US007533407B2

(12) **United States Patent**
Lewis et al.

(10) **Patent No.: US 7,533,407 B2**
(45) **Date of Patent: May 12, 2009**

(54) **SYSTEM AND METHODS FOR PROVIDING NETWORK QUARANTINE**

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(73) Assignee: **Microsoft Corporation**, Redmond, WA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 504 days.

(21) Appl. No.: **10/823,686**

(22) Filed: **Apr. 14, 2004**

(65) **Prior Publication Data**

US 2005/0131997 A1 Jun. 16, 2005

Related U.S. Application Data

(60) Provisional application No. 60/529,698, filed on Dec. 16, 2003.

(51) **Int. Cl.**
G06F 7/04 (2006.01)
G06F 21/00 (2006.01)

(52) **U.S. Cl.** **726/6**; 726/24; 726/25

(58) **Field of Classification Search** 726/2, 726/24, 25

See application file for complete search history.

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Assistant Examiner—Cordelia Kane
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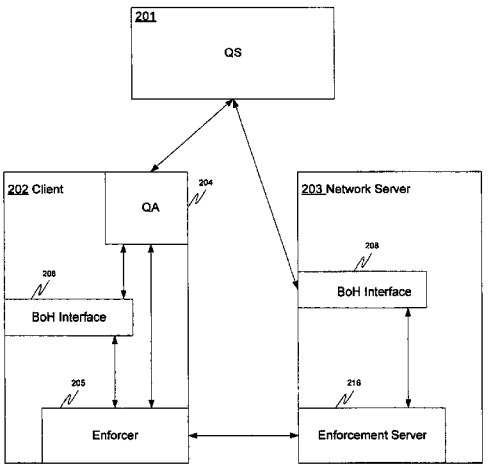
(57) **ABSTRACT**

A client quarantine agent requests bill of health from a quarantine server, and receives a manifest of checks that the client computer must perform. The quarantine agent then sends a status report on the checks back to the quarantine server. If the client computer is in a valid security state, the bill of health is issued to the client. If the client computer is in an invalid state, the client is directed to install the appropriate software/patches to achieve a valid state. When a client requests the use of network resources from a network administrator, the network administrator requests the client's bill of health. If the bill of health is valid, the client is admitted to the network. If the bill of health is invalid, the client is placed in quarantine.

16 Claims, 24 Drawing Sheets



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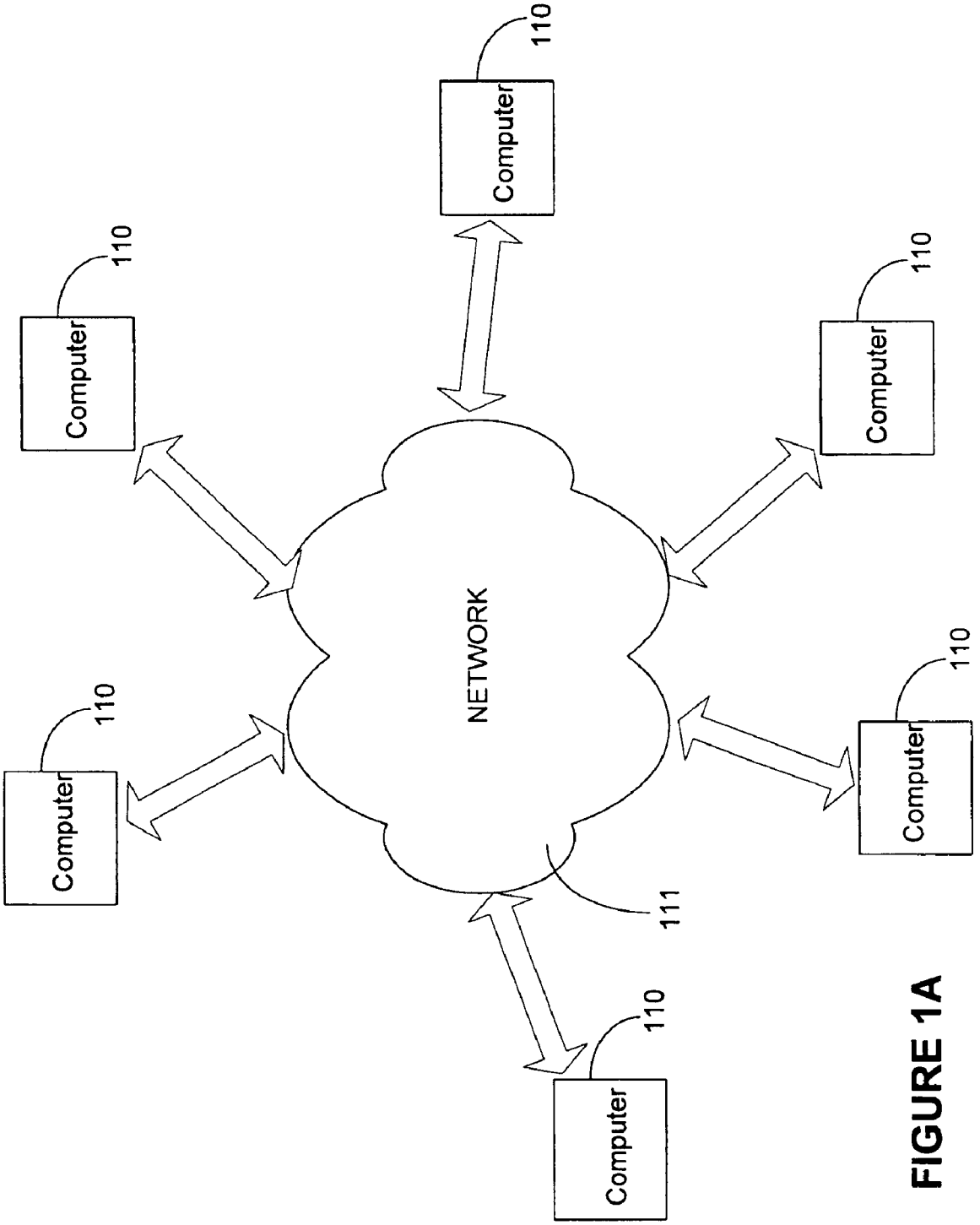

Computer
110
Computer
110
Computer
110
NETWORK
111
Computer
110
Computer
110
Computer
110

FIGURE 1A

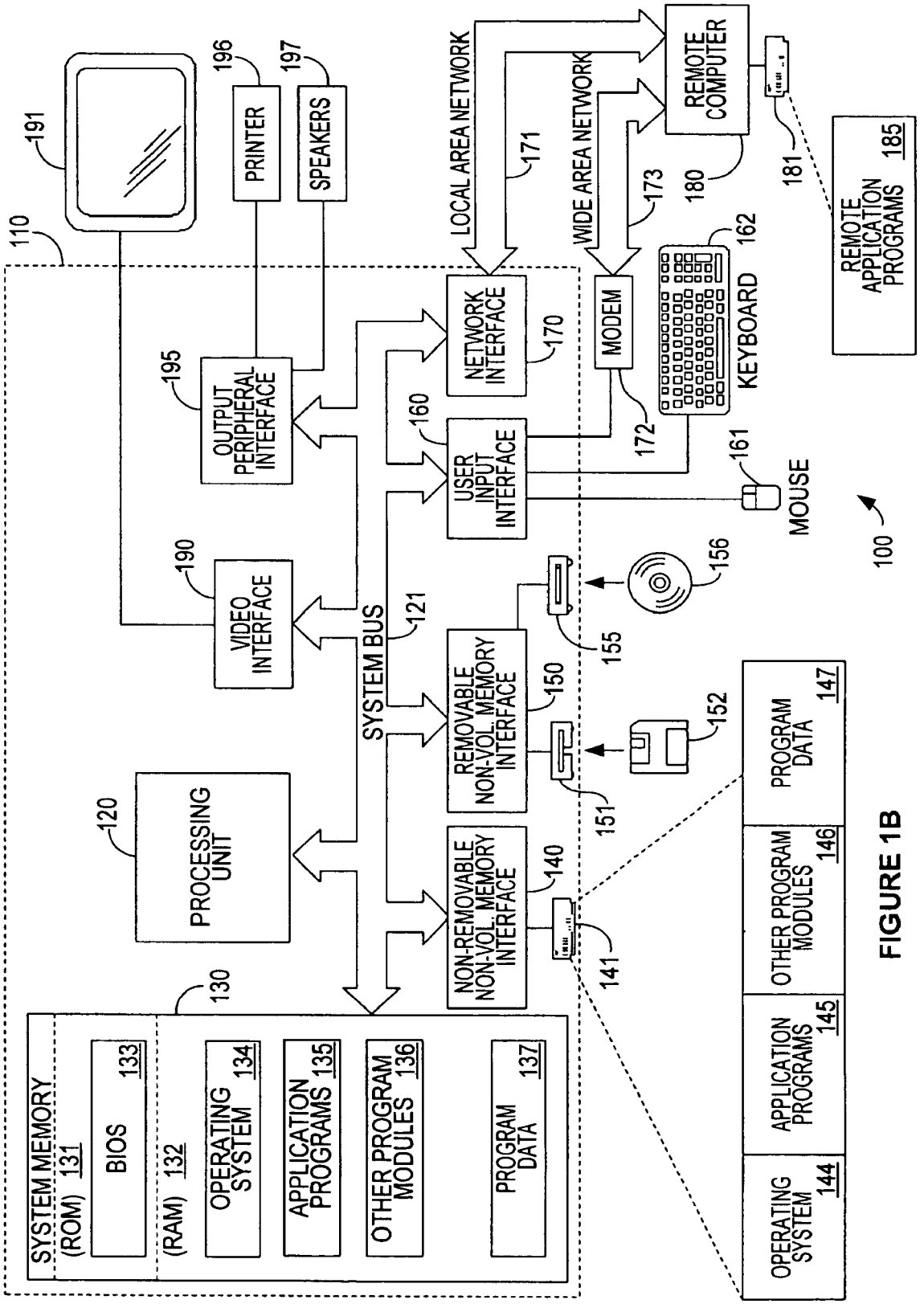

110
191
196
PRINTER
197
SPEAKERS
LOCAL AREA NETWORK
171
WIDE AREA NETWORK
173
REMOTE COMPUTER
180
181
REMOTE APPLICATION PROGRAMS 185
162
KEYBOARD
195
OUTPUT PERIPHERAL INTERFACE
NETWORK INTERFACE
170
MODEM
172
160
USER INPUT INTERFACE
161
MOUSE
100
190
VIDEO INTERFACE
121
SYSTEM BUS
156
155
REMOVABLE NON-VOL. MEMORY INTERFACE
150
152
151
120
PROCESSING UNIT
NON-REMOVABLE NON-VOL. MEMORY INTERFACE
140
141
130
SYSTEM MEMORY
(ROM) 131
BIOS 133
(RAM) 132
OPERATING SYSTEM 134
APPLICATION PROGRAMS 135
OTHER PROGRAM MODULES 136
PROGRAM DATA 137
PROGRAM DATA 147
OTHER PROGRAM MODULES 146
APPLICATION PROGRAMS 145
OPERATING SYSTEM 144

FIGURE 1B

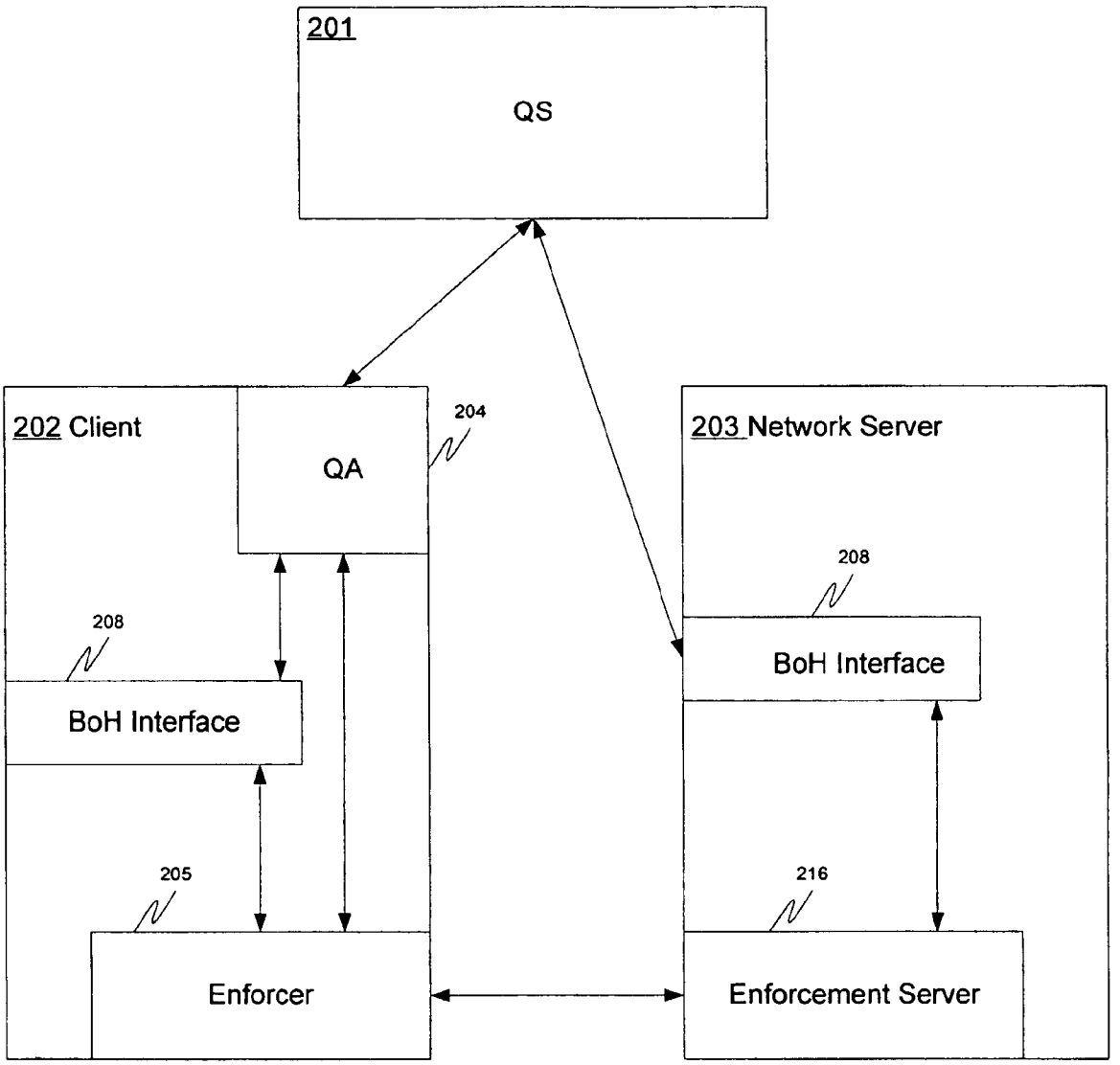

201
QS
202 Client
QA
204
203 Network Server
208
BoH Interface
208
BoH Interface
205
Enforcer
216
Enforcement Server

FIGURE 2

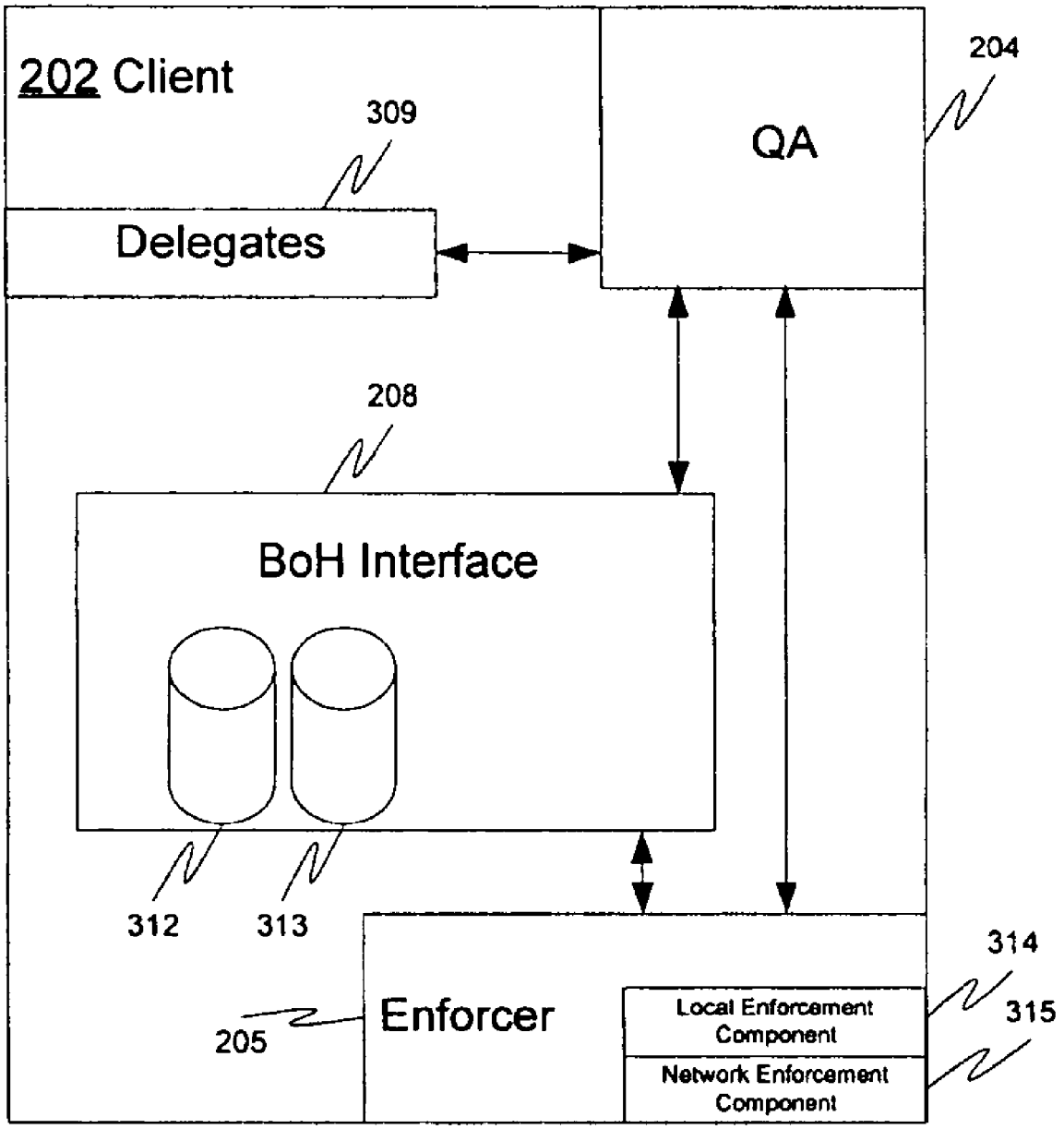

202 Client
309
Delegates
QA
204
208
BoH Interface
312
313
Enforcer
205
Local Enforcement Component
Network Enforcement Component
314
315

