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Van

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(54) **AUDITING COMMUNICATIONS**

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(51) **Int. Cl.**

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G06F 7/04	(2006.01)
H04L 29/06	(2006.01)
G06F 21/30	(2013.01)
G06F 21/00	(2013.01)

(52) **U.S. Cl.**

CPC ***H04L 63/08*** (2013.01); ***G06F 21/00*** (2013.01); ***G06F 21/30*** (2013.01); ***H04L 63/00*** (2013.01); ***H04L 63/108*** (2013.01)

(58) **Field of Classification Search**

CPC H04L 63/08
USPC 726/12, 1, 26, 4
See application file for complete search history.

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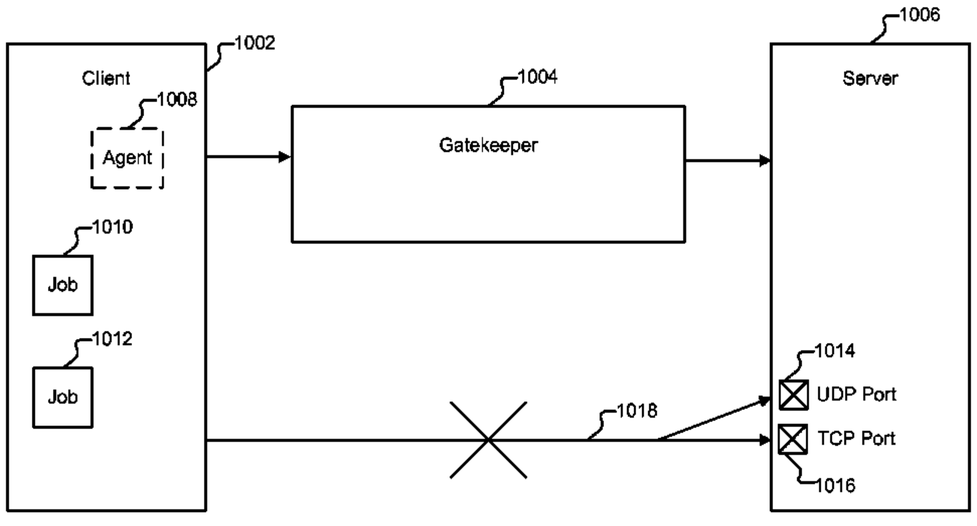
(57) **ABSTRACT**

Auditing a communication is disclosed. Credentials are received from a client. It is determined whether the client is authorized to communicate with a remote resource. If it is determined that the communication with the remote resource is allowed, a communication is forwarded from the local resource to the remote resource.

19 Claims, 15 Drawing Sheets



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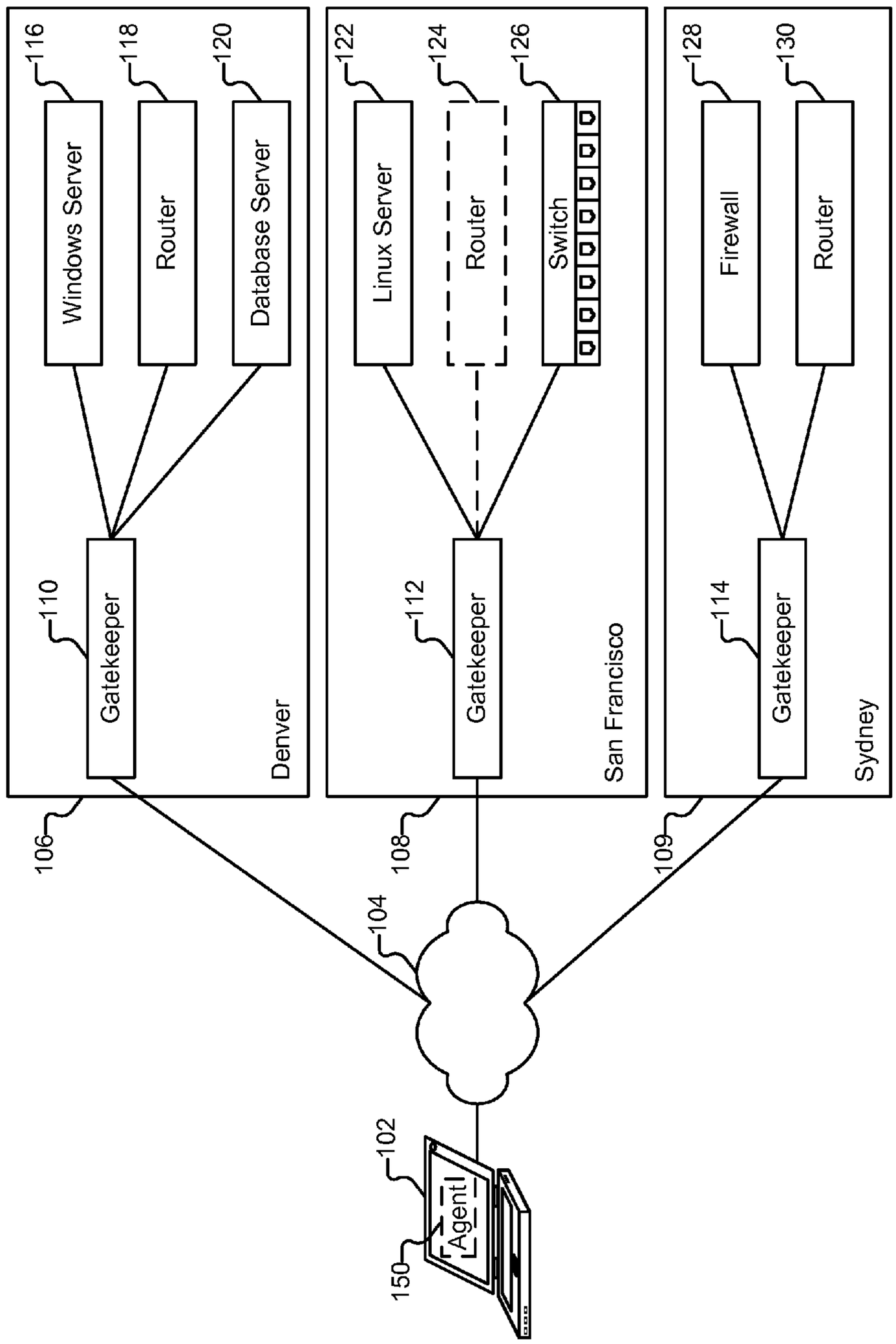
116
Windows Server
118
Router
120
Database Server
110
Gatekeeper
Denver
106
122
Linux Server
124
Router
126
Switch
112
Gatekeeper
San Francisco
108
128
Firewall
130
Router
114
Gatekeeper
Sydney
109
104
102
Agent
150

FIG. 1

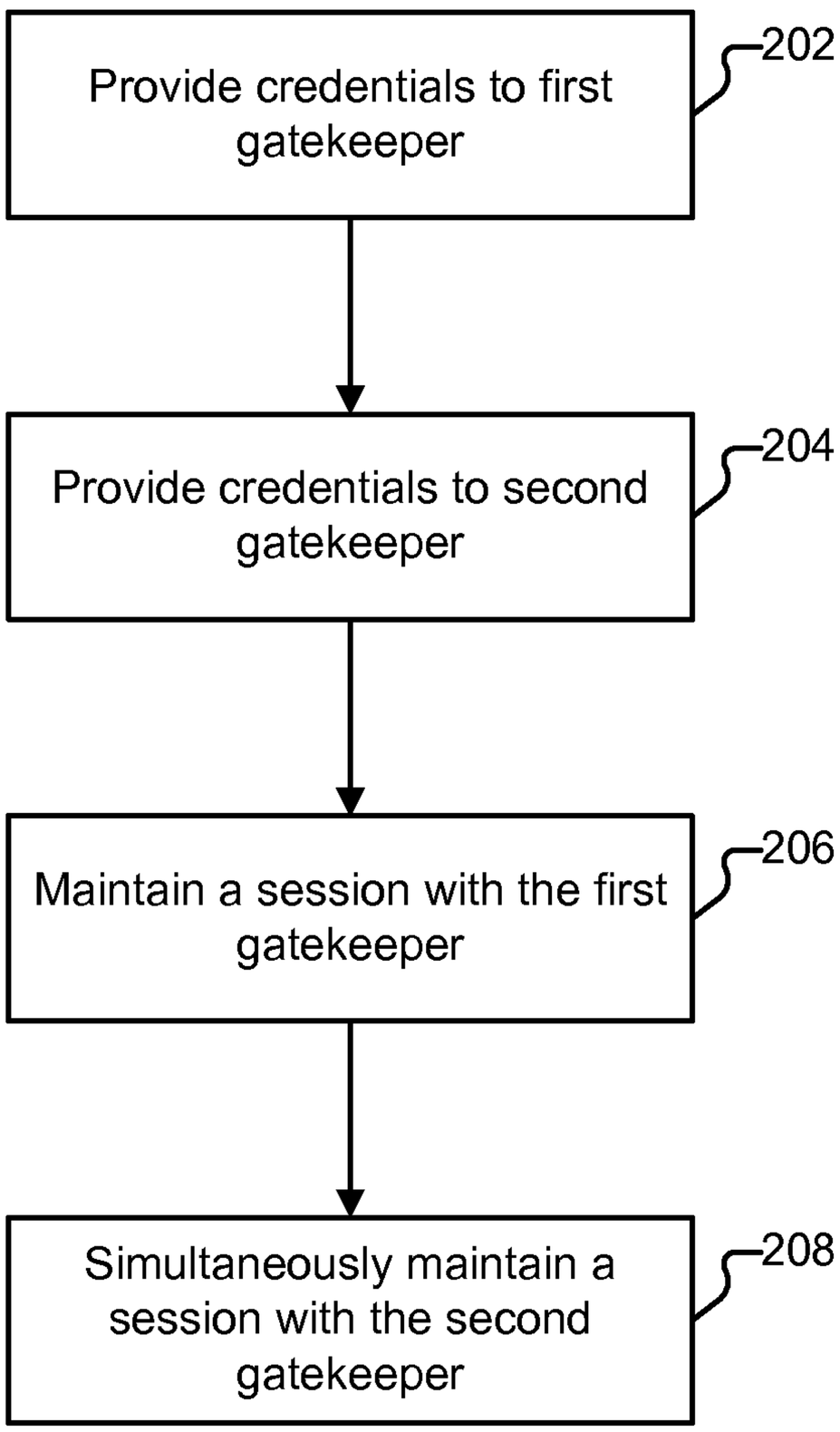
Provide credentials to first gatekeeper
202
Provide credentials to second gatekeeper
204
Maintain a session with the first gatekeeper
206
Simultaneously maintain a session with the second gatekeeper
208

