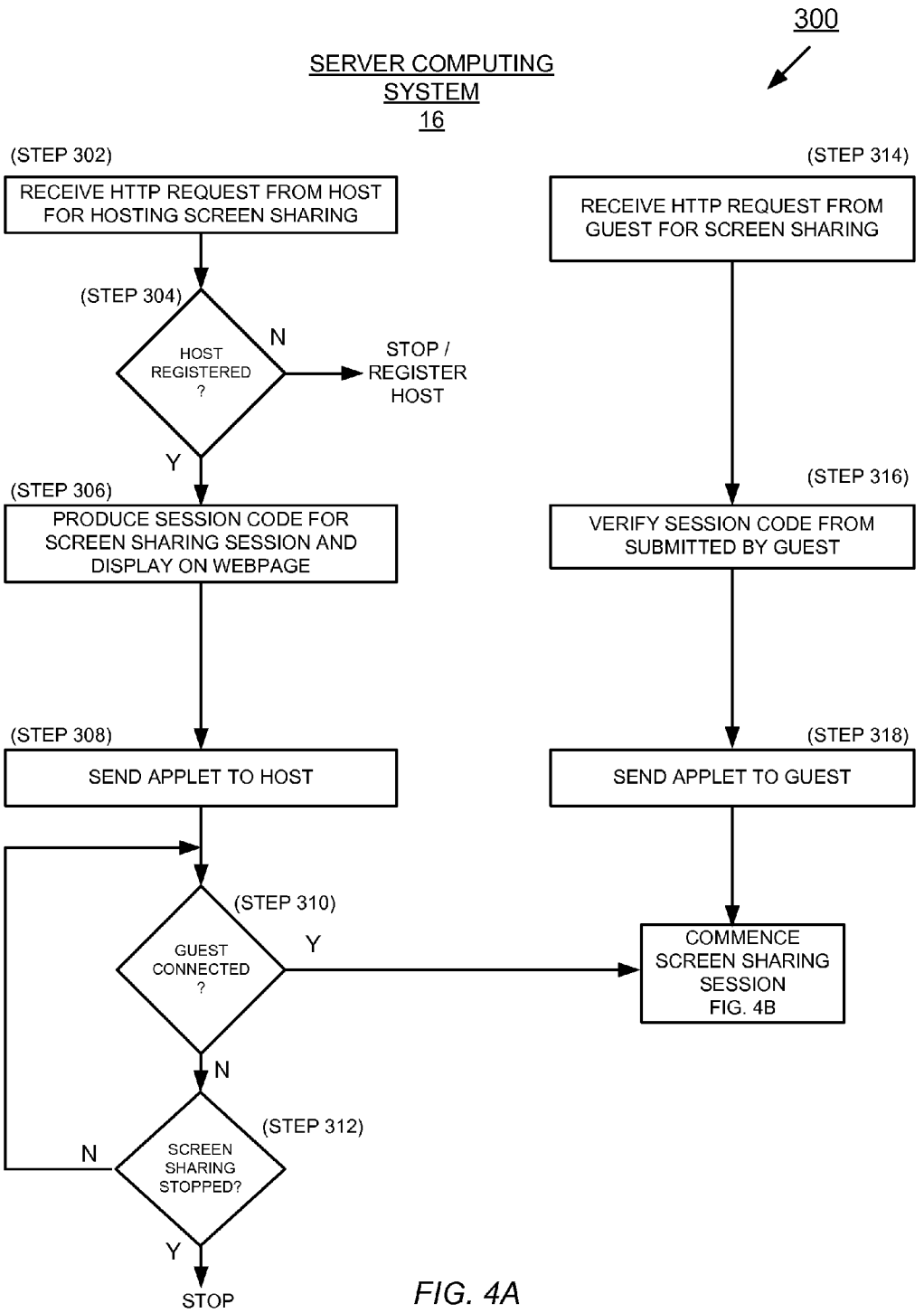
300
SERVER COMPUTING SYSTEM 16
(STEP 302)
RECEIVE HTTP REQUEST FROM HOST FOR HOSTING SCREEN SHARING
(STEP 304)
HOST REGISTERED ?
N
STOP / REGISTER HOST
Y
(STEP 306)
PRODUCE SESSION CODE FOR SCREEN SHARING SESSION AND DISPLAY ON WEBPAGE
(STEP 308)
SEND APPLET TO HOST
(STEP 310)
GUEST CONNECTED ?
Y
N
(STEP 312)
SCREEN SHARING STOPPED?
N
Y
STOP
(STEP 314)
RECEIVE HTTP REQUEST FROM GUEST FOR SCREEN SHARING
(STEP 316)
VERIFY SESSION CODE FROM SUBMITTED BY GUEST
(STEP 318)
SEND APPLET TO GUEST
COMMENCE SCREEN SHARING SESSION FIG. 4B

FIG. 4A

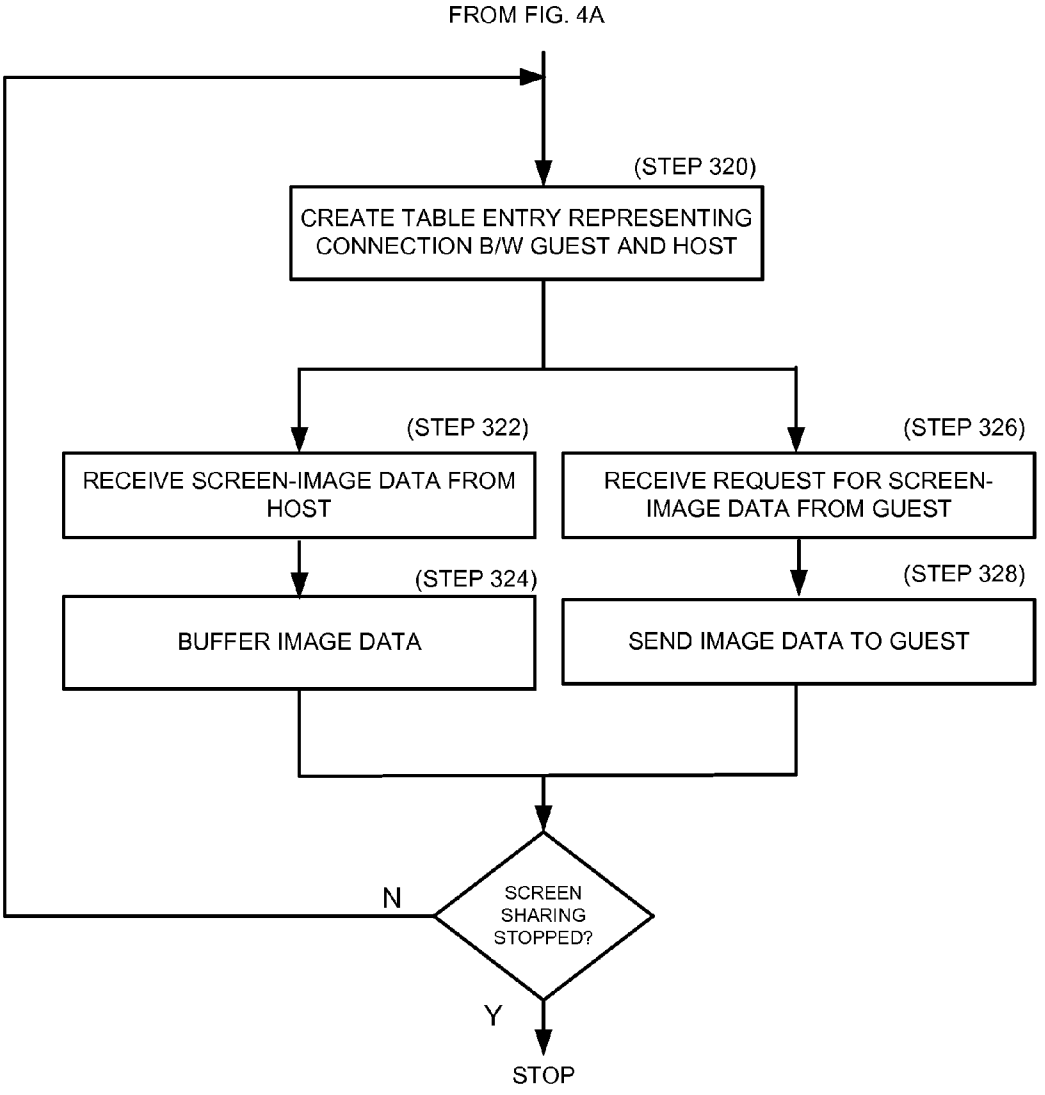
FROM FIG. 4A
(STEP 320)
CREATE TABLE ENTRY REPRESENTING CONNECTION B/W GUEST AND HOST
(STEP 322)
RECEIVE SCREEN-IMAGE DATA FROM HOST
(STEP 326)
RECEIVE REQUEST FOR SCREEN-IMAGE DATA FROM GUEST
(STEP 324)
BUFFER IMAGE DATA
(STEP 328)
SEND IMAGE DATA TO GUEST
SCREEN SHARING STOPPED?
N
Y
STOP

