US 20120017268A9

(19) **United States**

(12) **Patent Application Publication**
Dispensa

(10) **Pub. No.: US 2012/0017268 A9**

(48) **Pub. Date: Jan. 19, 2012**
CORRECTED PUBLICATION

(54) **ENHANCED MULTI FACTOR AUTHENTICATION**

(76) Inventor: **Steve Dispensa**, Leawood, KS (US)

(21) Appl. No.: **12/394,016**

(22) Filed: **Feb. 26, 2009**

Prior Publication Data

(15) Correction of US 2009/0300745 A1 Dec. 3, 2009
See (60) Related U.S. Application Data.

(65) US 2009/0300745 A1 Dec. 3, 2009

Related U.S. Application Data

(63) Continuation-in-part of application No. 11/862,173, filed on Sep. 26, 2007.

(60) Provisional application No. 60/866,068, filed on Nov. 16, 2006, provisional application No. 60/939,091, filed on May 21, 2007, provisional application No. 61/031,768, filed on Feb. 27, 2008.

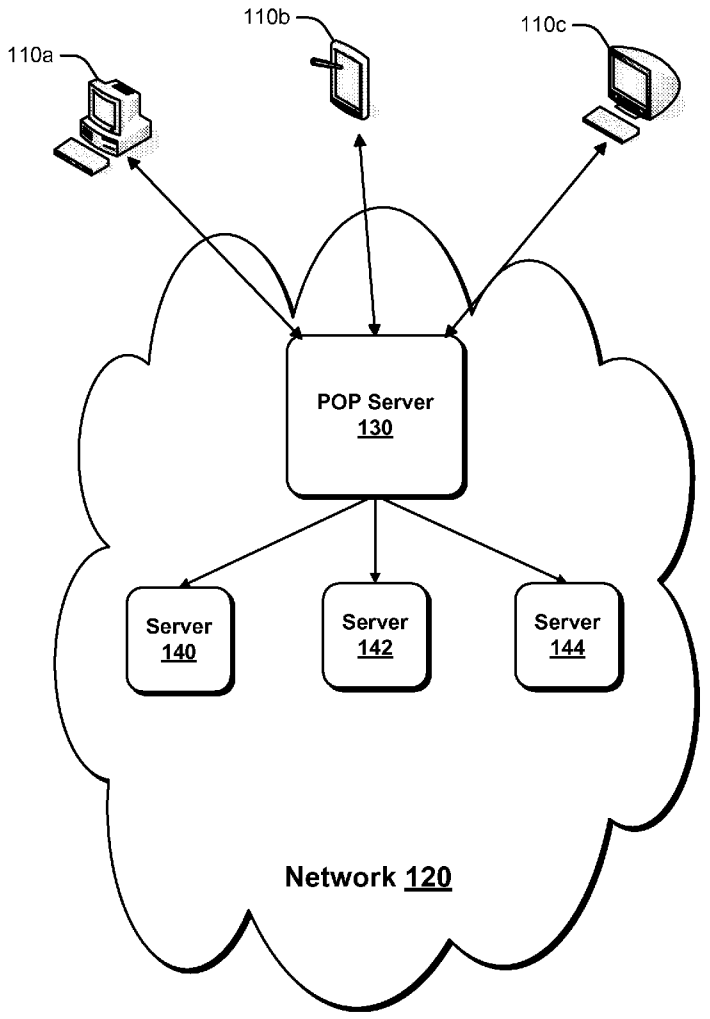
Publication Classification

(51) **Int. Cl.**
H04L 9/32 (2006.01)

(52) **U.S. Cl.** **726/7**; 726/3; 726/5

(57) **ABSTRACT**

In one embodiment, a network element comprises one or more processors, and a memory module communicatively coupled to the processor. The memory module comprises logic instructions which, when executed by the processor, configure the processor to receive, via a first communication channel, a primary authentication request transmitted from a user from a first device, process the primary authentication request to determine whether the user is authorized to access one or more resources, in response to a determination that the user is authorized to access one or more resources, initiate, a secondary authentication request, and transmit the secondary authentication request from the network element to the user via a second communication channel, different from the first communication channel.



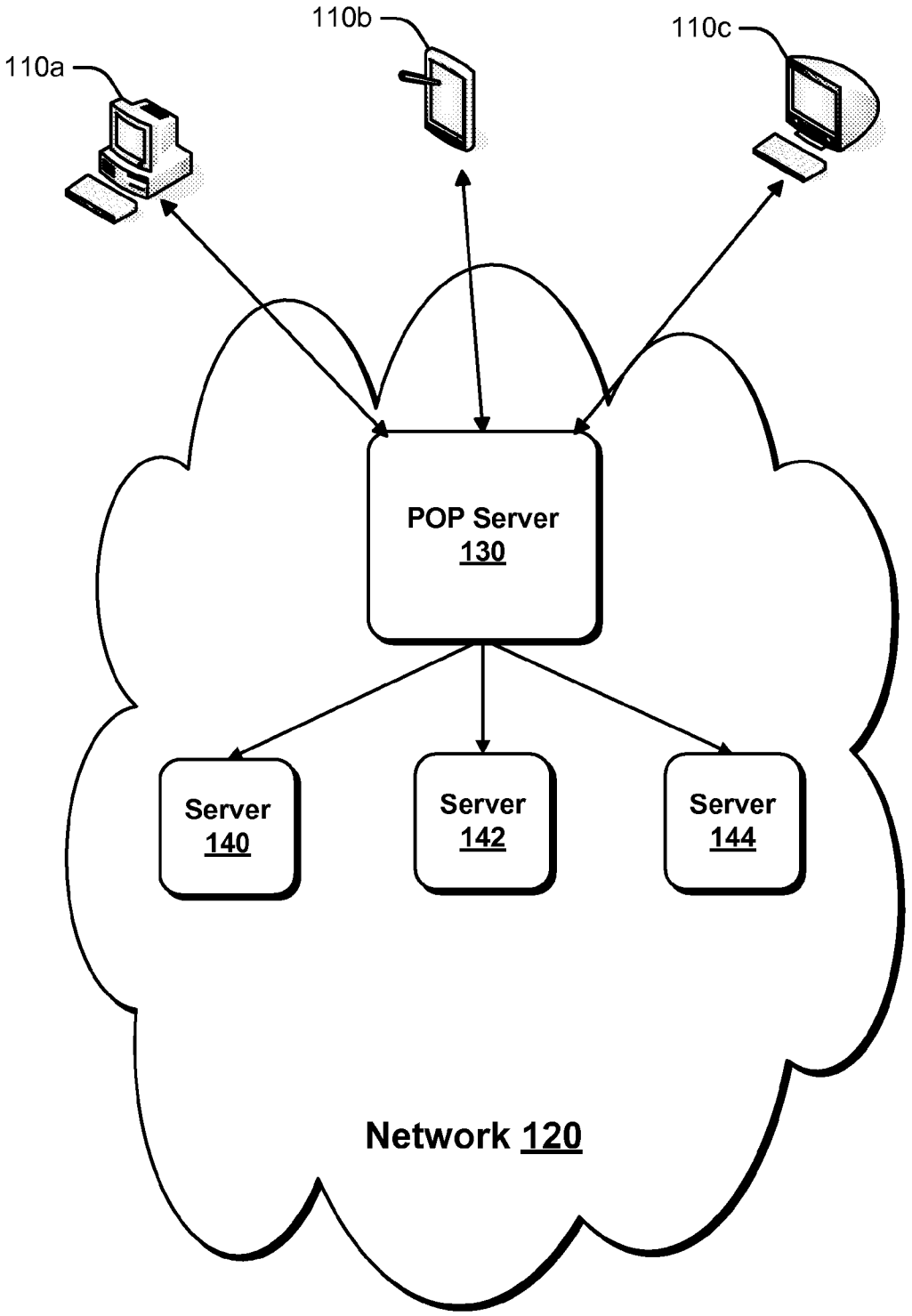

110a
110b
110c
POP Server
130
Server
140
Server
142
Server
144
Network 120

Fig. 1

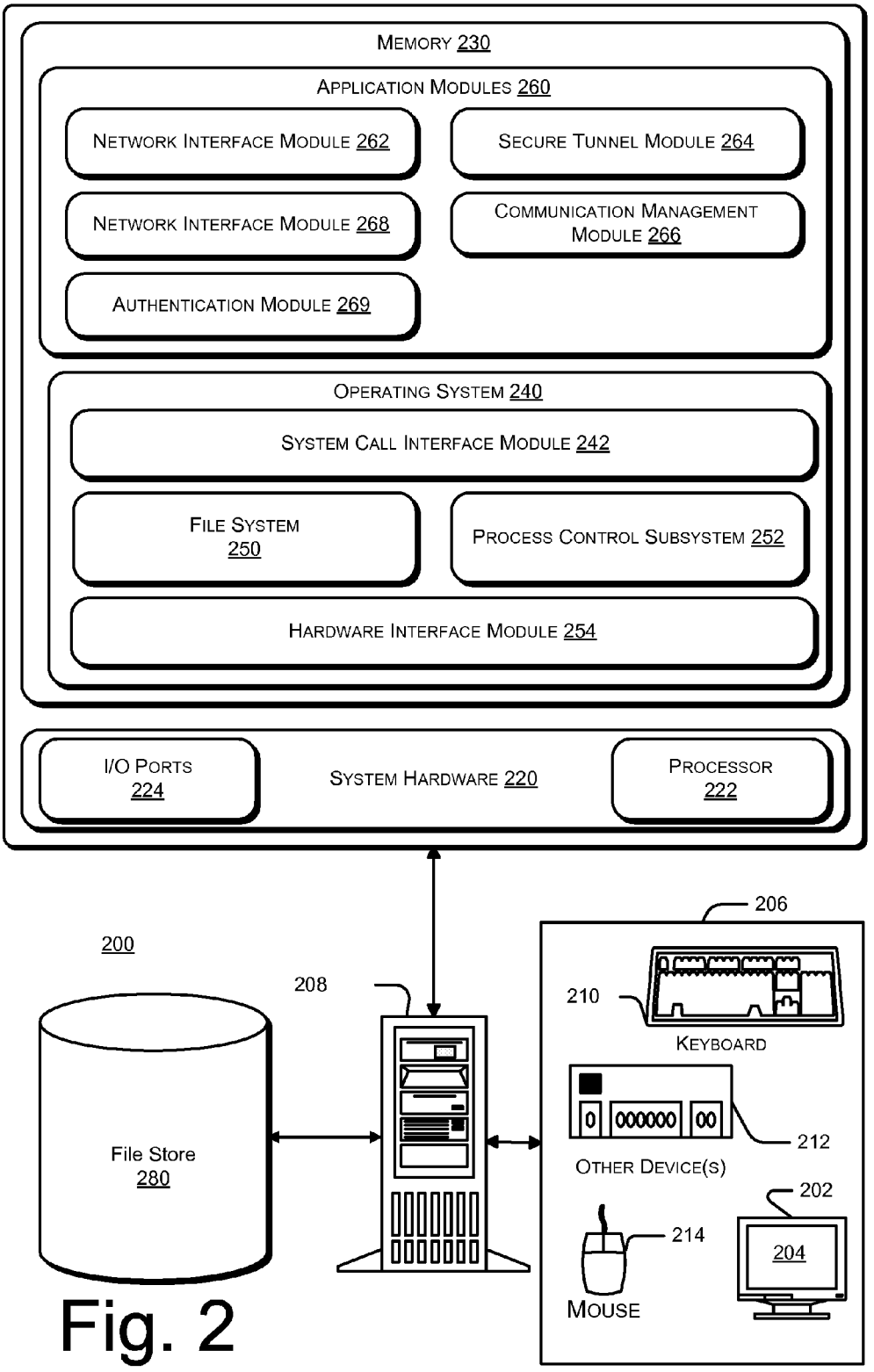

MEMORY 230
APPLICATION MODULES 260
NETWORK INTERFACE MODULE 262
SECURE TUNNEL MODULE 264
NETWORK INTERFACE MODULE 268
COMMUNICATION MANAGEMENT MODULE 266
AUTHENTICATION MODULE 269
OPERATING SYSTEM 240
SYSTEM CALL INTERFACE MODULE 242
FILE SYSTEM 250
PROCESS CONTROL SUBSYSTEM 252
HARDWARE INTERFACE MODULE 254
I/O PORTS 224
SYSTEM HARDWARE 220
PROCESSOR 222
206
200
208
210
KEYBOARD
212
OTHER DEVICE(S)
202
214
204
MOUSE
File Store 280