FIG. 2

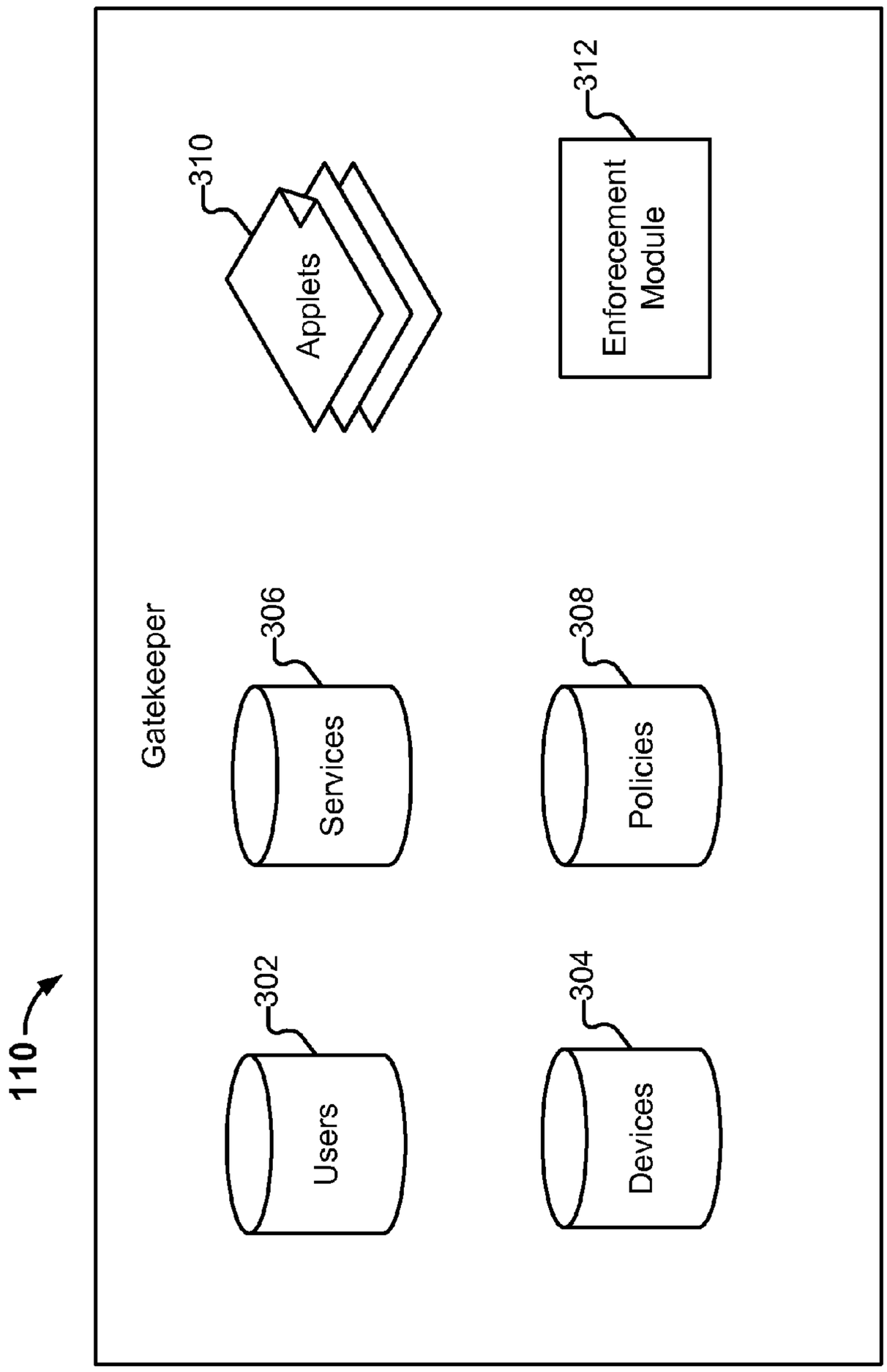
110
Gatekeeper
302
Users
304
Devices
306
Services
308
Policies
310
Applets
312
Enforcement Module

FIG. 3

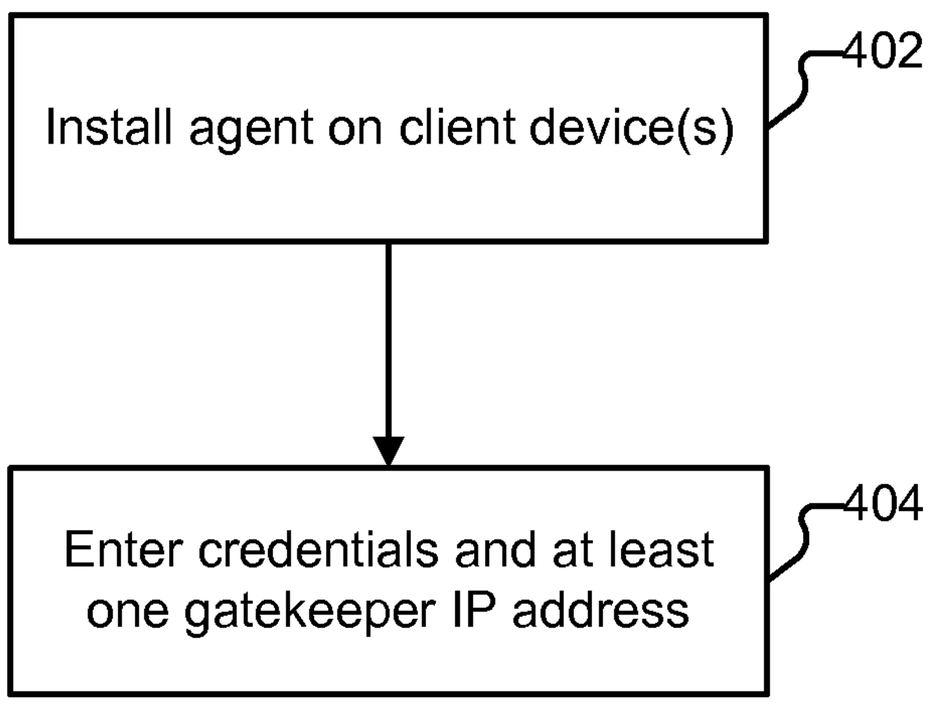
Install agent on client device(s)
402
Enter credentials and at least one gatekeeper IP address
404

FIG. 4

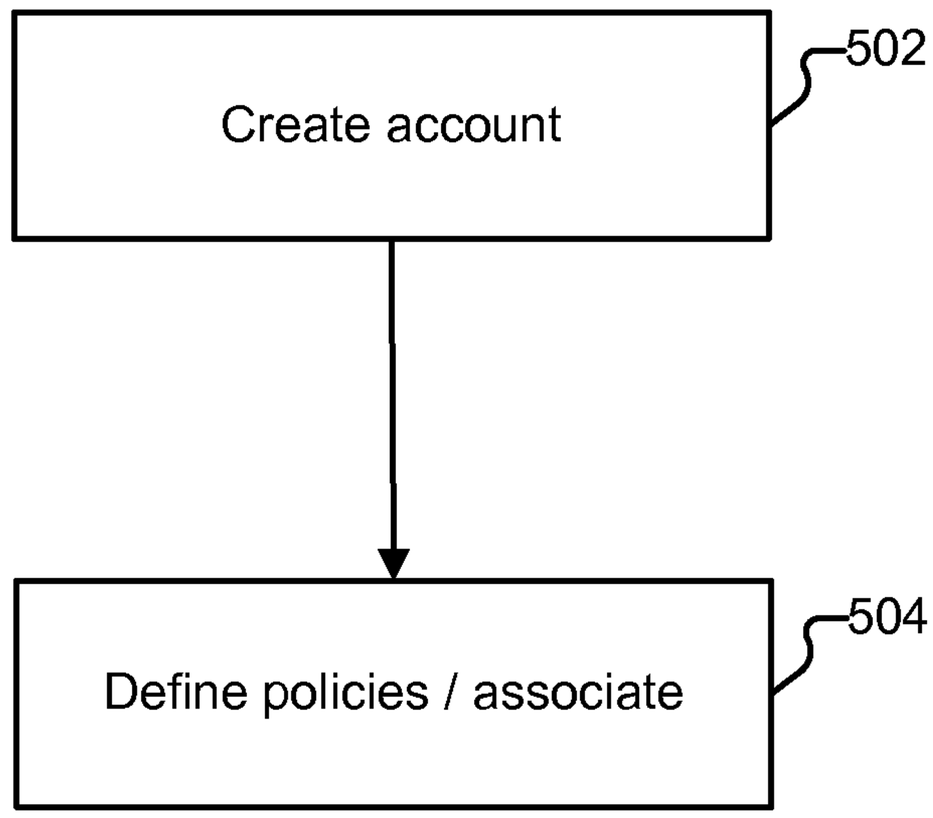

FIG. 5

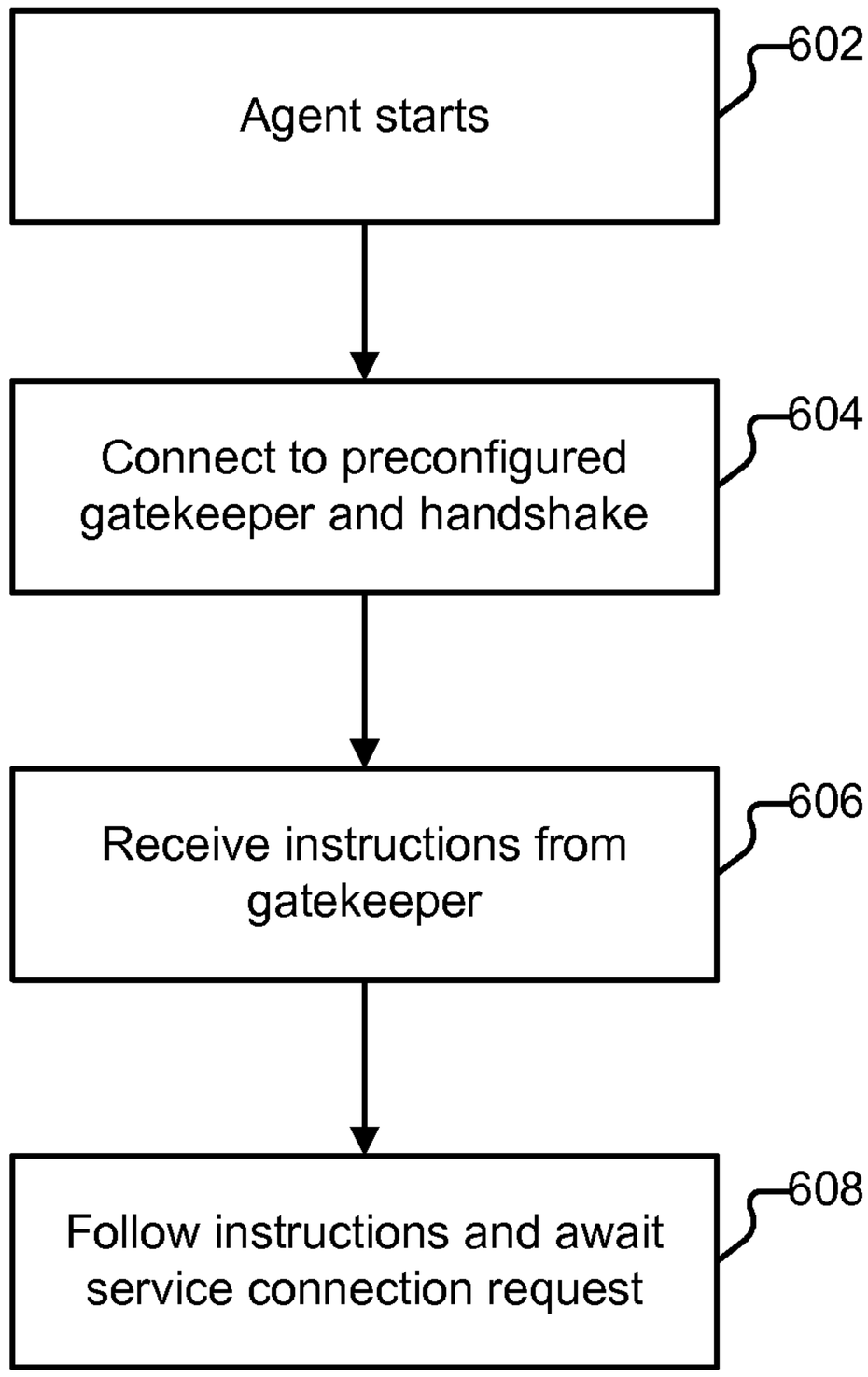
Agent starts
602
Connect to preconfigured gatekeeper and handshake
604
Receive instructions from gatekeeper
606
Follow instructions and await service connection request
608