FIG. 4B

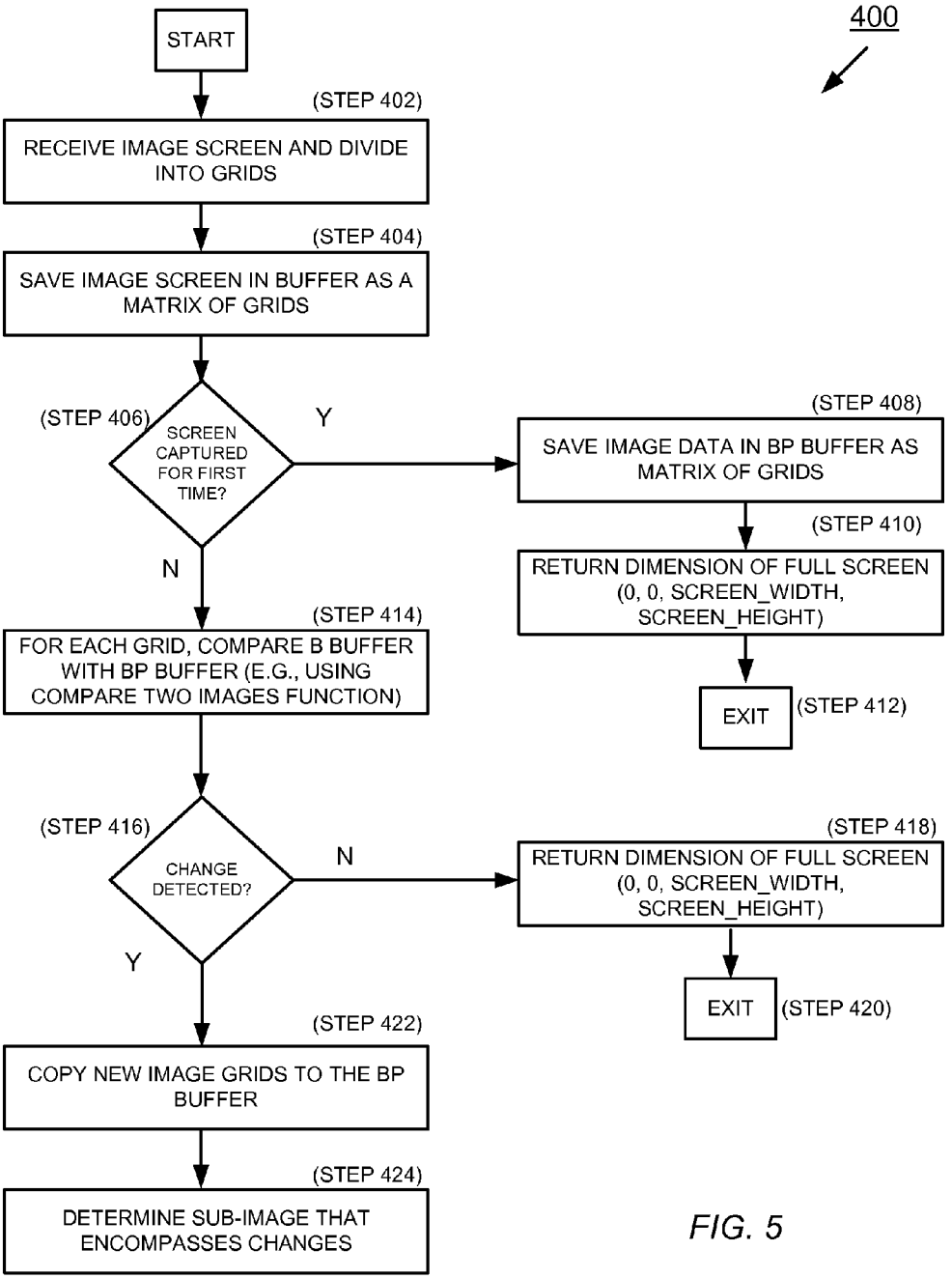
400
START
(STEP 402)
RECEIVE IMAGE SCREEN AND DIVIDE INTO GRIDS
(STEP 404)
SAVE IMAGE SCREEN IN BUFFER AS A MATRIX OF GRIDS
(STEP 406)
SCREEN CAPTURED FOR FIRST TIME?
Y
N
(STEP 408)
SAVE IMAGE DATA IN BP BUFFER AS MATRIX OF GRIDS
(STEP 410)
RETURN DIMENSION OF FULL SCREEN (0, 0, SCREEN_WIDTH, SCREEN_HEIGHT)
EXIT
(STEP 412)
(STEP 414)
FOR EACH GRID, COMPARE B BUFFER WITH BP BUFFER (E.G., USING COMPARE TWO IMAGES FUNCTION)
(STEP 416)
CHANGE DETECTED?
N
Y
(STEP 418)
RETURN DIMENSION OF FULL SCREEN (0, 0, SCREEN_WIDTH, SCREEN_HEIGHT)
EXIT
(STEP 420)
(STEP 422)
COPY NEW IMAGE GRIDS TO THE BP BUFFER
(STEP 424)
DETERMINE SUB-IMAGE THAT ENCOMPASSES CHANGES