Fig. 2

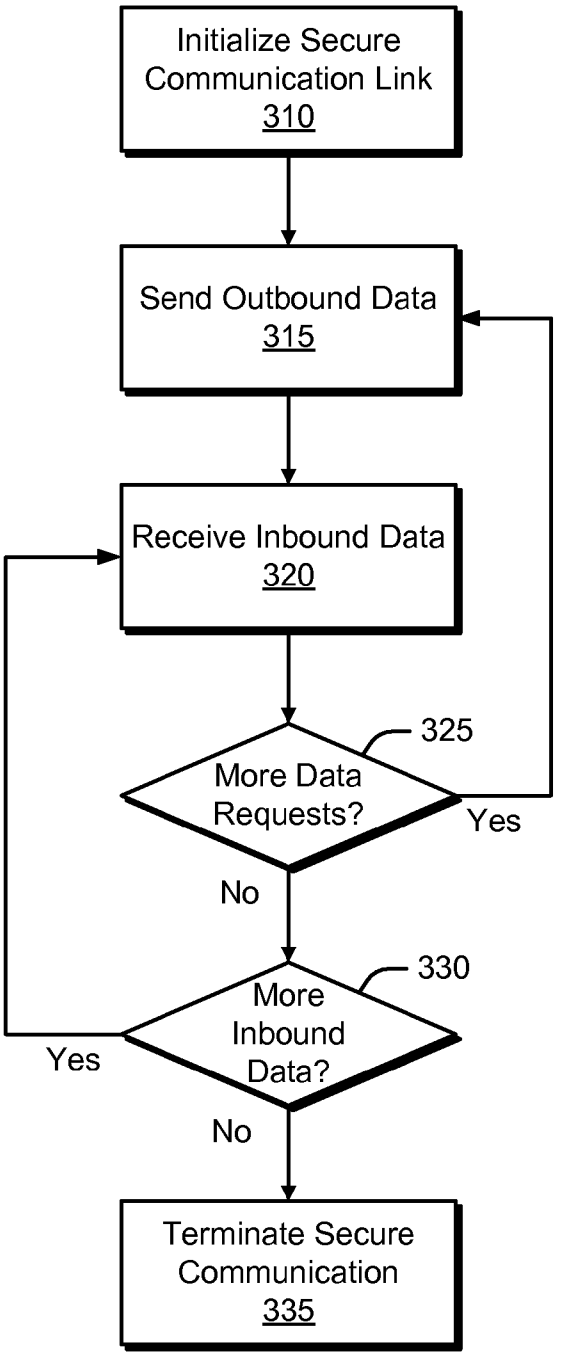

Initialize Secure Communication Link 310
Send Outbound Data 315
Receive Inbound Data 320
325
More Data Requests?
Yes
No
330
More Inbound Data?
Yes
No
Terminate Secure Communication 335

Fig. 3

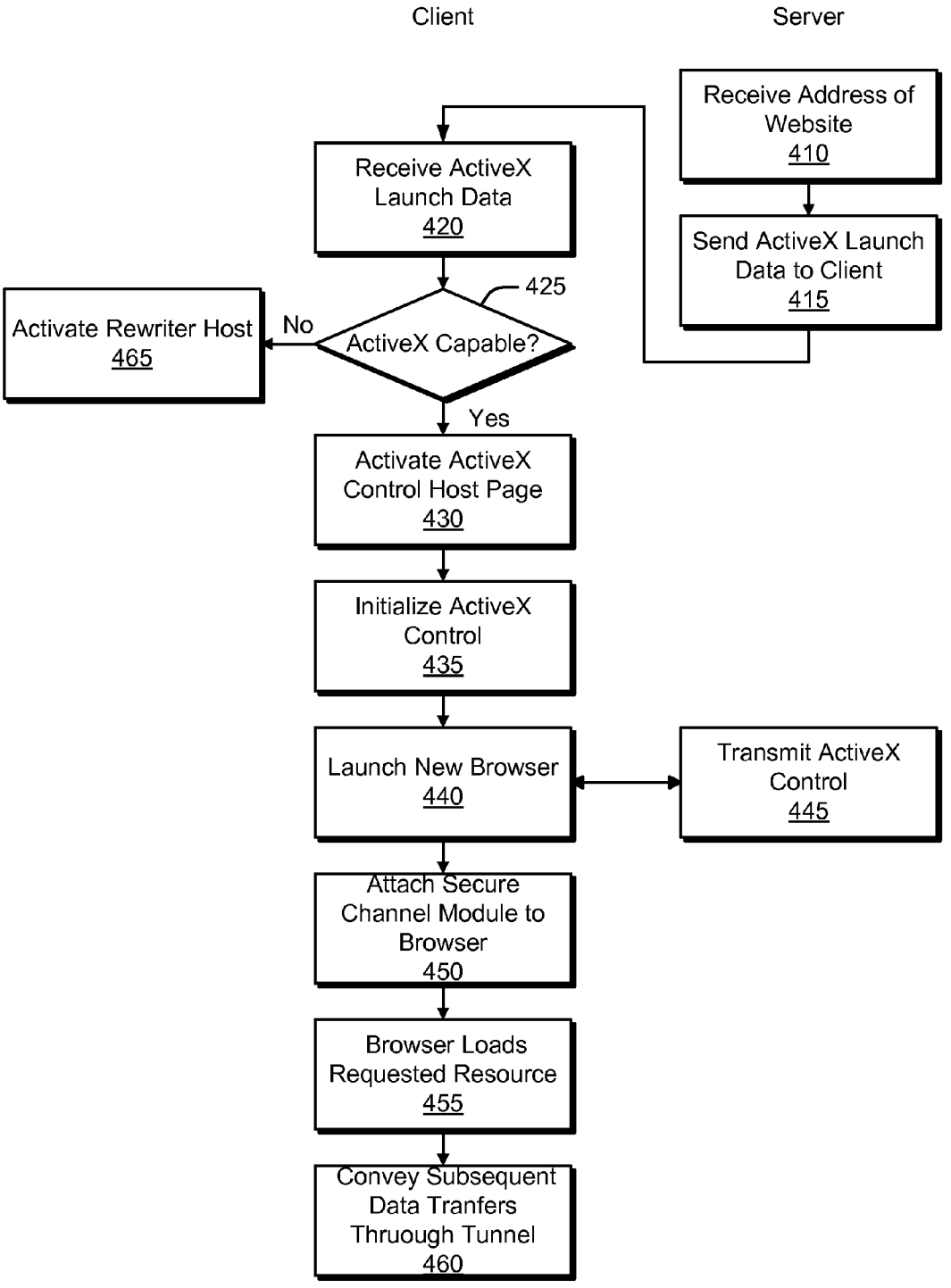

Client
Server
Receive Address of Website 410
Send ActiveX Launch Data to Client 415
Receive ActiveX Launch Data 420
425
ActiveX Capable?
No
Activate Rewriter Host 465
Yes
Activate ActiveX Control Host Page 430
Initialize ActiveX Control 435
Launch New Browser 440
Transmit ActiveX Control 445
Attach Secure Channel Module to Browser 450
Browser Loads Requested Resource 455
Convey Subsequent Data Tranfers Thruough Tunnel 460

Fig. 4

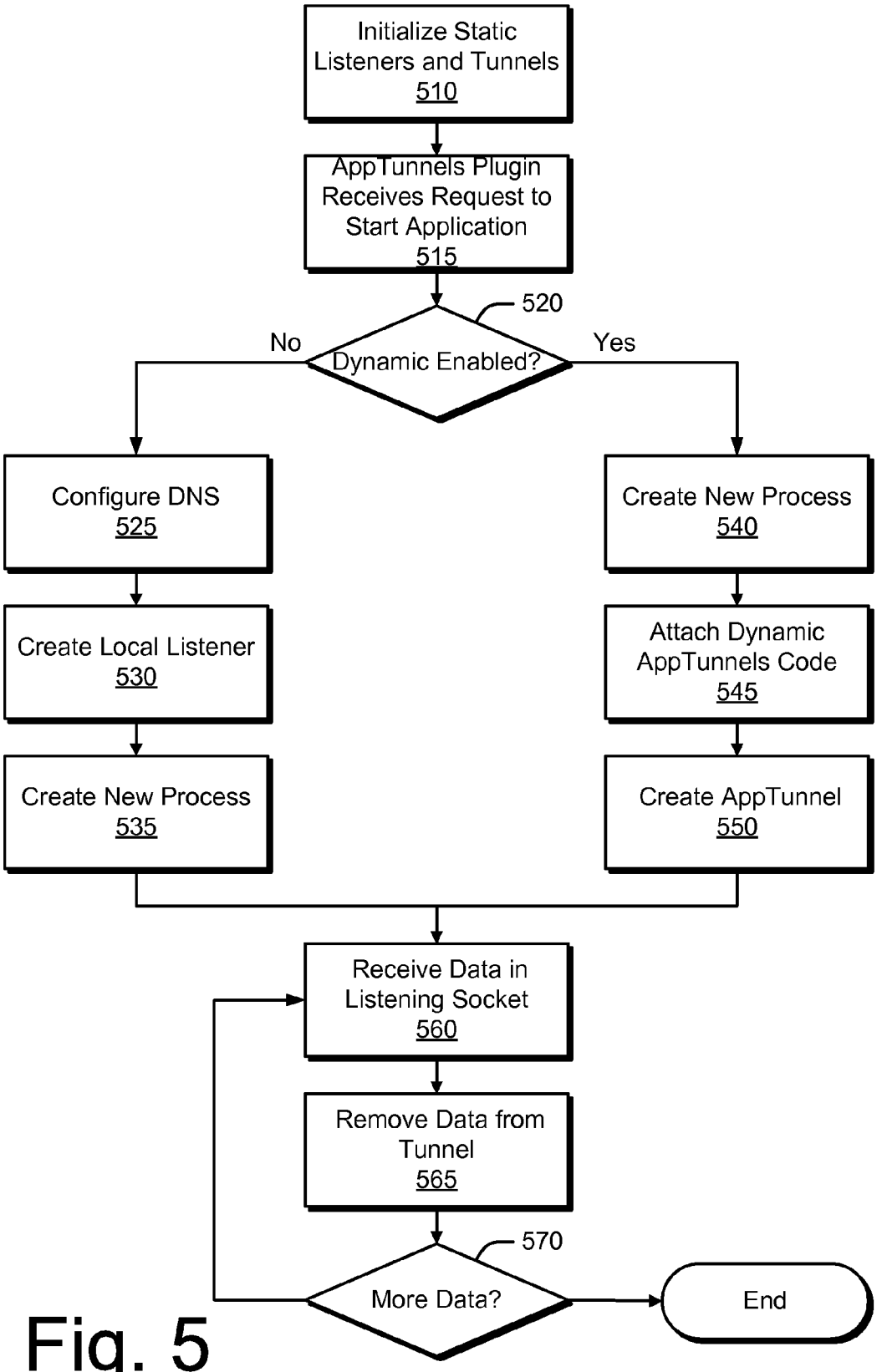

Initialize Static Listeners and Tunnels 510
AppTunnels Plugin Receives Request to Start Application 515
520
Dynamic Enabled?
No
Yes
Configure DNS 525
Create Local Listener 530
Create New Process 535
Create New Process 540
Attach Dynamic AppTunnels Code 545
Create AppTunnel 550
Receive Data in Listening Socket 560
Remove Data from Tunnel 565
570
More Data?
End