FIGURE 3

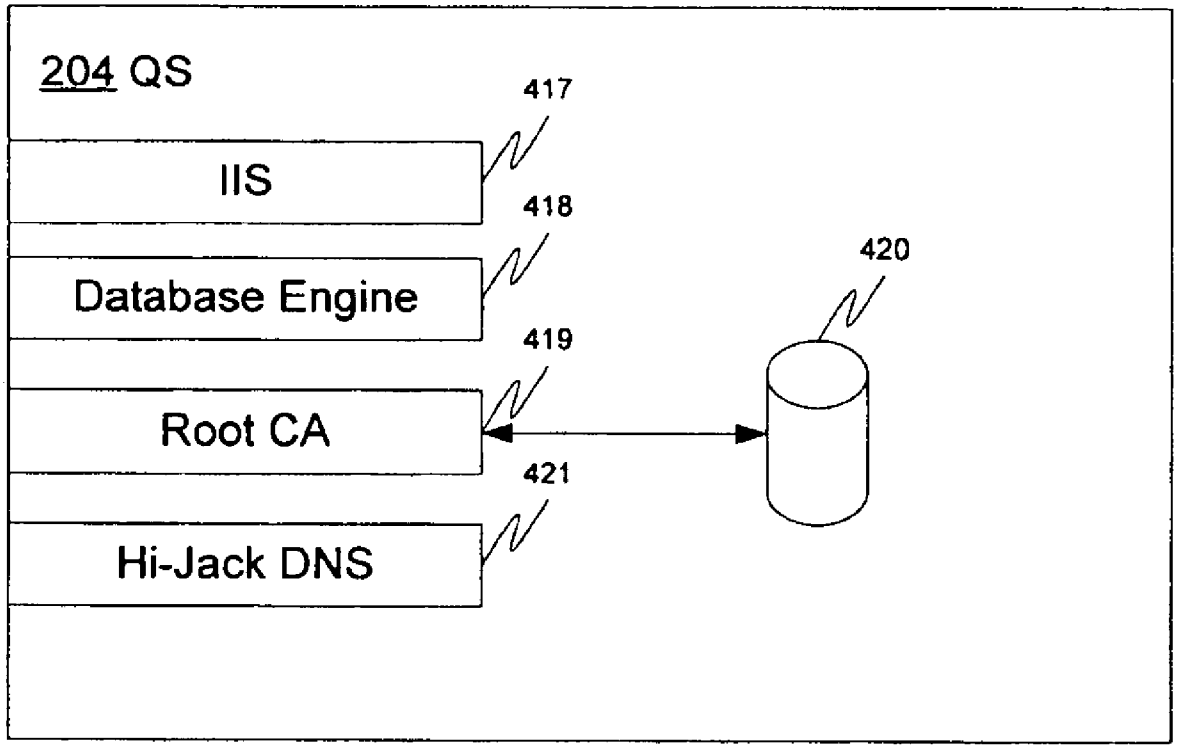

204 QS
417
IIS
418
Database Engine
420
419
Root CA
421
Hi-Jack DNS

FIGURE 4

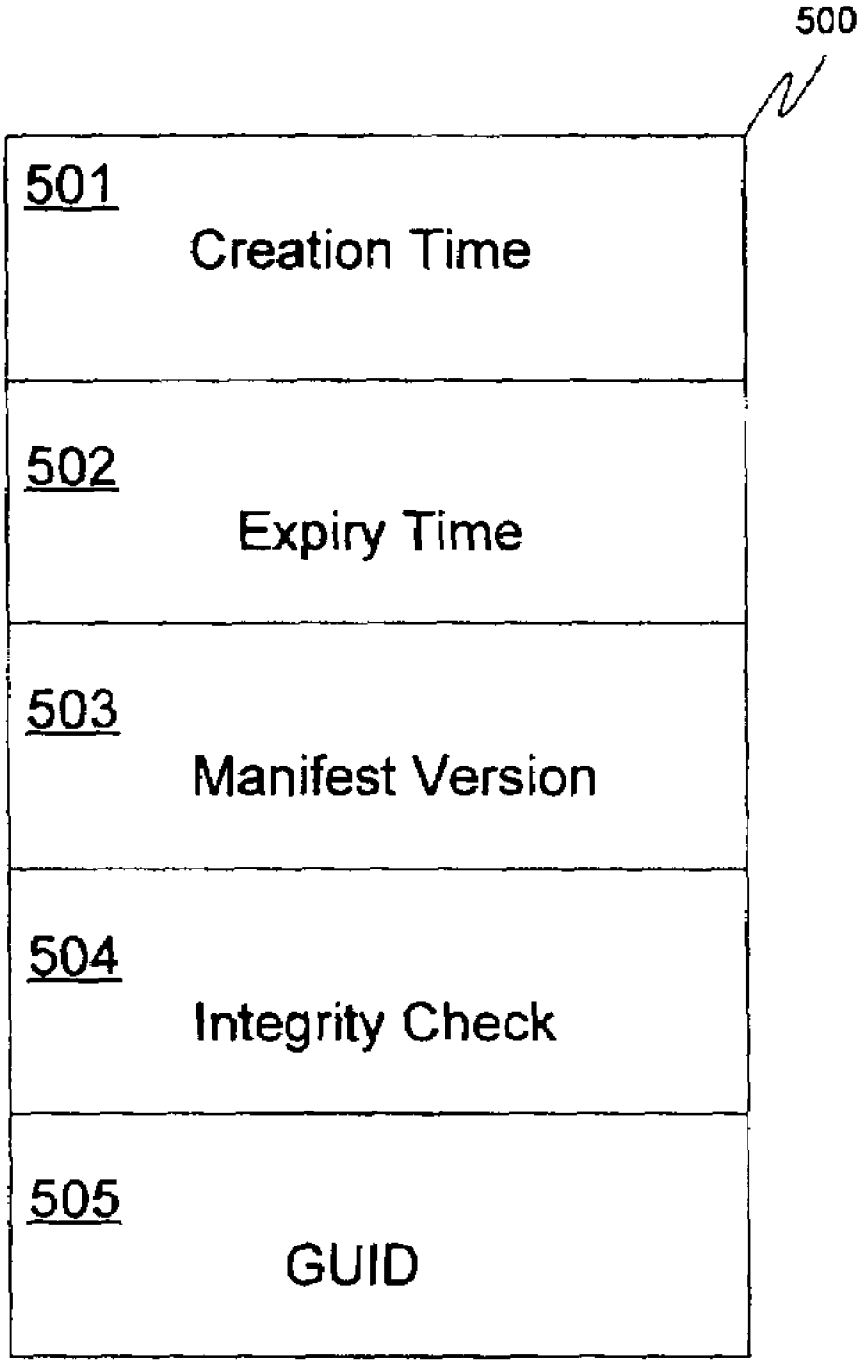

500
501
Creation Time
502
Expiry Time
503
Manifest Version
504
Integrity Check
505
GUID

FIGURE 5

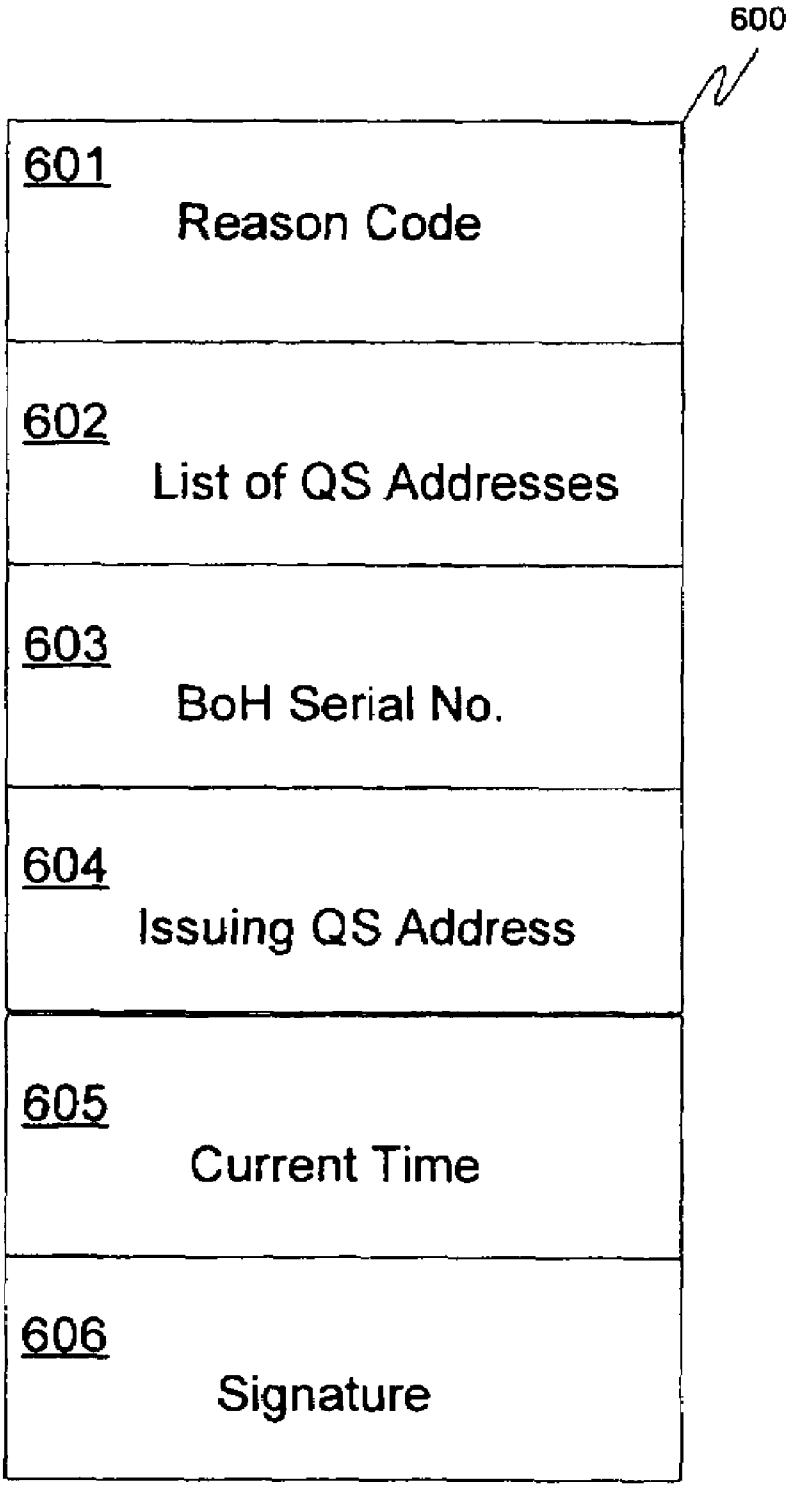
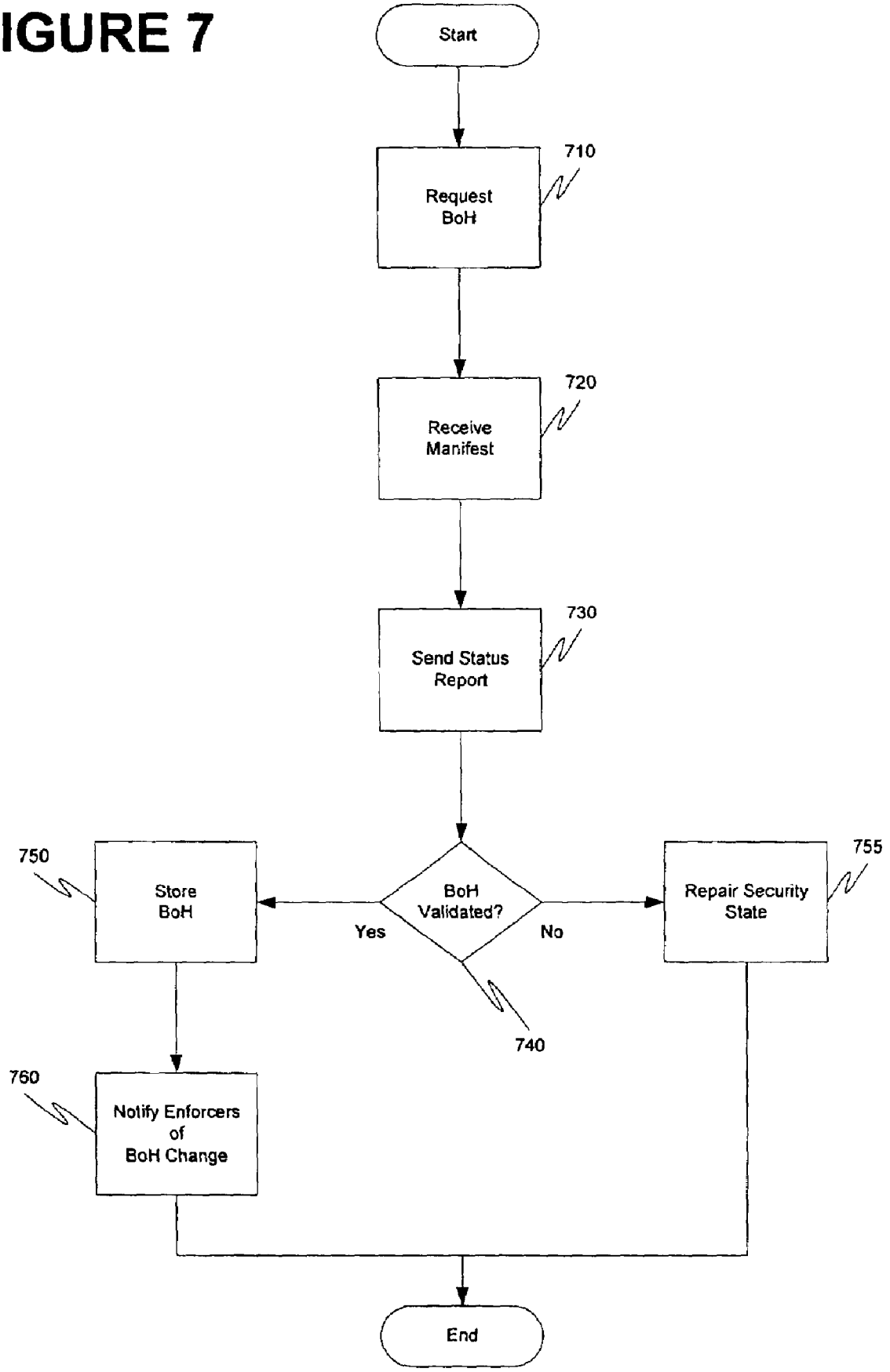

600
601
Reason Code
602
List of QS Addresses
603
BoH Serial No.
604
Issuing QS Address
605
Current Time
606
Signature

FIGURE 6

FIGURE 7


Start
710
Request BoH
720
Receive Manifest
730
Send Status Report
750
Store BoH
BoH Validated?
Yes
No
755
Repair Security State
740
760
Notify Enforcers of BoH Change
End

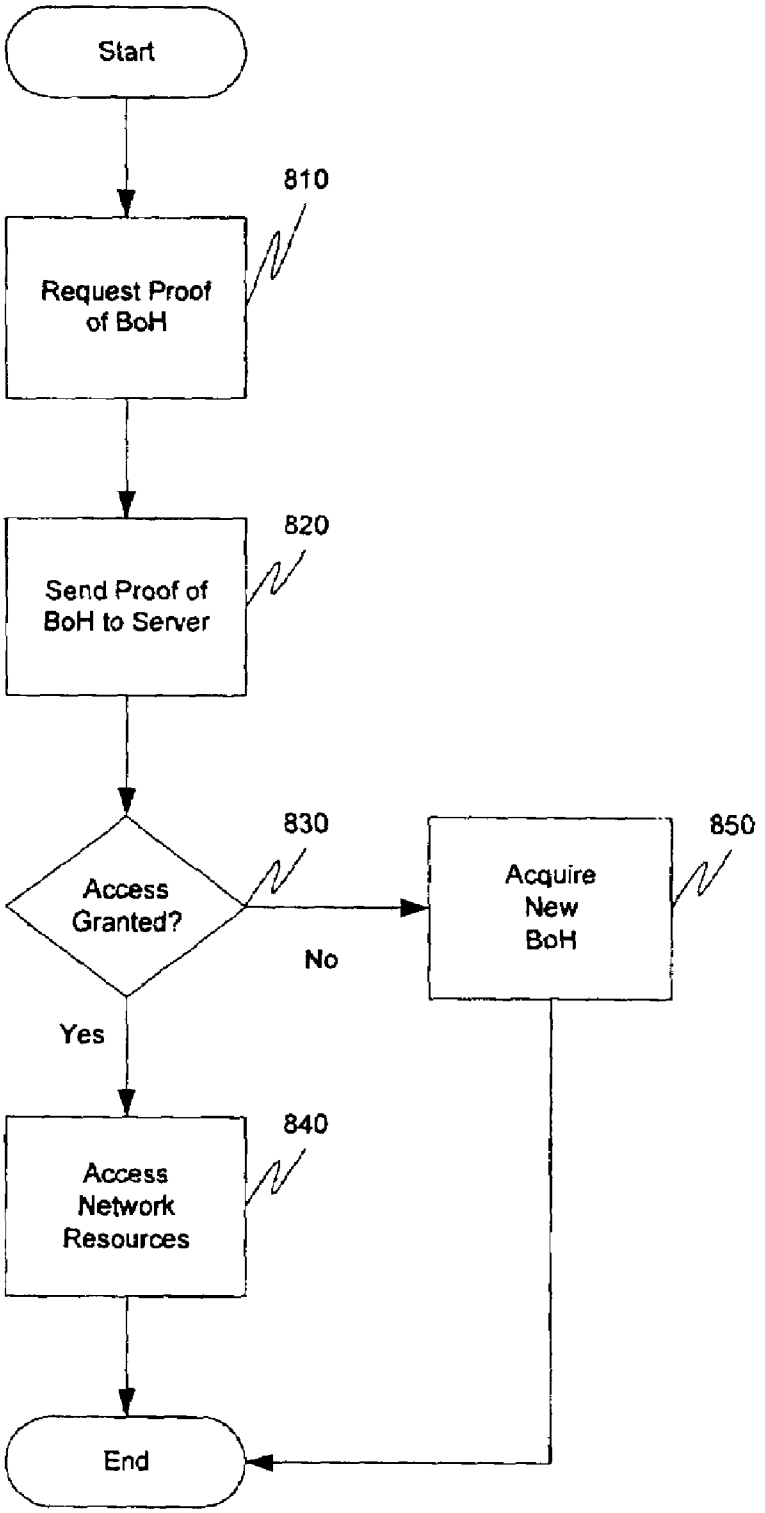

Start
810
Request Proof of BoH
820
Send Proof of BoH to Server
830
Access Granted?
No
850
Acquire New BoH
Yes
840
Access Network Resources
End