FIG. 5

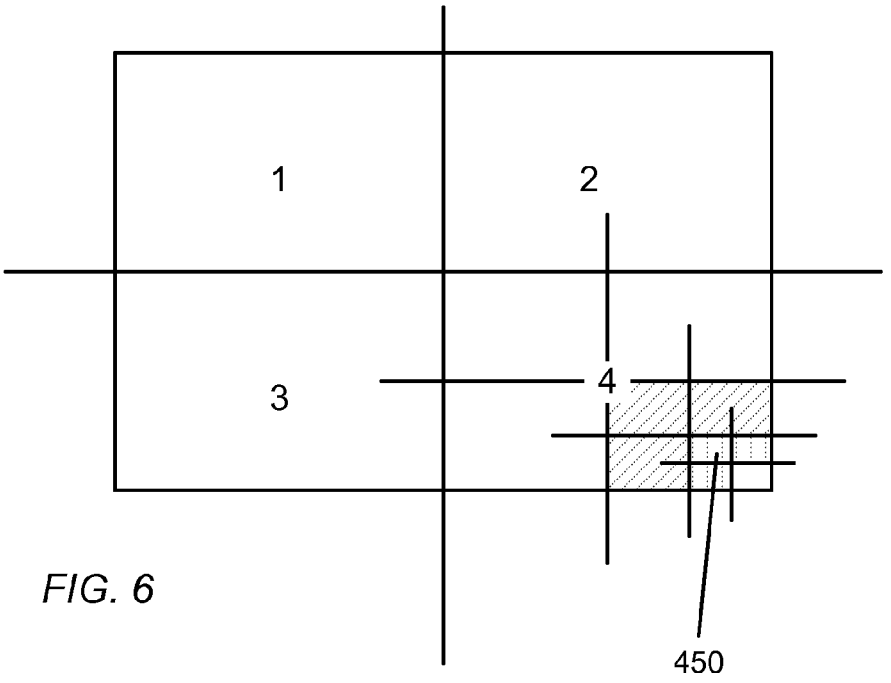
1
2
3
4
450

FIG. 6

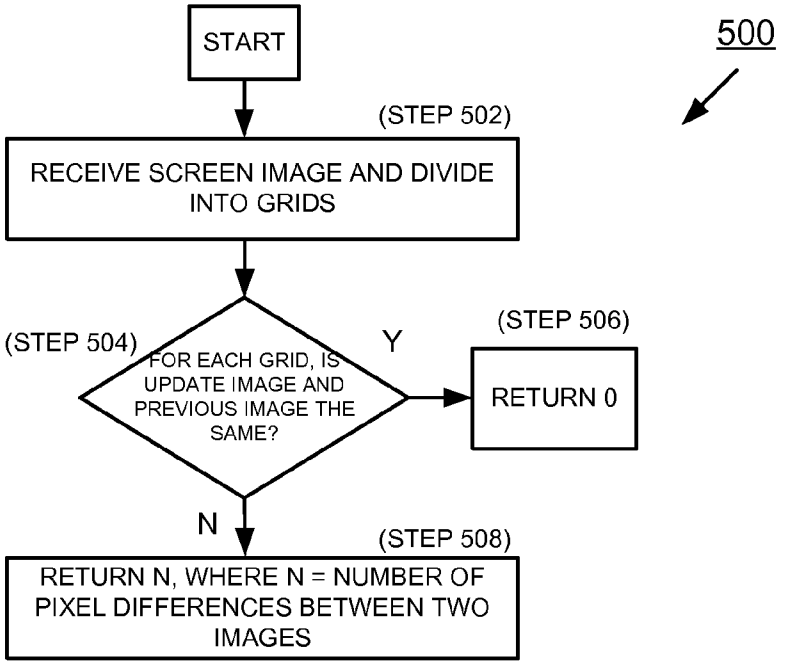
500
START
(STEP 502)
RECEIVE SCREEN IMAGE AND DIVIDE INTO GRIDS
(STEP 504)
FOR EACH GRID, IS UPDATE IMAGE AND PREVIOUS IMAGE THE SAME?
Y
(STEP 506)
RETURN 0
N
(STEP 508)
RETURN N, WHERE N = NUMBER OF PIXEL DIFFERENCES BETWEEN TWO IMAGES

FIG. 7

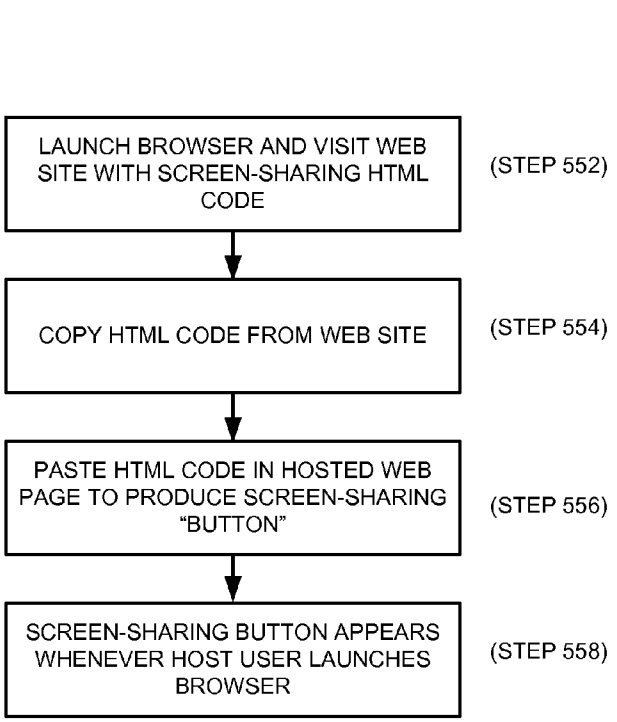

FIG. 8

```
<a href="http://www.showscreen.com/showscreen/auto_host3.asp" target="_blank"
onClick="this.newWindow = window.open('http://www.showscreen.com/showscreen/
auto_host3.asp?url=' + document.location, 'ShowScreen',
'toolbar=0,scrollbars=0,location=0,statusbar=0,menubar=0,resizable=1,width=300,height=100');
this.newWindow.focus();this.newWindow.opener=window;return false;"><img alt="ShowScreen
by HelpMeeting"
src="http://www.showscreen.com/showscreen/images/iexplore.gif" width="88" height="31"
border="0"></a
```

FIG. 9

SYSTEM AND METHOD FOR HOSTING BROWSER-BASED SCREEN SHARING

RELATED APPLICATION

[0001] This application is a continuation application of co-pending U.S. patent application Ser. No. 11/456,613, filed Jul. 11, 2006, and titled "One-Click Universal Screen Sharing," the entirety of which is incorporated by reference herein.