Fig. 5

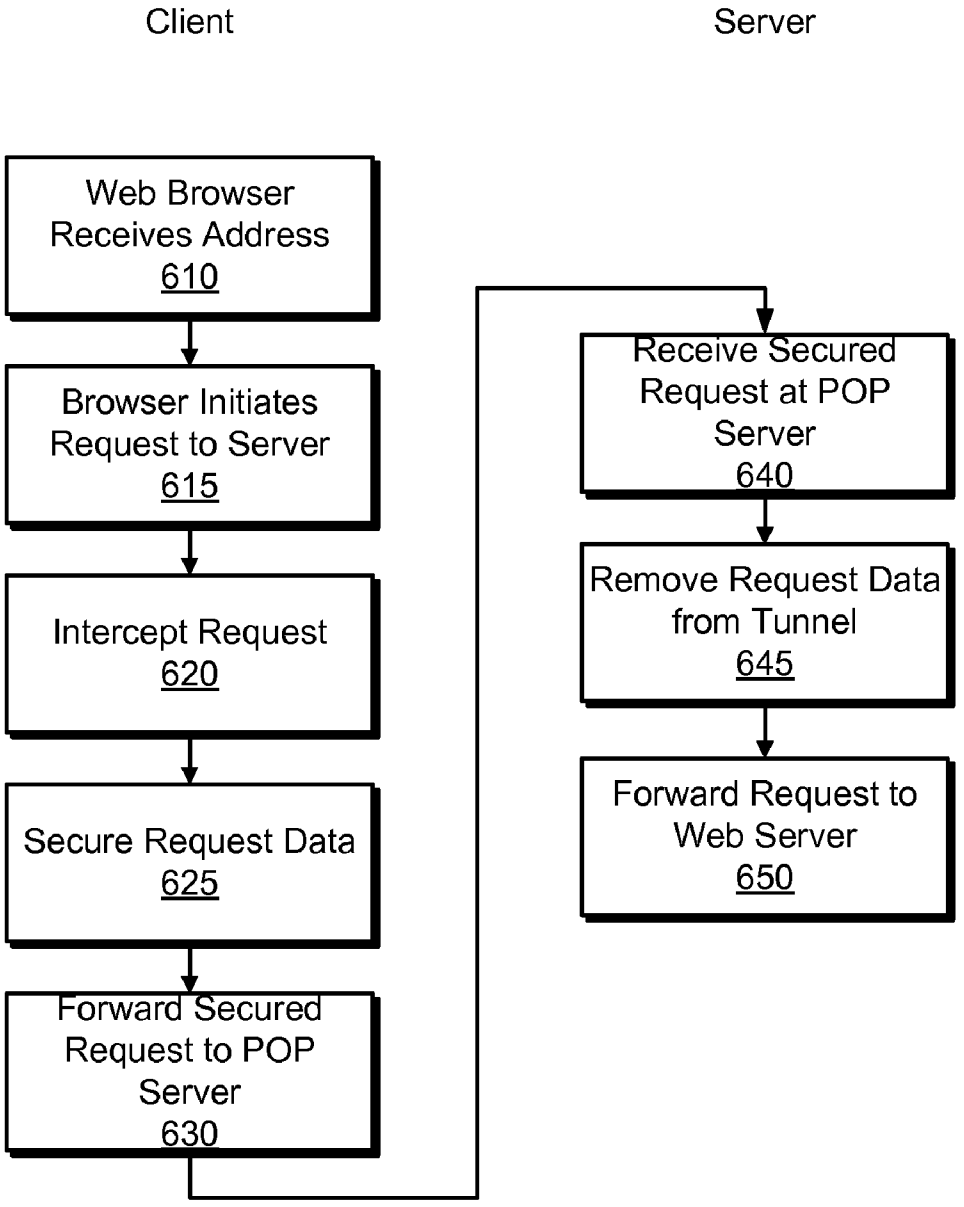

Client
Server
Web Browser Receives Address 610
Browser Initiates Request to Server 615
Intercept Request 620
Secure Request Data 625
Forward Secured Request to POP Server 630
Receive Secured Request at POP Server 640
Remove Request Data from Tunnel 645
Forward Request to Web Server 650

Fig. 6

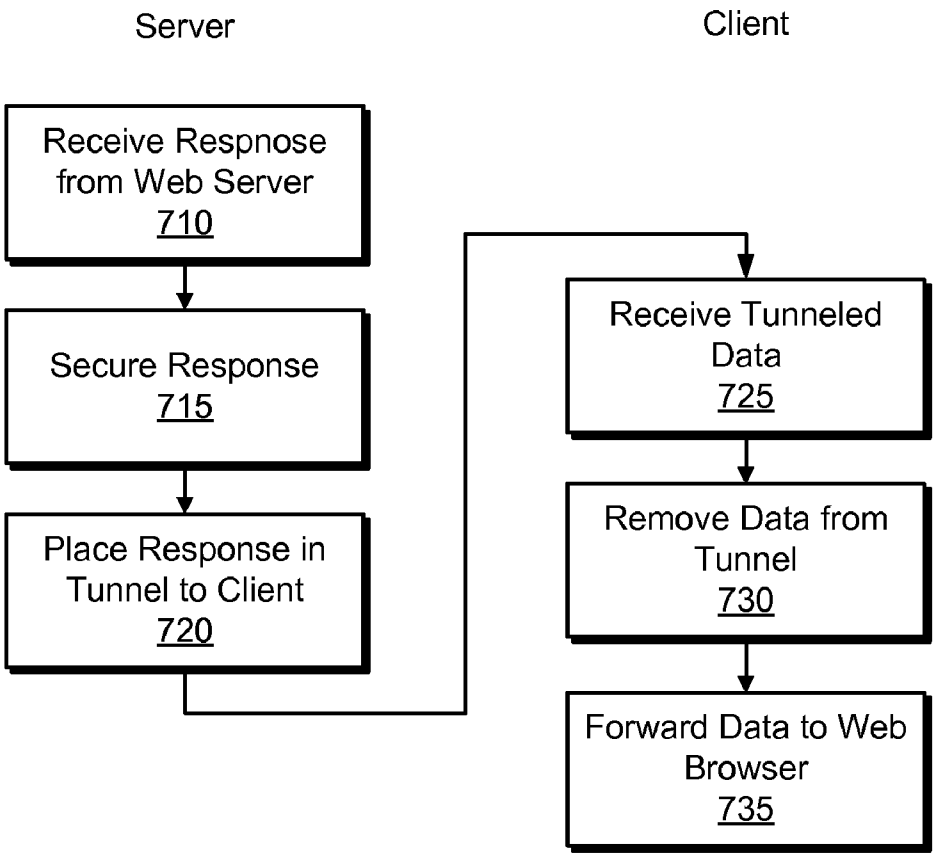

Server
Client
Receive Respnose from Web Server 710
Secure Response 715
Place Response in Tunnel to Client 720
Receive Tunneled Data 725
Remove Data from Tunnel 730
Forward Data to Web Browser 735

Fig. 7

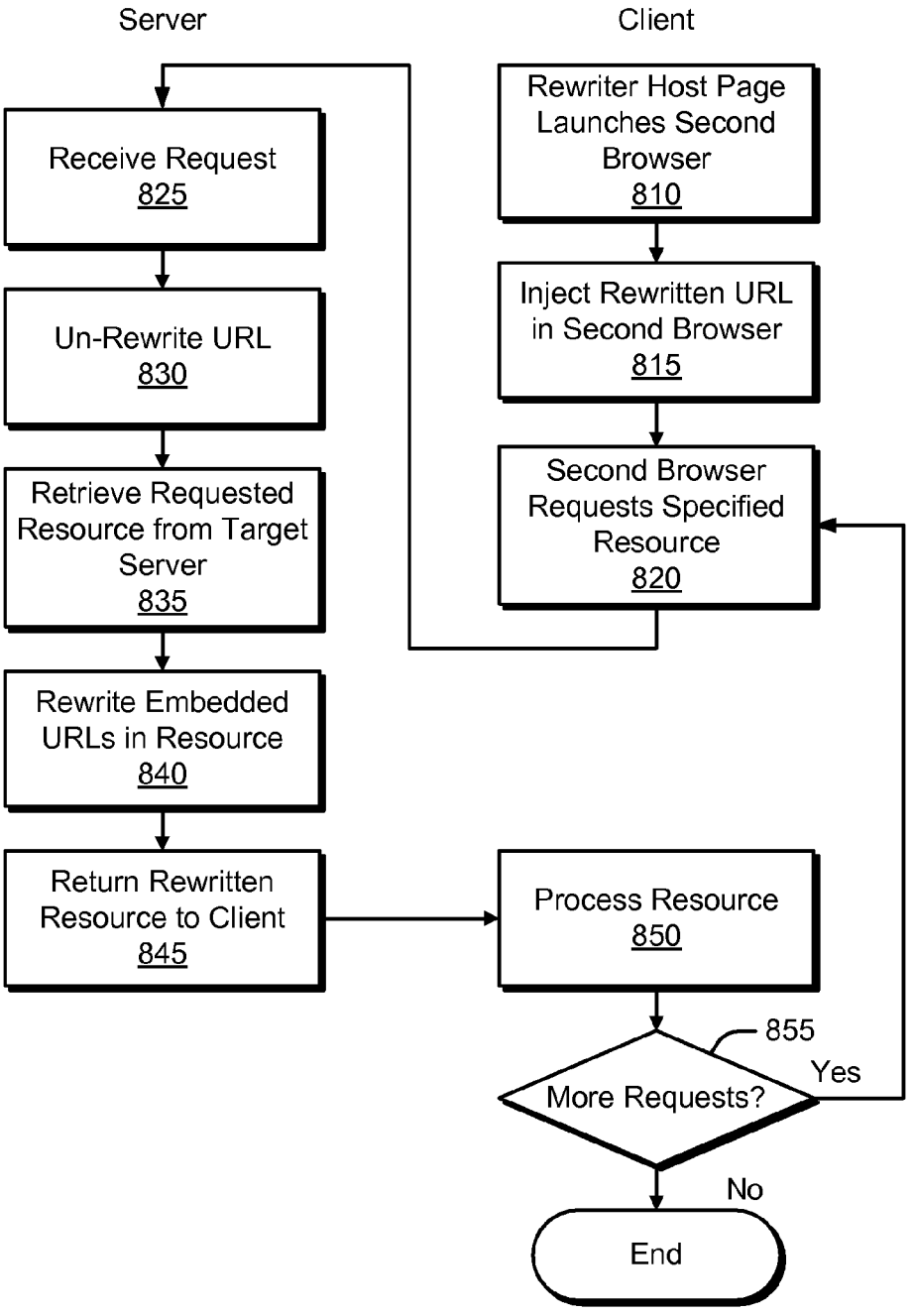

Server
Client
Receive Request
825
Un-Rewrite URL
830
Retrieve Requested Resource from Target Server
835
Rewrite Embedded URLs in Resource
840
Return Rewritten Resource to Client
845
Rewriter Host Page Launches Second Browser
810
Inject Rewritten URL in Second Browser
815
Second Browser Requests Specified Resource
820
Process Resource
850
855
More Requests?
Yes
No
End