FIG. 6

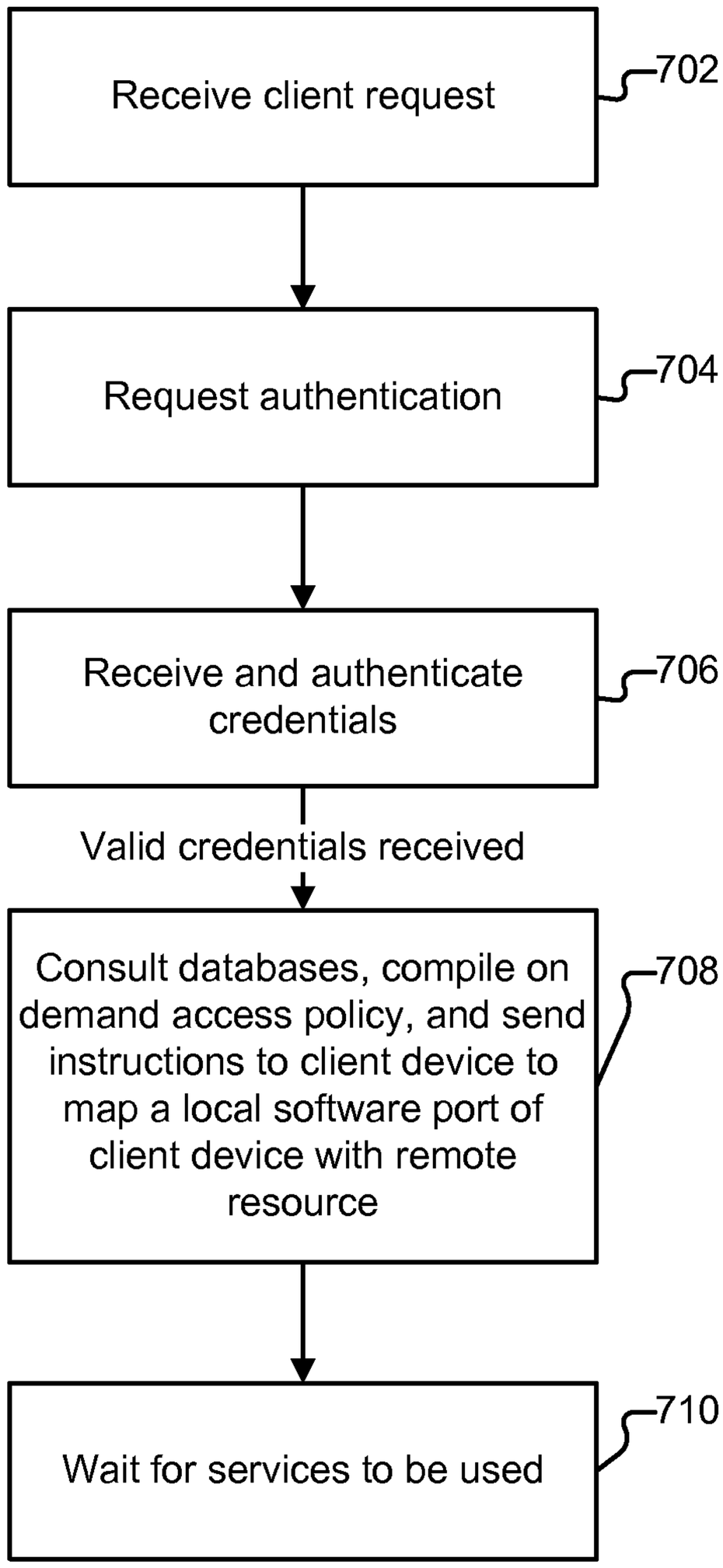
Receive client request
702
Request authentication
704
Receive and authenticate credentials
706
Valid credentials received
Consult databases, compile on demand access policy, and send instructions to client device to map a local software port of client device with remote resource
708
Wait for services to be used
710

FIG. 7

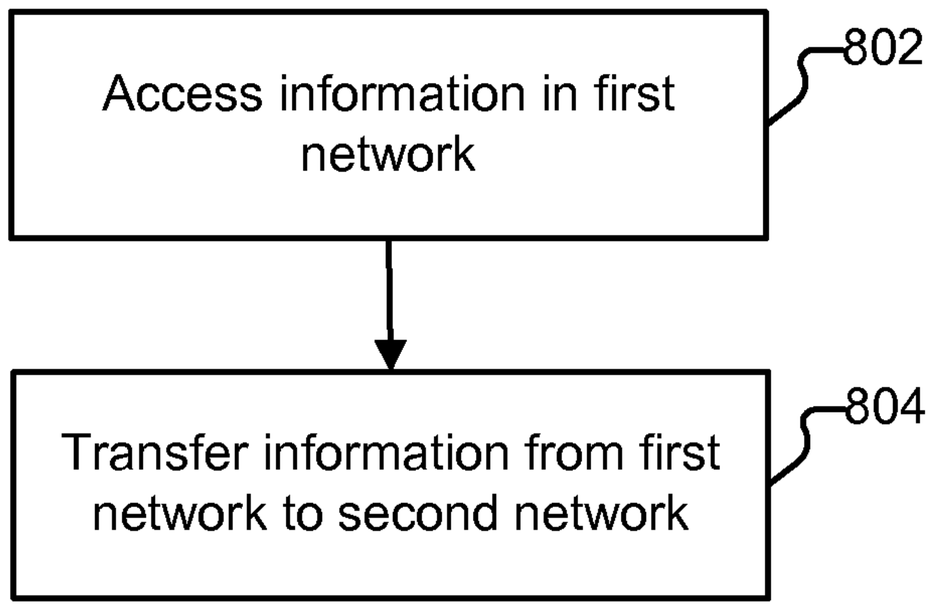
Access information in first network
802
Transfer information from first network to second network
804

FIG. 8

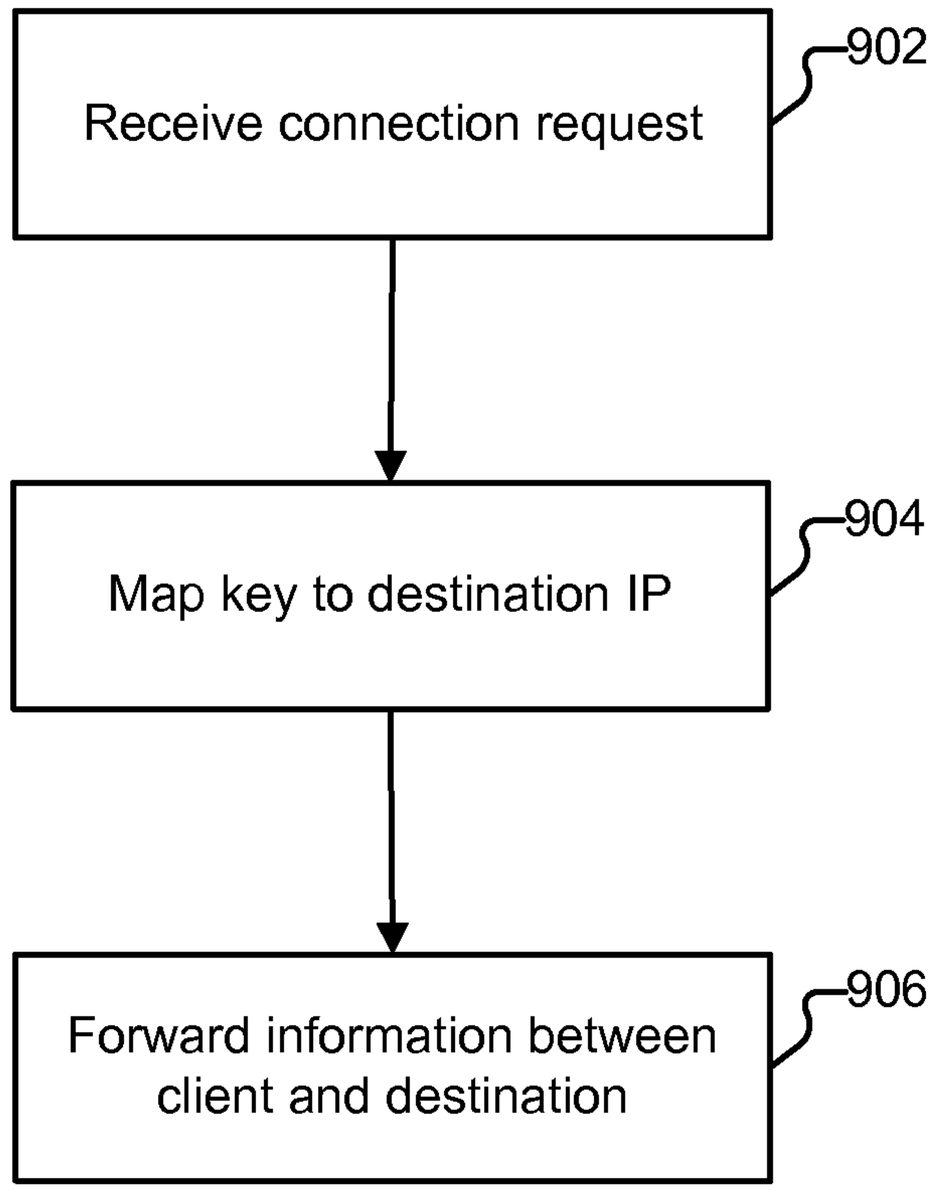
Receive connection request
902
Map key to destination IP
904
Forward information between client and destination
906

FIG. 9

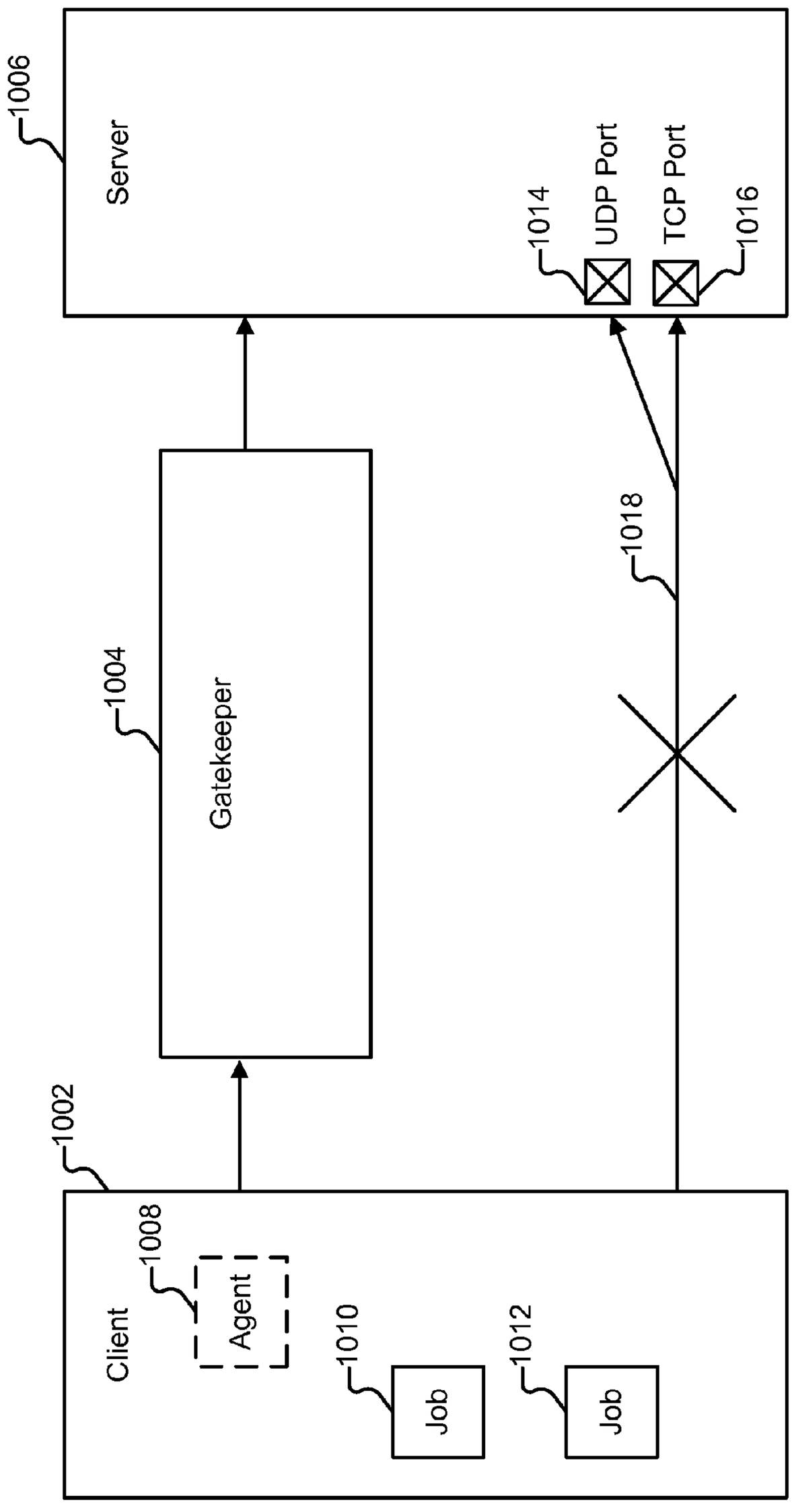
1006
Server
1014
UDP Port
TCP Port
1016
1018
1004
Gatekeeper
1002
Client
1008
Agent
1010
Job
1012
Job