FIELD OF THE INVENTION

[0002] The invention relates generally to screen sharing between computing systems connected to a network. More specifically, the invention relates to screen sharing that does not require the computing systems to deliberately download and install software in order to participate.

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BACKGROUND

[0004] Screen sharing between computing devices has a myriad of practical applications. For one, screen sharing enables remote technical support. Another practical use is collaboration between a host and a viewer. A host can give a presentation to one or more remote viewers, perform demonstrations, review documents, and share images.

[0005] Numerous implementations of screen sharing presently exist. One well-known implementation is virtual network computing (VNC). VNC is a screen sharing system that enables a user to view and interact with another computer remotely over the Internet. VNC has two components: a server component and a client (i.e., viewer) component. User interface commands pass from the viewer computer to the remote computer, which sends back screen updates.

[0006] Like many screen-sharing implementations, however, setting up a VNC screen sharing system requires downloading and installing special software at one or both of the client and remote computer systems. Use of such client software can require changing the computer system's configuration or setting viewing preferences. Moreover, many standard and personal firewalls often block ports commonly used by some screen sharing systems, requiring an administrator to configure the firewalls explicitly to allow traffic on these ports. Still other screen-sharing systems are operating system dependent (e.g., MAC OS, Windows) and, therefore, are unable to gain widespread adoption.

SUMMARY

[0007] In one aspect, the invention features a method of screen-sharing. Sent from a browser program running on a computing system to a server on a network is a request to host a screen-sharing session during which images displayed on a display screen of the computing system are shared for concurrent display with a guest computing system over the network. Received from the server over the network, in response to the request to host the screen-sharing session, is a web page with embedded program code for repeatedly capturing and transmitting image data corresponding to an image displayed on the display screen of the computing system to the server. The screen-sharing session is hosted at the computing system entirely through the browser program by executing the embedded program code to repeatedly capture images displayed over time on the display screen of the computing system and to transmit image data corresponding to the captured images to the server over the network.

[0008] In another aspect, the invention features a method of conducting a screen-sharing session during which a user of a guest computing system can view an image displayed on a display screen of a host computing system. In response to a request received from the host computing system to host a screen-sharing session, a first web page with embedded program code is transmitted over a network to the host computing system for repeatedly capturing and returning image data corresponding to an image displayed on the display screen of the host computing system to a server. In response to a request from the guest computing system to participate in the screen-sharing session, a second web page with embedded program code is transmitted to the guest computing system for generating a request for image data. Received over an HTTP (HyperText Transport Protocol) connection from the host computing system are image data corresponding to images displayed on the display screen of the host computing system. The image data have been repeatedly captured over time and transmitted over the HTTP connection in response to execution of the program code embedded in the first web page by a browser program running on the host computing system. A request is received from the guest computing system for image data, and image data received from the host computing system are transmitted to the guest computing system in response to the request received from the guest computing system.

[0009] In yet another aspect, the invention features a screen-sharing system comprising a guest computing system and a host computing system in communication with a server system over a network. The guest computing system automatically executes program code embedded in a web page received from the server system. The program code sends a request to the server system for image data corresponding to an image on a display screen of the host computing system. The host computing system runs a browser program that executes program code embedded in a web page received from the server system in response to a request from the host computing system to host a screen-sharing session. The host computing system hosts the screen-sharing session entirely through the browser program. The browser program executes the program code to capture image data repeatedly over time from the display screen of the host computing system and to transmit the captured image data to the server system. The server system sends captured image data received from the host computing system to the guest computing system in response to the request from the guest computing system.

[0010] In still another aspect, the invention features a method for enabling screen-sharing functionality. Hypertext markup language (HTML) code used to host a screen-sharing session is acquired and pasted into a web page. The HTML code launches a screen-sharing session when activated. The screen-sharing session is hosted by any computing system that downloads the web page with the HTML code through a browser program.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The above and further advantages of this invention may be better understood by referring to the following

description in conjunction with the accompanying drawings, in which like numerals indicate like structural elements and features in various figures. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention.

[0012] FIG. **1** is a block diagram representation of a screen-sharing system constructed in accordance with the invention.

[0013] FIG. **2** is a flow diagram of an embodiment of a process by which a guest computing system participates in a screen-sharing session.

[0014] FIG. **3** is a flow diagram of an embodiment of a process by which a host computing system hosts the screen-sharing session.

[0015] FIG. **4**A and FIG. **4**B are flow diagrams of an embodiment of a process by which a server system orchestrates a screen-sharing session between the host and guest computing systems.

[0016] FIG. **5** is a flow diagram of an embodiment of a process by which the host computing system can identify changes in a screen image since the previous screen update.

[0017] FIG. **6** is a diagram representing an embodiment of the screen image being iteratively partitioned when isolating a sub-image with detected image changes.

[0018] FIG. **7** is a flow diagram of an embodiment of a process by which the host computing system can identify changes in a screen image since the previous screen update.

[0019] FIG. **8** is a flow diagram of a process by which the host computing system can become enabled for hosting screen-sharing sessions.

[0020] FIG. **9** is a listing of exemplary HTML (Hypertext Markup Language Text) code that can be used to enable a host computing system for hosting screen-sharing sessions.

DETAILED DESCRIPTION

[0021] Web-based screen-sharing systems constructed in accordance with the invention employ standard browser technology to share the screen image of a host computing system with one or more guest computing systems in near real-time. Because browser technology has become widespread, most any web-enabled computing system can participate in the screen sharing of the present invention. Participating computing systems do not need to deliberately download and install special software in order to become capable of screen sharing. Rather, such computing systems can engage in screen sharing using readily available standard browser plug-ins, executing universally accepted HTML code, and communicating in accordance with the universally adopted HTTP (HyperText Transport Protocol). Further, the screen sharing is operating system independent. Thus, in this sense, the screen sharing of the present invention is universal.

[0022] In brief overview, a guest computing system (a viewer) and a host computing system (a screen sharer) are coupled to a server system over a network. The host computing system and guest computing systems each communicates with the server system through their web browser. Upon visiting the server system, the host computing system automatically downloads and executes an applet that includes screen-capture program code—screen sharing in accordance with the invention works with the screen of the host computing system as an image. Currently available software (e.g., JAVA version 1.3 and higher) includes program code for capturing the pixel data of the host screen image. Upon automatically executing this host applet, the host computing system sends the captured image data to the server. Broadband Internet access through, e.g., cable and DSL (Digital Subscriber Line), provide sufficient bandwidth for transporting the image data.

[0023] During an established screen-sharing session, the browser of the guest computing system also downloads an applet from the server. This guest applet continuously sends requests for image data to the server. In response, the server supplies image data received from the host. The guest computing system repaints its display screen with the received image data, thus reproducing the image of the host screen at the guest computing system.