Fig. 8

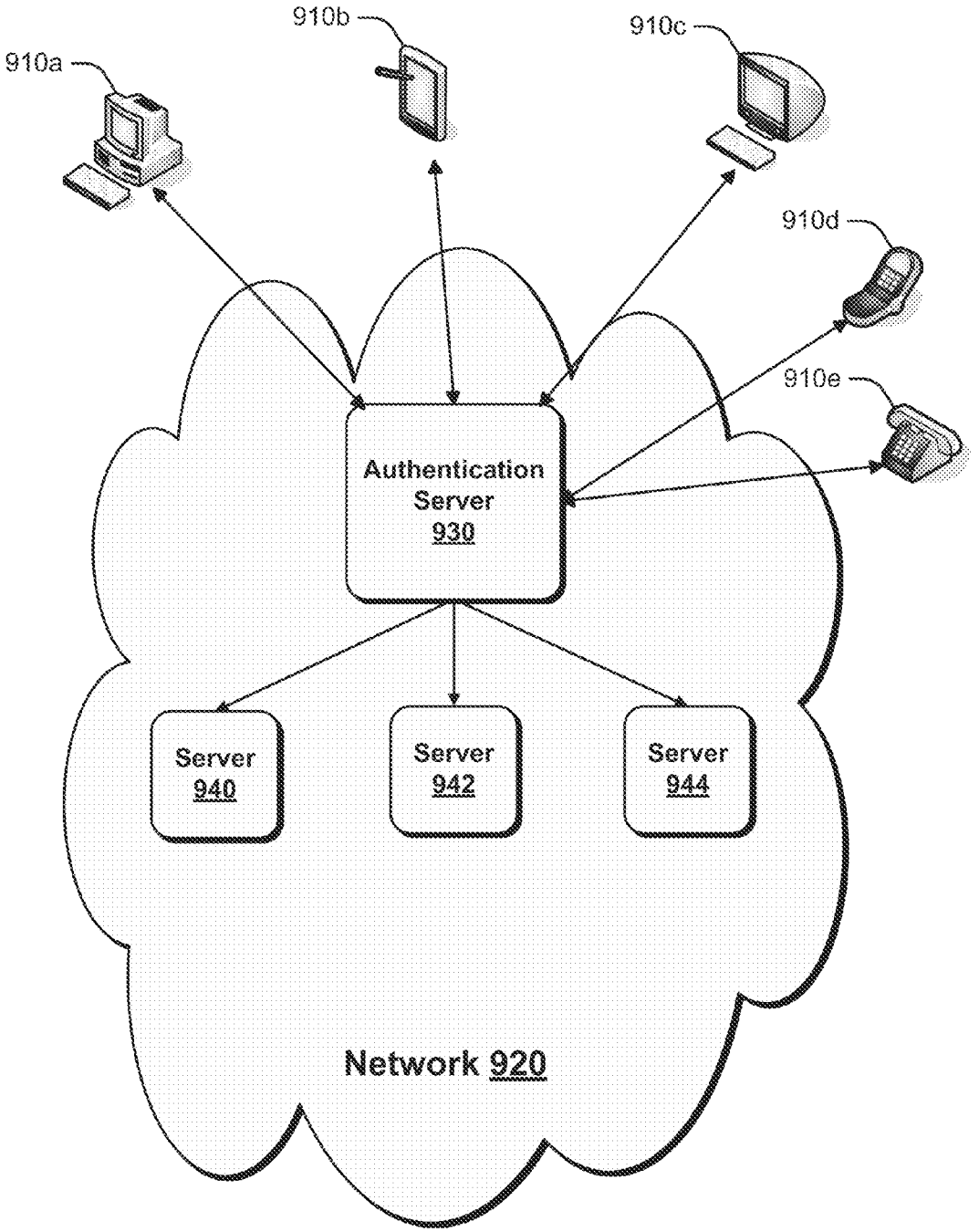

910a
910b
910c
910d
910e
Authentication Server 930
Server 940
Server 942
Server 944
Network 920

Fig. 9

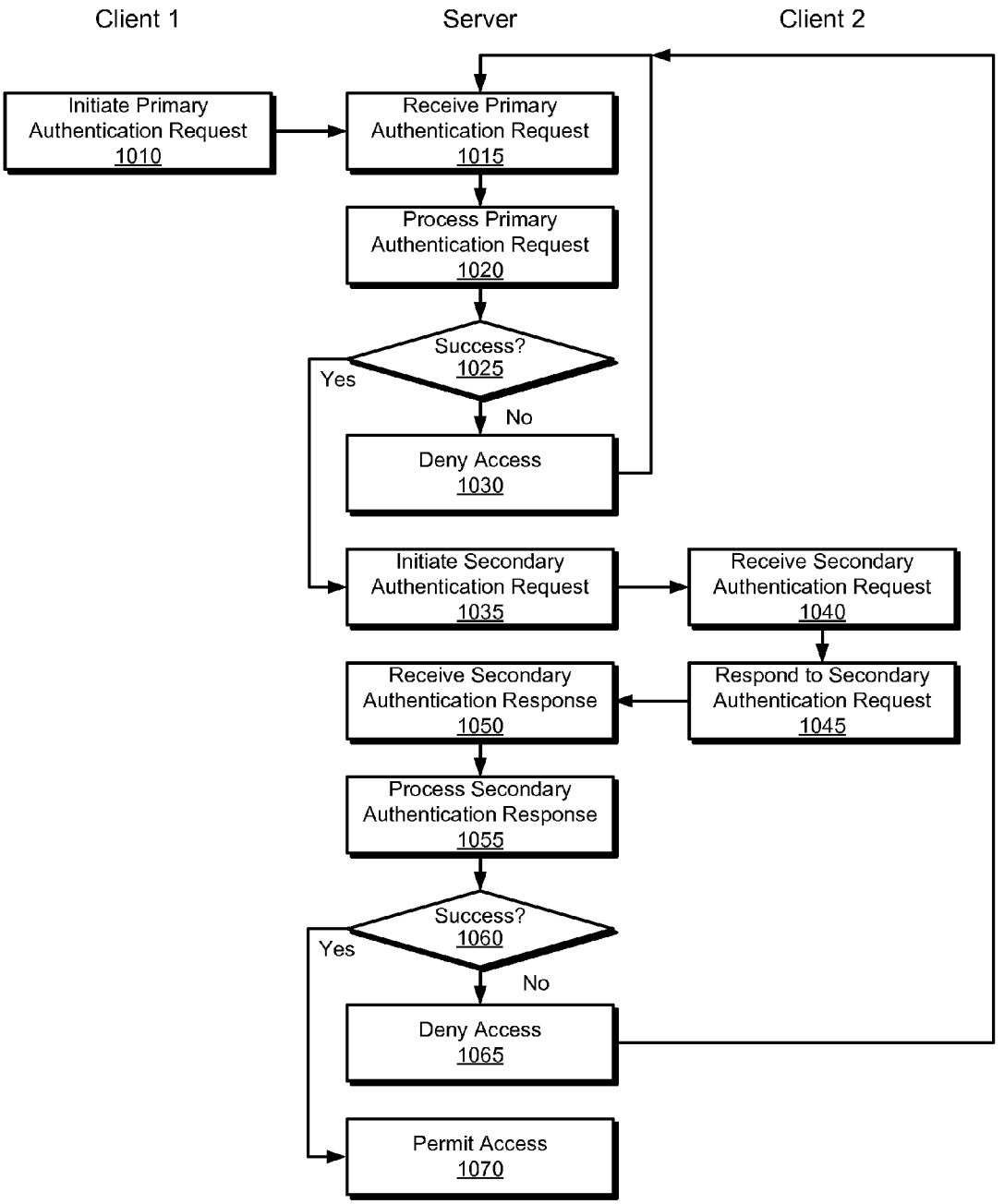

Client 1
Server
Client 2
Initiate Primary Authentication Request 1010
Receive Primary Authentication Request 1015
Process Primary Authentication Request 1020
Success? 1025
Yes
No
Deny Access 1030
Initiate Secondary Authentication Request 1035
Receive Secondary Authentication Request 1040
Respond to Secondary Authentication Request 1045
Receive Secondary Authentication Response 1050
Process Secondary Authentication Response 1055
Success? 1060
Yes
No
Deny Access 1065
Permit Access 1070

Fig. 10

1100

Username	Password	Approved Resource	Contact	Authentication Code
Bsmith	001101	Email Server	212-555-5555	5241
Bsmith	Alpha	FTP Server	408-215-9870	Mark41
Cwagner	M694U	Sales Database	303-214-4928	5908
Smarshall	6839	Internet Site	563-503-4385	djkwn
Tveit	460MIN	Sales Database	816-454-4392	jn340

Fig. 11

ENHANCED MULTI FACTOR AUTHENTICATION

RELATED APPLICATIONS

[0001] This application is a continuation-in-part of U.S. patent application Ser. No. 11/862,173 by Steve Dispensa, entitled MULTI FACTOR AUTHENTICATION. This application claims the benefit of U.S. Provisional Application No. 61/031,768, filed Feb. 27, 2008, entitled ENHANCED MULTI FACTOR AUTHENTICATION.

BACKGROUND

[0002] Internet access has become ubiquitous. In addition to traditional dial-up and Local Area Network-based network access, wireless access technologies including IEEE 802.11b and 802.11g (WiFi), WiMax, Bluetooth™, and others are being widely deployed. Many public locations, such as airports, bookstores, coffee shops, hotels, and restaurants have free or fee-based access to wireless Internet service. Some locations, such as hotel rooms, also offer internet access via Ethernet ports. In addition, businesses offer visiting professionals access to Internet service while they are on the premises.

[0003] Such Internet access services typically are not secured at the datalink layer. It is often possible for network administrators, other users, or even criminals to capture and view network transmissions made on these networks. The "last mile", or the few hops on the network that are closest to the end user, are often only lightly secured, if at all, and are particularly vulnerable to traffic snooping. Enhanced communication security would find utility.

[0004] In addition, authentication remains a persistent technical problem in the information technology industry. With the proliferation of untrusted applications and untrusted networks, and the increasing use of the Internet for business functions, the authentication issues have become prominent. Authentication refers to a process by which a user makes his or her identity known to a system or application which the user is attempting to access, and occasionally, also the process by which the user verifies the identity of the system being accessed. A common authentication technique involves the use of a shared username and password combination. This style of authentication is vulnerable to a number of weaknesses. For example, passwords must be made long enough to be secure while being short enough to be memorable. Additionally, the loss of the password is sufficient to allow an attacker to gain access to the system by impersonating the user. Therefore, additional authentication techniques would find utility.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] The detailed description is provided with reference to the accompanying figures. In the figures, the left-most digit(s) of a reference number identifies the figure in which the reference number first appears. The use of the same reference numbers in different figures indicates similar or identical items.

[0006] FIG. **1** is a schematic illustration of a networked computing environment in accordance with an embodiment.

[0007] FIG. **2** is a schematic illustration of a server in accordance with an embodiment.

[0008] FIGS. **3-8** are flow diagrams of embodiments of methods for secure network computing.

[0009] FIG. **9** is a schematic illustration of a networked computing environment in accordance with an embodiment

[0010] FIG. **10** is a flow diagram of embodiments of a method for multifactor authentication.

[0011] FIG. **11** is a schematic illustration of and embodiment of a data file which may be used in a multifactor authentication.

DETAILED DESCRIPTION

[0012] Described herein are exemplary systems and methods for secure network computing and multifactor authentication. The methods described herein may be embodied as logic instructions on a computer-readable medium. When executed on a processor, the logic instructions cause a general purpose computing device to be programmed as a special-purpose machine that implements the described methods. The processor, when configured by the logic instructions to execute the methods recited herein, constitutes structure for performing the described methods.

[0013] In the following description, numerous specific details are set forth in order to provide a thorough understanding of various embodiments. However, various embodiments of the invention may be practiced without the specific details. In other instances, well-known methods, procedures, components, and circuits have not been described in detail so as not to obscure the particular embodiments of the invention.

[0014] FIG. **1** is a schematic illustration of a networked computing environment in accordance with an embodiment. In the exemplary architecture depicted in FIG. **1**, one or more client computing devices **110***a*, **110***b*, **110***c* establish a communication connection with a point of presence (POP) server **130**, which in turn communicates with one or more target servers **140**, **142**, **144** via a network **120**. Target servers **140**, **142**, **144**, in turn, provide access to one or more computing resources such, as, e.g., internet services, electronic mail services, data transfer services, and the like.

[0015] Client computing devices **110***a*, **110***b*, **110***c* may be any computer-based communication device, including a personal computer **110***a*, a personal digital assistant (PDA) **110***b*, or a terminal device **110***c*. Client computing devices **110***a*, **110***b*, **110***c* establish a communication with POP server **130** via a communication network, which may be the same network **120** or a separate communication network. The particular form of communication network is not important. Communication network may comprise one or more direct communication links (e.g., a dial-up connection) between respective remote access devices **110***a*, **110***b*, **110***c*. Alternatively, the communication network may comprise a private data network such as, e.g., an X.25 network, a local area network (LAN), a wide area network (WAN), or a public network such as, e.g., the Internet.