FIGURE 8A

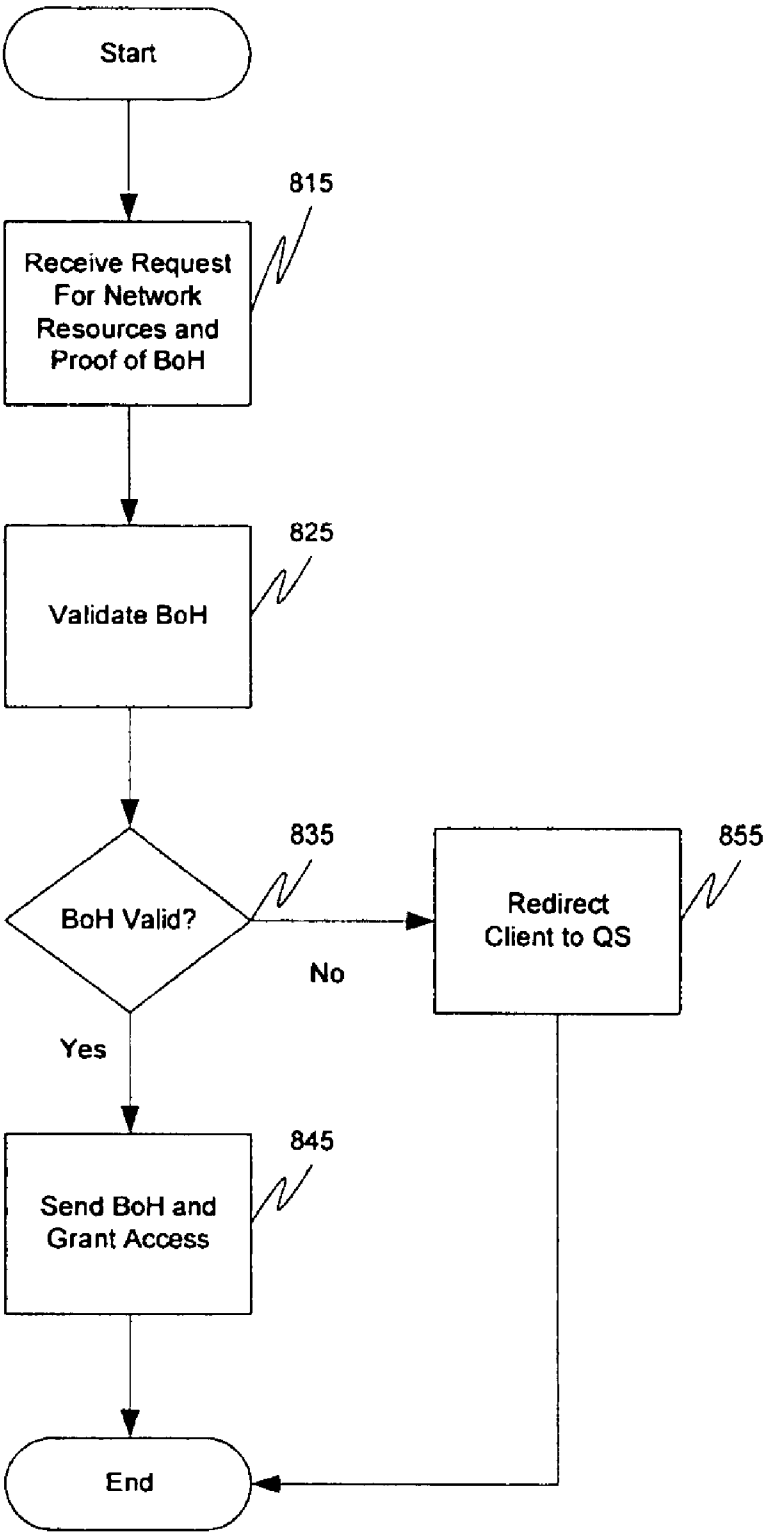
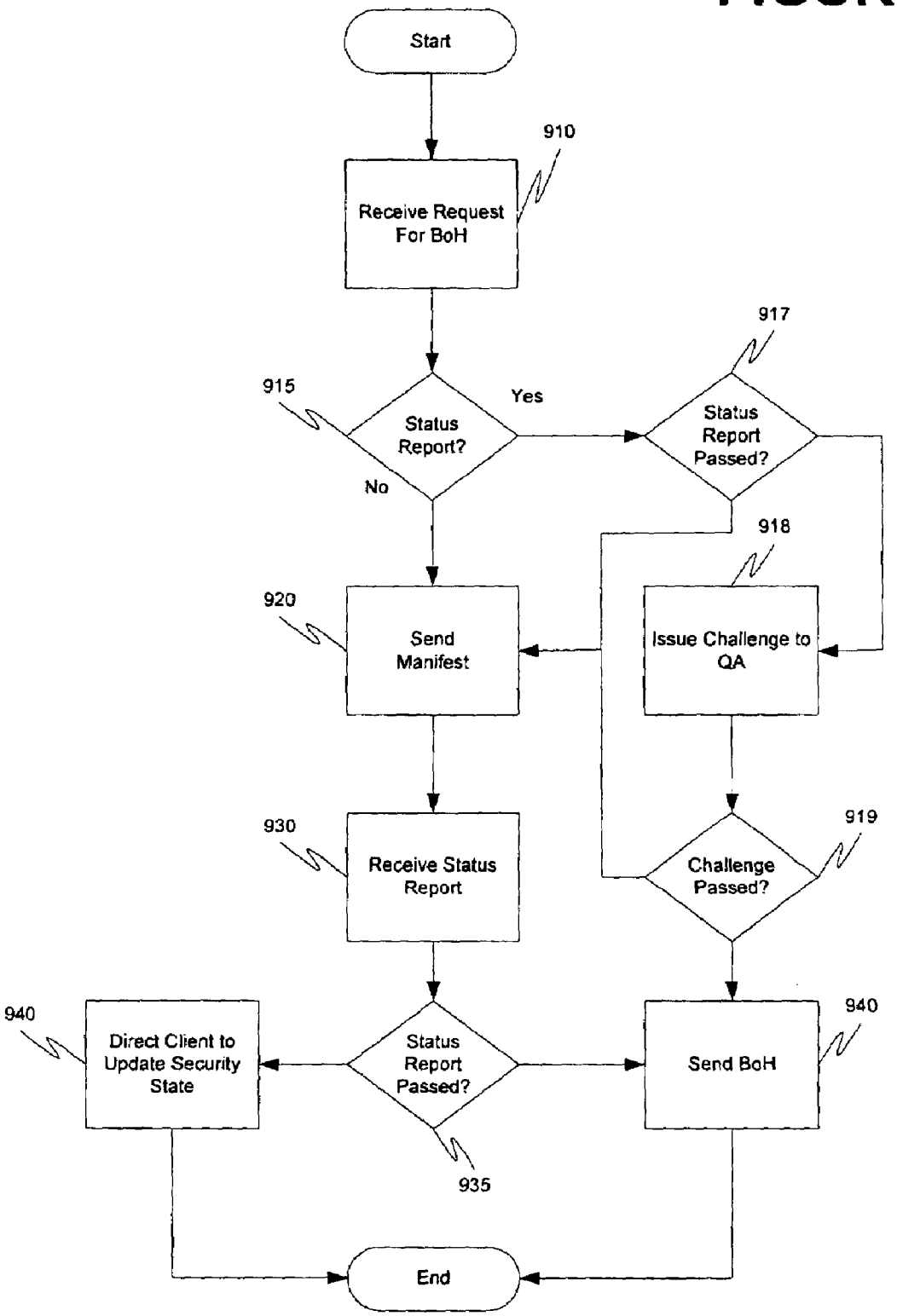

Start
815
Receive Request For Network Resources and Proof of BoH
825
Validate BoH
835
BoH Valid?
No
855
Redirect Client to QS
Yes
845
Send BoH and Grant Access
End

FIGURE 8B

FIGURE 9


Start
910
Receive Request For BoH
917
915
Status Report?
Yes
Status Report Passed?
No
918
920
Send Manifest
Issue Challenge to QA
930
Receive Status Report
919
Challenge Passed?
940
Direct Client to Update Security State
Status Report Passed?
Send BoH
940
935
End

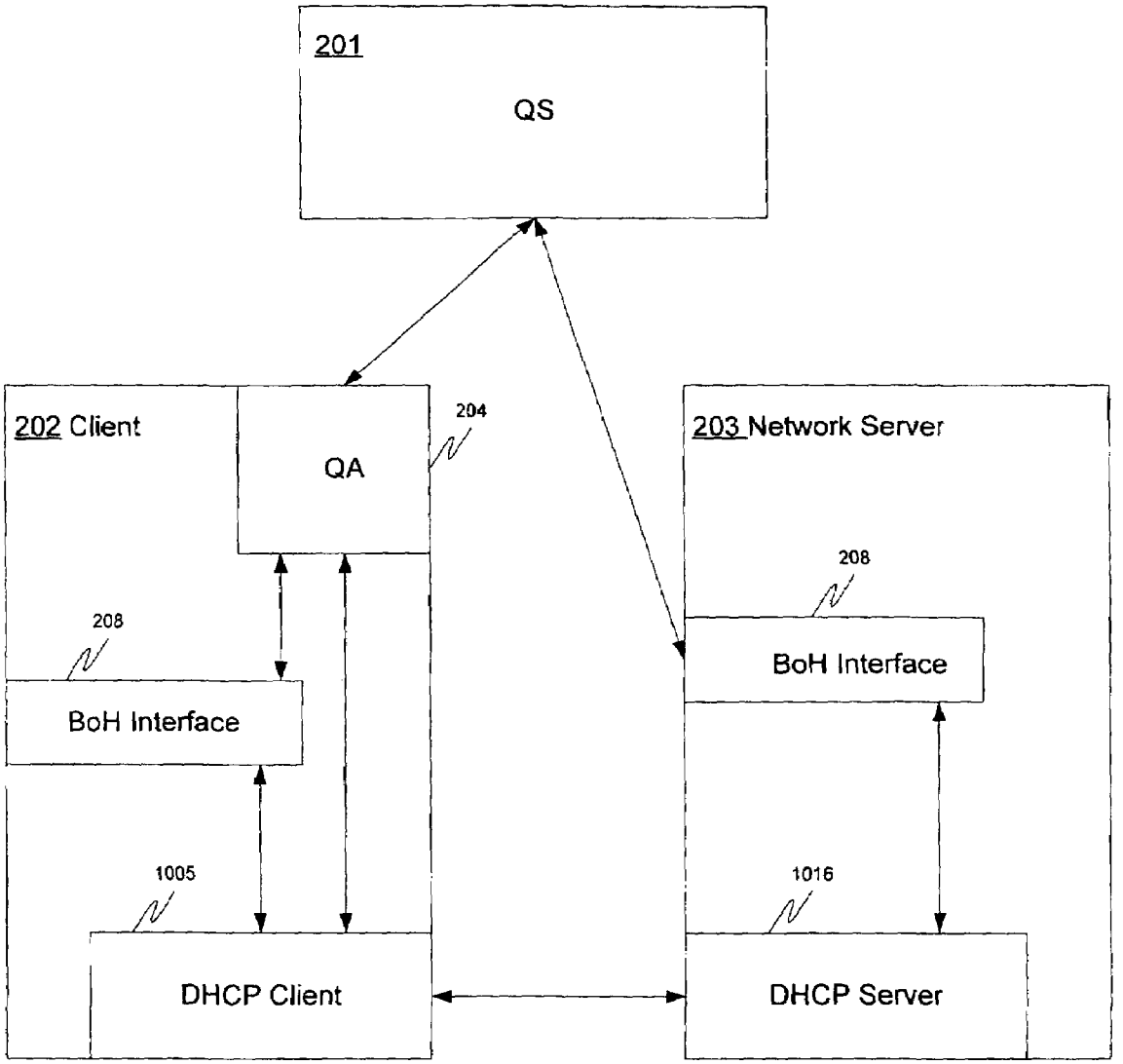

201
QS
202 Client
QA
204
203 Network Server
208
BoH Interface
208
BoH Interface
1005
1016
DHCP Client
DHCP Server

FIGURE 10

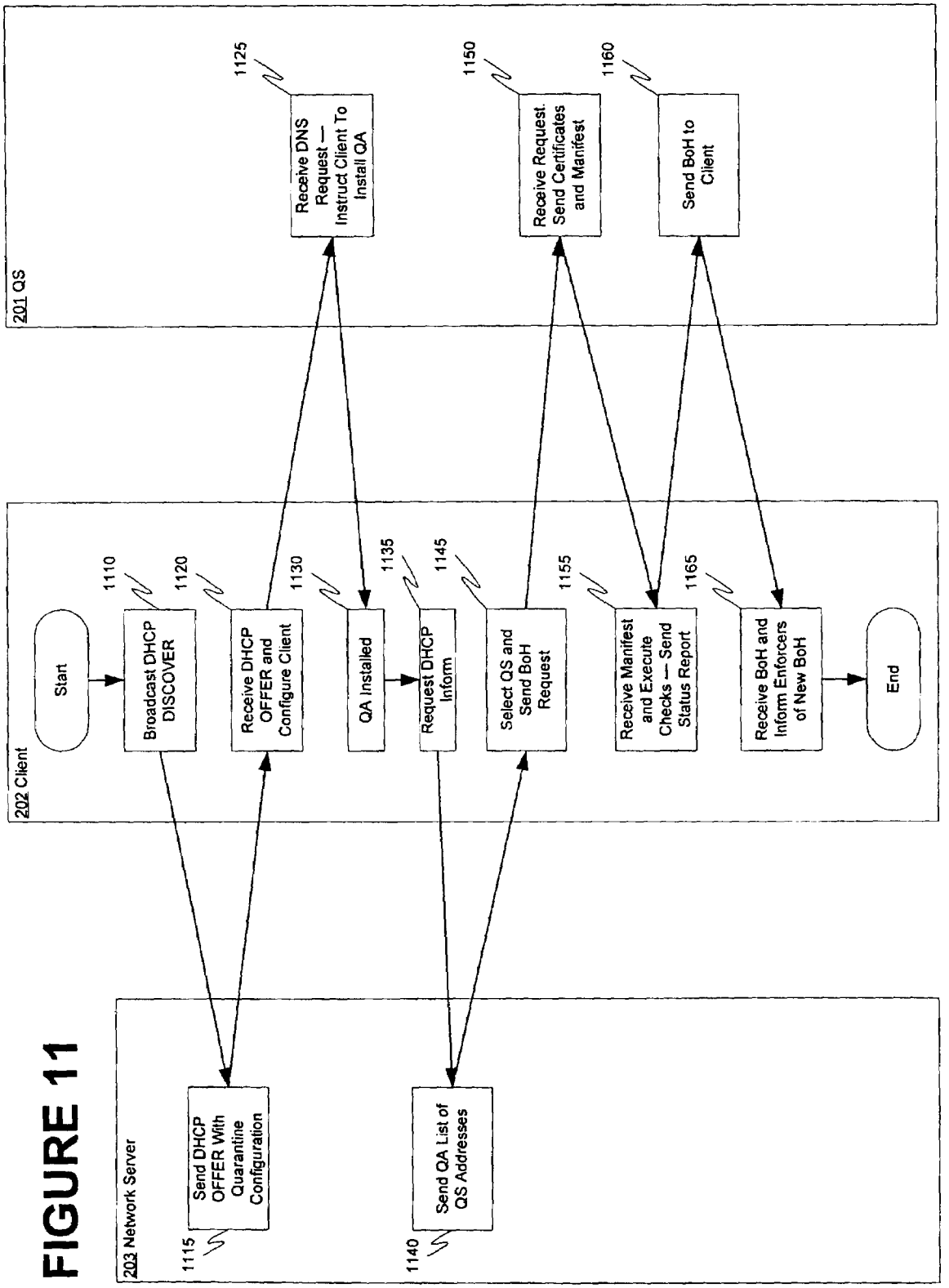
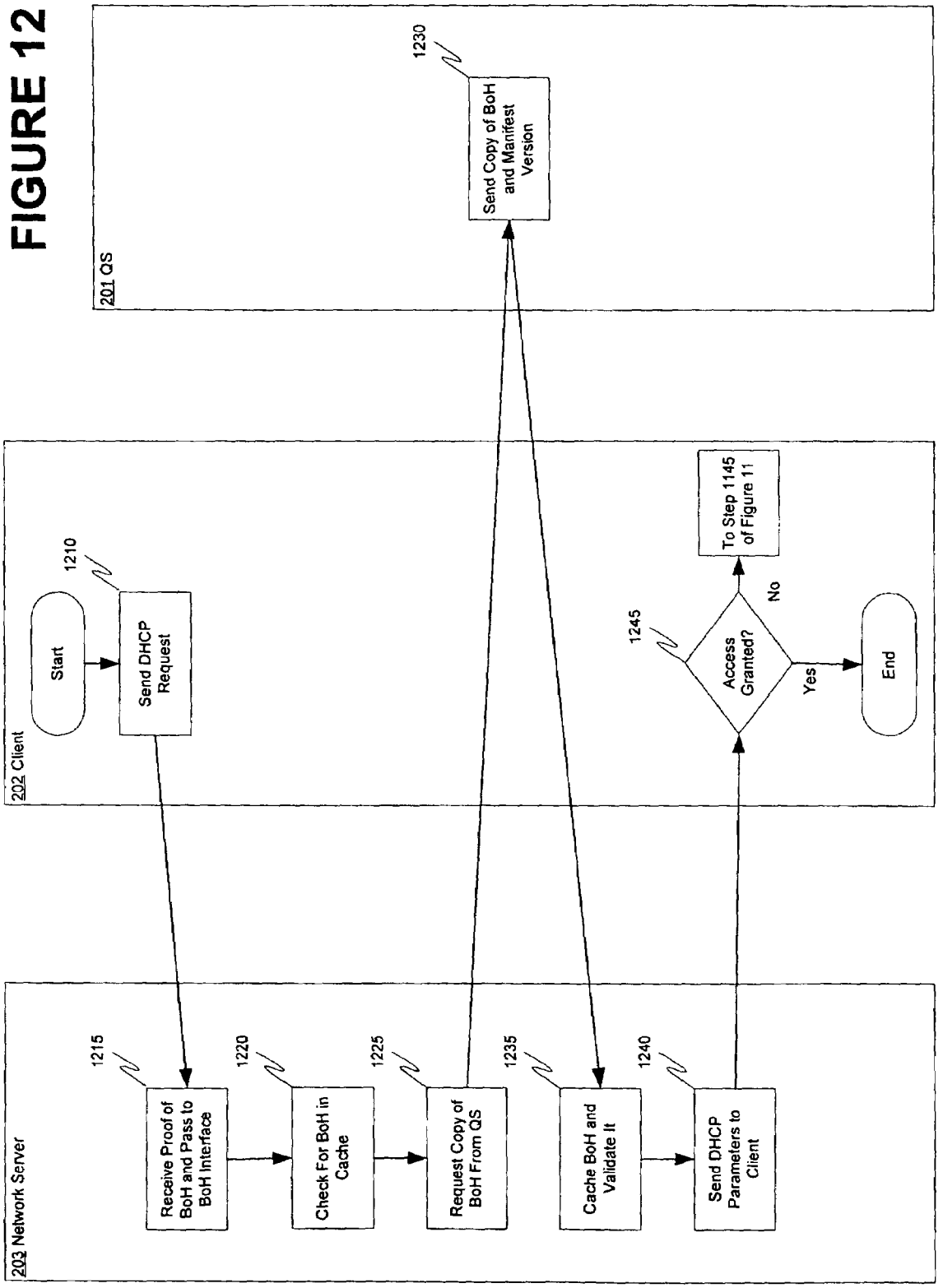

201 QS
202 Client
203 Network Server
Start
1110
Broadcast DHCP DISCOVER
1120
Receive DHCP OFFER and Configure Client
1130
QA Installed
1135
Request DHCP Inform
1145
Select QS and Send BoH Request
1155
Receive Manifest and Execute Checks — Send Status Report
1165
Receive BoH and Inform Enforcers of New BoH
End
1125
Receive DNS Request — Instruct Client To Install QA
1150
Receive Request. Send Certificates and Manifest
1160
Send BoH to Client
1115
Send DHCP OFFER With Quarantine Configuration
1140
Send QA List of QS Addresses