[0024] FIG. **1** shows an embodiment of a screen-sharing system **10** configured for screen sharing in accordance with the present invention. The screen-sharing system **10** includes a host computing system **12** and a guest computing system **14** in communication with a server system **16** over a network **18**. Each of the host and guest computing systems **12**, **14** may reside behind a respective firewall **20-1**, **20-2**. As described herein, the firewalls **20-1**, **20-2** do not impede screen sharing between the host and guest computing systems **12**, **14**.

[0025] Each computing system **12**, **14** includes a display screen **21** and a processor **22** in communication with system memory **24** over a signal bus **26**. Exemplary implementations of the computing systems **12**, **14** include, but are not limited to, personal computers (PC), Macintosh computers, workstations, laptop computers, kiosks, hand-held devices, such as a personal digital assistant (PDA), cellular phones, navigation and global positioning systems, and network terminals.

[0026] The system memory **24** includes non-volatile computer storage media, such as read-only memory (ROM) **28**, and volatile computer storage media, such as random-access memory (RAM) **30**. Typically stored in the ROM **28** is a basic input/output system (BIOS), which contains program code for controlling basic operations of the computing systems **12**, **14** including start-up of the computing device and initialization of hardware. Stored within the RAM **30** are program code and data. Program code includes, but is not limited to, application programs **32**, program modules **34** (e.g., browser plug-ins), and an operating system **36** (e.g., Windows 95, Windows 98, Windows NT 4.0, Windows XP, Windows 2000, Linux, and Macintosh).

[0027] Application programs **28** on the computing systems **12**, **14** include browser software. The browser software can be any commercially available Web browser, e.g., Microsoft INTERNET EXPLORER®, Mozilla FIREFOX®, NETSCAPE®, and SAFARI®. Currently, most computing devices already have an installed browser when purchased from a manufacturer and deployed in the business, enterprise, or home. When the browser of a computing system visits a Web site with an embedded applet, the computing system automatically downloads the applet from the Web server and automatically executes it. Execution of the applet may require the support of various browser plug-ins **34** (e.g., JAVA, ACTIVEX).

[0028] In one embodiment, the browser of each computing system **12**, **14** is a JAVA-enabled browser with an interpreter, e.g., a JAVA virtual machine, for interpreting JAVA bytecode (i.e., applets, scripts) and applications. Most commercially available Web browsers have the JAVA bytecode interpreter built into the Web browser. Because they are translated into an intermediate processor-independent bytecode supported by Java Virtual Machine, JAVA applets are operating system independent. In other embodiments, the browser of the guest computing system **14**, the browser of the host computing

system **12**, or browsers of both computing systems **12**, **14** are ACTIVEX-enabled, which execute downloaded ActiveX controls. In general, the principles of the invention apply to any browser capable of running applets or controls that perform screen capture.

[0029] Other application programs **28** can include, but are not limited to, an electronic mail client program, an instant messaging, and office applications, such as spreadsheet, word processor, and slide presentation software. Each application program **28** can be a proprietary or commercially available program and can run in conjunction with screen sharing.

[0030] Typically, the signal bus **26** connects the processor **22** to various other components of the computing system **12**, **14** including, for example, a user-input interface, a memory interface, a peripheral interface, a video interface, a local network interface, and a wide-area network interface (not shown). The display screen **21** connects to the signal bus **26** through the video interface. Exemplary implementations of the signal bus include, but are not limited to, a Peripheral Component Interconnect (PCI) bus, an Industry Standard Architecture (ISA) bus, an Enhanced Industry Standard Architecture (EISA) bus, and a Video Electronics Standards Association (VESA) bus. Over a wire or wireless link, the user-input interface is in communication with one or more user-input devices, e.g., a keyboard, a mouse, trackball, touch-pad, touch-screen, microphone, joystick, by which a user can enter information and commands into the computing system **12**, **14**. Each computing system **12**, **14** can reside behind a firewall **20-1**, **20-2**, such as ZoneAlarm™, a MICROSOFT XP® built-in, or Norton Security™ firewalls, or external firewalls to isolate the computing system from the network **18**.

[0031] Embodiments of the network **18** include, but are not limited to, local-area networks (LAN), metro-area networks (MAN), and wide-area networks (WAN), such as the Internet or World Wide Web. Each computing system **12**, **14** can connect to the server **16** over the network **18** through one of a variety of connections, such as standard telephone lines, digital subscriber line (DSL), asynchronous DSL, LAN or WAN links (e.g., T1, T3), broadband connections (Frame Relay, ATM), and wireless connections (e.g., 802.11(a), 802.11(b), 802.11(g)).

[0032] In one embodiment, the server **16** is a Web server and includes a server engine. The server engine receives HTTP requests to access web pages identified by URLs and provides the appropriate web page to the requesting computing system **12**, **14**. The server engine can also send an identifier to each computing system **12**, **14** when that computing system first communicates with the server **16**. In subsequent communications with the server **16**, each computing system **12**, **14** includes its identifier so that the server **16** can identify the source.

[0033] In general, the server **16** orchestrates the screen-sharing session between the host and guest computing systems **12**, **14**. The server **16** establishes a first HTTP connection **40** with the host **12** and a second HTTP connection **42** with the guest **14**. By the first connection **40**, the server **16** continuously receives image (i.e., pixel) data corresponding to the screen image of the host **12**. Over the second connection **42**, the server **16** continuously receives requests for image data from the guest **14** and responds with image data received from the host **12**. In effect, the server **16** is the hub of a connection **44** established between the host system **12** and the guest system **14** for purposes of screen sharing.

[0034] FIG. **2** shows an embodiment of a general process **100** of screen sharing in accordance with the present invention from the perspective of the guest **14**. When a user of the guest system **14** decides to participate in sharing the screen of the host system **12**, the user obtains (step **102**) a session code (or passcode). The user can receive this session code by telephone, email, instant messaging, or any other mode of direct or indirect communication, typically, although not necessarily, with the user of the host system **12**.

[0035] At step **104**, the user of the guest **14** launches the browser software and visits a specific website hosted by the server **16**. The browser can have a graphical screen-sharing button (e.g., within a toolbar) that, when pressed, sends an HTTP request to the server **16** to visit the specific website. Within the guest browser, a web page presents the guest with various options including an option to join a presentation. When the guest **14** chooses to join the presentation, the guest browser displays another web page having a field within which the guest **14** enters (step **106**) the session code and, optionally, additional data, such as a Guest name (used, e.g., in Web Conferencing) and a special operator password (used, e.g., in customer-support situations).

[0036] When the session code is valid, the guest **14** receives, from the server **16**, a web page with embedded program code (e.g., a JAVA applet), and automatically and continuously executes (step **108**) this program code. Execution of the program code causes the guest **14** to establish a connection with server **16** and to send (step **110**) an HTTP request regularly to the server **16** requesting pixel-level data corresponding to the screen image of the host screen. By convention, HTTP requests and responses transported over this connection are addressed to well-known port number **80** or to port **443** for secure https connections. Accordingly, for there to be any browser-to-Web server interaction over the network **18**, port **80** needs to be open in the firewall **20-2**. Consequently, screen-sharing traffic is able to pass through the firewall **20-2** unblocked.

