US008504822B2

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

(10) **Patent No.: US 8,504,822 B2**
(45) **Date of Patent: *Aug. 6, 2013**

(54) **TRANSPARENT PROXY OF ENCRYPTED SESSIONS**

(75) Inventors: **Jianxin Wang**, San Jose, CA (US); **Anupama Sundaresan**, San Jose, CA (US); **Vijaya Bharathi Kaza**, Santa Clara, CA (US); **Dario Calia**, San Jose, CA (US)

(73) Assignee: **Cisco Technology, Inc.**, San Jose, CA (US)

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

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **13/541,407**

(22) Filed: **Jul. 3, 2012**

(65) **Prior Publication Data**

US 2012/0272058 A1 Oct. 25, 2012

Related U.S. Application Data

(63) Continuation of application No. 11/605,087, filed on Nov. 28, 2006, now Pat. No. 8,214,635.

(51) **Int. Cl.**
H04L 29/06 (2006.01)
G06F 9/00 (2006.01)

(52) **U.S. Cl.**
USPC **713/156**; 716/11

(58) **Field of Classification Search**
USPC 713/151, 153, 156, 168, 175; 726/11, 726/12, 14, 15
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,491,750	A	2/1996	Bellare et al.
5,586,260	A	12/1996	Hu
5,915,087	A	6/1999	Hammond et al.
6,003,084	A	12/1999	Green et al.
6,182,141	B1	1/2001	Blum
6,298,380	B1	10/2001	Coile et al.
6,505,254	B1	1/2003	Johnson et al.
6,894,981	B1	5/2005	Coile et al.
6,978,367	B1	12/2005	Hind et al.
7,013,389	B1	3/2006	Srivastava et al.
7,047,560	B2	5/2006	Fishman et al.
7,111,162	B1	9/2006	Bagepalli et al.
7,136,359	B1	11/2006	Coile et al.
7,508,826	B2	3/2009	Miyata et al.
7,954,144	B1	5/2011	Ebrahimi et al.

(Continued)

OTHER PUBLICATIONS

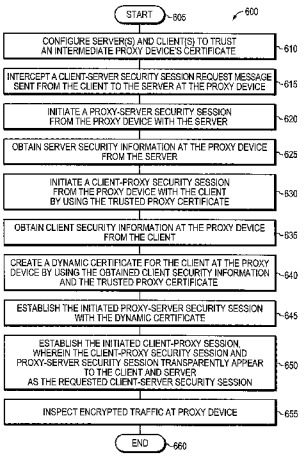
Dierks, T., et al. , Request for Comments 4346, entitled "The Transport Layer Security (TLS) Protocol Version 1.1", Network Working Group, IETF, Apr. 2006, pp. 1-82.

Primary Examiner — Nathan Flynn
Assistant Examiner — Abdullah Almamun
(74) *Attorney, Agent, or Firm* — Cesari and McKenna, LLP

(57) **ABSTRACT**

In one embodiment, a proxy device located between a first device and a second device intercepts a security session request for a security session between the first device and the second device. The proxy device obtains security information from the first device that includes at least a subject name of the first device. The proxy device creates a dynamic certificate using the subject name of the first device and a trusted proxy certificate of the proxy device. The proxy device establishes a security session between the proxy device and the second device using the dynamic certificate. Further, the proxy device establishes a security session between the first device and the proxy device using the trusted proxy certificate of the proxy device. The two security sessions collectively operate as a security session between the first device and the second device.

20 Claims, 7 Drawing Sheets



U.S. PATENT DOCUMENTS

2002/0025046 A1 2/2002 Lin
2003/0061353 A1 3/2003 Johnson et al.
2004/0015725 A1 1/2004 Boneh et al.
2004/0146163 A1 7/2004 Asokan et al.
2004/0168054 A1 8/2004 Halasz et al.
2004/0268148 A1 12/2004 Karjala et al.
2005/0050362 A1 3/2005 Peles
2005/0108430 A1 5/2005 Howarth et al.
2006/0174106 A1 8/2006 Bell et al.
2007/0088834 A1 4/2007 Litovski
2007/0192845 A1 8/2007 Lankheim
2007/0245414 A1 10/2007 Chan et al.
2008/0046714 A1 2/2008 Suganthi et al.
2009/0013399 A1 1/2009 Cottrell