FIGURE 11

FIGURE 12


201 QS
1230
Send Copy of BoH and Manifest Version
202 Client
Start
1210
Send DHCP Request
1245
Access Granted?
No
To Step 1145 of Figure 11
Yes
End
203 Network Server
1215
Receive Proof of BoH and Pass to BoH Interface
1220
Check For BoH in Cache
1225
Request Copy of BoH From QS
1235
Cache BoH and Validate It
1240
Send DHCP Parameters to Client

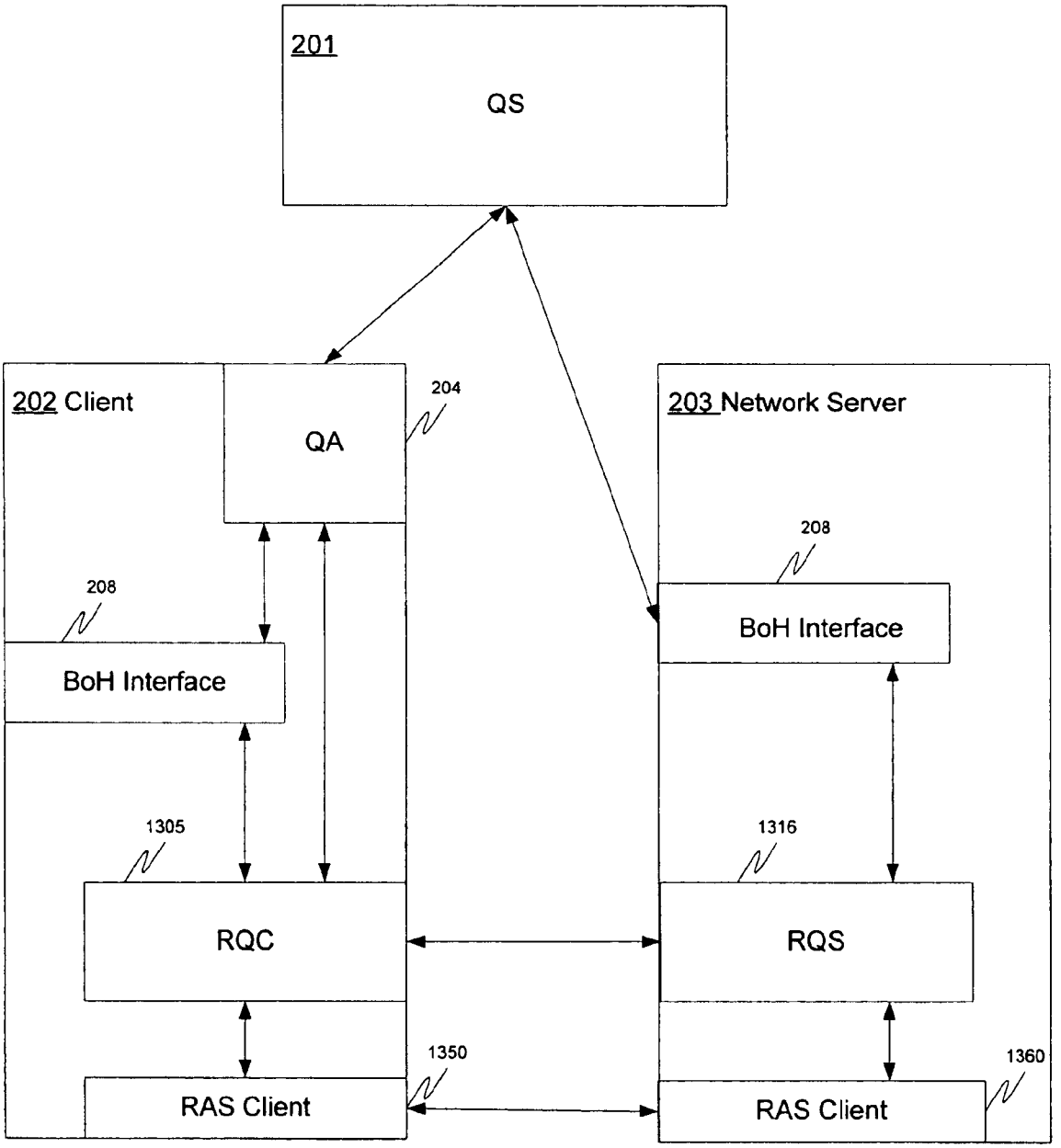

201
QS
202 Client
QA
204
203 Network Server
208
BoH Interface
208
BoH Interface
1305
RQC
1316
RQS
1350
RAS Client
1360
RAS Client

FIGURE 13

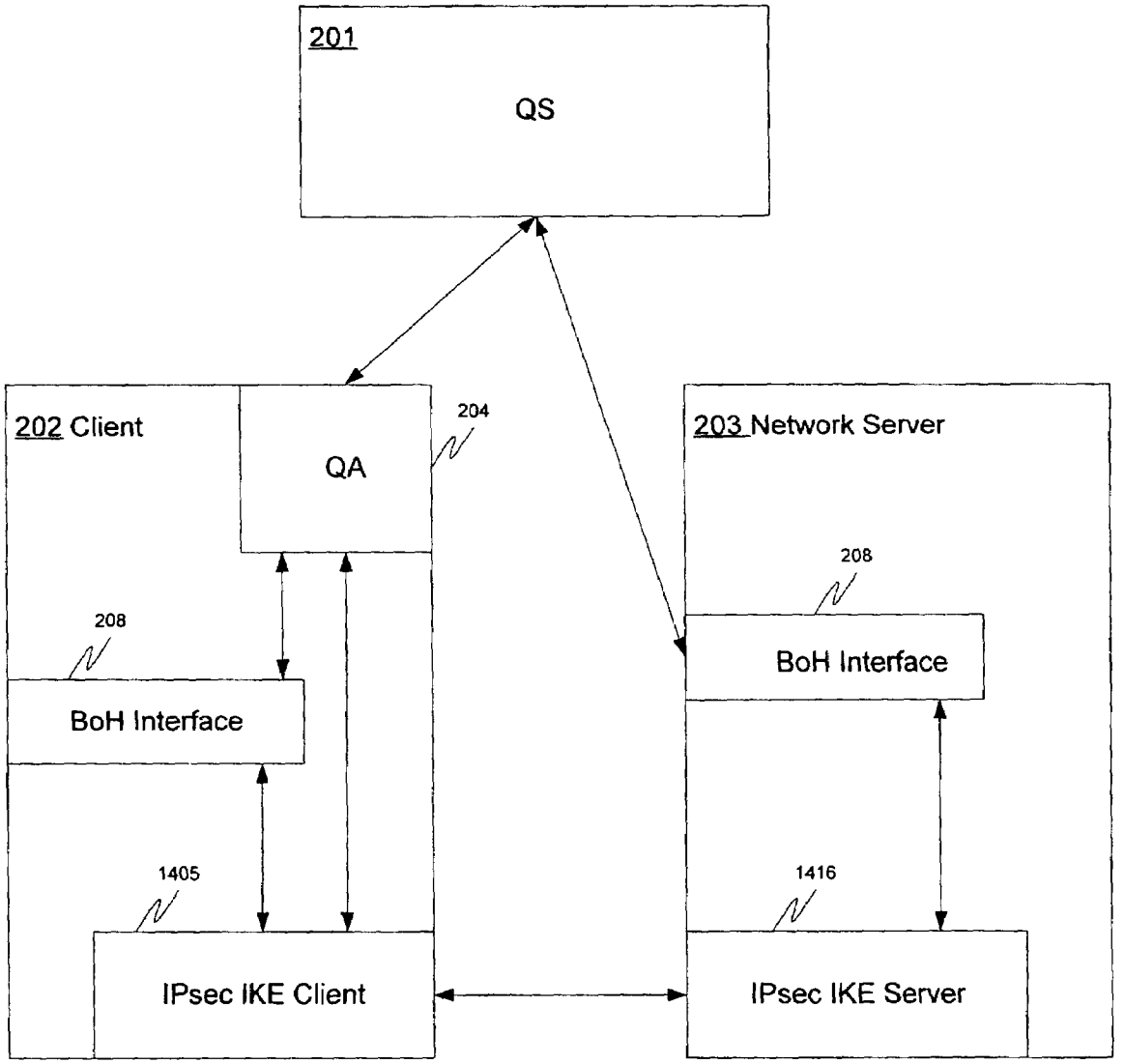

201
QS
202 Client
QA
204
203 Network Server
208
BoH Interface
208
BoH Interface
1405
1416
IPsec IKE Client
IPsec IKE Server

FIGURE 14

OPT	LEN	DATA (LEN Bytes)

FIGURE 15A

43	LEN 1	OPT	LEN 2	DATA (LEN1-2)

FIGURE 15B

43	255	220	253	TOKEN DATA (253 bytes)

FIGURE 15C

43	89	220	87	TOKEN DATA (50 bytes)	220	35	TOKEN DATA (35 bytes)

FIGURE 15D

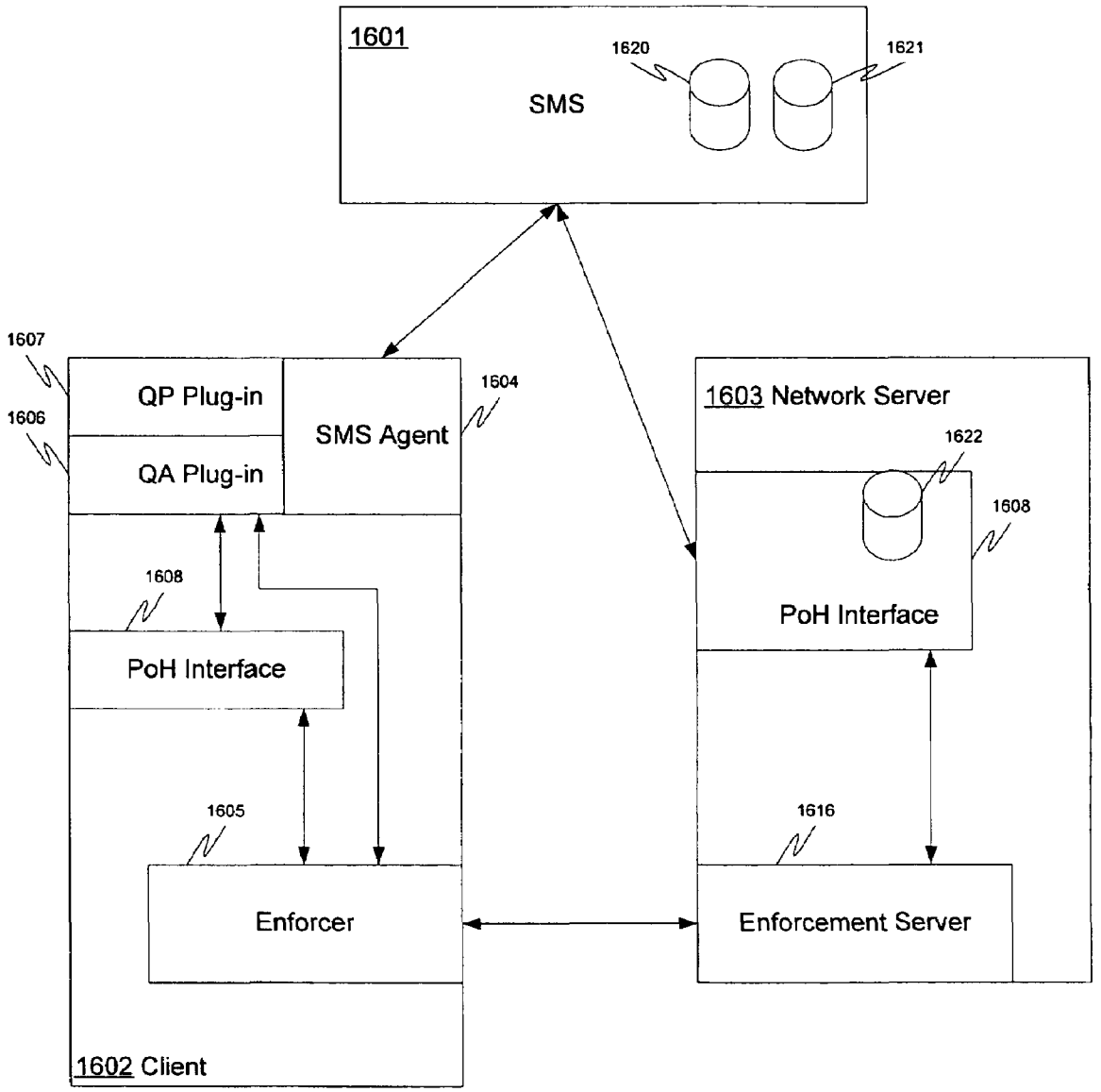

1601
SMS
1620
1621
1607
1606
QP Plug-in
QA Plug-in
SMS Agent
1604
1603 Network Server
1622
1608
PoH Interface
1608
PoH Interface
1605
Enforcer
1616
Enforcement Server
1602 Client

FIGURE 16

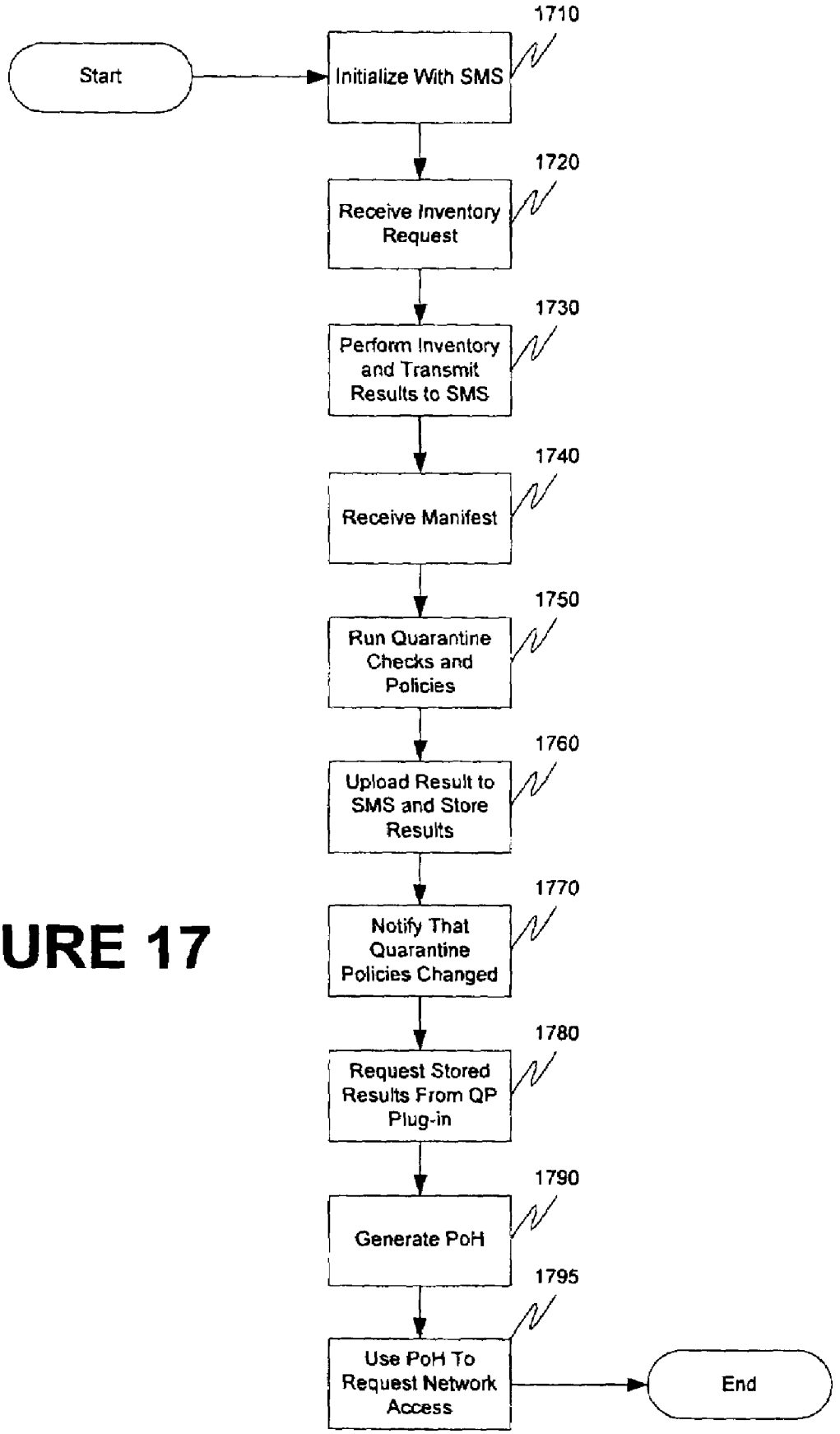

Start
Initialize With SMS
1710
Receive Inventory Request
1720
Perform Inventory and Transmit Results to SMS
1730
Receive Manifest
1740
Run Quarantine Checks and Policies
1750
Upload Result to SMS and Store Results
1760
Notify That Quarantine Policies Changed
1770
Request Stored Results From QP Plug-in
1780
Generate PoH
1790
Use PoH To Request Network Access
1795
End

FIGURE 17

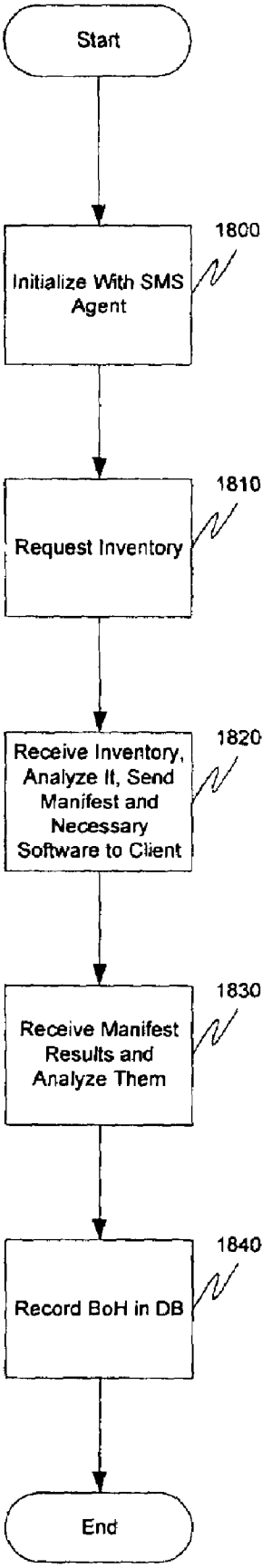

Start
Initialize With SMS Agent
1800
Request Inventory
1810
Receive Inventory, Analyze It, Send Manifest and Necessary Software to Client
1820
Receive Manifest Results and Analyze Them
1830
Record BoH in DB
1840
End