[0037] In response to the HTTP request, the guest **14** receives (step **112**) image data and screen coordinates from the server **16**. The image data received can correspond to a portion of the display screen of the host computing system **12** or to the display screen in its entirety. The guest computing system **14** uses the screen coordinates to repaint (step **114**) its display screen with the image data obtained from the server **16**. Accordingly, the user of the guest computing system **14** sees the screen image of the host computing system **12**.

[0038] Until the screen sharing session is terminated, the guest computing system **14** continuously sends (step **116**) requests to the server, receives image data from the server, and repaints its display screen accordingly. In one embodiment, the guest **14** sends another request for image data to the server **16** as soon as the guest **14** repaints its display screen. That is, the guest **14** continuously issues requests as quickly as it is able. In another embodiment, the guest **14** sends a request periodically at a predetermined frequency (e.g., 1s). Any changes to the screen of the host **12** appear real-time in the browser window of the guest **14**.

[0039] Advantageously, the user of the guest computing system **14** does not deliberately download and install software at the guest computing system **14** in order to participate in screen sharing. In contrast, the guest computing system **14** receives and executes the applet automatically in response to visiting the server web page, without the user of the guest **14** being aware of any downloaded applet.

[0040] FIG. **3** shows an embodiment of a general process **200** of screen sharing in accordance with the present invention from the perspective of the host computing system **12**. At step **202**, a user of the host **12** determines to host a screen-sharing session and launches the Web browser. The Web browser can display a graphical button that the user can press (step **204**) to visit a screen-sharing web page hosted by the server **16**. Alternatively, the user can enter the URL of the screen-sharing web page into the address field in the browser window, click on a link, or click on an icon in a browser toolbar, to list but a few mechanisms by which the user can visit the screen-sharing web page.

[0041] The screen-sharing web page can display various options, including an option to host a screen-sharing session. When the user chooses (step **206**) the option to host a screen-sharing session, the host **12** receives a session code (which appears in a new web page presented to the host **12**). In one embodiment, the host **12** receives the session code only if authorized to host screen-sharing sessions, as described below.

[0042] When the host **12** is establishing a screen-sharing session with the server **16** for a first time, a security certificate appears (step **207**) at the host **12** (i.e., before the host **12** sees the session code). The user of the host **12** accepts the certificate to establish a secure connection with the server **16**. In general, a security certificate appears for each new screen-sharing session, although the user of the host **12** can elect always to trust certificates from the server **16** so that subsequent screen-sharing sessions do not prompt a reappearance of the security certificate.

[0043] At step **208**, the user of the host computing system **12** distributes the session code to the guest. (For multiple guests, the user of the host **12** distributes the same session code to each guest). Exemplary methods for distributing the session code are described above. It is to be understood that the distribution of the session code does not need not occur at this particular point in the process **200**: the host **12** can begin sending image data to the server **16**, as described below, before the session code is given to any guests.

[0044] At step **210**, the host **12** receives and executes program code from the server **16** (e.g., a JAVA applet embedded in the new downloaded web page that displays the session code). The program code includes a screen-capture method for capturing a pixel-level snapshot of the screen of the host **12**. In one embodiment, the screen-capture method employs a JAVA version 1.3 method called createScreenCapture( ) An input parameter to the JAVA createScreenCapture method is a rectangle that defines the screen boundaries within which pixels are to be captured. Thus, the createScreenCapture method can be used to capture a specific area of the screen or of a specific visual object. The createScreenCapture method returns a pixel buffer containing the image (i.e., pixel data).

[0045] In general, the size of captured pixel buffer can be large. For example, for a 32-bit color screen with a resolution of 1280×1024, the size of a pixel buffer is at least 5,242,880 bytes (32*1280*1024). Transmitting this amount of data with sufficient frequency to achieve an animated screen image at the guest **14** may be unfeasible in networks where the bandwidth is insufficient to support the pixel data traffic.

[0046] Rather than send the entire screen image upon each execution of the screen-capture method, in one embodiment, the host **12** determines (step **212**) which sub-image of the screen image has changed since the last transmission of the pixel buffer and sends that sub-image to the server **16**. To make this determination, the host **12** runs program code (downloaded to the host **12** with the screen-capture code or as a result of executing the screen-capture code) that isolates the area of change to a rectangular sub-image, as described in more detail below.

[0047] The host **12** compresses (step **214**) the changed rectangular sub-image into a file, using either a JPEG (Joint Photographic Experts Group) or PNG (Portable Network Graphics) codec, and transmits (step **216**) the compressed rectangle sub-image with its rectangle coordinates (x, y, height, and width) to the server **16**. Depending on the contents of the screen image, the host **12** automatically and dynamically chooses the particular compression type. For example, JPG compression is preferred for high quality images and photographs, whereas PNG compression is preferred for the graphical applications, websites, etc. The connection between the host **12** and the server **16** transports HTTP requests and responses addressed to well-known port number **80** or to port **443** for secure https connections. Again, screen-sharing traffic is able to pass unblocked through any firewall **20-1** (FIG. **1**).

[0048] The host computing system **12** continuously (step **218**) determines screen image changes, compresses the image data, and sends the compressed image data to the server **16** until the screen-sharing session is terminated. In one embodiment, the host **12** starts determining screen image changes as soon as it transmits the compressed image data. That is, the host **12** continuously determines changes to the screen, compresses the changes, and forwards the changes to the server **16** as quickly as it is able. In another embodiment, the host **12** determines changes periodically at a predetermined frequency (e.g., 1s). After the host **12** starts sharing its screen, the screen continues to be shared provided the browser window remains open, although the browser window need not be the topmost window nor be maximized.

[0049] FIG. **4**A and FIG. **4**B show an embodiment of a general process **300** of screen sharing in accordance with the present invention from the perspective of the server computing system **16**. The particular numbering of the steps of the process **300** is not intended to imply that the process **300** occurs serially. For instance, during part of the process **300**, the server **16** is communicating with the host **12** while communicating with the guest **14**.

[0050] At step **302**, the server **16** receives an HTTP request from the host **12** for hosting a screen-sharing session. From the HTTP request, the server **16** is able to determine its originator (e.g., the HTTP request includes an identifier sent to the host **12** by the server **16** during a previous interaction between the two systems **12**, **16**). In a database of registered hosts, the server **16** determines (step **304**) whether the originator of the HTTP request (here, the host **12**) is authorized to host screen-sharing sessions. If the host **12** is not among the list of registered hosts, the server **16** can reject the connection or offer to register the host.

[0051] If the host **12** is a registered user, the server **16** produces (step **306**) a session code (e.g., randomly generated) and sends the session code to the host **12**, for display on the host screen. The server **16** also sends the screen-capture program code, described above, to the host **12**. The server **16** determines (step **310**) when a guest connects or is already connected to this session. Alternatively, the server **16** determines that the screen-sharing session terminates (step **312**), because, e.g., the host **12** cancels the session.