FIG. 10

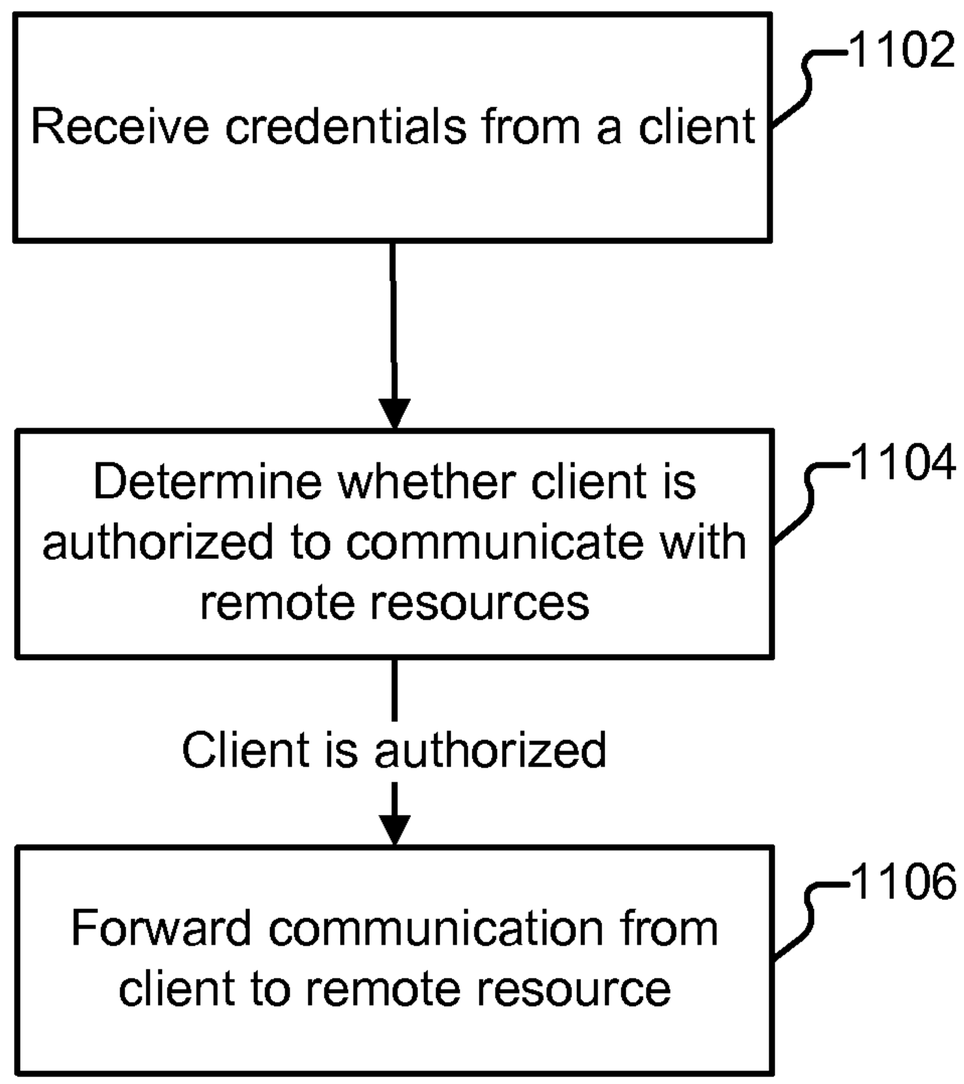
Receive credentials from a client
1102
Determine whether client is authorized to communicate with remote resources
1104
Client is authorized
Forward communication from client to remote resource
1106

FIG. 11

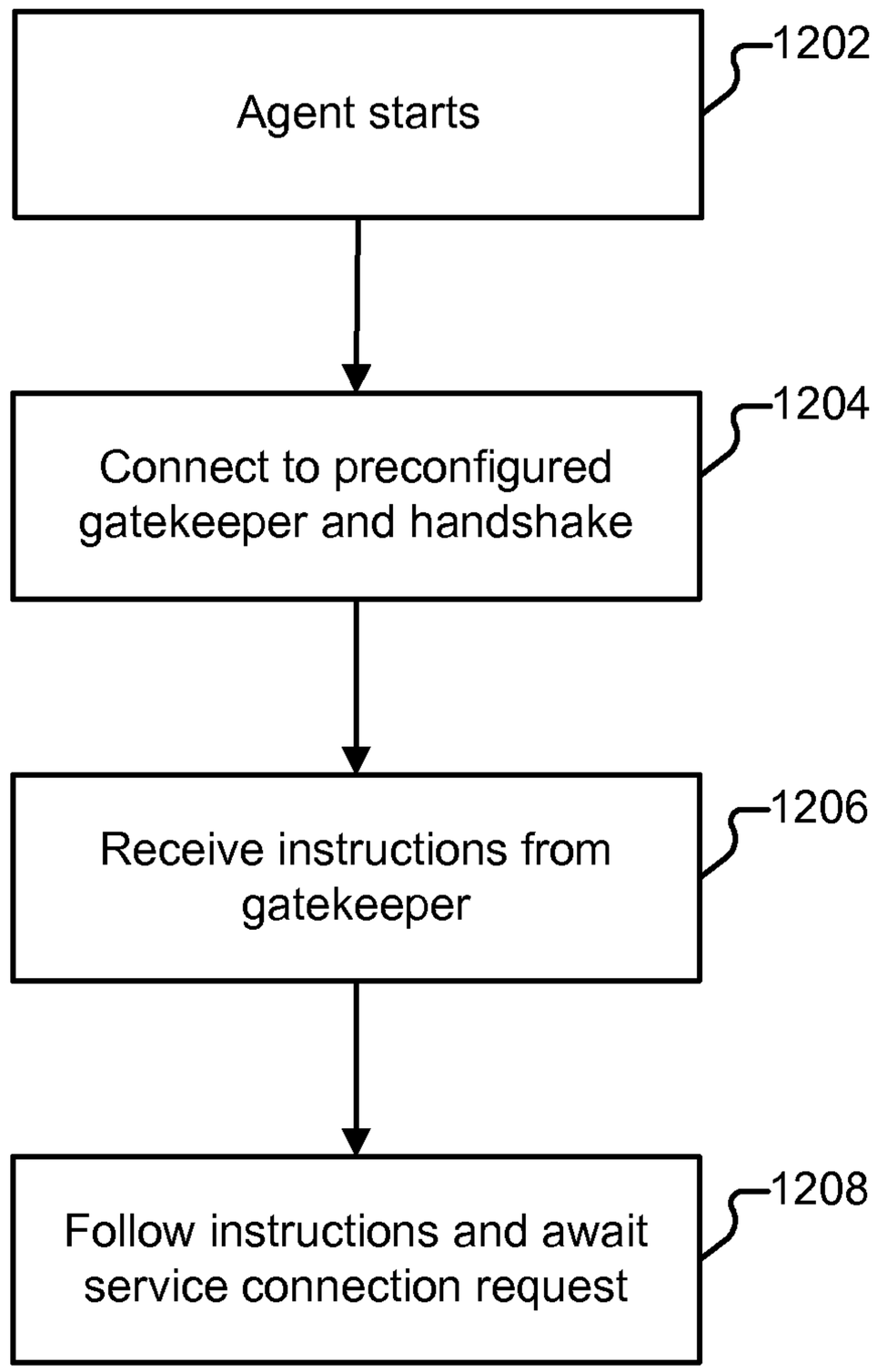
Agent starts
1202
Connect to preconfigured gatekeeper and handshake
1204
Receive instructions from gatekeeper
1206
Follow instructions and await service connection request
1208