[0016] In one embodiment, POP server **130** may be implemented by a general purpose computing device such as, e.g., a server, that executes logic instructions which cause the processor to execute various methods for performing secure network computing. FIG. **2** is a schematic illustration of an exemplary computer system **200** adapted to perform secure network computing. The computer system **200** includes a computer **208** and one or more accompanying input/output devices **206** including a display **202** having a screen **204**, a keyboard **210**, other I/O device(s) **212**, and a mouse **214**. The other device(s) **212** can include a touch screen, a voice-activated input device, a track ball, and any other device that allows the system **200** to receive input from a developer

and/or a user. The computer **208** includes system hardware **220** and random access memory and/or read-only memory **230**. A file store **280** is communicatively connected to computer **208**. System hardware **220** includes a processor **222** and one or more input/output (I/O) ports **224**. File store **280** may be internal such as, e.g., one or more hard drives, or external such as, e.g., one or more external hard drives, network attached storage, or a separate storage network.

[0017] Memory **230** includes an operating system **240** for managing operations of computer **208**. In one embodiment, operating system **240** includes a hardware interface module **254** that provides an interface to system hardware **220**. In addition, operating system **240** includes one or more file systems **250** that managed files used in the operation of computer **208** and a process control subsystem **252** that manages processes executing on computer **208**. Operating system **240** further includes a system call interface module **242** that provides an interface between the operating system **240** and one or more application modules **262** and/or libraries **264**.

[0018] In operation, one or more application modules **260** executing on computer **208** make calls to the system call interface module **242** to execute one or more commands on the computer's processor. The system call interface module **242** invokes the services of the file systems **250** to manage the files required by the command(s) and the process control subsystem **252** to manage the process required by the command(s). The file system **250** and the process control subsystem **252**, in turn, invoke the services of the hardware interface module **254** to interface with the system hardware **220**.

[0019] The particular embodiment of operating system **240** is not critical to the subject matter described herein. Operating system **240** may be embodied as a UNIX operating system or any derivative thereof (e.g., Linux, Solaris, etc.) or as a Windows® brand operating system.

[0020] In one embodiment, memory **230** includes one or more network interface modules **262**, **268**, one or more secure tunnel modules **264**, and one or more communication management modules **266**. Network interface modules may be implemented as web browsers such as, e.g., Internet Explorer, Netscape, Mozilla, or the like. Secure tunnel module **264** comprises logic instructions which, when executed by a processor, configure the processor to generate a secure communication tunnel between the POP server **130** and a client computing device such as, e.g., one or more of client computing devices **110***a*, **110***b*, **110***c*. Communication management module **266** comprises logic instructions which, when executed by a process, configure the processor to manage communications between the POP server **130** and one or more client computing devices **110***a*, **110***b*, **110***c* and between the POP server **130** and the one or more servers **140**, **142**, **144**.

[0021] In embodiments, POP server **130** receives a service request from a client computing device such as, e.g., one or more of client computing devices **110***a*, **110***b*, **110***c*, identifying one or more resources available on a server such as **140**, **142**, **144**. For example, the service request may be embodied as a Uniform Resource Locator (URL) transmitted to POP server **130** from a browser executing on a client computing device. In response to the service request, POP server **130** establishes a first communication link between the POP server **130** and the one or more resources available via a computing network identified in the service request. In one embodiment, POP server **130** may launch an independent request for the resource request for the resource identified in the service request from the client computing device. POP server **130** may further establish a first, secure communication link between the POP server **130** and the client computing device **110***a*, **110***b*, **110***c*, and connect a network interface module on the client computing device to the secure communication link.

[0022] POP server **130** may further manage communication activity between the client computing device and the one or more resources available via a computing network at the POP server. In one embodiment, managing communication activity may include passing information received from a server **140**, **142**, **144** in response to a resource request from the POP server **130** to a client computing device **110***a*, **110***b*, **110** *c* via a secure communication link.

[0023] Operations implemented by the various modules **262**, **264**, **266**, **268** and by client computing devices **110***a*, **110***b*, **110** *c* are explained with reference to FIGS. **3-8**. FIGS. **3-8** are flow diagrams of embodiments of methods for secure network computing. FIG. **3** is a flow diagram illustrating high-level operations executed by a computing device such as one of client computing devices **110***a*, **110***b*, **110***c* in a method for secure network computing. In one embodiment, at operation **310** a secure communication link is initialized between POP server **130** and the client computing device **110***a*, **110***b*, **110***c*. At operation **315** the client computing device sends outbound data via the secure communication link and at operation **320** the client computing device receives inbound data via the secure communication link. If, at operation **325** there are more outbound data requests, then control passes back to operation **315**. Similarly, if at operation **330** there is more inbound data control passes back to operation **320** and the inbound data is received. If there are no further data requests or inbound data remaining, then control passes to operation **335** and the secure communication link may be terminated. Operations illustrated in FIG. **3** are explained in greater detail in FIGS. **4-8**.

[0024] FIG. **4** is a flow diagram illustrating operations in a method for initializing a secure communication link between POP server **130** and a client computing device **110***a*, **110***b*, **110***c*. In one embodiment, POP server **130** implements an application tunneling technology, referred to herein as an AppTunnel, to construct a secure communication tunnel between POP server **130** and a client computing device **110***a*, **110***b*, **110***c*.

[0025] Referring to FIG. **4**, at operation **410** POP server **130** receives an address of one or more resources such as, e.g., a website or other resource available on network **120**. In one embodiment, the address received may represent a URL received in a service request from a web browser executing on client computing device **110***a*, **110***b*, **110***c*. In one embodiment, POP server **130** transmits an ActiveX control comprising launch data to client computing device **110***a*, **110***b*, **110***c*. In alternate embodiments, the ActiveX control client may be replaced with a plug-in module compatible with other protocols such as, for example, the JAVA architecture or a CORBA architecture.

[0026] At operation **420** the client computing device **110***a*, **110***b*, **110***c* receives the ActiveX launch data from server **130**. If, at operation **425** the client computing device is not compatible with ActiveX technology, then control passes to operation **465** and a rewriter host module may be activated. This procedure is explained in greater detail below. By contrast, if the client computing device **110***a*, **110***b*, **110***c* is capable of implementing an ActiveX control, then control

passes to operation **430** and the client computing device **110***a*, **110***b*, **110** *c*, activates an ActiveX control host page. The Active X control host page instructs the browser how to load the ActiveX control, where to retrieve it from (if it is not already locally cached), and with what parameters the control should be started. A similar host page may be used to embedding plug-ins into other browsers such as Mozilla, Netscape, etc. This information may be contained in an HTML <OBJECT> tag.

[0027] At operation **435** the client computing device **110***a*, **110***b*, **110***c* initiates the ActiveX control received from the server **130**. The ActiveX control causes the client computing device **110***a*, **110***b*, **110***c* to launch a new incidence of a browser or other network interface software (operation **440**). If additional ActiveX controls are necessary to enable the client computing device **110***a*, **110***b*, **110***c*, then one or more additional ActiveX controls maybe transmitted between the server **130** and the client computing device **110***a*, **110***b*, **110***c*.

[0028] At operation **450** the client attaches a secure channel module to the browser. In one embodiment, the secure channel module may be embodied as an AppTunnel client module. The AppTunnel secure channel module is described in detail in U.S. patent application Ser. No. 10/737,200, incorporated by reference here above. Portions of that description are excerpted in the following paragraphs.

[0029] Application tunneling is a method for transporting data from a user's computer to a third party computer (a "proxy"). In one implementation, Application data may be intercepted as soon as it is sent (i.e., above layer 4 of the OSI model), before it is encapsulated by Internet protocols such as TCP, UDP, or IP. Data may then be transported across the network to the proxy. In other implementations, this application-level data is acquired differently (perhaps, for example, through the use of a virtual adapter). In all cases, it is application-level data (OSI layers 5-7, depending on the application and the protocol) that is tunneled via AppTunnels.

[0030] AppTunnels is application tunneling technology that tunnels data from an application on a first computer to a second computer, perhaps over a secure tunnel, for further processing and proxying at that other computer. AppTunnels technology may be implemented in a Static form or in a Dynamic form. Static AppTunnels technology requires manual (or pre-configured) establishment of the application tunnels and listeners. By contrast, dynamic AppTunnels implements on-the-fly tunnel creation using hook mechanisms.

[0031] Encryption and/or other security technologies may be applied to the tunnel to add security to the data being transported, although this is not strictly necessary.

[0032] AppTunnels differs from existing tunneling technologies such as Generic Routing Encapsulation (GRE) in that it is designed to operate at the end user's computer, in such a way that the end user's applications do not have to be informed about the existence of the tunneling technology. By contrast, tunneling technologies such as GRE, on the other hand, are designed to be implemented in network elements such as routers.

[0033] AppTunnels differs from host-based encryption technologies such as SSL in several ways. First, SSL technology must be directly supported by the application in order to be applied. AppTunnels, however, does not require application awareness in order to be applied. Furthermore, SSL is closely tied to a particular security and encryption architecture. AppTunnels may be used with or without security technologies, and imposes no requirements on the underlying security technologies. AppTunnels has been used in conjunction with the WTP security protocol and with SSL.

[0034] To intercept the network traffic of an application a local listener is created and a tunnel is established between the first computer and the second computer. In one embodiment, a local listener may be implemented as listening TCP, UDP, or other socket(s) bound to a local host address (e.g., 127.0.0.1) on a computer. The port number, where applicable, may be determined by the tunneled application, and may be arbitrary in some protocols. Local listeners may be created either in response to instructions from dynamic AppTunnels hooks or by static configuration received in advance. It is also possible for a user to manually initiate the creation of a listener (and its associated tunnel). A data tunnel may be created between the AppTunnels client software and a compatible tunnel module on a server. In one embodiment, the tunnel may be implemented in accord with the WTP protocol described in U.S. patent application Ser. No. 10/737,200.

[0035] Once an AppTunnel has been initialized, the end user application can be directed to connect to the AppTunnel. The process for this varies per application. In the case of Dynamic AppTunnels, no other action is necessary; data simply starts flowing from the application to the AppTunnels software, which in turn tunnels the data across the connection to the WTP concentrator.

[0036] In the case of Static AppTunnels, one additional step is required. The application is tricked into connecting to the local listener instead of to the target server, as would otherwise naturally be the case. To trick the client, the DNS system is configured to return the localhost address (127.0.0.1, usually) to requests for the destination server's IP address. This is usually done by changing the locally-present "hosts" file that the computer's DNS system consults before returning an IP address. This hosts file is modified, with an entry being inserted for the name of the target server with the IP address of localhost. In one embodiment, the AppTunnels client may be implemented as an executable component that is incorporated into and run by the user's web browser such as, e.g., an ActiveX control. For other browsers or other platforms, a Netscape Plugin may be used.

[0037] In one embodiment, AppTunnels implements a method of intercepting traffic in order to tunnel it is as follows: First, the computer's DNS resolution system is modified to re-route traffic for target network servers to the local computer. Next, the AppTunnels Client establishes itself as a server on the port that the application would expect to connect to. Once established, applications transparently connect to the Client on the local computer rather than to their natural target-network servers. No configuration or modification of the tunneled application is necessary.

[0038] The AppTunnels method can be used to tunnel any user-mode data over a tunnel to the server **130**. This includes TCP and UDP on all platforms. Other protocols may be available for tunneling, depending on the platform. The AppTunnels architecture supports complex network protocols such as FTP, RPC, H.323, and other proprietary multi-connection protocols. It provides this support by inspection of protocol data at the server. A protocol may be termed 'complex' if it requires more than a simple client-to-server TCP connection.

[0039] In AppTunnels mode, the client computing device **110***a*, **110***b*, **110***c* receives a module called the AppTunnels Client, which attaches to the web browser. The AppTunnels

client enables the web browser to access target network web pages by proxying requests through the AppTunnels client. The AppTunnels client forwards the requests to the server **130**, which retrieves the requested document and returns it to the AppTunnels client, which in turn returns it to the web browser.

[0040] In brief, the client computing device **110***a*, **110***b*, **110***c* first reads the proxy settings configuration from the user's web browser. The client computing device **110***a*, **110***b*, **110***c* stores the proxy settings and configures the browser to use a proxy auto-configuration file. This file instructs the browser to request its new proxy settings from the AppTunnels client. The request is made and replied to, and the new settings cause all further requests for documents to be proxied through the AppTunnels client.

[0041] The AppTunnels client then establishes a connection to server **130** and authenticates itself. After authentication, the AppTunnels client establishes itself as a server application and listens for incoming requests from the browser. As requests are received, they are forwarded to server **130**. Responses are read in from the server and are sent back to the waiting browser.