[0052] At step **314**, the server **16** receives an HTTP request from the guest **14** for joining a screen-sharing session and presents a web page with a field for receiving a session code. The server **16** verifies (step **316**) a session code submitted by the user of the guest **14**. If the session code corresponds to a session code given to the host **12**, the server **16** sends (step **318**) an applet to the guest **14**. In addition, the server **16** uses the session code to link the guest **14** to the host **12**. For example, the server **16** can maintain a table for tracking screen-sharing sessions and generate (step **320**) a new entry in the table representing the screen-sharing session between the guest **14** and the host **12**. The session code can be used as an index to the table entry. In addition, the session code can operate within the table to link multiple guests to a single host (in those instances when multiple guests are participating in a screen-sharing session).

[0053] During the screen-sharing session, the server **16** receives (step **322**) screen image data from the host **12**. The server **16** stores (step **324**) screen image data updates received from the host **12** in a buffer. While communicating with the host **12**, the server **16** is also communicating with the guest **14**. At step **326**, the server **16** receives a request from the guest **14** for screen image data.

[0054] In general, the server **16** forwards (step **328**) image data received from the host **12** to the guest **14**. More specifically, the server **16** makes a determination as to which image data to send. To illustrate, the server **16** can track the last update to the host screen image that the server **16** sent to the guest **12**. When the server **16** receives a subsequent request for image data from the guest **14**, the server **16** identifies which image updates it has received from the host **12** since sending the last update to the guest **14**. If more than one screen image update has since arrived from the host **12**, instead of sending the next update in the series of unsent updates, the server **16** analyzes the unsent updates to determine if any one of them can be bypassed of if certain updates could be efficiently combined.

[0055] As an oversimplified illustration, consider for example that the last screen image update sent to the guest is number **100**, and that subsequent updates numbered **101** through **120** arrive at the server from the host. When the next request arrives from the guest **14**, the server **16** does not merely send the screen image update number **101**. Rather, the server **16** analyzes the newly arrived screen image updates (here, **101** through **120**) to determine if any of the later screen image updates encompasses one or more of the previous updates.

[0056] For example, screen image update number **120** may be a full screen update sent by the host **12** to establish image synchronization with the guest **14**. Consequently, it is enough for the server **16** to send screen image update number **120** to the guest **14**, because the other updates **101** through **119** are no longer needed (being subsumed by the full screen update). On a lesser scale, one of the later screen image updates may relate to a sub-image that fully encompasses the sub-image of an earlier screen image update. The server **16** can also combine non-overlapping screen image updates.

[0057] By discarding subsumed screen image updates and combining updates wherever appropriate, the server **16** avoids needless expenditure of bandwidth. This mechanism is particularly useful when the host uploads screen image updates at a faster rate than the guest downloads updated screen image data, or, in general, when the speed of the host **12** and multiple guests differ substantially.

[0058] FIG. **5** shows an embodiment of a general process **400** performed by the host **12** to determine which rectangular sub-image of the screen image has changed (since the last screen capture). At step **402**, the host **12** receives a captured screen image and divides the screen into grids. The screen image is saved (step **404**) to a buffer, b, as a matrix of grids. At step **406**, the host **12** determines whether this is a first occurrence of a capture of the screen image. If this capture is the first occurrence, the image is saved (step **408**) in a buffer, bp, as a matrix of grids. The program code executing at the host **12** returns (step **410**) the coordinates of the full screen image. Full screen coordinates include the screen origin (0, 0), the screen width, and the screen height. The program code then exits (step **412**).

[0059] If, instead, this capture is a subsequent occurrence, the image contents in the buffer, b, for each grid are compared (step **414**) with the image content in the buffer, bp. A process for determining differences is described below in connection with FIG. **7**. If, at step **416**, no differences are detected for any of the grids, the program code returns (step **418**) the coordinates of a full-screen image. If image data changes in any one or more of the grids, the new image grids are copied (step **422**) to the buffer, bp. The program code then determines (step **424**) a sub-image that encompasses the changes.

[0060] Various techniques can be used to find the sub-image that encompasses the pixel changes. For example, a first technique compares sub-images in grids one at a time, like squares in a chessboard, to determine whether that sub-image has changed.

[0061] A second technique executes similarly to the first technique, except that the second techniques divides the screen image into grids by dividing the image into four sections, as shown in FIG. **6**. Each sub-image that contains a difference is subdivided into quarters until a sub-image containing the pixel changes is small enough for transmission. FIG. **6** shows the fourth quadrant subdivided thrice to arrive at an acceptably sized sub-image **450** having changes for transmission to the server **16**. This technique can arrive at small sub-images faster than the first technique, except that changes occurring near the middle of the screen can involve all four initial sub-images. In such instances, the first technique is preferred. In one embodiment, the host **12** combines the two techniques, adaptively selecting the technique that is more appropriate for the particular screen-sharing situation.

[0062] FIG. **7** shows an embodiment of a process **500** by which the host computing system **12** detects pixel changes in the screen image. At step **502**, the screen image is received and divided into grids. The image of each new grid is compared (steps **504**) to the corresponding grid of the screen image in the buffer, bp. If no differences are detected, at step **506** the process **500** returns 0 (for no differences). If differences are found, at step **508** the process **500** returns N, where N is the number of pixel differences detected between the two compared grid images.

[0063] FIG. **8** shows an embodiment of a process **550** for enabling the host computing system **12** to conduct screen-sharing sessions in accordance with the invention. At step **552**, the user of the host computing system **12** launches the web browser and visits a web page that has HTML code for conducting screen sharing in accordance with the invention. The user copies (steps **554**) the HTML code from the web page (e.g., into the clipboard) and pastes (steps **558**) that HTML code into a web page used by the host computing system **12** for hosting screen-sharing session. Alternatively,

the HTML code can be e-mailed to the user. As another example, after the user registers with the server system **16**, a browser window opens with instructions for copying and pasting the HTML code. Other methods of distributing the HTML code can be practiced without departing from the principles of the invention.

[0064] The HTML code produces a screen-sharing graphical button that appears whenever a user of a computing system visits the web page with the HTML code. Activating the graphical button (e.g., with one mouse click) launches a screen-sharing session. This embodiment of the HTML code does not authenticate the host at the server **16**. Accordingly, anyone can host a screen-sharing session by visiting the web page and pressing the graphical screen-sharing button. This universality becomes particularly useful in customer support applications. In such customer support applications, an operator (i.e., an individual who is providing the customer support) may be required to provide an "operator's password" in order to see the screen (i.e., become a guest of the screen-sharing session).

[0065] As an illustrated example, most business enterprises maintain a web site that hosts one or more web pages that are accessible to their current and prospective customers. Any given enterprise can copy the screen-sharing HTML code into its "contact us" or "help" web page. A visitor of that web page sees the graphical screen-sharing button.