FIGURE 18

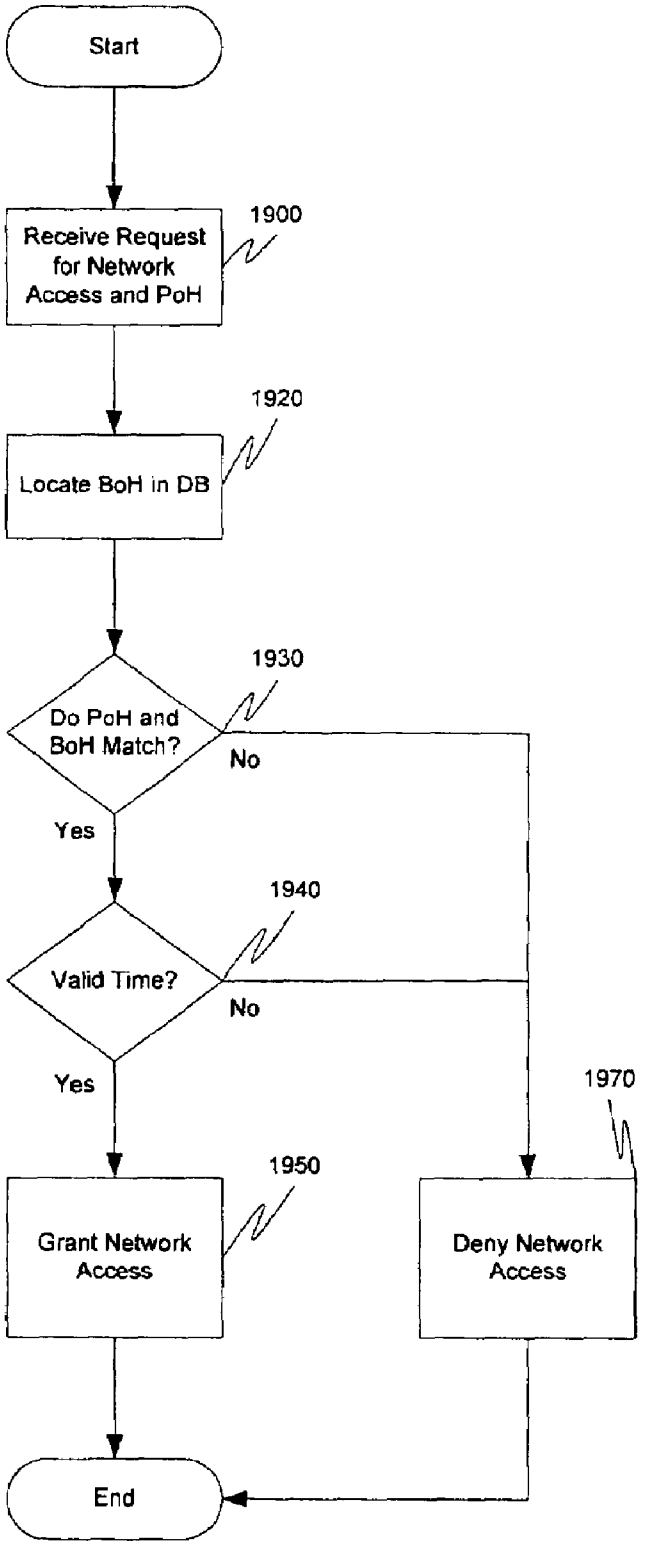

Start
Receive Request for Network Access and PoH
1900
Locate BoH in DB
1920
Do PoH and BoH Match?
1930
No
Yes
Valid Time?
1940
No
Yes
Grant Network Access
1950
Deny Network Access
1970
End

FIGURE 19

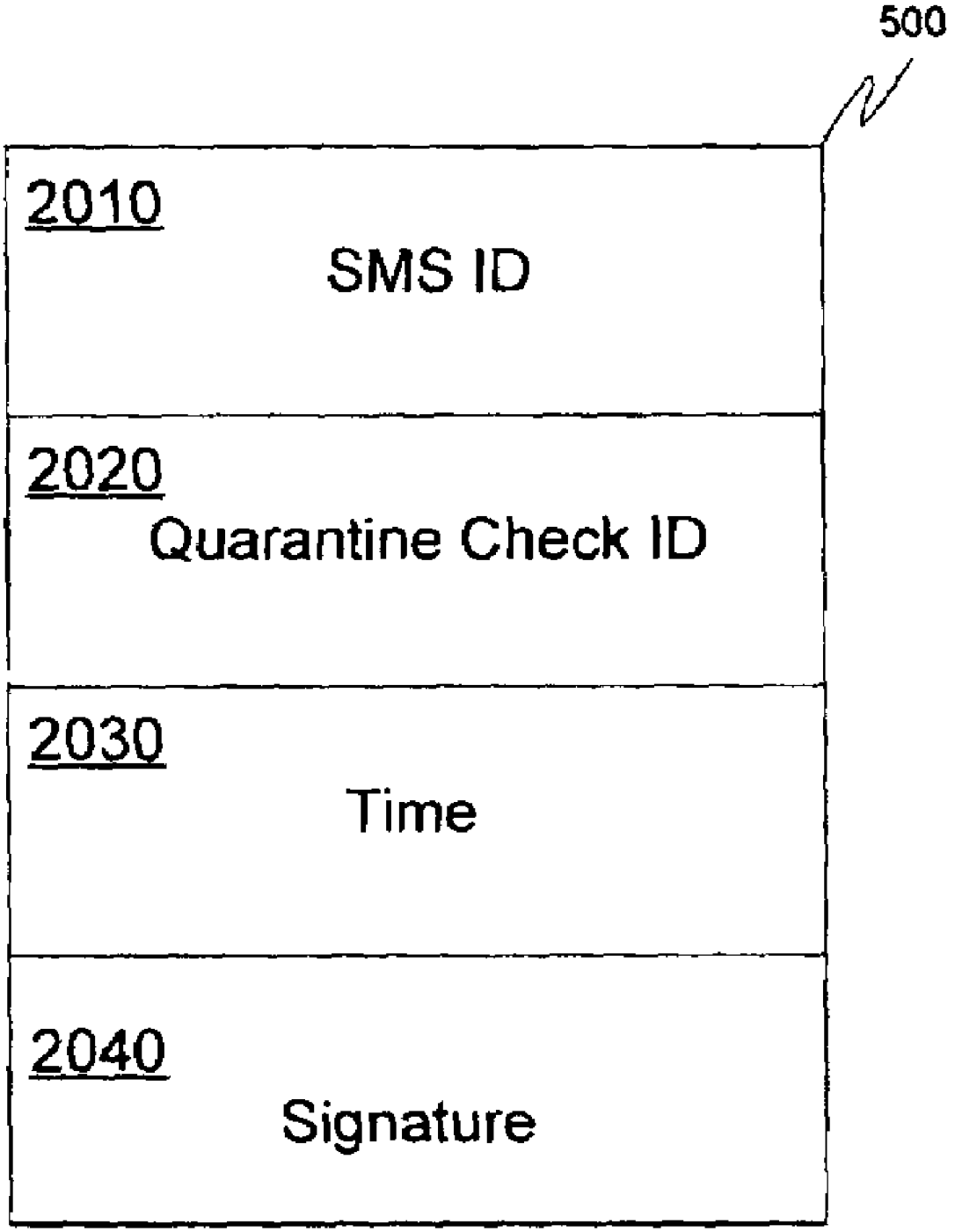

500
2010
SMS ID
2020
Quarantine Check ID
2030
Time
2040
Signature

FIGURE 20

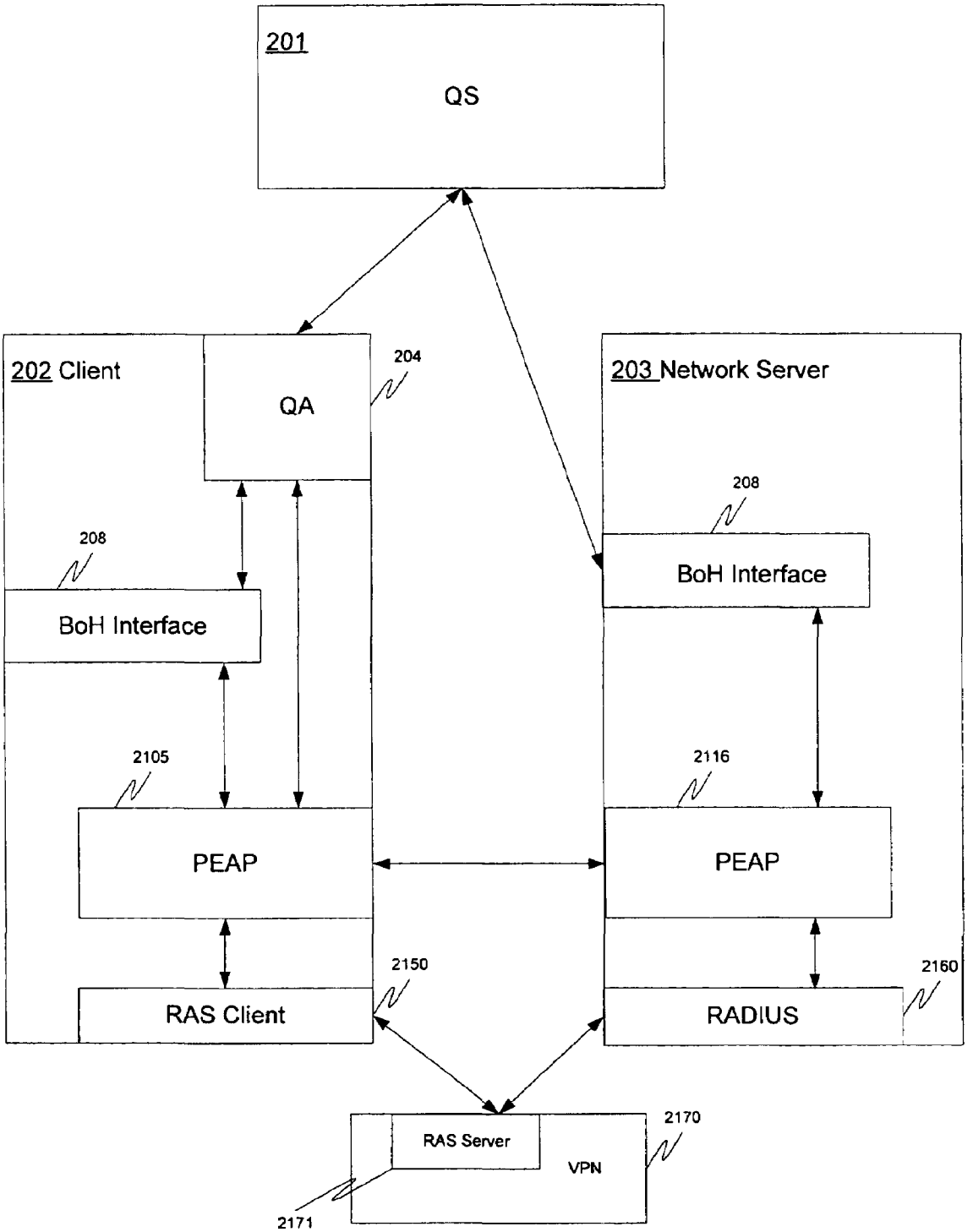
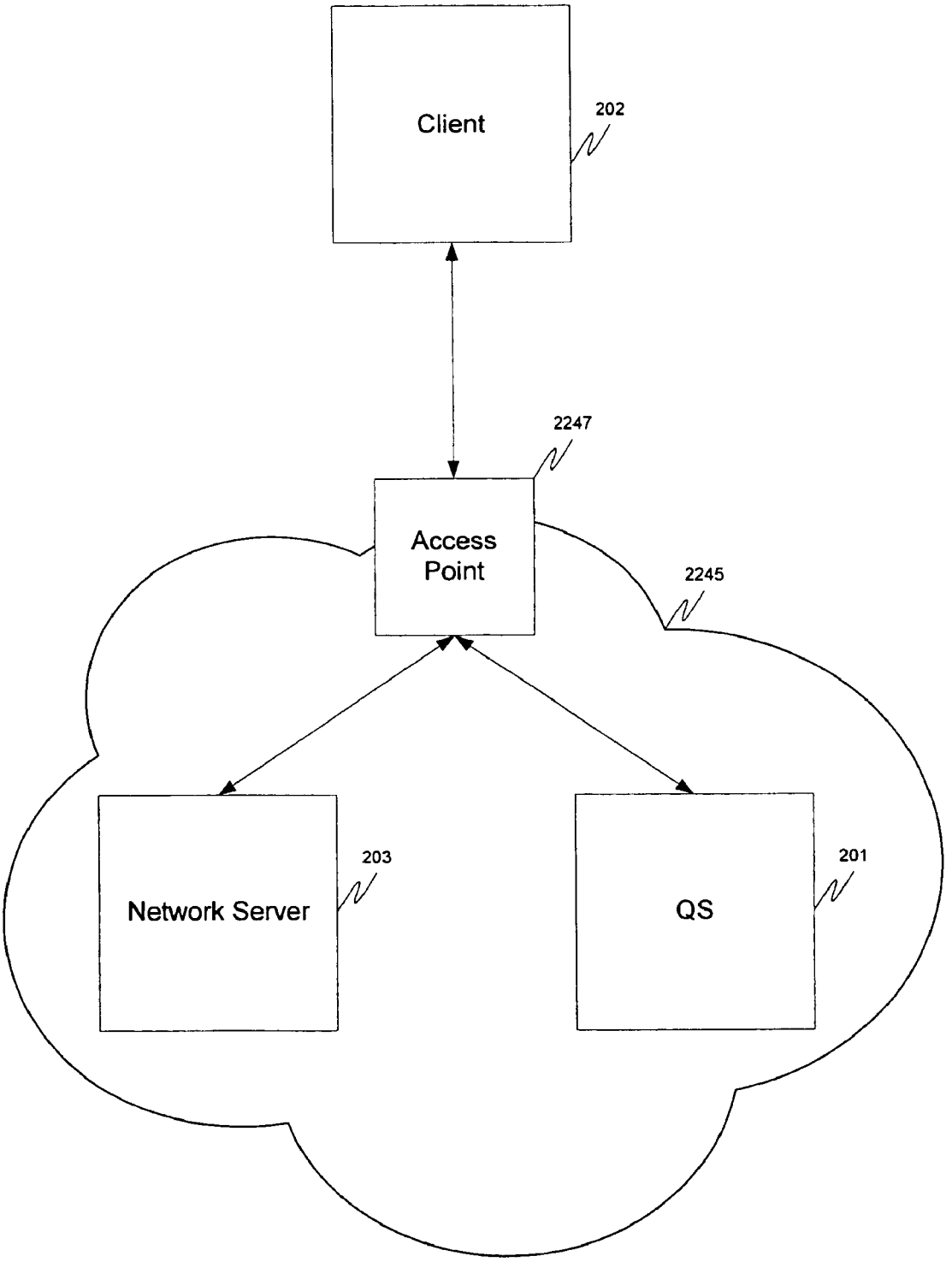

201
QS
202 Client
QA
204
208
BoH Interface
2105
PEAP
RAS Client
2150
203 Network Server
208
BoH Interface
2116
PEAP
RADIUS
2160
RAS Server
VPN
2170
2171

FIGURE 21

FIGURE 22



SYSTEM AND METHODS FOR PROVIDING NETWORK QUARANTINE

This patent application claims the benefit of U.S. Provisional Patent Application No. 60/529,698 file Dec. 16, 2003.

FIELD OF THE INVENTION

The present invention relates generally to network access management, and relates more particularly to checking the security state of clients before allowing them access to network resources.

BACKGROUND OF THE INVENTION

In computer networks, clients, servers, and peers commonly use trust models and mechanisms to ensure that unauthorized users do not gain access to network resources such as files, printers, other computers, or anything accessible on the network. These trust models and mechanisms are used to identify those users that are not malicious. However, it is possible that a user's machine poses and danger to the network without the user's knowledge. For example, a machine could contain a virus, or possess a security hole of which the user is unaware. Thus no matter how non-malicious the user is, the insecure state of the user's machine should be isolated from network until the security deficiencies are repaired. This security problem has particular application to three networking environments: Dynamic Host Configuration Protocol (DHCP), Virtual Private Networks (VPN), IEEE 802.1X, and Internet Protocol Security (IPsec).

DHCP is an Internet Protocol (IP) allocation specification whereby a server can allocate, or "lease," an IP address to a client for a specific amount of time. When a DHCP client attaches itself to the network for the first time, it broadcasts a DHCP DISCOVER packet. A DHCP server on the local segment intercepts the broadcast and returns a DHCP OFFER packet that contains an IP address and other information necessary for provisioning the client with network access. The client may receive multiple DHCP OFFER packets from several different servers, so it must choose between them, and broadcast a DHCP REQUEST packet that identifies the explicit server chosen. The chosen server would return a DHCPACK that tells the client the lease is finalized. If the offer is no longer valid for some reason-perhaps due to a time-out or another client allocating the lease-then the selected server must respond with a DHCPNAK message. This would cause the client to send another DHCPDISCOVER packet, starting the process over again.

If a client has obtained a network address through some other means (e.g., manual configuration), it may use a DHCPINFORM request message to obtain other local configuration parameters. Servers receiving a DHCPINFORM message construct a DHCPACK message with any local configuration parameters appropriate for the client. Once the client has the lease, it must be renewed prior to the lease expiration through another DHCP REQUEST message. If a client finishes using a lease prior to its expiration date, the client is sends a DHCP RELEASE message to the server so that the lease can be made available to other nodes. If the server does not hear from the client by the end of the lease, it marks the lease as non-renewed, and makes it available for other clients to use.

In conventional DHCP provisioning systems, the DHCP server may conduct an authentication procedure to ensure that clients requesting network access have verified credentials. For example, before providing the client with the DHCP

OFFER, the DHCP server on an organization's local area network (LAN) requires an access code to demonstrate that a user has authorization to access the LAN. The authentication procedure prevents unauthorized or malicious users from gaining access to network resources. However, the conventional authentication procedure does not prevent non-secure, or even malicious, machines from accessing the network. A user may have valid authorization to access the network, but the user's machine can be infected with a virus, or contain a security hole, that should be corrected before the machine is allowed access the network.

Another environment where a machine with a bad security state poses a risk to the network is VPN. VPN is the extension of a private network that encompasses links across shared or public networks like the Internet. A VPN enables you to send data between two computers across a shared or public internetwork in a manner that emulates the properties of a point-to-point private link. The act of configuring and creating a virtual private network is known as virtual private networking. To emulate a point-to-point link, data is encapsulated, or wrapped, with a header that provides routing information allowing it to traverse the shared or public transit internetwork to reach its endpoint. To emulate a private link, the data being sent is encrypted for confidentiality. Packets that are intercepted on the shared or public network are indecipherable without the encryption keys. The portion of the connection in which the private data is encapsulated is known as the tunnel. The portion of the connection in which the private data is encrypted is known as the virtual private network (VPN) connection.

VPN also uses an authentication protocol. A network access server (NAS) sends to VPN client a challenge, which consists of a session ID and an arbitrary challenge string, to the remote client. The remote client must return the user name and an encrypted form of the challenge string, the session ID, and the MD4-hashed password. This design, which uses a hash of the MD4 hash of the password, provides an additional level of security because it allows the server to store hashed passwords instead of clear-text passwords. However, once again the conventional authentication procedure does not prevent non-secure, or even malicious, machines from accessing the network. A VPN client may present valid authentication, but the VPN client machine itself can be infected with a virus, or contain a security hole, that should be corrected before the machine is allowed access the VPN.

Yet another environment where user authentication is insufficient is the use of IPsec. IPsec defines two functions that ensure confidentiality: data encryption and data integrity. IPsec uses an authentication header (AH) to provide source authentication and integrity without encryption, and the Encapsulating Security Payload (ESP) to provide authentication and integrity along with encryption. With IPsec, only the sender and recipient know the security key. If the authentication data is valid, the recipient knows that the communication came from the sender and that it was not changed in transit.