[0042] The browser is monitored by Dynamic AppTunnels for any network communication attempts. In one embodiment, these attempts may be monitored using function call hooks of the Microsoft Winsock library, but other hooks are possible, as are other monitoring architectures (such as, for example, Winsock Layered Service Providers). When new network traffic is detected, it is intercepted by the Dynamic AppTunnels code for further processing.

[0043] In one embodiment, child processes created by the browser may be injected with the Dynamic AppTunnels monitoring code. Thus, network traffic generated by child processes send will be encapsulated in the AppTunnel. Child process monitoring may be implemented using an API hook for all of the CreateProcess( ) family of functions. When a call to CreateProcess( ) is made, the Dynamic AppTunnels code receives it first, and ensures that the monitoring code is injected in the resulting new process.

[0044] In one embodiment, dynamic AppTunnels technology is implemented using API hooks. When dynamic AppTunnels receives a request to start a tunneled process, it creates a new process using the CreateProcess( ) API call. A new process may be created as suspended, so that the process does not run after it is initially created. At this point, one or more imported functions are substituted, or hooked, such that they point to wrapper functions that are part of the Dynamic AppTunnels software. The hooked functions are of two classes: network functions and process management functions.

[0045] In particular, the CreateProcess( ) function (and its relatives) may be hooked so that any child processes that are created can have the Dynamic AppTunnels monitoring code injected as well. This code is responsible for signaling the browser plugin that it should inject the rest of the hooks into the newly created process. Any child processes of that child are treated in the same way.

[0046] The networking functions that are hooked are related to connection requests and to name resolution requests. In general, all functions that are called during initial connection setup are intercepted. Once hooked, these functions receive any connection requests, and use this information for two purposes. The first is to coordinate with the tunneling protocol on the AppTunnel server to create an additional AppTunnel between the client and the AppTunnel server, and to create a local listener that is attached to that tunnel. The second is to re-direct the requesting application to the local listening socket, so that connections are made it instead of to the original target server. This process allows network traffic generated by the client to be captured by the browser plug-in and tunneled.

[0047] Alternatively, the plug-in may choose to examine the connection request information and make a decision at runtime as to whether the traffic should be tunneled or allowed to go straight out to the network as it otherwise would have. These decisions can be based on names (such as DNS or WINS names), network addresses, port numbers, or other identifying information. While this description has largely been written in the context of TCP sockets, it should be pointed out that other kinds of network traffic may be supported, including UDP and raw IP packets.

[0048] Referring back to FIG. **4**, at operation **455** the browser instantiated at the client computing device **110***a*, **110***b*, **110***c* loads the requested resource, which may be displayed on a suitable user interface such as, e.g., a computer screen or the like. At operation **460**, subsequent data transfer operations between the client computing device **110***a*, **110***b*, **110***c* and the server **130** are conveyed through the secure tunnel. When the user of the client computing device is finished with the browsing session, the browser may be closed. Closing the browser also closes any dynamic AppTunnels constructed between the client computing device **110***a*, **110***b*, **110***c* and the server **130**.

[0049] FIG. **5** is a flow diagram illustrating operations in a method for implementing an AppTunnel on a client computing device **110***a*, **110***b*, **110***c*. In one embodiment, the ActiveX control transmitted from the server **130** to the client computing device operations of FIG. **5** may cause the client computing device to perform the operations illustrated in FIG. **5**.

[0050] Referring to FIG. **5**, at operation **510** one or more static listeners and AppTunnels are initialized on the client computing device. At operation **515** the AppTunnels plugin (i.e., the ActiveX control) receives a request to start an application. For example, the plugin may receive a request to start an instance of a browser.

[0051] At operation **520** it is determined whether the device supports dynamic AppTunnels. As described above, AppTunnels can operate in either a static mode or in a dynamic mode. The difference is in the way the data is acquired for tunneling. Static AppTunnels uses a static local listening TCP/IP socket for each pre-configured service. If a user wants to use a web browser over a static AppTunnel, for example, there must be a configured application tunnel listening on TCP port **80** on the local host. Furthermore, the destination address for the AppTunnel must be specified. To cause the user's application to connect to the AppTunnels socket instead of trying to use Internet routes in the usual way, the DNS system of the client computing device is configured (usually using the computer's hosts file) to change the IP address of the server in question to point to the local host (usually 127.0.0.1), thereby fooling the application into making a local connection to the listening socket.

[0052] Thus, referring to FIG. **5**, if at operation **520** dynamic AppTunnels is not enabled, then control passes to operation **525** and the DNS system is configured, and at operation **530** a local listening socket is created. At operation **535** a new process is created.

[0053] By contrast, if at operation **520** the device accommodates dynamic AppTunnels, then control passes to opera-

tion **540** and a new process is created on the client computing device. In one embodiment creating a new process may involve a user clicking an HTML link on the web page in a browser executing on the client computing device. The ActiveX control then launches the new process and injects the Dynamic AppTunnels application monitoring code into the newly started process (operation **545**). At operation **550** a new AppTunnel is created between the client computing device and the server **130**.

[0054] Following either operation **535** or **550**, control passes to operation **560** and the application receives data in the listening socket generated by the AppTunnel. At operation **565** the data received in the AppTunnel is removed and passed to the process (i.e., the web browser) for further processing and presentation to a user via a suitable interface such as, e.g., a display. Operations **560-565** may be repeated until, at operation **570**, there is no more data to tunnel, whereupon operations terminate.

[0055] FIG. **6** is a flow diagram illustrating operations in a method for processing outbound traffic from a network interface module such as, for example, a web browser executing on a client computing device **110***a*, **110***b*, **110***c*. The operations of FIG. **6** depict traffic processing for a browser that has an AppTunnel module attached to the browser. Referring to FIG. **6**, at operation **610** the web browser receives an address of a resource available on network **120**. In one embodiment, the address may represent a Uniform Resource Locator (URL) of a resource available on network **120**. At operation **615** the browser initiates a service request for the resource. At operation **620** the service request is intercepted by the AppTunnel module. At operation **625** the AppTunnel client secures the request data and at operation **630** the AppTunnel client forwards the request to the POP server **130**. At operation **640** the secured request is received at the POP server **130**. At operation **645** the secure tunnel module **264** (i.e., the AppTunnel server) extracts the request data from the secure tunnel.

[0056] At operation **650** the POP server forwards the service request to the address identified in the service request. In one embodiment, the service request is received in a first network interface module **262** instantiated on POP server **130**, and POP server **130** instantiates a second network interface module **268** and launches a service request from the second network interface module.

[0057] FIG. **7** is a flow diagram illustrating operations in a method for processing inbound traffic such as, for example, one or more resources returned from a service request. Referring briefly to FIG. **7**, at operation **710** the data returned by the resource request is received at the POP server **130**. In one embodiment, the data is received in the second network interface module **268** instantiated on the POP server **130**. At operation **715** the response data is secured. In one embodiment, response data is operated on by the secure tunnel module **264**. At operation **720** the response data is placed in the secure tunnel to the client computing device **110***a*, **110***b*, **110** *c* via the first network interface module **262**.

[0058] At operation **725** the client receives the response data transmitted to the client by the server. At operation **730** the data is removed from the secure tunnel established by AppTunnels. In one embodiment, the AppTunnels client attached to the browser in the client computing device **110***a*, **110***b*, **110***c* removes the received data from the tunnel and, at operation **735**, forwards the data to the web browser. The web browser may present the data on a user interface such as, e.g., a display, for viewing by the user.

[0059] Referring back to FIG. **4**, if at operation **425** the client computing device is not capable of executing a plugin such as, e.g., an ActiveX control, then control passes to operation **465** and a URL rewriter technique is activated. URL rewriting is a method of providing a reverse proxy server for use in secure remote access systems and other applications without the need for any locally installed code. Most web browsers can exchange traffic with web servers using a protocol known as secure HTTP, or HTTPS. However, most websites do not support HTTPS. To add security to every website the user requests, special HTTPS requests are made to a URL rewriter server instead of the target web server, using HTTPS to the rewriter. The rewriter then forwards the request to the target web server by proxy, using the expected destination protocol of the web server (typically HTTP). On return, the web data is returned over HTTPS to the client's browser. It should be noted that any other form of browser-based security, or no security whatsoever, could be used in the communications link to the rewriter.

[0060] It should be noted that references to other web data will now cause the user's browser to make direct requests to the target server, rather than ask the rewriter server. Thus, references to other web content (hyperlinks, images, java applets, and so on) may be rewritten in the webpage so that they refer to the rewriter instead of to the target server to ensure that all web traffic is routed through the rewriter, and not via direct connections. Accordingly, any web references in the returned document are rewritten with references to the URL rewriter server.

[0061] FIG. **8** is a flow diagram illustrating operations in a method for processing inbound traffic such as, for example, one or more resources returned from a service request. Referring briefly to FIG. **8** at operation **810** a rewriter host page on the client computing device **110***a*, **110***b*, **110***c* launches a second web browser using instructions embedded in the HTML and JavaScript code that is a part of the page. At operation **815** the rewritten URL is written into the second browser. At operation **820** the second browser requests the specified resource using the rewritten URLs.

[0062] At operation **825** the server **130** receives the service request from the client computing device **110***a*, **110***b*, **110***c*. At operation **830** the server **130** un-rewrites the URL, and at operation **835** the server retrieves the requested resource from the server **140**, **142**, **144** hosting the resource on the network **120**. At operation **840** the server rewrites the embedded URLs in the retrieved resource, and at operation **845** the server returns the rewritten resource to the client.

[0063] At operation **850** the client computing device **110***a*, **110***b*, **110***c* receives and processes the requested resource. In one embodiment, processing the requested resource may include presenting the resource on a suitable display. If at operation **855** there are more requests to be processed, then control passes back to operation **820**, and the browser requests the specified resource(s). By contrast, if at operation **855** there are no further resource requests, then the process terminates.

[0064] Thus, the operations described in FIGS. **3-8** enable a client device such as one or more of client computing devices **110***a*, **110***b*, **110***c* to establish a secure "last mile" communication link, thereby enabling secure communication with resources hosted by one or more servers **140**, **142**, **144** in a network **120**. The systems and methods described herein are

agnostic regarding the type of encryption applied (if any) to communication links between POP server **130** and servers **140**, **142**, **144**.

[0065] The systems described above are browser-based systems. In alternate embodiments, a client computing device **110***a*, **110***b*, **110***c* may download and install a permanent piece of client encryption module onto the end user's computer. The permanent client provides encryption services between the client computing device **110***a*, **110***b*, **110***c* and the servers **140**, **142**, **144**. With a permanent client encryption module, the end user does not have to navigate to the service provider's website in order to turn on secure surfing. Further, a client-based approach can support all Internet-based applications.

[0066] In another embodiment, an ActiveX control installs and initializes a virtual VPN Miniport, as described in U.S. patent application Ser. No. 10/737,200. The ActiveX control captures and processes any relevant traffic on the computer. In this way, end user traffic is directed into the secured tunnel described above.

[0067] A virtual VPN Miniport can support non-TCP protocols, while maintaining the convenience of a web-based environment. It can also secure applications that have already been started. For example, if the end user were running an instant messaging client, that client's communications would be secured from the time of connection forward, without a need to re-launch the client. Installation of a VPN driver can be silent and automatic, and only needs to occur one time. From that point on, the ActiveX control activates the VPN driver and manages network routes to cause traffic to be directed into the VPN driver for encryption.

[0068] Access to the POP server **130** may be provided by a number of methodologies. In one embodiment access to POP server **130** may be provided on a pay-for-service business model. In this embodiment, POP server **130** may include a transaction processing module to process payment transactions, e.g., by a credit card or other payment mechanism. Charges may be levied on the basis of bandwidth consumed, or by a time parameter (i.e., minutes, hours, days, years, etc.).

[0069] In alternate embodiments access to server **130** may be implemented on the basis of advertising revenue. For example, pay-per-click advertising can be implemented, using randomly-selected advertisements, pay-per-click advertising can be implemented, using information gained by inspecting the user's traffic during secure surfing to select targeted advertisements, or traditional Internet banner advertisements can be inserted, either randomly or based on inspection of the secured data. Advertisements can be inserted in the initial service provider web page, in the refreshed web page that hosts the ActiveX control, or even inline with the displayed web pages.