FIG. 12

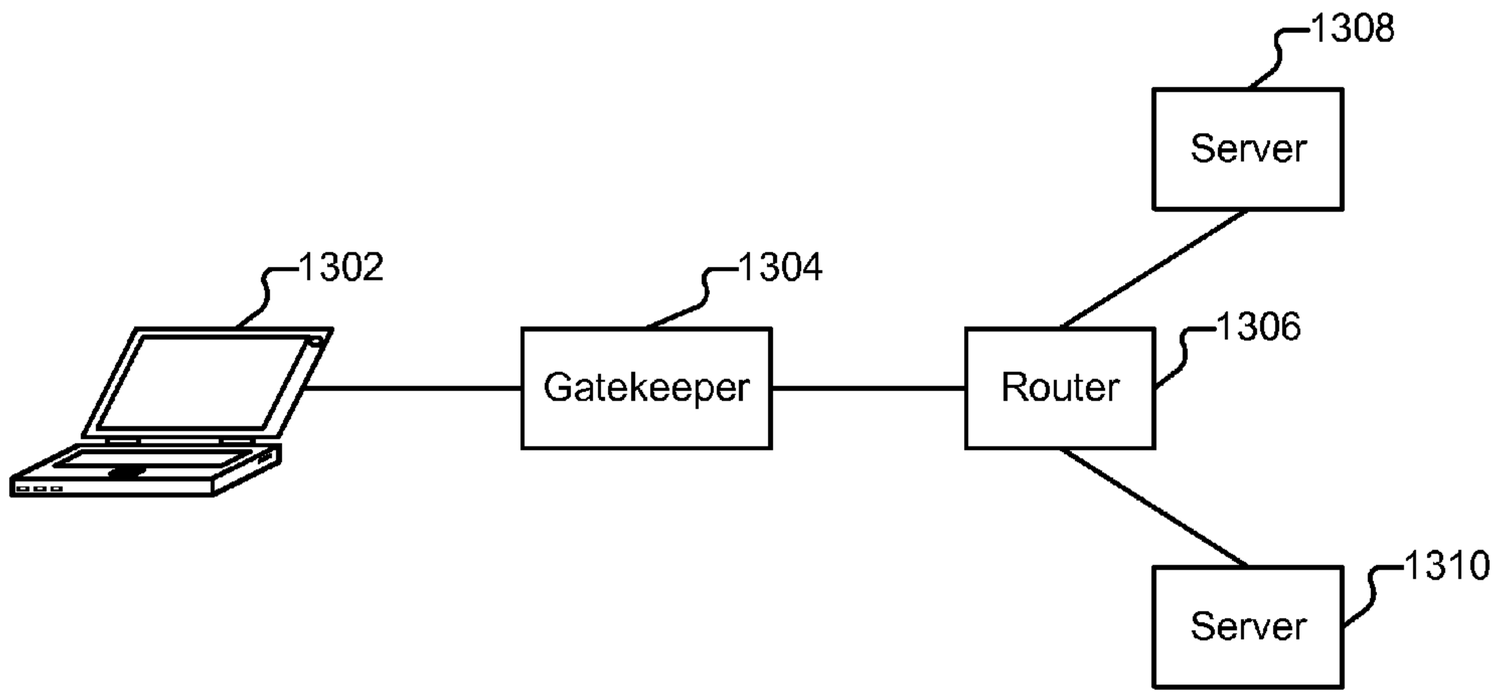

FIG. 13A

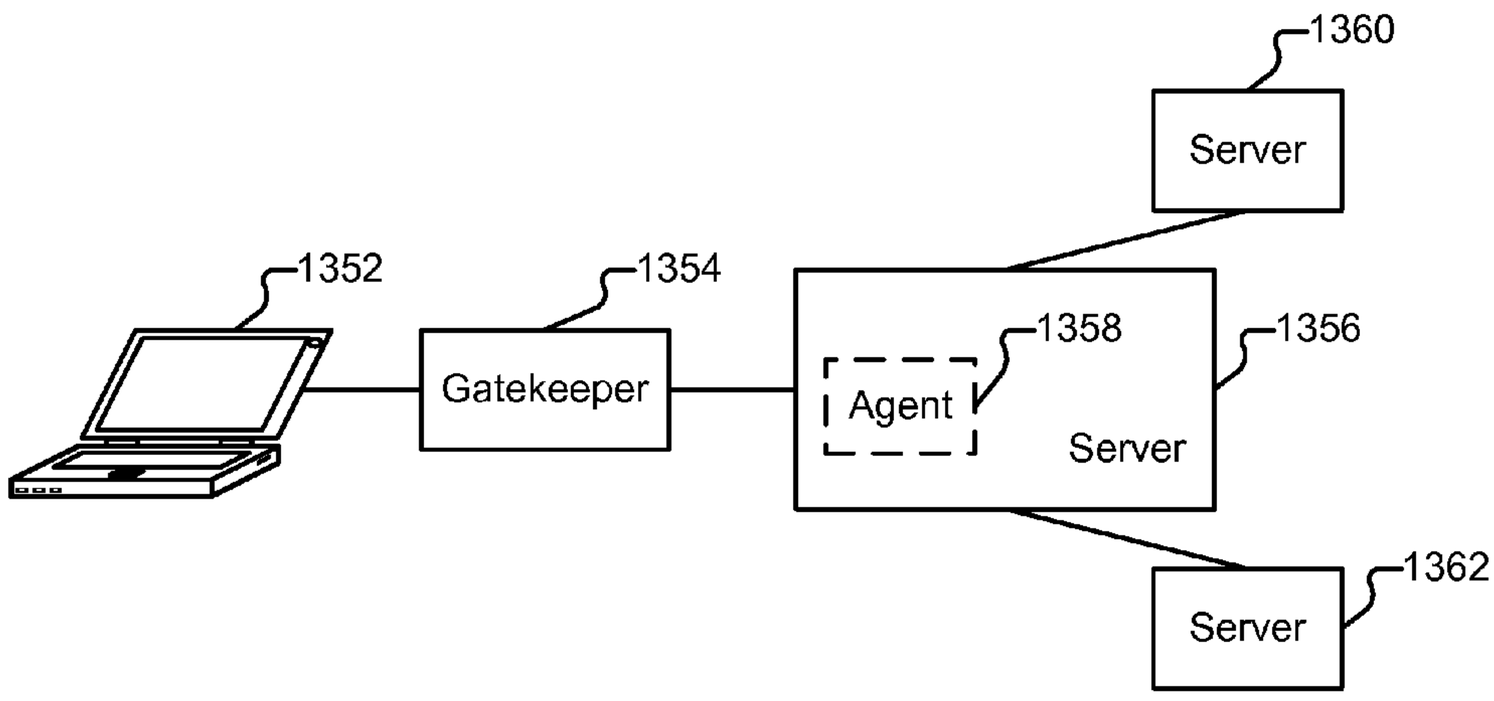

FIG. 13B

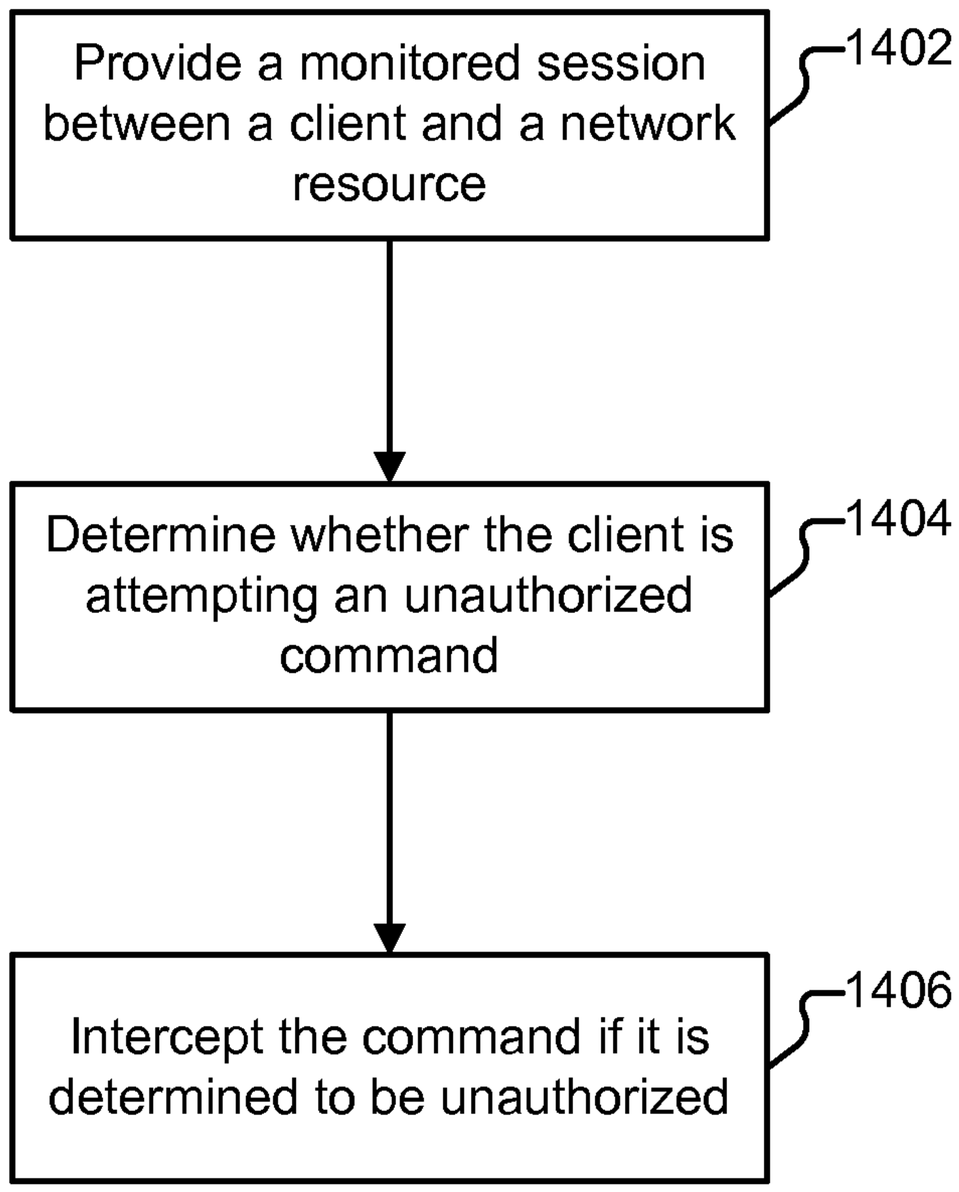
Provide a monitored session between a client and a network resource
1402
Determine whether the client is attempting an unauthorized command
1404
Intercept the command if it is determined to be unauthorized
1406

FIG. 14

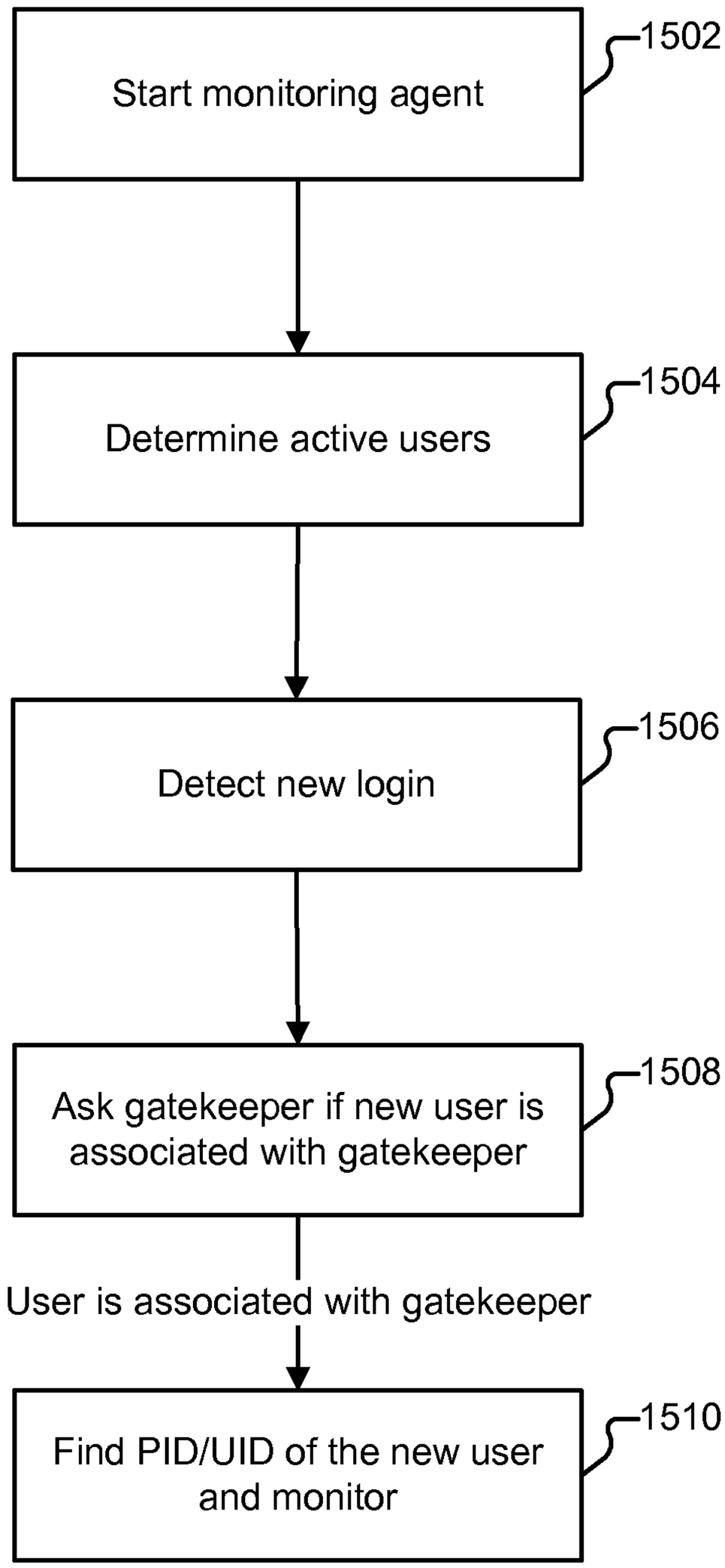
Start monitoring agent
1502
Determine active users
1504
Detect new login
1506
Ask gatekeeper if new user is associated with gatekeeper
1508
User is associated with gatekeeper
Find PID/UID of the new user and monitor
1510

FIG. 15

AUDITING COMMUNICATIONS

CROSS REFERENCE TO OTHER APPLICATIONS

This application is a continuation of co-pending U.S. patent application Ser. No. 11/786,970, entitled AUDITING COMMUNICATIONS filed Apr. 13, 2007 which is incorporated herein by reference for all purposes, which claims priority to U.S. Provisional Patent Application No. 60/792,160 entitled MULTI-NETWORK CONNECTIVITY filed Apr. 13, 2006 which is incorporated herein by reference for all purposes and also claims priority to U.S. Provisional Patent Application No. 60/857,659 entitled AUTOMATIC INTERVENTION filed Nov. 7, 2006 which is incorporated herein by reference for all purposes.