IPsec can be envisioned as a layer below the TCP/IP stack. This layer is controlled by a security policy on each computer and a negotiated security association between the sender and receiver. The policy consists of a set of filters and associated security behaviors. If a packet's IP address, protocol, and port number match a filter, the packet is subject to the associated security behavior. The first such packet triggers a negotiation of a security association between the sender and receiver. Internet Key Exchange (IKE) is the standard protocol for this negotiation. During an IKE negotiation, the two computers

agree on authentication and data-security methods, perform mutual authentication, and then generate a shared key for subsequent data encryption.

After the security association has been established, data transmission can proceed for each computer, applying data security treatment to the packets that it transmits to the remote receiver. The treatment can simply ensure the integrity of the transmitted data, or it can encrypt it as well. Data integrity and data authentication for IP payloads can be provided by an authentication header located between the IP header and the transport header. The authentication header includes authentication data and a sequence number, which together are used to verify the sender, ensure that the message has not been modified in transit, and prevent a replay attack.

However, once again the conventional authentication procedure does not prevent non-secure, or even malicious, machines from accessing the network. A computer may present valid authentication, but the machine itself can be infected with a virus, or contain a security hole, that should be corrected before the machine is allowed access the network resources of another computer.

IEEE 802.1x is a standard for port-based network access control that provides authenticated network access to 802.11 wireless networks and wired Ethernet networks. Port-based network access control uses the physical characteristics of a switched local area network (LAN) infrastructure to authenticate devices that are attached to a LAN port and to prevent access to that port in cases where the authentication process fails.

During a port-based network access control interaction, a LAN port adopts one of two roles: authenticator or supplicant. In the role of authenticator, a LAN port enforces authentication before it allows user access to the services that can be accessed through that port. In the role of supplicant, a LAN port requests access to the services that can be accessed through the authenticator's port. An authentication server, which can either be a separate entity or co-located with the authenticator, checks the supplicant's credentials on behalf of the authenticator. The authentication server then responds to the authenticator, indicating whether the supplicant is authorized to access the authenticator's services.

The authenticator's port-based network access control defines two logical access points to the LAN, through one physical LAN port. The first logical access point, the uncontrolled port, allows data exchange between the authenticator and other computers on the LAN, regardless of the computer's authorization state. The second logical access point, the controlled port, allows data exchange between an authenticated LAN user and the authenticator. IEEE 802.1x uses standard security protocols, such as Remote Authentication Dial-In User Service (RADIUS), to provide centralized user identification, authentication, dynamic key management, and accounting.

However, once again the conventional authentication procedure does not prevent non-secure, or even malicious, machines from accessing the network. A computer may present valid authentication, but the machine itself can be infected with a virus, or contain a security hole, that should be corrected before the machine is allowed access the network resources of another computer. Accordingly, the is a need in the art for a system and method to ensure that clients are not provisioned with network access until they are secure, and can prove their security state.

BRIEF SUMMARY OF THE INVENTION

In view of the foregoing, the present invention provides a system for ensuring that machines having invalid or corrupt states are restricted from accessing network resources. The invention provides a quarantine server located on a trusted machine in a network, and a quarantine agent located on a client computer that wishes to gain access to network resources administered by an organization. The quarantine agent requests a bill of health (BoH) from the quarantine server. The quarantine server responds with a manifest of checks that the client computer must perform. The quarantine agent then sends a status report on the checks back to the quarantine server. If the client computer is in a valid state, the BoH is issued to the client. A valid state may be that all necessary patches are installed, or that necessary security software is installed. If the client computer is in an invalid state, the client is directed to install the appropriate software/patches to achieve a valid state.

When a client requests the use of network resources from a network administrator, the network administrator requests the client's BoH. If the BoH is valid, the client is admitted to the network. If the BoH is invalid, or if the client does not have a quarantine agent, the client is placed in quarantine, in which the only network resources accessible to the client are those necessary to install the quarantine agent and requisite software/patches to achieve a valid state.

Additional features and advantages of the invention are made apparent from the following detailed description of illustrative embodiments which proceeds with reference to the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings incorporated in and forming a part of the specification illustrate several aspects of the present invention, and together with the description serve to explain the principles of the invention. In the drawings:

FIG. **1**A is a schematic generally illustrating an exemplary network environment across which the present invention operates.

FIG. **1**B is a block diagram generally illustrating an exemplary computer system on which the present invention resides;

FIG. **2** is a schematic overview of the components of the present invention;

FIG. **3** illustrates a client computer of the present invention;

FIG. **4** illustrates a quarantine server of the present invention;

FIG. **5** illustrates a bill of health data structure of the present invention;

FIG. **6** illustrates a proof of bill of health data packet of the present invention;

FIG. **7** is a flow diagram depicting the operation of the client when acquiring a bill of health;

FIG. **8**A is a flow diagram depicting the operation of the client when attempting to access network resources;

FIG. **8**B is a flow diagram depicting the operation of the network server when a client is attempting to access network resources;

FIG. **9** is a flow diagram depicting the operation of the quarantine server.

FIG. **10** is a schematic overview of the invention where Dynamic Host Configuration Protocol (DHCP) is used;

FIG. **11** is flow diagram of the operation of the invention where DHCP is used;

FIG. **12** is another flow diagram of the operation of the invention where DHCP is used;

FIG. **13** is a schematic overview of the invention where Virtual Private Networking (VPN) is used;

FIG. **14** is a schematic overview of the invention where Internet Protocol Security is used;

FIG. **15**A illustrates an exemplary DHCP option;

FIG. **15**B illustrates an exemplary Encapsulated Vendor-Specific Extension option **43**;

FIG. **15**C illustrates a token in a DHCP message;

FIG. **15**D illustrates two tokens in a DHCP message;

FIG. **16** is a schematic overview of the invention where Systems Management Server (SMS) is used;

FIG. **17** is a flow diagram of the operation of the client of the invention where SMS is used;

FIG. **18** is a flow diagram of the operation of the SMS in the invention;

FIG. **19** is a flow diagram of the operation of the network server where SMS is used;

FIG. **20** illustrates a proof of health of the present invention;

FIG. **21** is a schematic overview of an alternative embodiment of the invention where VPN is used; and

FIG. **22** is a schematic overview of an embodiment of the invention employing a firewall and an access point for the firewall.

While the invention will be described in connection with certain preferred embodiments, there is no intent to limit it to those embodiments. On the contrary, the intent is to cover all alternatives, modifications, and equivalents as included within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

Turning to the drawings, wherein like reference numerals refer to like elements, the present invention is illustrated as being implemented in a suitable computing environment. The following description is based on embodiments of the invention and should not be taken as limiting the invention with regard to alternative embodiments that are not explicitly described herein.

In the description that follows, the present invention is described with reference to acts and symbolic representations of operations that are performed by one or more computing devices, unless indicated otherwise. As such, it will be understood that such acts and operations, which are at times referred to as being computer-executed, include the manipulation by the processing unit of the computing device of electrical signals representing data in a structured form. This manipulation transforms the data or maintains them at locations in the memory system of the computing device, which reconfigures or otherwise alters the operation of the device in a manner well understood by those skilled in the art. The data structures where data are maintained are physical locations of the memory that have particular properties defined by the format of the data. However, while the invention is being described in the foregoing context, it is not meant to be limiting as those of skill in the art will appreciate that various of the acts and operations described hereinafter may also be implemented in hardware.

An example of a networked environment in which the invention may be used will now be described with reference to FIG. **1**A. The example network includes several computers **110** communicating with one another over a network **111**, represented by a cloud. Network **111** may include many well-known components, such as routers, gateways, hubs, etc. and allows the computers **110** to communicate via wired and/or wireless media. When interacting with one another over the network **111**, one or more of the computers may act as clients, network servers, quarantine servers, or peers with respect to other computers. Accordingly, the various embodiments of the invention may be practiced on clients, network servers, quarantine servers, peers, or combinations thereof, even though specific examples contained herein do not refer to all of these types of computers.

FIG. **1**B illustrates an example of a suitable computing system environment **100** on which the invention may be implemented. The computing system environment **100** is only one example of a suitable computing environment and is not intended to suggest any limitation as to the scope of use or functionality of the invention. Neither should the computing environment **100** be interpreted as having any dependency or requirement relating to any one or combination of components illustrated in the exemplary computing environment **100**.

The invention is operational with numerous other general-purpose or special-purpose computing system environments or configurations. Examples of well known computing systems, environments, and configurations that may be suitable for use with the invention include, but are not limited to, personal computers, server computers, hand-held or laptop devices, multiprocessor systems, microprocessor-based systems, set-top boxes, programmable consumer electronics, network PCs, minicomputers, mainframe computers, distributed computing environments that include any of the above systems or devices, and the like.

The invention may be described in the general context of computer-executable instructions, such as program modules, being executed by a computer. Generally, program modules include routines, programs, objects, components, data structures, etc., that perform particular tasks or implement particular abstract data types. The invention may also be practiced in distributed computing environments where tasks are performed by remote processing devices that are linked through a communications network. In a distributed computing environment, program modules may be located in both local and remote computer-storage media including memory-storage devices.

With reference to FIG. **1**B, an exemplary system for implementing the invention includes a general-purpose computing device in the form of a computer **110**, which may act as a client, network server, quarantine server, or peer within the context of the invention. Components of the computer **110** may include, but are not limited to, a processing unit **120**, a system memory **130**, and a system bus **121** that couples various system components including the system memory **130** to the processing unit **120**. The system bus **121** may be any of several types of bus structures including a memory bus or memory controller, a peripheral bus, and a local bus using any of a variety of bus architectures. By way of example, and not limitation, such architectures include Industry Standard Architecture bus, Micro Channel Architecture bus, Enhanced ISA bus, Video Electronics Standards Associate local bus, and Peripheral Component Interconnect bus, also known as Mezzanine bus.

The computer **110** typically includes a variety of computer-readable media. Computer-readable media can be any available media that can be accessed by the computer **110** and include both volatile and nonvolatile media, removable and

non-removable media. By way of example, and not limitation, computer-readable media may include computer storage media and communication media. Computer storage media include both volatile and nonvolatile, removable and non-removable media implemented in any method or technology for the storage of information such as computer-readable instructions, data structures, program modules, or other data. Computer storage media include, but are not limited to, RAM, ROM, EEPROM, flash memory or other memory technology, CD-ROM, digital versatile disks or other optical disk storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to store the desired information and which can be accessed by the computer **110**. Communication media typically embody computer-readable instructions, data structures, program modules, or other data in a modulated data signal such as a carrier wave or other transport mechanism and include any information-delivery media. The term "modulated data signal" means a signal that has one or more of its characteristics set or changed in such a manner as to encode information in the signal. By way of example, and not limitation, communication media include wired media such as a wired network or direct-wired connection and wireless media such as acoustic, RF, infrared, and other wireless media. Combinations of the any of the above should also be included within the scope of computer-readable media.

The system memory **130** includes computer storage media in the form of volatile and nonvolatile memory such as read only memory (ROM) **131** and random access memory (RAM) **132**. A basic input/output system **133** (BIOS), containing the basic routines that help to transfer information between elements within the computer **110**, such as during start-up, is typically stored in ROM **131**. RAM **132** typically contains data and program modules that are immediately accessible to or presently being operated on by the processing unit **120**. By way of example, and not limitation, FIG. **1**B illustrates an operating system **134**, application programs **135**, other program modules **136**, and program data **137**.

The computer **110** may also include other removable/non-removable, volatile/nonvolatile computer storage media. By way of example only, FIG. **1**B illustrates a hard disk drive **141** that reads from or writes to non-removable, nonvolatile, magnetic media, a magnetic disk drive **151** that reads from or writes to a removable, nonvolatile, magnetic disk **152**, and an optical disk drive **155** that reads from or writes to a removable, nonvolatile optical disk **156** such as a CD ROM or other optical media. Other removable/non-removable, volatile/nonvolatile computer storage media that can be used in the exemplary computing environment **100** include, but are not limited to, magnetic tape cassettes, flash memory cards, digital versatile disks, digital video tape, solid state RAM, solid state ROM, and the like. The hard disk drive **141** is typically connected to the system bus **121** through a non-removable memory interface such as the interface **140**, and the magnetic disk drive **151** and the optical disk drive **155** are typically connected to the system bus **121** by a removable memory interface, such as the interface **150**.

The drives and their associated computer storage media discussed above and illustrated in FIG. **1**B provide storage of computer-readable instructions, data structures, program modules, and other data for the computer **110**. In FIG. **1**B, for example, the hard disk drive **141** is illustrated as storing an operating system **144**, application programs **145**, other program modules **146**, and program data **147**. Note that these components can either be the same as or different from the operating system **134**, application programs **135**, other program modules **136**, and program data **137**. The operating system **144**, application programs **145**, other program modules **146**, and program data **147** are given different numbers to illustrate that, at a minimum, they are different copies.

A user may enter commands and information into the computer **110** through input devices such as a keyboard **162** and a pointing device **161**, commonly referred to as a mouse, trackball, or touch pad. Other input devices (not shown) may include a microphone, joystick, game pad, satellite dish, scanner, or the like. These and other input devices are often connected to the processing unit **120** through a user input interface **160** that is coupled to the system bus **121**, but may be connected by other interface and bus structures, such as a parallel port, game port, or a universal serial bus. A monitor **191** or other type of display device is also connected to the system bus **121** via an interface, such as a video interface **190**. In addition to the monitor **191**, the computer **110** may also include other peripheral output devices such as speakers **197** and a printer **196** which may be connected through an output peripheral interface **195**.

The computer **110** may operate in a networked environment using logical connections to one or more remote computers, such as a remote computer **180**. The remote computer **180** may be another personal computer, a server, a router, a network PC, a peer device, or other common network node and typically includes many or all of the elements described above relative to the personal computer **110** although only a memory storage device **181** has been illustrated in FIG. **1**B. The logical connections depicted in FIG. **1**B include a local area network (LAN) **171** and a wide area network (WAN) **173** but may also include other networks. Such networking environments are commonplace in offices, enterprise-wide computer networks, intranets, and the Internet.

When used in a LAN networking environment, the personal computer **110** is connected to the LAN **171** through a network interface or adapter **170**. When used in a WAN networking environment, the computer **110** typically includes a modem **172** or other means for establishing communications over the WAN **173**, such as the Internet. The modem **172**, which may be internal or external, may be connected to the system bus **121** via the user input interface **160** or other appropriate mechanism. In a networked environment, program modules depicted relative to the personal computer **110**, or portions thereof, may be stored in the remote memory storage device **181**. By way of example, and not limitation, FIG. **1**B illustrates the remote application programs **185** as residing on the memory device **181**. It will be appreciated that the network connections shown are exemplary, and other means of establishing a communications link between the computers may be used.

In the description that follows, the invention is described with reference to acts and symbolic representations of operations that are performed by one or more computers, unless indicated otherwise. As such, it will be understood that such acts and operations, which are at times referred to as being computer-executed, include the manipulation by the processing unit of the computer of electrical signals representing data in a structured form. This manipulation transforms the data or maintains them at locations in the memory system of the computer, which reconfigures or otherwise alters the operation of the computer in a manner well understood by those skilled in the art. The data structures where data are maintained are physical locations of the memory that have particular properties defined by the format of the data. However, while the invention is being described in the foregoing context, it is not meant to be limiting as those of skill in the art will appreciate that various of the acts and operations described hereinafter may also be implemented in hardware.

With reference to FIG. **2**, the invention comprises at least a quarantine server (QS) **201**, a client **202**, and a network server **203**. The client **202** includes a quarantine agent (QA) **204** for communicating with the QS **201**, and an enforcer **205** for communicating with the network server **203**. The network server **203** includes an enforcement server **216**, which denies client **202** access to network resources until client **202** obtains a valid bill of health (BoH) and presents proof of that BoH signifying that client **202** is in a valid security state. Until client **202** obtains a valid BoH, the client **202** is in a quarantine state and has access only to designated network resources for fixing the client's security state. One such accessible resource is the QS **201**, which issues the BoH.

To obtain the BoH, the QA **204** sends a BoH request to the QS **201**, which returns a manifest indicating checks that must be performed on client **202**. The QA **204** receives the manifest and returns a status report back to the QS **201** indicating the result of the checks. If the client **202** passed all of the checks in the manifest, then the QS **201** issues a validated BoH to the QA **204** of the client **202**. The client **202** further comprises a BoH interface **208** for providing and validating proof of the BoH. The enforcer **205** obtains proof of the BoH from the BoH interface **208** and then presents that proof of BoH to network server **203**. Network server **203** also includes a BoH interface **208**. Network server **203** employs the BoH interface **208** to validate the BoH by comparing the BoH either to a stored BoH, or a BoH obtained from QS **201**. Upon recognizing from the proof of BoH that client **202** is in a valid security state, network server **203** allows client **202** access to network resources. However, if the client **202** failed the checks in manifest, client **202** is directed to make changes necessary for a valid security state. The system and methods of the present invention are now described below in greater detail.

In one embodiment of the invention, the QA **204** is a service running on the client **202**. With reference to FIG. **3**, the client **202** further comprises delegates **309**, and BoH interface **208** comprises Manifest/Status Report store **312** and BoH store **313**. The delegates **309** are responsible for running the checks on the client **202** as outlined by the manifest. Each delegate **309** runs a script or process that may be configured or hard coded into the delegate **309**, and passes the result of the check back to the QA **204**, which compiles a status report based on those results. The checks performed may include, but are not limited to, whether software is installed, patch state of installed software, installed software version, the state of the firewall, registry keys and values, file system objects, file shares, services, anti-virus tools, and anti-virus signatures and states. The manifest, in addition to indicating the latest version of the QA **204**, dictates which delegates **309** should be executed, and which checks should be performed. The Manifest/Status Report store **312** stores past and present versions of manifests and status reports. The BoH store **313** stores past and present versions of obtained BoHs. The BoH interface **208** provides the QA **204** and the enforcer **205** with the latest BoH from the BoH store **313**. The BoH interface **208** creates the proof of BoH, explained herein.

The enforcer **205** is a component running on client **202** that includes a local enforcement component **314** and a network enforcement component **315**. The local enforcement component **314** is responsible for quarantining (i.e. restricting outside access to the local machine) when client **202** is in a quarantine state. The local enforcement component **314** is used to isolate the local client **202** from other machines. This allows the client **202** to protect itself from being attacked if it finds itself insecure but not infected. The present invention isolates vulnerable as well as infected machines into an isolated quarantine network, thus the local enforcement component **314** prevents infection the insecure client **202** until the required patches are installed. An Internet Connection Firewall (ICF) is an exemplary local enforcement component **314** of the present invention. The local enforcement component **314** is called by the QA **204** when the quarantine changes state. When in quarantine, the local enforcement component **314** provides greater restriction to local access by outside machines; however, when the quarantine state changes to non-quarantine, the restriction against outside access is lessened.

The network enforcement component **315** provides an interface for communicating with the enforcement server **216** located on network server **203**. The network enforcement server queries the BoH store **313** for proof of BoH, and presents the proof of BoH to enforcement server **216** in an attempt to gain access to network resources provided by network server **203**. The network enforcement component **315** receives back from the enforcement server **216** an indication of whether network access is granted, and if not, why the proof of BoH failed. The enforcement server **216** on network server **203** validates the BoH for valid creation date, valid expiry date, a manifest version that is the same or greater than the local manifest version, and valid integrity check on the BoH.

FIG. **5** illustrates the BoH **500** that is issued by a QS. The BoH is a data structure that includes the creation time **501** of the BoH, the expiry time **502** of the BoH, the manifest version **503** against which the BoH was issued, and an integrity check **504** indicating that the BoH has not been tampered. Alternatively, the BoH also contains a network globally unique identifier (GUID) **505** for which the BoH was issued. In one embodiment, the BoH is implemented as an X.509 certificate. In this embodiment, the Subject Alternative Name of the X.509 certificate contains a machine account name for which the BoH was issued.