[0070] Multiple levels of service may be defined. For example, low-quality service might be provided free of charge, while high-quality service might be provided for a fee. Service levels may be differentiated by one or more facts such as, for example throughput (i.e., a performance aspect might be controlled), bandwidth (i.e., the total number of bytes transferred might be capped), data transfer (i.e., a transfer cap might be imposed per day, per month, or per year), or some combination thereof. Other options include allowing only a limited amount of time to use the system or bandwidth in a tier or a certain amount of throughput for a certain amount of time, with decreased throughput after the elapse of that time, or restricting access to certain resources based on the service level.

[0071] Last-mile encryption service may be provided to a user with no pre-existing account. The web-based interface can be used simply by entering the address of a website that is to be securely accessed. In the installed client case, the user logs in anonymously using the supplied anonymous login method. Anonymous users may be granted a different tier of service, as described above.

[0072] In an anonymous user case, cookie-based, form-based, or IP address-based information may be used to correlate the anonymous user's browsing activities, for purposes including providing advanced service features (such as browsing history, enhanced status reporting, etc), selecting relevant advertising, or for other purposes.

[0073] Users that desire temporary top-tier service may be given the option of paying electronically for a one-time use of the service without creating an account.

[0074] Users that wish to use the service repeatedly may wish to create a user account. The user account could then be used to track browsing history, make more intelligent decisions about advertising content to be presented, or offer other value-added services. Users of the service would then be prompted to log in to the website (or to the downloaded client software) using the established authentication credentials. Optionally, a cookie-based login persistence mechanism can be supported, allowing the user to go for a period of time without the need to log in.

Multi-Factor Authentication

[0075] As described above, authentication remains a technical challenge in the information technology sector. Described herein are multifactor authentication techniques which may be used alone, or in combination with other security techniques described herein to provide secure access to resources in a computer network. Embodiments of multifactor authentication techniques will be described in the context of a computer network similar to the network described in with reference to FIG. **1**. It will be understood, however, that authentication techniques as described herein may be implemented in a wide variety of computer networks.

[0076] FIG. **9** is a schematic illustration of a networked computing environment in accordance with an embodiment. In the exemplary architecture depicted in FIG. **9**, one or more client computing devices **910***a*, **910***b*, **910***c*, **910***d*, **910***e* establish a communication connection with an authentication server **930**, which in turn communicates with one or more target servers **940**, **942**, **944** via a network **920**. Target servers **940**, **942**, **944**, in turn, provide access to one or more computing resources such, as, e.g., internet services, electronic mail services, data transfer services, and the like.

[0077] Client computing devices **910***a*, **910***b*, **910***c*, **910***d*, **910***e* may be any computer-based communication device, including a personal computer **910***a*, a personal digital assistant (PDA) **910***b*, a terminal device **910***c*, a mobile telephone **910***d*, or a land-line telephone **910***e*. Client computing devices **910***a*, **910***b*, **910***c*, **910***d*, **910***e* establish a communication with authentication server **930** via a communication network, which may be the same network **920** or a separate communication network. The particular form of communication network is not important. Communication network may comprise one or more direct communication links (e.g., a dial-up connection) between respective remote access

devices **910***a*, **910***b*, **910***c*, **910***d*, **910***e*. Alternatively, the communication network may comprise a private data network such as, e.g., an X.25 network, a local area network (LAN), a wide area network (WAN), or a public network such as, e.g., the Internet.

[0078] Authentication server **930** may be embodied as a computing device, substantially as described in with reference to FIG. **2**, above. Referring briefly to FIG. **2**, the computing device **200** and comprise one or more authentication modules **269** which may execute when as an application module and the memory **230** of the computing system **200**. In some embodiments, the authentication module **269** and implemented logic instructions which, when executed by a processor such as the processor **222**, cause the authentication module **269** to implement multifactor authentication procedures to manage access to one or more resources of the computer network **920**, such as for example, resources provided by servers **940**, **942**, or **944**.

[0079] In some embodiments, the authentication server **930** implements a first authentication process in response to an authentication request from a client computing device such as one of client computing devices **910***a*, **910***b*, **910***c*, **910***d*, **910***e*. If the first authentication process is successful, then the authentication server **930** originates a second authentication request to a client device such as one of client computing devices **910***a*, **910***b*, **910***c*, **910***d*, **910***e*. In some embodiments, the authentication request from the client is transmitted through a first communication channel and the second authentication request originated by the authentication server **930** is transmitted using a second communication channel, different from the first communication channel. The authentication server **930** may process the response to the second authentication request and allow or deny access to a resource based on the response. In some embodiments the first communication channel and the second communication channel may be across separate communication networks. For example, the first communication channel may be across the computer network, while the second communication channel may be across a telephone network.

[0080] One embodiment of multifactor authentication will be explained with reference to FIG. **10**, which is a flow diagram of embodiments of a method for multifactor authentication. Referring to FIG. **10**, at operation **1010***a* first client initiates a primary authentication request for access to a resource provided by computer network **920**. In some embodiments, the primary authentication request may include a username and password combination associated with a user and/or a device from which the primary authentication request is originated. The primary authentication request may be transmitted to the authentication server **930** to a first communication channel.

[0081] Operation **1015** the authentication server **930** receives the primary authentication request, and at operation **1020** the authentication server **930** processes the primary authentication request. In some embodiments, the authentication server **930** performs a centralized authentication function which manages authentication to one or more resources and network **920**. For example, authentication server **930** may maintain a data file comprising username and password combinations which may be associated with one or more resources of the computer network **920**. FIG. **11** is a schematic illustration of and embodiment of a data file which may be used in a multifactor authentication. Referring briefly to FIG. **11**, the illustrated data file **1100** includes a column for usernames, a column for passwords, and a column for approved resources. Usernames and passwords may be logically associated with the approved resource indicated in the table **1100**. A single username may be associated with multiple passwords for different approved resources. In one embodiment, processing the primary authentication request may comprise searching the data file **1100** maintained by the authentication server for a username and password combination that corresponds to the username and password combination receipt in the primary authentication request.

[0082] If, an operation **1025**, the primary authentication request is unsuccessful, i.e., if there is no corresponding username and password combination in the data table **1100**, then the authentication server **930** denies the requestor access to network resource(s). in some embodiments, the authentication server **930** may transmit an error message to the requestor indicating that the username and password are invalid. Control that returns to operation **1015** and the authentication server **930** continues to monitor for another primary authentication request.

[0083] By contrast, if that operation **1025** primary authentication request is successful, i.e., if there is a corresponding username and password combination in the data table **1100**, then control passes to operation **1035** and the authentication server **930** initiates a secondary authentication request. The secondary authentication request is transmitted from the authentication server **930** to the user via a second communication channel, different from the first communication channel. In some embodiments, the secondary authentication request is transmitted from the authentication server **930** to a second client in the user's possession. For example, the user may initiate the primary authentication request from a computing device such as a desktop computer or laptop computer and the authentication server **930** may transmit the secondary authentication request by initiating a telephone call to a telephone registered to the user. Referring briefly again to FIG. **11**, a user may register, via a suitable user interface, a contact number to which the secondary authentication request may be transmitted from the authentication server **930**. In response to a successful primary authentication request, the authentication server **930** may initiate a call to contact number indicated in the data table **1100**. It should be noted that a user may provide different contact numbers for different resources.

[0084] At operation **1040** the secondary authentication request is received at the second client. The secondary authentication request may comprise a voice message which makes a request for information to authenticate the user. In some embodiments, the system may allow a user to prerecord a customized secondary authentication request in the user's own voice. For example, the user may record a message requesting a specific sequence of keystrokes or requesting the user to speak to a specific word or group of words. Having a user recorded message in the second authentication request helps to authenticate the system to the user, thereby eliminating or at least reducing the likelihood of a "man in the middle" attack on the system. In alternate embodiments, rather than using a prerecorded message in the user's voice, a user may select one or more tokens to be presented with a secondary authentication requests. For example, a token may include a predetermined word or character or numeric sequence selected by the user.

[0085] At operation **1045** the user response to the secondary authentication request initiated by the authentication server **930**. For example, in some embodiments the user may

respond by pressing a predetermined sequence of keystrokes on a telephone keypad, or by pressing the pound key or the star key. In alternate embodiments the user may respond by speaking a predetermined word or series of words. In alternate embodiments the user need not provide an affirmative response; simply answering the telephone call may suffice as a response.

[0086] In some embodiments, the secondary authentication request initiated by the authentication server **930** may be implemented as a text message rather than a telephone call. Accordingly, the response to the secondary authentication request may also be implemented as a text message in which the user transmits a predetermined character or series of characters back to the authentication server **930**.

[0087] In alternate embodiments, the secondary authentication request may require a user to initiate a call back in order to authenticate the user. For example, the secondary authentication request may transmit a text message or a voice call requesting the user to call back to the system to authenticate the user. In some embodiments, a return phone number may be included with the secondary authentication request, while in other embodiments a user may be required to call a predetermined phone number. As described above, the user may be required to provide one or more codes in the secondary authentication response.

[0088] At operation **1050** the authentication server **930** receives the response to the secondary authentication request, and at operation **1055** the authentication server **930** processes the response. In some embodiments, authentication server **930** maintains authentication codes which represent the anticipated response to the secondary authentication request in the data table **1100**. The response to the secondary authentication request received from the user may be compared with the authentication code stored in the data table **1100** in order to determine whether the user is authentic.

[0089] If, at operation **1060**, the response to the secondary authentication request fails to successfully authenticate the user then access to network resources is denied at operation **1065** and control passes back to operation **1015** in the authentication server monitors for additional incoming primary authentication requests. In some embodiments, the authentication server **930** may implement an error routine in response to a failed a secondary authentication request. The authentication routine may transmit an error message to the user via the first communication channel, the second communication channel, or both. The error message may instruct the user that authentication has failed and they provide the user with an opportunity to restart the authentication process.

[0090] By contrast, is that operation **1060** the response to the secondary authentication request successfully authenticates the user then control passes to operation **1070** and the user is granted access to the network resource or resources associated with the username and password in the data table **1100**. Control then passes back to operation **1015** and the authentication server **930** continues to monitor for additional primary authentication request.

[0091] Thus, the operations depicted in FIG. **10** enable the network infrastructure depicted in FIG. **11** to implement a multifactor authentication process. In some embodiments described herein, the multifactor authentication process utilizes two separate network devices, i.e., a computing device and a telephone. In some embodiments, the multifactor authentication process may utilize a single network device, i.e., a computing device, which executes two or more logical network devices. For example, a user may initiate a primary authentication request from a first application executing on the computing device, and the second authentication request may be directed to a second application executing on the computing device. For example, the second application may be an Internet Protocol (IP) telephony application.

[0092] Various features may be added to the functionality of the basic authentication process described herein. In some embodiments, the authentication server **930** may store in a memory module such as cache memory the results of a primary authentication request initiated by a user, alone or in combination with the results of a secondary authentication response provided by the user. The results may be stored in for a predetermined period of time or for a dynamic period of time. Thus, when a user has successfully authenticated himself or herself to the system additional authentication may not be required during the time period. The authentication server **930** may require that subsequent primary authentication requests be initiated from the same network address in order to bypass the secondary authentication request. Thus, in some embodiments the authentication server **930** may detect the network address from which the primary authentication request is initiated and may store the network address in a memory module.

[0093] Further, there may be circumstances in which secondary authentication requests may not be necessary. For example, if a user is located on a trusted network in the secondary authentication request may be bypassed. Thus, in some embodiments of the authentication server **930** may detect the network address from which the primary authentication request is initiated and may compare the network address with a list of approved network addresses stored in a memory module.

[0094] Still further, there may be circumstances in which the authentication server **930** declines to initiate a secondary authentication requests. In some embodiments, in the event of a predetermined number of failures for a primary authentication request the authentication server **930** may flag a user as a suspect for fraudulent access and may decline to initiate a secondary authentication request unless further conditions are met. In some embodiments, in the event multiple primary authentication requests are received from different network addresses within a predetermined period of time the authentication server may flag a user as a suspect for fraudulent access and may decline to initiate a secondary authentication request unless further conditions are met. For example, a user may be required to reset passwords or to speak personally with an administrator.