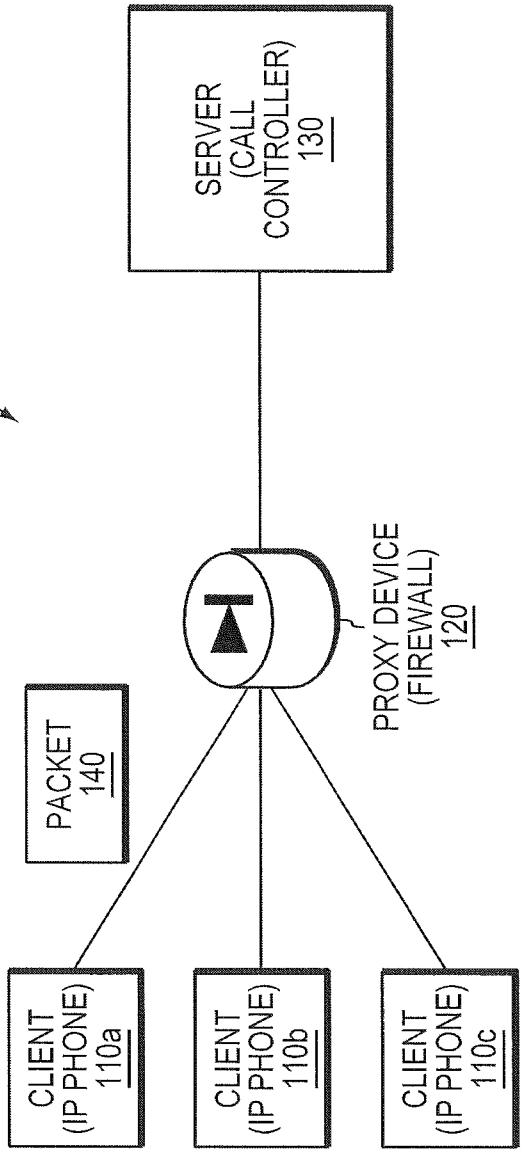

100
SERVER (CALL CONTROLLER) 130
PROXY DEVICE (FIREWALL) 120
PACKET 140
CLIENT (IP PHONE) 110a
CLIENT (IP PHONE) 110b
CLIENT (IP PHONE) 110c