FIG. **6** illustrates the proof of BoH **600** that is exchanged between the client **202** and the network server **203** (FIG. **2**). The proof of BoH **600** is a data packet that includes a reason code **601**, a list of QS addresses **602**, a BoH serial number **603**, the issuing QS address **604**, the current time **605**, and a signature **606** using the private key encryption of the BoH. The signature is an RSA or DSS encrypted signature using the private key of a public/private key pair. If the proof of BoH **600** is sent as a request for network resources, the reason code **601** is set to "request," the BoH serial number **603** is set to the serial number of the client's BoH, and the issuing QS address **604** is set to the address of the QS that issued the BoH. The list of QS addresses **602** contains zero or more address of QSs, and the current time **605** is set to the current time on the client. If the proof of BoH **600** is sent as a response to a request for network resources, the reason code **601** is set to one of "OK," "Invalid BoH," "Invalid Manifest Version," and "Invalid Time." The BoH serial number **603** is set to the serial number of the network server's BoH, and the issuing QS address is set to the address of the QS that issued the network server's BoH. The list of QS addresses **602** contains zero or more QS addresses, and the current time **605** is set to the current time of the network server. The signature uses the private key encryption of the network server's BoH.

With reference to FIG. **4**, the QS **201** includes an Internet Information Service (IIS) **417** for providing a default web page. When client **202** is in quarantine and a user opens a web browser on client **202**, QS **201** provides a web page to inform the user that the client **202** is in quarantine and corrective action must be taken. The IIS **417** further provides an install package for installing the QA **204**, as well as latest versions of

enforcers **205**, delegates **309** (FIG. **3**), and manifests. The user may download the software provided by the IIS **417**, or if the QA **204** is already installed, the QA **204** downloads the newest software automatically. The QS **201** further includes a database engine **418** for storing manifests, status reports, failure reports, and QA root certificates. Status reports received from QAs are stored in the database engine **418**, as are failure reports received from network servers **203** that indicate instances where a BoH was not validated. The QS **201** communicates with network servers **203** to provide them with information for validating BoHs received from clients **202**. Still further, the QS **201** includes a root certificate authority **419** for issuing root certificates, and a certificate store **420** for storing root certificates, web server certificates, and BoHs. The QS **201** also includes a hijack DNS component **421** for intercepting DNS queries from quarantined clients. In an alternative embodiment of the invention, the QS **201** is installed on the same physical machine as the network server **203**.

With reference to FIGS. **3** and **7**, the operation of the client **202** is now described with respect to acquiring a BoH. When the QA is initialized with a QS for the first time, the client user is asked to trust the QS. The QA and QS then establish a secure sockets layer (SSL) channel, and exchange root certificates. At step **710**, the client **202** is in a quarantine state, so the QA **204** issues a BoH request to a QS. This request may be prompted by a notice from enforcer **205** that the current BoH was rejected, because the QA **204** periodically updates the BoH, or because the client **202** has no BoH at all. At step **720**, the QA **204** receives the manifest from the QS. The manifest is encrypted with the private key of the QS. The QA **204** passes the manifest to the delegates **309**, which execute the checks in the manifest and return their results to the QA **204**. At step **730**, the QA **204** sends the status report to the QS. If a validated BoH is received by the QS at step **740**, the QA **204** passes the BoH to the BoH interface **208** for storage in the BoH store **313** at step **750**. At step **760**, the QA **204** notifies the enforcers **205** that the BoH store **313** has changed. If a BoH is not received at step **740**, then client **202** did not pass all of the manifest checks, and further action must be taken at step **755** to repair the client **202** by downloading the necessary patches and software.

Alternatively, if a status report already exists it may be sent with the BoH request at step **710**. If the status report passes, the QA **204** receives a challenge from the QS to verify that the QA **204** is legitimate. If the QA **204** fails the challenges, the QA **204** receives a manifest from the QS as at step **720**. If the QA **204** passes the challenge, it receives a BoH and proceeds to step **750**. The QA **204** will also periodically update its manifest. To update the manifest, the QA **204** sends the QS its most recent BoH. The QS checks the manifest version of BoH and determines whether it is the most recent version. If so, the QS returns an "OK." If the BoH was not generated from the most recent manifest, the QS returns a "Failed" along with the current manifest.

With reference to FIGS. **3** and **8**A, the operation of the client **202** is now described with respect to accessing network resources of network server **203**. At step **810**, the enforcer **205** requests a proof of BoH from BoH interface **208**. At step **820**, the enforcer sends the proof of BoH along with a request for network resources to network server **203**. If the proof of BoH was valid and the network server grants access at step **830**, then the client **202** accesses the network resources at step **840**. If the network server does not grant access at step **830**, either because the proof of BoH was invalid or there was no proof of BoH, then the client **202** acquires a new BoH at step **850**, as described previously.

With reference to FIGS. **3** and **8**B, the operation of the network server is now described with respect to granting access to client **202**. At step **815** the enforcement server **216** receives a request for network resources along with a proof of BoH from client **202**. The proof of BoH is validated by the BoH Interface **208** at step **825**. In validating the proof of BoH, the BoH Interface compares the BoH to cached BoHs. If the received BoH does not match one in a cache, a copy of the BoH is requested from the QS **201**. If the copy matches the received BoH, or if the received BoH was found in the cache, the BoH is validated. Otherwise, it is not. At step **835**, the enforcement server **216** determines from the BoH Interface **208** whether the BoH was validated. If the BoH was validated, the enforcement server **216** sends its own proof of BoH to client **202**, and grants network resources at step **845**. If the BoH was not validated, the enforcement server **216** sends its own proof of BoH, and redirects the client **202** to the QS **201** at step **855**.

With reference to FIGS. **4** and **9**, the operation of the QS **201** is now described. At step **910**, QS **201** receives a request for a BoH. The QS **201** determines whether the request includes a status report at step **915**. If a status report was included, the QS **201** determines at step **917** whether the status report passes—i.e., did the client pass all of the checks contained in the most recent manifest. If the status report did pass, the QS **201** issues the client a challenge at step **918** to determine whether the client's QA is legitimate. The QS **201** determines whether the client passed the challenge at step **919**. If the client passed the challenge, the QS proceeds to step **940**. If the client didn't pass the challenge or the status report, or if there was no status report, the QS proceeds to step **920**. At step **920**, the QS **201** sends the most recent manifest stored in the database engine **418** to the requesting client, encrypted using the QS's private key. At step **930**, the QS **201** receives a status report detailing the results of the checks mandated by the manifest. The QS **201** determines whether the status report passed at step **935**. If the status report passed, the QS **201** generates a BoH, encrypts it with its public key, and sends it to the client at step **940**. If the status report failed, the QS **201** directs the client regarding how to update the client's system at step **950**.

The implementation of the invention varies depending upon the protocol used by the enforcer **205** and enforcement server **216** (FIG. **2**). The enforcement protocols supported by the invention include, but are not limited to, Dynamic Host Configuration Protocol (DHCP), virtual private networks (VPN), 802.1X protocol, and IP Security Protocol (IPsec).

In one embodiment, the enforcer **205** is implemented as a DHCP client, and the enforcement server is implemented as a DHCP server. FIG. **10** illustrates an overview of this embodiment, including the client **202**, QA **204**, QS **201**, network server **203**, and BoH interface **208** as previously described. FIG. **10** also illustrates client **202** comprising DHCP client **1005** as an enforcer, and network server **203** comprising DHCP server **1016** as an enforcement server. DCHP client **1005** requests a lease from DHCP server **1016** so that it may have access to a network through network server **203**. DHCP server **1016** provisions DCHP client **1005** with an IP address, default gateway, subnet mask, DNS, and static routes.

With reference to FIG. **11**, the operation of the present embodiment is now described. When client **202** boots it attempts acquire access to the local network through network server **203**. However, when the client **202** does not have a QA installed, it cannot supply a BoH to network server **203**. Thus, at step **1110** client **202** broadcasts a DHCP DISCOVER message to the local network without a proof of BoH as a DHCP option in the message. The message is received by the DHCP

server **1016** in the network server **203**. When the DHCP server **1016** recognizes that no proof of BoH is presented, DHCP server **1016** supplies a DCHP OFFER message to client **202** at step **1115**. This DHCP OFFER message contains a lock-down configuration and a proof of BoH for the network server **203**. The lock-down configuration includes the IP address of a QS as the DNS address in the DHCP OFFER. At step **1120**, the client **202** receives the DHCP OFFER message and the DCHP client **1005** configures the client **202** with the information in the DHCP OFFER message, such that when a user of client **202** opens a web browser, the DNS request goes to QS **201**. At step **1125**, QS **201** receives the DNS request and supplies the client **202** with a default web page on QS **201** that requests the user to trust the web site and instructs the user of the client **202** to install a QA by clicking on a link to the QA. The install package for the QA may be located on the QS **201**, or on an external fix-up server (not shown).

At step **1130**, the QA is installed on the client **202**. Recognizing that the client **202** does not possess a BoH, at step **1135** the QA **204** requests that DHCP client **1005** to issue a DHCP INFORM message to acquire the IP address of a QS. At step **1140**, DHCP server **1016** provides the client **202** with a list of QSs. At step **1145**, the QA **204** selects a QS from the list at random, for example QS **201**, and requests a BoH. At step **1150**, the QS receives the request and sends its root certificates and the latest version of the manifest. At step **1155**, the client **202** receives the manifest, executes all of the checks, and provides QS **201** with a status report requesting a BoH. Assuming the status report passes, the QS **201** provides the client **202** with a BoH at step **1160**. The client **202** receives the BoH at step **1165**, and informs its DHCP client **1005** that a new BoH has been received.

With reference to FIG. **12**, the discussion is continued. At step **1210**, the DHCP client recognizes that a new BoH has been received, and sends a DHCP REQUEST message requesting a new lease, with the proof of BoH encoded in the message as a DHCP option. At step **1215**, the DHCP sever **1016** on network server **203** receives the DHCP request and finds the proof of BoH option. The DHCP server **1016** passes the proof of BoH to the BoH interface on network server **203**, which gets the BoH serial number and issuing QS and checks in a local cache of received BoHs for the BoH at step **1220**. Assuming the BoH is not found in the cache, the network server **203** requests the BoH from the QS **201**. The QS **201** sends network server **203** the BoH along with the manifest version for the BoH at step **1225**. At step **1230**, the network server **203** receives the BoH, caches it, validates the proof of BoH from the client **202** using the BoH from the QS **201**, and compares the manifest version numbers of the two BoHs. If the validation and comparison fails, then the DHCP server **1016** returns a lock-down configuration along with the BoH of the network server **203** to DHCP client **1005**. If the validation and comparison passes, the DHCP server **1016** returns a normal set of IP parameters that grant the DHCP client access to the network through network server **203**, along with the BoH of the network server **203**. At step **1235**, the DHCP client **1005** receives the DHCP parameters and configures client **202** accordingly. At step **1240**, client **202** determines whether network access was granted. If network access was granted, the quarantine is released. If network access was not granted, client **202** proceeds to step **1145** of FIG. **11** so that a new BoH may be obtained.

The lock-down configuration is a set of system settings that are sent via DHCP to any machine deemed unsafe, i.e. quarantined. The purpose is to prevent the unsafe machine from talking to any other network node except for the few select servers it can use to update its compliance with network security policy. This is done by setting the configuration options outlined below and relying on the TCP/IP stack to perform the enforcement.

In the DHCP OFFER message, the IP address (which is assigned to the client) is set to the next available IP in matching scope. Quarantine IP address assignment follows the same process as normal address assignment. The IP address given out is the next available address out of the matching scope. Therefore, both quarantined and safe machines, on the same physical network, are on the same logical network. The subnet mask, contained in the DHCP OFFER message at option code 1, is set to a Value of 255.255.255.255. This defines the network to one machine, the client, and prevents it from resolving addresses of other machines on the same logical network. This prevents the quarantine machine from finding the IP addresses of other quarantined or healthy clients. The default route, contained in the DHCP OFFER message at option code 3, is set to a value of 0.0.0.0 so that any attempt to send a packet to another machine, except explicitly defined ones, will fail. The DNS, contained in the DHCP OFFER message at option code 6, is set to the IP address of the hi-jack DNS of the QS. Whenever the client performs name resolution on any address, it will receive the IP of QS. This way any client will be redirected to fix-up page on QS. Static routes, as contained in option code 33 of the DHCP OFFER message, include the QS IP, fix-up server IPs (if any exist), and a web proxy IP. Static routes are necessary to allow connectivity to servers for getting corporate security policy manifest to the QA, updating the client with latest settings, bootstrapping the client with a QA, and getting internet connectivity. All of the IP settings and routes are configured by IT administrator.

There is one quarantine-specific DHCP option defined to support token exchange. Tokens are used to represent the proof of BoH and are provided to the DHCP client by the QA. They are treated by the DC as a binary blob, obtained from QA, that is encoded in the Encapsulated Vendor-Specific Extensions Option (**43**). The DHCP client sends the token to the DHCP server as part of the DHCP DISCOVER, DHCP REQUEST or DHCP INFORM messages. The DHCP server validates the token and sends an error code back to the DHCP client. The DHCP client then reports the error code to the QA.

Generic DHCP option consists of Option Code, Length and Data fields, as illustrated in FIG. **15**A. New token option will be encoded using Encapsulated Vendor-Specific Extensions Option (**43**) and be used in conjunction with Vendor Class Identifier (**60**). The token option will be used for 2 purposes: to encapsulate the security token and allow it to be sent in a DHCP message to the DHCP server, and to carry the error code from the DHCP server to QA via the DHCP client. Both option **60** and **220** will need to be included in a DHCP message. Option **60** will indicate to our server that set of options packaged within Option **43** are ours. Server will then parse option **43** and retrieve Option **220** data.

The definition of Encapsulated Vendor-Specific Extensions Option (**43**) is shown in FIG. **15**B, where OPT=Option Code and LEN=Byte length of data. For tokens less than 253 single instance of Option **43** are required. An example of how a token of size **200** would be encoded is shown if FIG. **15**C. Multiple tokens can also be packaged in the DHCP message. This is done by having multiple Option **220** instances within Option **43**. An example of 2 tokens, 50 and 35 bytes each, is shown in FIG. **15**D.

When the quarantine system is installed on the DHCP server, the administrator is queried for an IP address of a QS. The DHCP server then sets up communication with the QS and confirms trust with the administrator. Alternatively, the

DHCP relies on credentials presented by the QS. The DHCP server requests the QS for a list of root certificates, and adds those certificates to a store. The DHCP server then requests IP address for QSs, as well as a BoH. The DHCP also queries the QS whether DHCP quarantining is enabled on the QS. The DHCP server is then configured to supply a proof of BoH in a BoH option, and to validate a proof of BoH contained in a BoH option, as well as return the lock-down (quarantine) configuration if a BoH validation fails.

In another embodiment where the invention in used in a VPN environment, the enforcer is implemented as a Remote Access Quarantine Client (RQC), and the enforcement server is implemented as a Remote Access Quarantine Server (RQS). FIG. **13** illustrates an overview of this embodiment, including the client **202**, QA **204**, QS **201**, network server **203**, and BoH interface **208** as previously described. FIG. **13** also illustrates client **202** comprising RQC **1305** as an enforcer, and network server **203** comprising RQS **1316** as an enforcement server. FIG. **13** further illustrates the client **202** comprises a Remote Access Service (RAS) client **1350**, and network server **203** comprises RAS server **1360**. The RAS client **1350** and the RAS server **1360** establish a VPN between the client **202** and the network server **203**. The RAS server **1360** establishes an IP filter to filter packets incoming from the client **202** until a proof of BoH has been presented and validated.

The RAS client **1350** attempts to establish a VPN and notifies the RQC **1305** of the attempt. The RQC **1305** sends a request for network services to RQS **1316**, along with a proof of BoH if client **202** possesses one. If the BoH is invalid, or if no proof of BoH is presented, RQS **1316** returns the address of a QS, thereby redirecting the client **202** to a QS. If the BoH is validated, the RQS **1316** sends the client **202** its own proof of BoH, and informs the RAS server **1360** to remove the IP filter and allow the VPN connection. Acquisition and validation of BoHs is explained in the description of FIGS. **7** and **8**.

In another embodiment where the invention in used in an alternative VPN environment, the enforcer and enforcement servers are implemented as Protected Extensible Authentication Protocol (PEAP) clients. Protected Extensible Authentication Protocol (PEAP) is a member of the family of Extensible Authentication Protocol (EAP) protocols. Extensible Authentication Protocol (EAP) is an extension to the Point-to-Point Protocol (PPP) that allows for arbitrary authentication mechanisms to be employed for the validation of a PPP connection. PEAP uses Transport Level Security (TLS) to create an encrypted channel encrypted channel between an authenticating PEAP client, such as a wireless computer, and a PEAP authenticator, such as an Internet Authentication Service (IAS) or Remote Authentication Dial-In User Service (RADIUS). PEAP does not specify an authentication method, but provides additional security for other EAP authentication protocols, such as EAP-MSCHAPv2, that can operate through the TLS encrypted channel provided by PEAP.

FIG. **13** illustrates an overview of this embodiment, including the client **202**, QA **204**, QS **201**, network server **203**, and BoH interface **208** as previously described. FIG. **13** also illustrates client **202** comprising PEAP client **2105** as an enforcer, and network server **203** comprising PEAP client **2116** as an enforcement server. FIG. **13** further illustrates the client **202** comprises a Remote Access Service (RAS) client **2150**, and network server **203** comprises RADIUS server **2160**. Furthermore, this embodiment includes VPN server **2170** including RAS server **2171**. The RAS client **2150** attempts to establish a VPN connection with the RAS server **2171**. However, to avoid modifying the VPN server **2170**, the BoH is authenticated using PEAP through the RADIUS server **2160**. The RAS server **2171** establishes an IP filter to filter packets incoming from the client **202** until a proof of BoH has been presented and validated by the network server **203**, and the RADIUS server **2160** notifies the RAS server **2171** through RADIUS protocol that the IP filter can be lifted.

The RAS client **1350** attempts to establish a VPN and notifies the PEAP client **2105** of the attempt. The PEAP client **2105** sends a request for network services to PEAP client **2116**, along with a proof of BoH if client **202** possesses one. If the BoH is invalid, or if no proof of BoH is presented, PEAP client **2116** returns the address of a QS, thereby redirecting the client **202** to a QS. If the BoH is validated, the PEAP **2116** sends the client **202** its own proof of BoH, and forwards the proof of BoH of the client **202** to the RADIUS server **2160**. The RADIUS server **2160** then informs the RAS server **2170** via RADIUS protocol to remove the IP filter and allow the VPN connection. Acquisition and validation of BoHs is explained in the description of FIGS. **7** and **8**. Moreover, this embodiment permits the VPN server **2170** to be replaced by an 802.1X compliant device. Thus, the 802.1X device will not authenticate a supplicant (client **202**) until the supplicant has presented valid credentials, and the RADIUS server **2160** has informed the 802.1X device that the supplicant has a valid BoH.