BACKGROUND OF THE INVENTION

One tool used in network security is the ability to monitor and log administrator actions. For example, when an administrator logs into a production server at midnight each night, runs assorted tests, and emails log files associated with the results of those tests to another server, each of those actions may be monitored and logged. If problems occur, the administrator(s) logged into the system at the time of the problem can be questioned and their actions can be evaluated.

Typically when administrators find themselves performing the same set of tasks repeatedly, they seek to automate those tasks. For example, instead of manually running the tests and emailing the results each night, an administrator might create a cron job or batch file that performs those actions, schedule it to run every night at midnight, and then cease logging in at night. Unfortunately, while automating tasks can be efficient, it can also pose security risks. While the nightly actions continue to be performed, the administrator has ceased logging in and thus the monitoring system that monitors the actions of the administrator may no longer be effective at determining the administrator as the source of the activity. This can be particularly problematic in the case of consultants or other temporary employees that may leave batches processes behind when they stop administering the enterprise.

Therefore, it would be desirable to have a better way to monitor and authenticate activity.

BRIEF DESCRIPTION OF THE DRAWINGS

Various embodiments of the invention are disclosed in the following detailed description and the accompanying drawings.

FIG. **1** is a block diagram illustrating an embodiment of an environment in which point to multi-point connections are made.

FIG. **2** is a flow chart illustrating an embodiment of a process for communicating with a plurality of networks.

FIG. **3** is a block diagram illustrating an embodiment of a gatekeeper.

FIG. **4** is a flow chart illustrating an embodiment of a process for enrolling a user with a gatekeeper.

FIG. **5** is a flow chart illustrating an embodiment of a process for enrolling a user with a gatekeeper.

FIG. **6** is a flow chart illustrating an embodiment of a process for establishing a session with a gatekeeper.

FIG. **7** is a flow chart illustrating an embodiment of a process for establishing a session with a client.

FIG. **8** is a flow chart illustrating an embodiment of a process for communicating information across a plurality of networks.

FIG. **9** is a flow chart illustrating an embodiment of a process for communicating information across a plurality of networks.

FIG. **10** is a block diagram illustrating an embodiment of an environment having communication auditing.

FIG. **11** is a flow chart illustrating an embodiment of a process for auditing a communication.

FIG. **12** is a flow chart illustrating an embodiment of a process for auditing a communication.

FIG. **13**A is a block diagram illustrating an embodiment of an environment having network security.

FIG. **13**B is a block diagram illustrating an embodiment of an environment having network security.

FIG. **14** is a flow chart illustrating an embodiment of a process for detecting unauthorized commands.

FIG. **15** is a flow chart illustrating an embodiment of a process for detecting unauthorized commands.

DETAILED DESCRIPTION

The invention can be implemented in numerous ways, including as a process, an apparatus, a system, a composition of matter, a computer readable medium such as a computer readable storage medium or a computer network wherein program instructions are sent over optical or communication links. In this specification, these implementations, or any other form that the invention may take, may be referred to as techniques. A component such as a processor or a memory described as being configured to perform a task includes both a general component that is temporarily configured to perform the task at a given time or a specific component that is manufactured to perform the task. In general, the order of the steps of disclosed processes may be altered within the scope of the invention.

A detailed description of one or more embodiments of the invention is provided below along with accompanying figures that illustrate the principles of the invention. The invention is described in connection with such embodiments, but the invention is not limited to any embodiment. The scope of the invention is limited only by the claims and the invention encompasses numerous alternatives, modifications and equivalents. Numerous specific details are set forth in the following description in order to provide a thorough understanding of the invention. These details are provided for the purpose of example and the invention may be practiced according to the claims without some or all of these specific details. For the purpose of clarity, technical material that is known in the technical fields related to the invention has not been described in detail so that the invention is not unnecessarily obscured.

FIG. **1** is a block diagram illustrating an embodiment of an environment in which point to multi-point connections are made. In the example shown, client **102** is used to administer various nodes (also referred to herein as "devices") in three networks. Examples of users of client **102** include in-house engineers/administrators, consultants, vendors, and managed service providers (hereinafter referred to collectively as "administrators"). In some cases, administrators administer entire nodes (such as a file server). In other cases, administers administer subsets of nodes such as by administering particular services without administering other services on the same node. As used herein, the "resources" administered by an administrator refer to the nodes and/or services an adminis-

trator is authorized to access. Some of the resources administered may be critical pieces of infrastructure, such as production servers or databases.

Network **106** is an enterprise network located in Denver that includes (among other nodes) a Windows server **116**, a router **118**, and a database server **120**. Network **108** is an enterprise network located in San Francisco that includes (among other nodes) a Linux server **122**, a router **124**, and a switch **126**. Network **109** is an enterprise network located in Sydney that includes (among other nodes) a firewall **128** and a router **130**. In the example shown, networks **106-109** are disjoint, meaning that they do not share a direct connection (e.g., from network **106** to network **108**) but instead are connected via the Internet **104**. In some embodiments the networks may be in close physical proximity but otherwise disjoint, such as in an environment where blade computers and virtualization software are used.

In the example shown, a particular administrator (also referred to herein as "Alice") has the responsibility of administering resources on nodes **116-122** and **126-130** using her company issued laptop, client **102**. Alice does not administer node **124**. Other examples of clients include workstations, personal computers, and cellular phones/personal digital assistants (PDAs), as well as other types of information appliances, as applicable. In some embodiments, an agent **150** facilitates communication between client **102** and networks **106-109**.

Suppose Alice is physically located in Albuquerque. As described in more detail below, she uses client **102** to maintain concurrent sessions with gatekeepers **110**, **112**, and **114**. After authenticating Alice, the gatekeepers provide client **102** with instructions that map ports on Alice's laptop with services on the devices she is authorized to administer. Alice is presented an abstracted consolidated view of those resources on networks **106-109** to which she is authorized access, and cannot view the resources on those networks that she is not authorized to access. Networks **106-109** may each contain hundreds or thousands of nodes. Nonetheless, using the techniques described herein, only the subset of resources Alice is authorized to access will be visible to her. For example, after authenticating to gatekeepers **110-114** and initiating sessions with those gatekeepers, Alice will be able to copy files from Windows server **116** to Linux server **122** by using native tools on her laptop such as the file explorer and/or an scp client, while simultaneously viewing the configuration of firewall **128**. Alice will not be able to see router **124** (represented here using dashed lines).

FIG. **2** is a flow chart illustrating an embodiment of a process for communicating with a plurality of networks. In some embodiments the process shown in FIG. **2** is performed by client **102**. As described in more detail below, in some embodiments agent **150** facilitates the process shown in FIG. **2**. The process begins at **202** when one or more credentials are provided to a first gatekeeper. For example, at **202** client **102** provides credentials to gatekeeper **110**. In some embodiments, Alice provides credentials at **202** by starting agent **150** on her laptop, and providing agent **150** with the IP address of gatekeeper **110**, and a username and password by which gatekeeper **110** can authenticate her. In various embodiments other authentication techniques are used instead of or in addition to providing a name and a password, such as by requiring Alice to provide a secondary authentication factor or a digital certificate.

At **204**, one or more credentials are provided to a second gatekeeper. For example, at **204**, client **102** provides credentials to gatekeeper **112**. In some embodiments Alice is prompted to provide the addresses of all the gatekeepers she authorized to communicate with along with the credentials needed to authenticate to those gatekeepers. For example, when Alice first uses client **102** to communicate with networks **106-109**, as part of a setup phase, she might be requested to provide the IP addresses of gatekeepers **110-114** and any logins/passwords associated with those gatekeepers.

In some embodiments, the gatekeepers maintain lists of other gatekeepers and the authorized users of those gatekeepers. When Alice attempts to log in to a first gatekeeper, that gatekeeper may be configured to automatically provide Alice's credentials to the other gatekeepers in lieu of Alice providing it to each gatekeeper herself.

At **206**, a session is maintained with the first gatekeeper. For example, after validating Alice's credentials, gatekeeper **110** determines the resources to which Alice should be granted access and provides client **102** with instructions for reaching those resources. As described in more detail below, gatekeeper **110** facilitates communication between Alice and the resources during the session with gatekeeper **110**.

At **208**, a session is maintained with a second gatekeeper while simultaneously maintaining a session with the first gatekeeper. For example, at **208**, Alice has two concurrent sessions with two gatekeepers—gatekeeper **110** and gatekeeper **112**. As applicable, Alice can maintain more than two sessions. For example, if Alice authenticates to gatekeeper **114**, Alice can establish three concurrent sessions, one each with gatekeepers **110-114**, and is able to simultaneously see resources **116-122** and **126-130**.

FIG. **3** is a block diagram illustrating an embodiment of a gatekeeper. In the example shown, gatekeeper **110** includes a user database **302**. User database **302** includes a list of users authorized to access gatekeeper **110** and those users' credentials. For example, user database **302** might include Alice's username (e.g., alice.jones) and information suitable to authenticate Alice (e.g., a hash of her passphrase, a digital certificate, etc.).

Device database **304** includes a list of all of the devices on a network that can be made available to administrators via a gatekeeper. For example, Windows server **116**, router **118**, and database server **120** could be included in gatekeeper **110**'s device database, along with information such as those nodes IP addresses and, if applicable, network name.

Service database **306** includes a list of services provided by the devices in device database **304**. Examples of services include FTP and SSH. In some embodiments the services listed in service database **306** include all services listening on the ports of the devices listed in device database **304**.

Policy database **308** includes four dimensional policies that govern the resources that client **102** is allowed to access. The dimensions are user, time, service, and device. An example policy could be represented in policy database **306** as a row entry of the form (user,time,service,device). For example, suppose Alice is permitted to connect to Windows server **116** nightly so that she can perform integrity checks. User database **302** includes an entry for Alice. Device database **304** includes an entry for Windows server **116** and its IP address. Service database **306** includes entries KVM_web and RDP, the two connection methods that Windows server **302** supports. Suppose Alice is only permitted to connect using KVM_web. A policy defining her access rights might be represented in policy database **306** as (alice.jones,23:00, 23:59, RDP, WindowsServer116), where 23:00 indicates that she may start using the service at 23:00 and where 23:59 indicates that her authorization to use the service ends at 23:59.

In some embodiments Alice receives permission to access a bundle of services (e.g., FTP and SSH) across a bundle of

devices (e.g., nodes **116**, **120**, and **122**) during certain time periods, without being constrained to use, e.g., SSH on node **116** but not on node **120**. Similarly, Alice may be permitted to perform any of those services on any of those devices during a time window (e.g., 8 am to noon) rather than specifying precise times that specific tasks may be performed. In various embodiments, policies may include fewer or more dimensions. For example, Alice may not be constrained by time in some actions, or the time constraints may be more flexible.

In various embodiments, other data structures are used to store and provide access to the information contained in databases **302-308** such as flat files. In the example shown, the contents of each database is thin. For example, while there may be many different versions of FTP offered across several different platforms (e.g., FTP for Windows, FTP for Linux, and the assorted versions thereof), there might be only a single "FTP" entry in the services database that is used to indicate any and all of those particular instances of FTP.

Enforcement module **312** provides agent **150** with instructions based on applicable policies stored in policy database **308**. Gatekeeper **110** also includes a variety of applets **310** that can be provided to client **102** as needed.

FIG. **4** is a flow chart illustrating an embodiment of a process for enrolling a user with a gatekeeper. In some embodiments the process shown in FIG. **4** is performed by client **102**. The process begins at **402** when an agent such as agent **150** is installed on a client device such as client **102**. Administrators often use multiple clients, such as workstations during regular business hours, laptops when at home, and PDAs or other portable devices when mobile. Accordingly, the process performed at **402** may be repeated for each of the clients the administrator intends to use to access resources on the networks the administrator administers. Similarly, the process performed at **402** may be repeated whenever Alice obtains a new laptop or otherwise upgrades client **102**. In some embodiments the agent is a Java-based package and is cross-platform. In other embodiments, platform specific agents are used at **402**.