[0095] In some embodiments, the authentication server **930** may provide a user interface that enables users to register one or more telephone numbers or contact addresses for the network device intended for use for the secondary authentication request. The user interface may further permit users to select one or more authentication codes or personal identification numbers (PINs) for both the primary authentication request and the secondary authentication response.

[0096] Various alternate embodiments may be implemented. For example, n some situations it may not be possible to submit a user's primary authentication credentials to the authentication server without incurring unwanted side-effects. For example, logging into a web application using primary authentication credentials may cause the application to take actions such as creating a user session, logging a message, or the like that may be undesirable.

[0097] In such situations, a the authentication server may implement a pre-authentication process. After receiving the primary authentication credentials, the authentication system can attempt to pre-authenticate them using a different API interface, rather than pre-authenticating to the target server itself. For example, in a web application such as Microsoft's Outlook Web Access, the system may pre-authenticate the user by calling the Windows LogonUser( ) API, which checks the user's username and password against the Windows password database. Alternatively, in a Citrix environment, the system could pre-authenticate the user using the Citrix authentication APIs.

[0098] If the pre-authentication step is successful, the secondary authentication may be implemented as described before. Only if that is also successful are the user's credentials submitted to the application in question for final log-in. This becomes a three-phase login, but it has the benefit of allowing compatibility with applications that would not otherwise support the two-phase approach.

[0099] In addition, the strength of the authentication process can be increased using voice-print technology during the confirmation call. During the secondary authentication call, the system asks the user to repeat a series of words. The user repeats the words, and the system makes a determination of whether the user is who he claims to be by evaluating the user's voice against a voice database, using voice matching algorithms.

[0100] Again, this makes the system three-factor: the primary authentication is something the user knows, the secondary is something the user has (phone), and the tertiary authentication is something the user is (his voice).

[0101] This system can also be used for multi-person authentication. For example, in situations which require the approval of more than one to allow an action to complete, multiple secondary authentication calls can be placed. For example, in the case of a bank transfer requiring two people to agree to the transaction, the system may place multiple confirmation calls, one to every person authorized to approve the transaction. It could then play back details of the proposed transaction to each user (which can happen simultaneously), and if a minimum number of those users confirm the transaction, the system returns success. This system can scale to an arbitrarily large number of required confirmations.

Enhanced Multi-Factor Event Confirmation System

[0102] Security-related events occur continuously on a day-to-day basis. Security events include authentications to secure computer systems, financial transactions through a bank or brokerage, or particular line-of-business events such as the submission of source code to a source control system or the accessing of a patient's medical records. These events provide an opportunity for fraud, both on an individual and on a bulk scale, and consequently, securing these events is of the greatest importance.

[0103] Existing event confirmation systems typically rely on a single authentication factor being presented by the person triggering the event. For example, login to a company's remote access system is typically secured using a username and a password assigned to the user logging in. Or, in the case of a credit card transaction, the card number (which is, essentially, a secret known only to the cardholder) is presented, along with the associated expiration date and sometimes a signature.

[0104] Each of these existing single-factor systems carries with it the implicit weakness associated with the single factor in question: secrets can be lost or stolen, cards can be cloned, and so on. Introducing a second factor into the verification process can significantly increase the security of event confirmations. The PhoneFactor system provides such a second factor.

[0105] PhoneFactor operates by placing a telephone call over the public telephone network to a user's pre-registered phone number (or one of several pre-registered phone numbers). The phone call includes any relevant details of the event in question and prompts the user to confirm the event. The user confirms the event by entering a series of digits and/or symbols using the phone's keypad.

[0106] Generally:

[0107] 1) User initiates an event

[0108] 2) PhoneFactor verifies any required business rules (correct username/password, for example)

[0109] 3) If successful—PhoneFactor places a call to the user's pre-registered phone number

[0110] a. If successful—PhoneFactor plays back event data to the user and prompts the user to confirm the event

[0111] b. If the data match the user's expectations, the user confirms the event by entering a pre-arranged set of keystrokes

[0112]) If a failure occurs at any point during the above procedure, the event is deemed not to be confirmed.

[0113] The out-of-band nature of PhoneFactor dramatically complicates the attacker's job, since he now must successfully subvert two entirely different networks based on two entirely different technologies.

[0114] For example, one event type is login to a computer network through a remote access system. After the user's username and password are entered and confirmed, PhoneFactor generates a phone call to a pre-registered phone number including relevant details of the event, such as the geographic location from which the login is being attempted. If the information provided by the PhoneFactor phone call matches the user's expectations, the user enters a pre-registered sequence of keypresses into the phone, confirming the event.

[0115] Another example is in the realm of online banking. Say, for example, a bank customer initiates a wire transfer for $1,000 to an account ending in 1111. The PhoneFactor system makes a phone call to the user's registered phone number and reads off this information. If the information matches the user's expectations, the user confirms the event in the usual way.

[0116] Another example of event confirmation is in the area of healthcare. A healthcare worker may log into a medical records system, triggering a login event confirmation similar to the one described above. Later in the session, the user may add a prescription to the patient's record, prompting an additional event confirmation. In this way, multiple event confirmations can be mixed and matched, allowing implementers of the technology to make tailored decisions about which events benefit from confirmation in which circumstances.

[0117] PhoneFactor can add event confirmations to a variety of existing systems in a variety of circumstances. One kind of integration involves the use of third-party fraud scoring systems. These systems evaluate a group of factors, such as time of day, network addressing information, and so on, to determine if the transaction taking place is likely to be legiti-

mate or fraudulent, and if it is suspected to be the latter, an event confirmation using PhoneFactor can be initiated.

[0118] There are several cases in which the user would refuse to confirm the event, or even signal a fraud alert. One such case is if the user receives a phone call that was not expected—for example, the user is driving down the road, nowhere near a computer, and the phone rings. The user would refuse to confirm the event because he did not trigger it.

[0119] Fraud alerts can be sent in real-time at the request of the user to alert the appropriate company representatives or authorities that a fraudulent event has been triggered. This kind of "hot lead" may improve investigators' chances at locating the fraudster.

[0120] The PhoneFactor event confirmation system may be implemented as follows. Administrators of the system to be protected define in advance a variety of events for which confirmation is desired. These events are configured using a computer-based confirmation interface that allows the user to create an appropriate event template, consisting of:

[0121] One or more pre-recorded outgoing messages to the user, selected from a chosen message set (perhaps per-language, per-region, etc.)

[0122] Zero or more digit strings, which are rendered in spoken language during the event confirmation call using pre-recorded numerical recordings, selected from a language number set

[0123] Zero or more text-to-speech fields, rendered in the user's selected language

[0124] The order in which these elements are to appear in the outgoing PhoneFactor message is supplied

[0125] Pre-recorded static messages may also be included in the outgoing message, for purposes such as marketing or user information.

[0126] Event templates may be customized on a per-language, per-region, or other basis. These message sets contain one message for each requirement in the event template. For example, administrators may define an English message set and a Spanish message set. During submission of the PhoneFactor request, the submitter requests a specific message set, and messages from that message set are chosen to be played in the outgoing PhoneFactor message.

[0127] The combination of event templates, message sets, and the specified response keystroke sequence allows for a variety of implementation alternatives. For example, the user could be prompted using the Wire Transfer template, with the English message set, and the confirmation code could be the last four digits of the user's bank account number.

[0128] PhoneFactor event confirmation can be applied to a wide variety of problem spaces and contexts, and can play an important role in fraud prevention when dealing with sensitive events and information.

[0129] Reference in the specification to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in connection with that embodiment may be included in at least an implementation. The appearances of the phrase "in one embodiment" in various places in the specification may or may not be all referring to the same embodiment.

[0130] Also, in the description and claims, the terms "coupled" and "connected," along with their derivatives, may be used. In some embodiments, "connected" may be used to indicate that two or more elements are in direct physical or electrical contact with each other. "Coupled" may mean that two or more elements are in direct physical or electrical contact. However, "coupled" may also mean that two or more elements may not be in direct contact with each other, but may still cooperate or interact with each other.

[0131] Thus, although embodiments of the invention have been described in language specific to structural features and/or methodological acts, it is to be understood that claimed subject matter may not be limited to the specific features or acts described. Rather, the specific features and acts are disclosed as sample forms of implementing the claimed subject matter.

What is claimed is:

1. A method to authenticate a resource access request, comprising:

receiving, in an authentication server in a communication network, a primary authentication request transmitted from a user via a first communication channel;

processing the primary authentication request to determine whether the user is authorized to access one or more resources;

in response to a determination that the user is authorized to access one or more resources, initiating, in a network element, a secondary authentication request; and

transmitting the secondary authentication request from the network element to the user via a second communication channel, different from the first communication channel.

2. The method of claim **1**, wherein the primary authentication request is originated from a first computing device coupled to the communication network and includes a username and a password.

3. The method of claim **2**, wherein processing the primary authentication request comprises searching a data file maintained by the authentication server for a corresponding username and password.

4. The method of claim **2**, wherein the primary authentication request further comprises an identifier associated with a specific network resource, and wherein processing the primary authentication request comprises searching a data file maintained by the authentication server for a corresponding username and password associated with the specific network resource.

5. The method of claim **4**, wherein transmitting the secondary authentication request from the network element to the user via a second communication channel comprises originating a call from a network element to a telephone number associated with the username.

6. The method of claim **5**, wherein the call requests an authentication response from the user.

7. The method of claim **6**, wherein originating a call from the network element to a telephone number associated with the username comprises playing a prerecorded message approved by the user.

8. The method of claim **1**, further comprising:

receiving, in the network element, a response to the secondary authentication request;

processing the response to the secondary authentication request to determine whether the user is authentic;

in response to a determination that the user is authentic, granting access to one or more network resources.

9. The method of claim **8**, wherein the response to the secondary authentication request comprises at least one of a key sequence entered into a communication device or a voice message entered into the communication device.

10. The method of claim **8**, further comprising caching a successful response to the secondary authentication request for a predetermined period of time.

11. A network element, comprising:

one or more processors;

a memory module communicatively coupled to the processor and comprising logic instructions stored in a computer readable medium which, when executed by the processor, configure the processor to:

receive, via a first communication channel, a primary authentication request transmitted from a user from a first device;

process the primary authentication request to determine whether the user is authorized to access one or more resources;

in response to a determination that the user is authorized to access one or more resources, initiate, a secondary authentication request; and

transmit the secondary authentication request from the network element to the user via a second communication channel, different from the first communication channel.

12. The network element of claim **11**, wherein the primary authentication request is originated from a first computing device coupled to the communication network element and includes a username and a password.

13. The network element of claim **12**, further comprising logic instructions stored in a computer readable medium which, when executed by the processor, configure the processor to search a data file maintained by the authentication server for a corresponding username and password.

14. The network element of claim **12**, wherein the primary authentication request further comprises an identifier associated with a specific network resource, and further comprising logic instructions stored in a computer readable medium which, when executed by the processor, configure the processor to search a data file maintained by the authentication server for a corresponding username and password associated with the specific network resource.

15. The network element of claim **14**, further comprising logic instructions stored in a computer readable medium which, when executed by the processor, configure the processor to originate a call from the network element to a telephone number associated with the username.

16. The network element of claim **15**, wherein the call requests an authentication response from the user.

17. The network element of claim **16**, further comprising logic instructions stored in a computer readable medium which, when executed by the processor, configure the processor to play a prerecorded message approved by the user.

18. The network element of claim **17**, further comprising logic instructions stored in a computer readable medium which, when executed by the processor, configure the processor to:

receive, in the network element, a response to the secondary authentication request;

process the response to the secondary authentication request to determine whether the user is authentic;

in response to a determination that the user is authentic, grant access to one or more network resources.

19. The network element of claim **18**, wherein the response to the secondary authentication request comprises at least one of a key sequence entered into a communication device or a voice message entered into the communication device.

20. The network element of claim **18**, further comprising caching a successful response to the secondary authentication request for a predetermined period of time.

* * * * *