In another embodiment where the invention is implemented using IPsec, the enforcer **205** and enforcement server **216** use IPsec Internet Key Encryption (IKE). FIG. **14** illustrates an overview of this embodiment, including the client **202**, QA **204**, QS **201**, network server or peer **203**, and BoH interface **208** as previously described. FIG. **14** also illustrates client **202** comprising IPsec IKE enforcer **1405** as an enforcer, and network server **203** comprising IPsec IKE enforcer **1416** as an enforcement server. In this embodiment, the IPsec policy of the client **202** and the peer **203** is modified to require a validated proof of BoH before access is granted to each other's network resources. Acquisition and validation of BoHs is explained in the description of FIGS. **7** and **8**.

FIG. **16** illustrates yet another embodiment of the invention, in which the QS is replaced with a Microsoft® Systems Management Server (SMS). However, any server performing the functions of the SMS described herein is considered to be equivalently embodied in the present invention. SMS helps ensure that software used by clients complies with corporate guidelines, requirements, or standards. For example, there can be an organizational requirement to use only a certain version of a software product. The product compliance feature works with the software inventory feature. The software inventory feature tracks software that is installed on client computers. Inventory data can show required critical software patches that are not yet deployed to specific computers. The product compliance feature identifies which software complies with corporate guidelines, requirements, or standards, and which does not. After noncompliant software is identified, you use software distribution to upgrade the software to bring it into compliance. Instead of relying on software databases to map discovered files to known applications, SMS scans the resource headers of program files or binary files to build a complete picture of the software that is installed on each managed client computer. Such an approach is inherently scalable and automatically identifies new applications when they are released. SMS is used to check installed software on all managed systems against a database of available critical updates. SMS can then automatically download and deploy the latest patches to those systems that require them.

This embodiment of the invention comprises at least an SMS **1601**, a client **1602**, and a network server **1603**. The client **1602** includes an SMS agent **1604** for communicating

with the SMS **1601**, a QA plug-in **1606** for the SMS agent **1604**, a quarantine policy (QP) plug-in **1607** for the SMS agent **1604**, a Proof of Health (PoH) interface **1608**, and an enforcer **1605** for communicating with the network server **1603**. The network server **203** includes a PoH interface **1608**, an SMS identity database (ID DB) **1622**, and an enforcement server **1616**, which denies client **1602** access to network resources until client **1602** presents a PoH signifying that client **1602** is in a valid security state. Until client **1602** presents a valid PoH, the client **1602** is in a quarantine state and has access only to designated network resources for fixing the client's security state. One such accessible resource is the SMS **1601**, which issues the quarantine checks, quarantine policy, software, and patches necessary to present a valid PoH.

The SMS **1601** is available from the Microsoft Corporation, and is modified to issue a manifest of quarantine policies and checks, and to store the most recent checks and policies in an SMS quarantine database (DB) **1620**. The SMS quarantine DB **1620** also stores the software and patches necessary to implement the quarantine policies and checks. The SMS **1601** is also modified to analyze the manifest results, and store an SMS ID DB **1621** a BoH, quarantine check ID, and public key for each client. The quarantine check ID is a globally unique ID that identifies the quarantine checks that were performed for the BoH. Because a manifest may require checks that are not mandatory, the quarantine check ID computed as the SHA1 hash of the mandatory quarantine checks. The SMS ID DB **1621** is replicated and updated on each authenticated network server, and is accessible only to authenticated network servers. Thus, the SMS ID DB **1621** and SMS ID DB **1622** are identical.

The QA plug-in **1606** and QP plug-in **1607** are plug-ins for the SMS agent **1604** that is available from the Microsoft Corporation. The QP plug-in **1607** is responsible for executing and implementing the quarantine checks and policies received from the SMS **1601**. The QA plug-in is responsible for using the results of the quarantine policies and checks to generate a PoH. As shown in FIG. **20**, the PoH comprises an SMS GUID **2010** for uniquely identifying the associated BoH record in an SMS ID DB, the quarantine check ID **2020**, the time **2030** the PoH was generated, and a signature **2040** using the private key of the client.

The operation of the present embodiment is substantially similar to that of the previous embodiments. Accordingly, only the differences between the present embodiment and the previous embodiments are explained. With reference to FIG. **17**, the client **1602** is initialized with the SMS **1601** at step **1710**. The client may be directed to initialize with the SMS **1601** by a network server, as part of a start-up protocol, or for any other reason. At step **1720**, SMS agent **1604** on client **1602** receives a request for a software inventory for the client. At step **1730**, the SMS **1604** agent performs the inventory and returns the results to the SMS **1601**. At step **1740**, the SMS agent **1604** receives a manifest from the SMS **1601** containing quarantine policy and quarantine checks that the client **1602** must implement. The SMS agent also receives the software and patches that it needs to implement the quarantine policy and pass the quarantine checks.

The quarantine policy and checks are then passed to the QP plug-in **1607**, which performs the checks and implements the policy at step **1750**. At step **1760**, the client **1602** uploads the results of the quarantine policy and checks to the SMS **1601**, and also stores the results using Windows Management Instrumentation (WMI). The QA plug-in **1606** then sends a WMI event message at step **1770** notifying the other client components that the quarantine policy has changed. Assuming access to network resources is desired, the enforcer **1605** will request a PoH from QA plug-in **1606** at step **1780**. At step **1790**, the QA plug-in will query the QP plug-in for the quarantine policy and check results and use them to generate a PoH, which is returned to the enforcer **1605**. The enforcer **1605** can then use the PoH to request access to network resources from a network server at step **1795**. Thereafter, the client **1602** may request a new manifest if the PoH fails, or at any other time, and the SMS **1601** may request a new inventory when new software or patches are added, or at any other time.

FIG. **18** illustrates that SMS **1601** is initialized with the client **1602** at step **1800**. The SMS **1601** sends an inventor request to the SMS agent **1604** requesting a software inventory for the client **1602** at step **1810**. At step **1820**, the SMS **1601** receives the inventory, analyzes it, and sends a manifest to client **1602**. The manifest includes quarantine policies and quarantine checks, as well as software and patches that the client **1602** lacks, as observed from the inventory. At step **1830**, the SMS **1601** receives the results of the execution of the quarantine policies and checks. Assuming the client **1602** correctly implemented the quarantine policies, the results will pass and a BoH is recorded in the SMS ID DB **1622** at step **1840**, along with the public key of the client **1602** and the quarantine check GUID. The SMS ID DB for all network servers is also updated.

FIG. **19** illustrates the operation of the network server **1603** in processing a request for network access. At step **1900** the enforcement server **1616** receives a request for network resources including a PoH. The enforcement server **1616** passes the PoH to the PoH interface **1608**, which at step **1920** uses the SMS ID **2010** to locate the BoH, the public key of the client **1602**, and the quarantine check GUID in the SMS ID DB **1622**. At step **1930**, the PoH interface **1608** decrypts the PoH using the public key of the client **1602** and compares the quarantine check ID **2020** of the PoH with the quarantine check ID of the BoH. If they do not match, network access is denied at step **1670**. If they do match, the time **2030** of the PoH is compared with the current time at step **1940**. If the time **2030** is within an acceptable range of the current time, network access is granted at step **1950**. Otherwise, network access is denied at step **1670**.

This embodiment of the invention is also implemented using the DHCP, PEAP VPN, PEAP 802.1X, or IPsec network protocol environments as previously described, as well as any network protocol environment supporting the requirements of PoH validation describe above.

In another embodiment of the invention, an access point acts as an intermediary between the client and the network server. FIG. **22** illustrates a modification of any of the previous embodiments of the invention, where network server **203** is protected by a firewall **2245**, and client **202** communicates with network server **203** through access point **2247**. Access point **2247** communicates with client **202** using a standard protocol, such as 802.11, and filters all packets received from client **202**. When access point **2247** receives a request for access to network resources protected by the firewall, access point **2247** forwards the BoH or PoH to the network server **203** for validation. If the network server **203** validates the BoH or PoH, it notifies access point **2247** that the client **202** is authorized to access the requested network resource. Access point **2247** then grants client **202** access to the network resource. If network server **203** does not validate the BoH or PoH, it notifies the access point **2247** that client **202** is not authorized to access the requested network resource. Access point **2247** then denies access.

In an alternative to this embodiment, the QS **201** is also protected by the firewall **2245**. When the request for access to network resources is rejected, client **202** redirected to QS **201**. However, because QS **201** is also protected by the firewall **2245**, the request for manifest is received by the access point **2247**. Access point **2247** forwards the request to the QS **201**, and QS **201** returns a current manifest to access point **2247**. Access point **2247** then forwards the manifest to client **202**. The results of the manifest checks are then sent by the client **202** to access point **2247**, and access point **2247** forwards results to QS **201**. Accordingly, client **202** can communicate with QS **201** and network server **203** using a standard protocol, even when QS **201** and network server **203** are protected by a firewall **2245**.

A white list is needed for those systems that for some reason or other cannot go through the quarantine checks. While this is rarely needed for clients, it would be common with servers. The white list mechanism differs between the DHCP and IPsec embodiments. The VPN embodiment does not allow for a white list.

A DHCP white list is implicitly created by statically hosting a system. A system that has been statically hosted will never be quarantined using this system. This option should be used on servers. For clients that need to be white listed the QS supports manually creating BoH tokens with long lifetimes. These tokens can then be manually provisioned on the client by being entered in a REG_SZ registry key.

An IPsec white list can be created two ways. For systems that support IPsec the preferred solution is to generate a long-lived IPsec cert and deploy this cert, along with the quarantine IPsec policies, to that system. The management tool supports both generation of that cert and export of the quarantine IPsec policies to perform this task. For systems that do not support IPsec a white list is only needed if they need to initiate connections to the trusted members of the network. Trusted members will automatically fall back to clear so no white list is necessary if the white list systems only need to respond to connections.

The foregoing description of various embodiments of the invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise embodiments disclosed. Numerous modifications or variations are possible in light of the above teachings. The embodiments discussed were chosen and described to provide the best illustration of the principles of the invention and its practical application to thereby enable one of ordinary skill in the art to utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. All such modifications and variations are within the scope of the invention as determined by the appended claims when interpreted in accordance with the breadth to which they are fairly, legally, and equitably entitled.

What is claimed is:

1. A system for providing quarantine on a network comprising:

a client device seeking access to a network resource, the client device configured to:

perform a first plurality of checks specified by a first manifest,

store a first status report at the client device, the first status report specifying results of the first plurality of checks, and

send a Bill of Health (BoH) request that contains the first status report;

a first server device that:

receives the BoH request sent by the client device,

determines whether the first status report indicates that the client device passed all of the checks specified by a second manifest that specifies a second plurality of checks that the client device must perform,

sends to the client device the second manifest when the first status report indicates that the client device did not pass all of the checks specified by the second manifest,

receives, from the client device, a second status report that indicates results of the client device performing the second plurality of checks,

stores a Bill of Health (BoH) for the client device when the second status report indicates that the client device passed all of the checks in the second plurality of checks, the BoH comprising a creation time of the BoH, an expiration date of the BoH, a manifest version identifier that identifies a version number of the second manifest, and an integrity check;

if the results of the second plurality of checks show that the client device passed all of the checks in the second plurality of checks, sends, to the client device, a certificate that provides proof that the client device possesses a required configuration, the certificate comprising a serial number of the BoH, an address of the first server device, and a digital signature; and

a second server device that:

receives a request for access to the network resource from the client device, the request including the certificate,

uses the serial number in the certificate and the address of the first server device to retrieve the BoH from the first server device,

uses the digital signature of the certificate to determine whether any part of the certificate has been modified after the certificate was issued by the first server device,

after retrieving the BoH, uses the integrity check to determine whether the BoH has been tampered,

determines whether the expiration date of the BoH has passed,

determines whether the manifest version identifier identifies a most recent manifest version number,

provides access to the network resource when the second server device determines that the certificate has not been modified after the certificate was issued by the first server device, that the BoH has not been tampered, that the expiration date for the BoH has not passed, and that the manifest version identifier specifies the most recent manifest version number,

wherein the second server device denies the client device access to the network resource when the second server device determines that the certificate has been modified after the certificate was issued by the first server device, that the BoH has been tampered, that the expiration date for the BoH has passed, or that the manifest version identifier does not identify the most recent manifest version number;

wherein the client device periodically requests that the certificate be updated by the first server device, regardless of whether the client device sends further requests for access to the network resource to the second server device.

2. The system of claim **1**, wherein the second plurality of checks includes at least one of checks for; installed software, a software version, an installed patch, an installed anti-virus

system, an anti-virus state, a firewall state, an installed service, file sharing, a registry value, a registry key, and a file system state.

3. The system of claim **1**, wherein the client device comprises delegates that perform the checks in the first plurality of checks and the second plurality of checks.

4. The system of claim **1**, wherein the client device stores a copy of the certificate in a database.

5. The system of claim **1**, wherein if the client device cannot provide proof that the client device possesses the required configuration, the second server device directs the client device to the first server device.

6. The system of claim **1**, wherein the second server device includes a second database that is a replica of a first database, wherein the client device proves possession of the required configuration by sending the second server device the serial number of the BoH, wherein the second server device compares the serial number of the BoH to a unique identifier stored with the certificate in the second database.

7. The system of claim **1**, wherein the first server device requests a software inventory from the client device and sends, to the client device, software necessary for the required configuration.

8. The system of claim **1**, further comprising an access point for mediating communication between the client device and the second server device, wherein the second server device is protected by a firewall.

9. The system of claim **1**, wherein the first server device and the second server device are one computing device.

10. A method for a client device to acquire access to a network resource, comprising:

performing, at the client device, a first plurality of checks specified by a first manifest;

storing a first status report at the client device, the first status report specifying results of the first plurality of checks;

sending a Bill of Health (BoH) request that contains the first status report from the client device to a first server device;

receiving, at the client device, a second manifest of checks from the first server device when the first server device determines that the first status report indicates that the client device did not pass all of the checks specified by the second manifest, wherein the checks of the second manifest determine whether the client device possesses a required configuration;

performing, at the client device, the checks in the second manifest of checks;

sending, from the client device to the first server device, a second status report that indicates results of the checks of the second manifest;

receiving, at the client device from the first server device, a certificate that provides proof that the client device possesses the required configuration,

wherein the certificate comprises a serial number of a BoH for the client device stored at the first server device, an address of the first server device, and a digital signature, and

wherein the BoH comprises a creation time of the BoH, an expiration date for the BoH, a manifest version identifier that identifies a version number of the second manifest, and an integrity check;

sending, from the client device to a second server device that controls access to the network resource, a request for access to the network resource;

sending from the client device to the second server device, the certificate;

receiving, at the client device, access to the network resource when the certificate has not been modified after the certificate was issued by the first server device, the BoH has not been tampered, the expiration date for the BoH has not passed, and the manifest version identifier of the BoH identifies a most recent manifest version number;

periodically requesting, from the client device, that the certificate be updated by the first server device, regardless of whether the client device sends further requests for access to the network resource to the second server device.

11. The method of claim **10**, further comprising:

receiving, at the client device, a request for a software inventory from the first server device;

receiving, at the client device, software necessary for the required configuration; and

installing the software at the client device.

12. The method of claim **10**, wherein the first server device and the second server device are one computing device.

13. A method for quarantining a client device from access to a network resource, comprising:

receiving, at a first server device, a request for access to the network resource from the client device;

receiving, at the first server device from the client device, a certificate that provides proof that the client device has a required configuration, wherein the certificate specifies a serial number of a Bill of Health (BoH) generated by a trusted server device that only generates the BoH when the trusted server device receives, from the client device, a status report that indicates results of checks specified in a manifest sent to the client device by the trusted server device and the results of the checks show that the client device passed all the checks;

sending, from the first server device to the trusted server device, a request for the BoH, the request for the BoH specifying the serial number of the BoH;

receiving, at the first server device, the BoH, the BoH specifying a creation time of the BoH, an expiration date for the BoH, a manifest version identifier that specifies a version number of the manifest, and an integrity check;

validating, at the first server device, the certificate when the certificate has not been modified after the certificate was issued by the trusted server device, the BoH has not been tampered, the expiration date of the BoH has not passed, and the manifest version identifier specifies a most recent manifest version number;

if the certificate is valid, allowing the client device access to the network resource;

if the certificate is invalid, denying the client device access to the network resource; and

wherein the trusted server device periodically receives from the client device a request that the certificate be updated, regardless of further requests for access to the network resource.

14. The method of claim **13**, further comprising, if the certificate is invalid, directing, at the first server device, the client device to the trusted server device so that the required configuration is obtained.

15. One or more computer readable storage media having computer-executable instructions that, when executed by a processing unit in a client device, cause the client device to perform a method for the client device to acquire access to a network resource, the method comprising the steps of:

performing, at the client device, a first plurality of checks specified by a first manifest;

storing a first status report at the client device, the first status report specifying results of the first plurality of checks;

sending a Bill of Health (BoH) request that contains the first status report from the client device to a first server device;

receiving, at the client device, a second manifest of checks from the first server device when the first server device determines that the first status report indicates that the client device did not pass all of the checks specified by the second manifest, wherein the checks of the second manifest determine whether the client device possesses a required configuration of installed software;

performing, at the client device, the checks in the second manifest of checks;

sending a second status report that indicates results of the checks of the second manifest from the client device to the first server device;

receiving, at the client device from the first server device, a certificate that provides proof that the client device possesses the required configuration,

wherein the certificate comprises a serial number of a BoH for the client device stored at the first server device, an address of the first server device, and a digital signature, and

wherein the BoH comprises a creation time of the BoH, an expiration date for the BoH, a manifest version identifier that identifies a version number of the second manifest, and an integrity check;

sending, from the client device to a second server device that controls access to the network resource, a request to access to the network resource;

sending, from the client device to the second server device, the certificate;

receiving, at the client device, access to the network resource when the certificate has not been modified after the certificate was issued by the first server device, the BoH has not been tampered, the expiration date for the BoH has not passed, and the manifest version identifier of the BoH identifies a most recent manifest version number; and

periodically sending, from the client device to the first server device, a request to update the certificate, regardless of further requests for access to the network resource.

16. A system for a client device to acquire access to a network resource, comprising:

a processing unit; and

a memory coupled with and readable by the processing unit and having stored therein instructions which, when executed by the processing unit, cause a module to perform the following acts:

performing, at the client device, a first plurality of checks specified by a first manifest;

storing a first status report at the client device, the first status report specifying results of the first plurality of checks;

sending a Bill of Health (BoH) request that contains the first status report from the client device to a first server device;

receiving, at the client device, a second manifest of checks from the first server device when the first server device determines that the first status report indicates that the client device did not pass all of the checks specified by the second manifest, wherein the checks of the second manifest determine whether the client device possesses a required configuration;

performing, at the client device, the checks in the second manifest of checks;

sending, from the client device to the first server device, a second status report that indicates results of the checks of the second manifest;

receiving, at the client device from the first server device, a certificate that provides proof that the client device possesses the required configuration,

wherein the certificate comprises a serial number of a BoH for the client device stored at the first server device, an address of the first server device, and a digital signature, and

wherein the BoH comprises a creation time of the BoH, an expiration date for the BoH, a manifest version identifier that identifies a version number of the second manifest, and an integrity check;

storing the certificate at the client device;

sending, from the client device to a second server device that controls access to the network resource, a request to access the network resource;

determining, at the client device, whether the certificate stored at the client device is valid;

sending, from the client device to the first server device, a request to update the proof if the certificate is no longer valid;

sending, from the client device to the second server device, the certificate of the required configuration; and

periodically sending, from the client device to the first server device, requests to update the certificate, regardless of further requests for access to the network resource.

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