At **404**, user credentials are provided, along with the location of at least one gatekeeper. For example, at **404**, Alice starts agent **150** and is prompted to enter the location of at least one gatekeeper and the credentials that she would like to use to authenticate to that gatekeeper. If Alice has access to multiple gateways, she may provide their information at **404** as well, or the gatekeepers may communicate Alice's information amongst themselves without her needing to enter more than one gatekeeper's information into agent **150**. In some embodiments, the agent itself requires credentials to start, and Alice is prompted to provide those credentials at startup.

FIG. **5** is a flow chart illustrating an embodiment of a process for enrolling a user with a gatekeeper. In some embodiments the process shown in FIG. **5** is performed by gatekeeper **110**. The process begins at **502** when an account for a user such as Alice is established. One way of establishing an account is to create an entry in the user database that specifies the user's credentials and whether the user is subject to time based restrictions or may always access authorized resources (an "always on" account). For example, suppose another user, Bob, is hired to assist Alice on a large project during an upcoming weekend. Bob's account can be created at any time, but an indicator can be associated with his account that his account should only be active between 17:00 on Friday through 21:00 on Sunday.

At **504**, the created user account is mapped or associated with applicable policies, such as that the user may access FTP and SSH on Linux server **122**. In some embodiments, the policies applicable to a particular user are based on the user's role. For example, all database administrators may be given the same access to the same resources. In such a case, templates or wizards may be used by the entity configuring the gatekeeper. If the user should be given access to resources on different networks, that access can be specified at **504** by a single entity and propagated to the corresponding gatekeepers of those networks, or the individual gatekeepers can each be manually configured. In some embodiments the credentials used by a user such as Alice may vary across gatekeepers. For example, Alice may connect to gatekeeper **110** using a name/password pair, and connect to gatekeeper **112** using a digital certificate. In such case, the user and policy databases maintained by those gateways may link Alice's accounts such as by associating each of her accounts with a unique identifier.

FIG. **6** is a flow chart illustrating an embodiment of a process for establishing a session with a gatekeeper. In some embodiments the process is performed by client **102**. The process begins at **602** when agent **150** is started. In some embodiments agent **150** is configured to load whenever client **102** is booted or whenever a user such as Alice logs into client **102**. Agent **150** can also be configured to load only when Alice takes an action such as clicking on a program icon. In various embodiments, Alice is required to provide credentials to agent **150** before she is granted access to it.

At **604**, the agent connects to the first preconfigured gatekeeper (e.g., specified at **404** in the process shown in FIG. **4**) and performs a handshake.

At **606**, the agent receives instructions that indicate how authorized resources can be accessed. As described in more detail below, the instructions might include information on port binding/forwarding.

At **608**, the agent follows the instructions received at **606** and awaits service connection requests. For example, at **608** the agent might bind a service to localhost port **6000** and await the user's use of that port.

FIG. **7** is a flow chart illustrating an embodiment of a process for establishing a session with a client. In some embodiments the process shown in FIG. **7** is performed by gatekeeper **110**. The process begins at **702** when a client connection request is received. For example, at **702** a connection request is received from client **102**. At **704**, authentication is requested from the client. At **706**, the received credentials are validated.

At **708**, an on-demand access policy is compiled and sent to the client. For example, at **708** each of the databases **302-308** is queried for entries pertaining to the user of the client and instructions are transmitted to the client that indicate how the client may access the resources enumerated in the compiled access policy.

Suppose, for example, that Alice is establishing a session with gatekeeper **112**. On network **108**, Alice is authorized to access Linux server **122** and switch **126** using the FTP, SSH, and telnet services, but is not authorized to access router **124** at all, and is not authorized to access any other services on nodes **122** or **126**. Also suppose that Linux server **122** supports all three services, while router **124** only supports the telnet service. At **708**, client **102** receives instructions to port forward 127.0.0.1 port 21 to Linux server **122**'s FTP service, forward 127.0.0.1 port 22 to Linux server **122**'s SSH service, forward 127.0.0.1 port 23 to Linux server **122**'s telnet service, and forward 127.0.0.2 port **123** to router **126**'s telnet service. Per the received instructions, agent **150** will bind to the local port, set up a listener, and the listener will port forward as appropriate.

In some embodiments, rather than forwarding directly to the service, agent **150** is instructed to forward localhost to a

port on the gatekeeper, which in turn forwards to the appropriate resource. In such a case, a unique identifier is used by the gatekeeper to map the localhost and remote resource to one another. By using this technique, encryption can be used in the communications between client **102** and resources that might typically otherwise be sent in the clear, such as communications sent to an ODBC port. Additionally, the IP address of the resource need not be exposed to client **102**. If client **102** is lost or stolen, a nefarious individual attempting to connect to remote resources will be thwarted accordingly.

Suppose another administrator, Charlie, is in charge of administering a subset of ten of the twenty five database servers in the Denver office (network **106**), and should be granted access to the ODBC port (and nothing else) on each of those servers. If the process shown in FIG. **7** were performed with respect to Charlie, at **708** Charlie's client might receive instructions that his agent **150** should port forward 127.0.0.1-127.0.0.10 to each of those databases, respectively. Charlie's client may also be configured to use a single address but different TCP port numbers for each of the databases (e.g., 127.0.0.1:6000-127.0.0.1:6009) as applicable. Typically, database servers offer many services. By using the techniques described herein, administrators may only access those services access to which they are authorized.

At **710**, a session has been established and, as described in more detail below, the gatekeeper can be configured to listen for services to be used (e.g., connection requests to be made).

FIG. **8** is a flow chart illustrating an embodiment of a process for communicating information across a plurality of networks. The process shown in FIG. **8** can be used to perform cross network, cross platform, and/or cross protocol exchanges. In some embodiments the process shown is performed by client **102**. The process begins at **802** when information is accessed at a first location. Suppose Alice wishes to copy a file from Windows server **116** in network **106** to Linux server **122** in network **108**. Windows server **116** supports SMB on port **139**. Linux server **122** supports SSH on port 22. At **802**, Alice accesses the file by using native tools on her laptop, such as by navigating to the directory in which the file is located with the Windows file explorer. When Alice navigates to \\localhost:139, a connection is made to an SMB mount on Windows server **116**.

At **804**, the information is transferred from the first network to the second network. For example, at **804** Alice might open a tool such as an scp program, right click the file on Windows server **116** as shown in the file explorer window, and copy and paste it into the scp program. Agent **150** facilitates the copying of the file from Windows server **116** to Linux server **122** in a manner transparent to Alice. In various embodiments, a graphical user interface (GUI) may also be provided to client **102** which shows a list of the resources available via agent **150** and launches applications, etc. as the user interacts with the GUI.

The techniques described herein also allow administrators to run tools local to their clients against remote resources. For example, suppose Charlie (a database administrator) has a set of database diagnostic tools on his laptop that can be configured to work against a local database. By port forwarding his localhost to a remote database, Charlie is able to run his tools on the remote database. Additionally, it is possible that Charlie's database diagnostic tools may be buggy or otherwise harmful. Because he is constrained to accessing a small subset of the network, his tools are less likely to have catastrophic effects on the network at large if they behave in an undesirable manner.

FIG. **9** is a flow chart illustrating an embodiment of a process for communicating information across a plurality of networks. In some embodiments the process shown in FIG. **9** is performed by a gatekeeper such as gatekeeper **110**. The process begins at **902** when a request specific to a particular device and service is received. For example, after portion **608** of the process shown in FIG. **6** is performed, agent **150** may observe that a user is attempting to communicate with a particular localhost port. At **902**, a connection request is received by gatekeeper **110** accordingly. As applicable, decryption is performed and at **904**, the requested resource is mapped to the actual resource. For example, at **904** requests intended for the SSH port of Linux server **122** received by gatekeeper **112** are mapped to the IP address of Linux server **122**. At **906**, information destined to/from client **102** and the intended destination (e.g., Linux server **122**) is bi-directionally forwarded.

Auditing Communications

FIG. **10** is a block diagram illustrating an embodiment of an environment having communication auditing. In the example shown, client **1002** includes an agent **1008**. An administrator would like to execute two jobs (**1010** and **1012**) on a periodic basis, without having to be logged into client **1002** at the time. Suppose the administrator would like job **1010** to execute at midnight and the administrator would like job **1012** to run at three in the morning and that both jobs include transmitting information to server **1006**. In the example shown, server **1006** is a production server with thousands of ports. In some embodiments client **1002** and server **1006** are members of disjoint networks, such as is the case with client **102** and Windows server **116** in FIG. **1**. In some embodiments client **1002** and server **1006** are on two segments of an intranet.

In a traditional environment, end users might be permitted to access server **1006** to perform assorted tasks and an administrator might be permitted to make direct connections to ports such as UDP port **1014** and TCP port **1016** (and any of the other thousands of ports on server **1006**). In such a scenario client **1002** would typically be permitted to access server **1006** at all times—not just at midnight and three. In the example shown, however, direct connections from client **1002** to administrative ports **1014** and **1016** are not permitted, as indicated in FIG. **10** by line **1018** being crossed out.

Using the techniques described herein, gatekeeper **1004** is placed between client **1002** and server **1006**. In some embodiments client **1002** is client **102**. In some embodiments client **1002** is a server such as Linux server **122**. Agent **1008** is configured to emulate the actions a user might take if the user were actively using client **1002**. For example, and as described in more detail below, agent **1008** can be configured to store credentials and automatically provide them to gatekeeper **1004** upon request.

In the example shown, in order for jobs **1010** and **1012** to run successfully, client **1002** must authenticate itself to gatekeeper **1004** and gatekeeper **1004** must confirm that the resources requested by client **1002** are authorized for use by client **1002**. Agent **1008** is configured to port forward localhost ports on client **1002** to gatekeeper **1004** as applicable. Jobs **1010** and **1012** are configured to make use of resources by their local address. For example, suppose job **1010** is a shell script. At the top of the file a list of variables might be provided, one of which specifies the local address and port (e.g., 127.0.0.1:25) that forwards to the desired remote resource.

If the administrator attempts to run job **1010** before midnight, gatekeeper **1004** will not forward information to server **1006**. As a result, while the job may run locally, when it attempts to access port 127.0.0.1:25, the connection attempt will fail. If the administrator attempts to run job **1010** at

midnight, however, connection attempts to port 127.0.0.1:25 will succeed and the job will be able to execute as planned.

FIG. **11** is a flow chart illustrating an embodiment of a process for auditing a communication. In some embodiments the process shown is performed by gatekeeper **1004**. The process begins at **1102** when credentials are received from a client such as client **1002**. As described in more detail below, the credentials received at **1102** may be automatically supplied by an agent such as agent **1008**, without the intervention of a user.

At **1104** it is determined whether the client is authorized to communicate with any remote resources. For example, at **1104** the user credentials are verified and gatekeeper **1004** determines whether the client (using the user's credentials) is authorized to access any resources and if so, whether any time constraints associated with use of those resources are satisfied.

If it is determined that the client is authorized to communicate with resources, at **1106** communications are forwarded from the client to the resource. In some embodiments communications are forwarded bidirectionally. Gatekeeper **1004** can be configured to cease performing the forwarding of **1106** for a variety of reasons. For example, authorization may be granted based on a specified session length—job **1010** may be permitted to run for a window of time of up to an hour, at which point in time access by client **1002** of server **1006** is revoked. In other embodiments, if a process is still running when the designated time limit is reached, a grace period (e.g., of an additional 30 minutes) may be provided, or additional steps may be taken such as paging the administrator responsible for the job.