[0066] In one embodiment, activating the screen-sharing button invokes a pop-up window with a session code that the visitor can share with a guest (presumably, the host of the "contact us" web page). Instead of invoking a pop-up window, in another embodiment activation of the screen-sharing button switches the user to another host web page with the session code. The visitor shares this session code with an operator associated with the host. After the operator (turned guest) connects with the session code, the visitor (turned host) is sharing its screen. Before being allowed to view the screen, the operator is asked to provide a password to ensure that only an authorized operator, i.e., an authorized representative of the enterprise, provides the customer support. The screen sharing between the visitor-host and operator-guest can be used to supplement a telephone conversation between the parties. Alternatively, the visitor-host and operator-guest can engage in a chat session or exchange emails while screen sharing.

[0067] It is to be understood that such one-click screen-sharing can be added as a feature to web pages in a variety of forms, e.g., as a graphical button in a toolbar, as a menu item, as an icon on a search engine. Application programs, such as instant messaging and office applications, can be adapted to provide one-click screen sharing.

[0068] FIG. **9** shows an embodiment of HTML code that can be copied and pasted into a web page in order to provide screen-sharing capability at the host computing system. The exemplary URL within the HTML code (www.showscreen.com) is a URL for the server **16**. The HTML code opens a new window and redirects the browser to the server **16** from which the host applet is downloaded. This embodiment of the HTML code does not authenticate the host.

[0069] Aspects of the present invention may be implemented, in whole or in part, as one or more computer-readable software programs embodied on or in one or more articles of manufacture. The article of manufacture can be, for example, any one or combination of a floppy disk, a hard disk, hard-disk drive, a CD-ROM, a DVD-ROM, a flash memory card, an EEPROM, an EPROM, a PROM, a RAM, a ROM, or a magnetic tape. In general, any standard or proprietary, programming or interpretive language can be used to produce the computer-readable software programs. Examples of such languages include C, C++, Pascal, JAVA, BASIC, Visual Basic, and Visual C++. The software programs may be stored on or in one or more articles of manufacture as source code, object code, interpretive code, or executable code.

[0070] Although the invention has been shown and described with reference to specific preferred embodiments, it should be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention as defined by the following claims. For example, the guest computing system **14** can operate in a mode, called the HTTP mode, when a JAVA applet is not used. In this mode, the above-described functionality is achieved through JAVASCRIPT AND HTML.

What is claimed is:

1. A method of screen-sharing, comprising:

sending, from a browser program running on a computing system to a server on a network, a request to host a screen-sharing session during which images displayed on a display screen of the computing system are shared for concurrent display with a guest computing system over the network;

receiving from the server over the network, in response to the request to host the screen-sharing session, a web page with embedded program code for repeatedly capturing and transmitting image data corresponding to an image displayed on the display screen of the computing system to the server; and

hosting the screen-sharing session at the computing system entirely through the browser program by executing the embedded program code to repeatedly capture images displayed over time on the display screen of the computing system and to transmit image data corresponding to the captured images to the server over the network.

2. The method of claim **1**, wherein sending the request to host the screen-sharing session from the browser program running on the computing system to the server on the network occurs in response to a single click of an input device that activates a region on a web page displayed in a browser window on the display screen of the computing system, the single click being sufficient to start the hosting of the screen-sharing session and the sending of image data corresponding to captured images to the server.

3. The method of claim **1**, wherein the embedded program code detects changes in a captured image since a previously captured image.

4. The method of claim **3**, wherein sending the image data corresponding to captured images to the server includes sending only the detected image changes to the server.

5. The method of claim **1**, further comprising compressing the image data corresponding to captured images before sending the image data to the server over the network.

6. The method of claim **5**, wherein the compressing includes selecting a file type in which to save the compressed image data.

7. The method of claim **6**, wherein the file type is one of a JPG and a PNG file type.

8. The method of claim **1**, further comprising receiving a session code to be shared with a user of the guest computing

system in order to allow the guest computing system to participate in the screen-sharing session.

9. The method of claim **1**, wherein the embedded program code includes a JAVA applet that uses a screen-capture method.

10. A method of conducting a screen-sharing session during which a user of a guest computing system can view an image displayed on a display screen of a host computing system, the method comprising:

transmitting over a network, in response to a request received from the host computing system to host a screen-sharing session, a first web page with embedded program code to the host computing system for repeatedly capturing and returning image data corresponding to an image displayed on the display screen of the host computing system;

transmitting to the guest computing system, in response to a request from the guest computing system to participate in the screen-sharing session, a second web page with embedded program code for generating a request for image data;

receiving, over an HTTP (HyperText Transport Protocol) connection from the host computing system, image data corresponding to images displayed on the display screen of the host computing system, the image data having been repeatedly captured over time and transmitted over the HTTP connection in response to execution of the program code embedded in the first web page by a browser program running on the host computing system;

receiving a request from the guest computing system for image data; and

transmitting image data received from the host computing system to the guest computing system in response to the request received from the guest computing system.

11. The method of claim **10**, further comprising determining from multiple updates of image data received from the host computing system, which image data to send to the guest computing system.

12. The method of claim **10**, further comprising providing a session code to the host computing system.

13. The method of claim **10**, further comprising maintaining a registry of host computing systems authorized to host screen-sharing sessions.

14. The method of claim **13**, further comprising the step of searching the registry using an identifier provided by the host computing system to determine whether the host computing system is authorized to host the screen-sharing session.

15. A screen-sharing system comprising:

a guest computing system and a host computing system in communication with a server system over a network;

the guest computing system automatically executing program code embedded in a web page received from the server system, the program code sending a request to the server system for image data corresponding to an image on a display screen of the host computing system;

the host computing system running a browser program that executes program code embedded in a web page received from the server system in response to a request from the host computing system to host a screen-sharing session, the host computing system hosting the screen-sharing session entirely through the browser program, the browser program executing the program code to capture image data repeatedly over time from the display screen of the host computing system and to transmit the captured image data to the server system; and

the server system sending captured image data received from the host computing system to the guest computing system in response to the request from the guest computing system.

16. The screen-sharing system of claim **15**, wherein the host computing system sends the request to host the screen-sharing session from the browser program running on the server system to the server on the network occurs in response to a single click of an input device that activates a region on a web page displayed in a browser window on the display screen of the host computing system, the single click being sufficient to start hosting the screen-sharing session and sending image data corresponding to captured images to the server system.

17. The screen-sharing system of claim **15**, wherein the program code received from the server system in response to the request to host the screen-sharing session includes a JAVA applet that uses a screen-capture method.

18. The screen-sharing system of claim **15**, wherein the embedded program code received from the server system in response to the request to host the screen-sharing session detects changes in captured image data.

19. The screen-sharing system of claim **18**, wherein sending the captured image data to the server system includes sending only the detected image changes to the server.

20. The screen-sharing system of claim **15**, wherein the host computing system compresses the captured image data before sending the captured image data to the server system over the network.

21. A method for enabling screen-sharing functionality, the method comprising:

acquiring hypertext markup language (HTML) code used to host a screen- sharing session; and

pasting the HTML code into a web page, the HTML code launching a screen-sharing session when activated, said screen-sharing session being hosted by any computing system that downloads the web page with the HTML code through a browser program.

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