FIG. **12** is a flow chart illustrating an embodiment of a process for auditing a communication. In some embodiments the process shown is performed by client **1002**. The process begins at **1202** when agent **1002** is started. In some embodiments agent **1202** is configured to start at startup, such as by using/etc/init.d or other startup script. In some embodiments the agent is configured to start just prior to any jobs that make use of the script. For example, if job **1010** is executed as a cron job, the cron entry may include execution of the agent as the first command, with the execution of the job listed as a second command, separated by a semicolon.

At **1204**, agent **1008** connects to the first preconfigured gatekeeper (e.g., specified at **404** in the process shown in FIG. **4**) and performs a handshake. In the example shown, user credentials are provided automatically. For example, during configuration of agent **1002**, a user might be presented with the option of checking a box to save entered credentials and have them automatically provided when needed.

At **1206**, the agent receives instructions that indicate how authorized resources can be accessed. At **1208**, the agent follows the instructions received at **1206** and awaits service connection requests. For example, at **1208** the agent might bind a service to localhost port **6000**.

In some embodiments a user's access to a resource may be set to always on (no time restriction). One scenario in which an always on access level might be set is if a particular job makes frequent regular use of a service (e.g., every hour). Nonetheless, it is still possible to determine which user is responsible for the recurring job, and the user is still confined to a specific port, and security benefits are realized accordingly.

Automatic Intervention

FIG. **13**A is a block diagram illustrating an embodiment of an environment having network security. In the example shown, client **1302** is used by an administrator to configure and maintain router **1306**. Router **1306** may be one of a variety of routers. For example, router **1306** may be sophisticated and new, offering many of its own security features. Router **1306** may also be ten years old. The techniques described herein can be used to extend security features to either such router.

As described in more detail below, gatekeeper **1304** facilitates communications between client **1302** and router **1306**. For example, in some embodiments gatekeeper **1304** serves a Java applet to client **1302** configured such that a user can use the Java applet to communicate with router **1306**. Router **1306** is connected to additional devices such as server **1308** and server **1310**. By using the techniques described herein, a user of client **1302** can be prevented from roaming from router **1306** to those devices.

FIG. **13**B is a block diagram illustrating an embodiment of an environment having network security. In the example shown, client **1352** is used by an administrator to configure and maintain server **1356**. Gatekeeper **1354** facilitates communications between client **1352** and server **1356**. For example, in some embodiments gatekeeper **1354** serves a Java applet to client **1352** configured such that a user can use the Java applet to communicate with server **1356**. As described in more detail below, in some embodiments an agent **1358** resident on server **1356** monitors for socket open attempts. Server **1356** is connected to additional devices such as servers **1360** and **1362**. By using the techniques described herein, a user of client **1352** can be prevented from roaming from server **1356** to those devices.

FIG. **14** is a flow chart illustrating an embodiment of a process for detecting unauthorized commands. In some embodiments the process shown in FIG. **14** is performed by gatekeeper **1304**. The process begins at **1402** when a monitored session between a client and a network resource is provided. For example, at **1402** a client such as client **1302** requesting access to router **1306** authenticates itself to gatekeeper **1304**. After verifying client **1302**'s credentials, gatekeeper **1304** serves a Java applet to client **1302** that allows the user of client **1302** to communicate with router **1306**. In various embodiments, the applet provided by gatekeeper **1304** supports common protocols (which can be used, e.g., if client **1302** doesn't have an appropriate native client) and is preconfigured with the information needed for client **102** to communicate with router **1306**. In some embodiments the applet provided is one of the applets **310** shown in FIG. **3**.

Gatekeeper **1304** is able to monitor the bidirectional data stream between client **1302** and router **1306** and can capture the user's keystrokes as well as the output of the router during the session. In some embodiments the data stream is logged to a syslog server and can be subsequently used forensically and/or to diagnose historical network problems. At **1404** gatekeeper **1304** monitors for indications that a user is attempting to execute an unauthorized command. For example, at **1404** gatekeeper **1304** determines whether a user is attempting to roam from the router out to server **1308** or **1310**.

A variety of techniques can be used to detect attempts at unauthorized commands. In some embodiments a blacklist is used. Routers typically have a finite set of commands that administrators may use to manipulate the router. Commands that establish outgoing connection attempts, such as SSH and telnet can be added to a blacklist of commands for which gatekeeper **1304** monitors the keystrokes sent by client **1302** to router **1306**. If blacklisted commands are detected, gatekeeper **1304** can intercept the command before it is passed to router **1306** (**1406**).

When gatekeeper **1304** intervenes it can take a variety of actions—for example, it can drop the command or replace the command with a bogus command that is passed onto router

1306 as a typo so that the router rejects it. In some embodiments gatekeeper 1304 echoes a warning back to client 1302 that an unauthorized attempt to roam has been detected and logged and that any additional attempts will trigger a call to law enforcement, result in the locking of the user's account, etc. Irrespective of whether law enforcement will actually be contacted, such warning messages may discourage additional attempts at roaming on the part of a curious or nefarious administrator. In various embodiments, additional information such as the client's host name and local IP address are collected in the event of an unauthorized command attempt so that if the user is behind a NAT and/or shares login and password information with other contractors, the user can be more easily identified.

Gatekeeper 1304 can also take additional silent actions such as sending an email to a supervisor or triggering a pager alert, and locking a user's account after a certain number of unauthorized attempts is received.

In some embodiments a whitelist is used to detect attempts at unauthorized commands. In such a scenario, the set of commands an administrator may send from client 1302 to router 1306 is limited to a prespecified set. Any commands not on the whitelist are intercepted by gatekeeper 1304.

In various embodiments different actions are taken by gatekeeper 1304 based on which unauthorized command is detected. For example, reboot-type commands (reboot, shutdown) might trigger a warning, while roaming commands (telnet, ssh, rlogin, connect) might be dropped. Additionally, which commands appear on a blacklist or whitelist can be defined on the gatekeeper a per user basis. Thus irrespective of whether the router supports configurable logins, a user Alice can be restricted to using three commands while a user Bob can be restricted to using five commands.

Servers such as server 1356 typically support considerably more commands than a router such as router 1306. As such, using the blacklist and whitelist approaches may not be practical or effective. For example, a user might author a script on server 1356 that calls telnet, or may rely on shell features such as tab completion to provide the server with unauthorized commands without explicitly typing them. Instead of relying on white and/or blacklists, in some embodiments server 1356 is configured with an agent that monitors for socket open attempts and kills them.

FIG. 15 is a flow chart illustrating an embodiment of a process for detecting unauthorized commands. In some embodiments the process shown in FIG. 15 is performed by server 1356. The process begins at 1502 when a monitoring agent such as agent 1358 is started. In some embodiments monitoring agent 1358 is started at server 1356's boot time.

At 1504, agent 1358 determines a list of active users such as root, nobody, ftp, etc. Monitoring agent 1358 continually looks for new logins to server 1356 and when one is detected (1506), at 1508 the monitoring agent asks gatekeeper 1354 whether the new server user has been provided by gatekeeper 1354. If so, at 1510 the monitoring agent obtains information such as the pid and uid of the new user. If any processes associated with the new user attempt to open sockets, monitoring agent kills them. Additional remediation, such as sending warning messages to the user or contacting a supervisor can also be performed, as applicable.

Although the foregoing embodiments have been described in some detail for purposes of clarity of understanding, the invention is not limited to the details provided. There are many alternative ways of implementing the invention. The disclosed embodiments are illustrative and not restrictive.

What is claimed is:

1. A gatekeeper device, comprising:

an interface configured to receive credentials from a remote client, wherein the remote client is configured to receive and follow instructions for accessing a remote resource; and

a set of one or more processors configured to:

determine that the remote client is authorized to communicate with the remote resource, wherein determining that the remote client is authorized to communicate with the remote resource includes:

determining, using the received credentials, that the remote client is authorized to access the remote resource; and

determining that one or more constraints associated with use of the remote resource are satisfied;

provide a set of instructions to the remote client indicating how the remote resource can be accessed, wherein the set of instructions includes instructions to map a port on the remote client with the remote resource;

obtain a communication from the remote client that is intended for the remote resource; and

forward, based at least in part on the determination that the remote client is authorized to communicate with the remote resource, the communication to the remote resource; and

a memory coupled to the set of one or more processors and configured to provide the set of one or more processors with instructions.

2. The gatekeeper device recited in claim 1, wherein the provided set of instructions include mapping a client local resource with the remote resource through the gatekeeper device.

3. The gatekeeper device recited in claim 1, wherein the provided set of instructions include information associated with at least one of a port binding and a port forwarding.

4. The gatekeeper device recited in claim 1, wherein determining that the one or more constraints are satisfied includes determining that a client request occurs at an authorized time.

5. The gatekeeper device recited in claim 1, wherein determining that the remote client is authorized includes determining a window of time during which a communication request from the remote client to the remote resource is authorized.

6. The gatekeeper device recited in claim 1, wherein communications from the remote client that are intended for the remote resource continue to be forwarded from the remote client to the remote resource.

7. The gatekeeper device recited in claim 1, wherein the set of one or more processors is further configured to determine whether the remote client ceases to be authorized to communicate with the remote resource.

8. The gatekeeper device recited in claim 7, wherein forwarding of communications from the client to the remote resource is refused in response to determining that the remote client is no longer authorized to communicate with the remote resource.

9. The gatekeeper device recited in claim 7, wherein forwarding of communications from the client to the remote resource is refused after a period of time upon determining that the remote client is no longer authorized to communicate with the remote resource.

10. A method, comprising:

receiving, via an interface, credentials from a remote client, wherein the remote client is configured to receive and follow instructions for accessing a remote resource;

determining, using a gatekeeper device, that the remote client is authorized to communicate with the remote

resource, wherein determining that the remote client is authorized to communicate with the remote resource includes:

determining, using the received credentials, that the remote client is authorized to access the remote resource; and

determining that one or more constraints associated with use of the remote resource are satisfied;

providing a set of instructions to the remote client indicating how the remote resource can be accessed, wherein the set of instructions includes instructions to map a port on the remote client with the remote resource;

obtaining a communication from the remote client that is intended for the remote resource; and

forwarding, based at least in part on the determination that the remote client is authorized to communicate with the remote resource, the communication to the remote resource.

11. The method of claim **10**, wherein the provided set of instructions include mapping a client local resource with the remote resource through the gatekeeper device.

12. The method of claim **10**, wherein the provided set of instructions include information associated with at least one of a port binding and a port forwarding.

13. The method of claim **10**, wherein determining that the one or more constraints are satisfied includes determining whether a client request occurs at an authorized time.

14. The method of claim **10**, wherein determining that the remote client is authorized includes determining a window of time during which a communication request from the remote client to the remote resource is authorized.

15. The method of claim **10**, wherein communications from the remote client that are intended for the remote resource continue to be forwarded from the remote client to the remote resource.

16. The method of claim **10**, further comprising, determining, using the gatekeeper device, whether the remote client ceases to be authorized to communicate with the remote resource.

17. The method of claim **16**, wherein forwarding of communications from the remote client to the remote resource is refused in response to determining that the remote client is no longer authorized to communicate with the remote resource.

18. The method of claim **16**, wherein forwarding of communication from the remote client to the remote resource is refused after a period of time upon determining that the client is no longer authorized to communicate with the remote resource.

19. A computer program product, the computer program product being embodied in a non-transitory computer readable storage medium and comprising computer instructions for:

receiving credentials from a remote client, wherein the client is configured to receive and follow instructions for accessing a remote resource; and

determining, using a gatekeeper device, that the remote client is authorized to communicate with the remote resource, wherein determining that the remote client is authorized to communicate with the remote resource includes:

determining, using the received credentials, that the remote client is authorized to access the remote resource; and

determining that one or more constraints associated with use of the remote resource are satisfied;

providing a set of instructions to the remote client indicating how the remote resource can be accessed, wherein the set of instructions includes instructions to map a port on the remote client with the remote resource;

obtaining a communication from the remote client that is intended for the remote resource; and

forwarding, based at least in part on the determination that the remote client is authorized to communicate with the remote resource, the communication to the remote resource.

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