FIG. 1

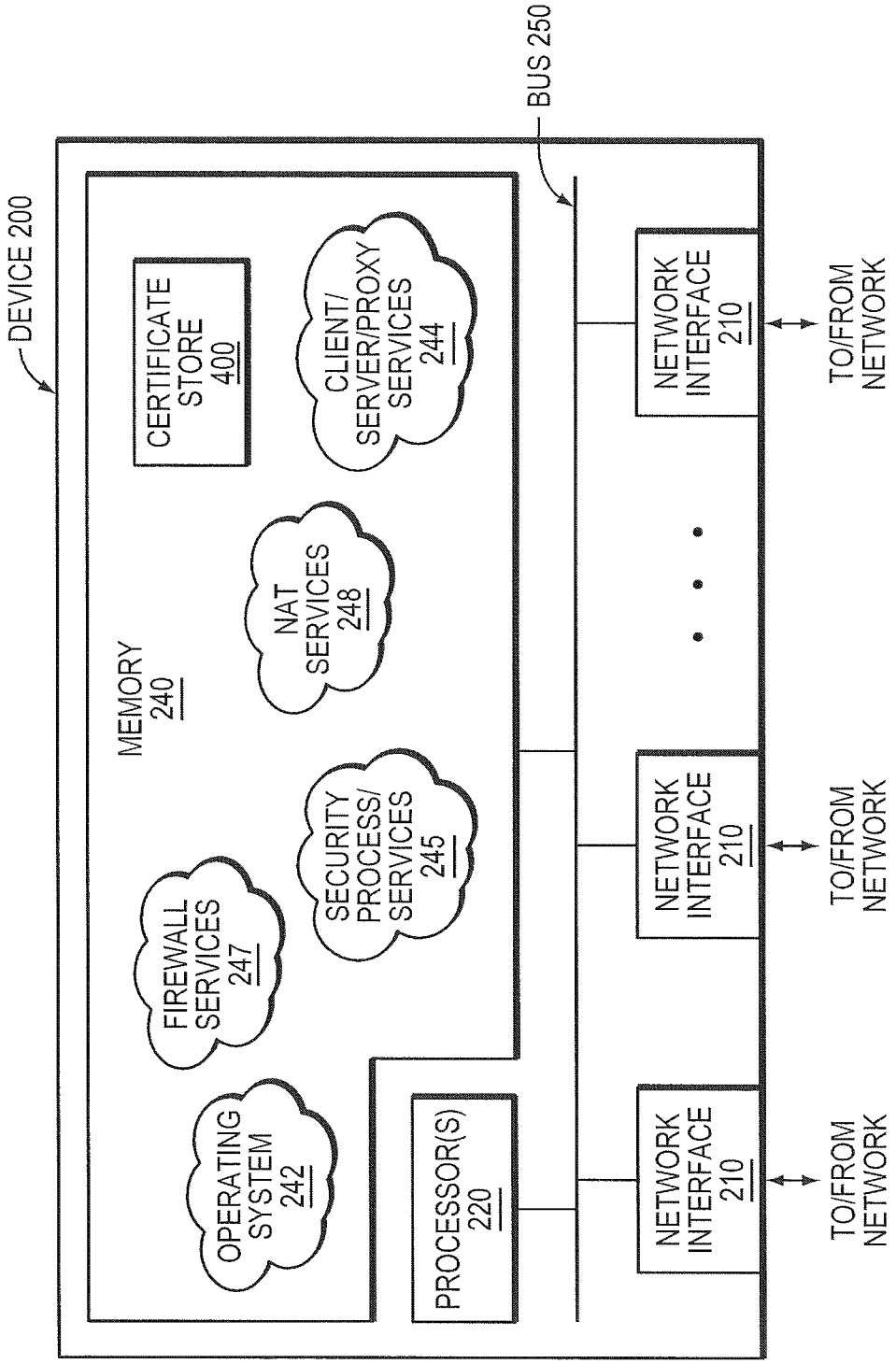

DEVICE 200
BUS 250
MEMORY 240
CERTIFICATE STORE 400
CLIENT/ SERVER/PROXY SERVICES 244
NAT SERVICES 248
SECURITY PROCESS/ SERVICES 245
FIREWALL SERVICES 247
OPERATING SYSTEM 242
PROCESSOR(S) 220
NETWORK INTERFACE 210
NETWORK INTERFACE 210
NETWORK INTERFACE 210
TO/FROM NETWORK
TO/FROM NETWORK
TO/FROM NETWORK

FIG. 2

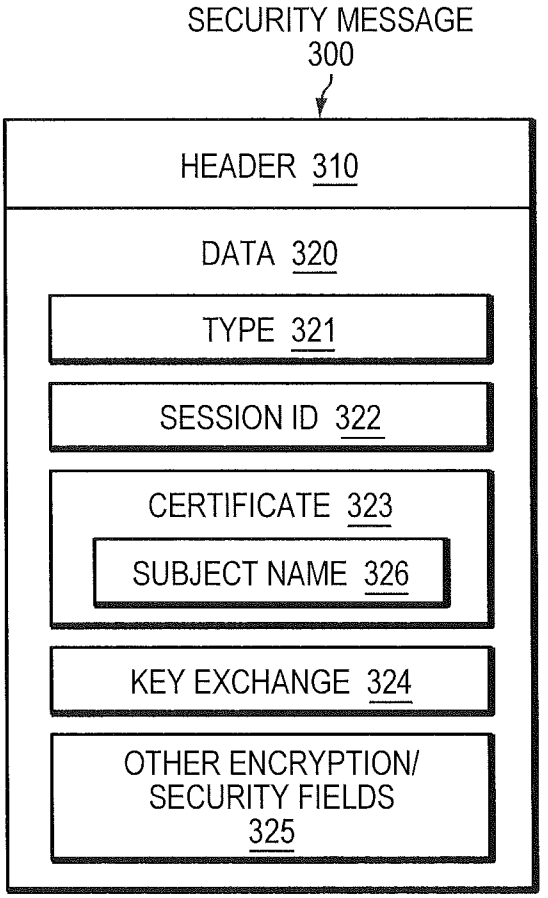

SECURITY MESSAGE
300
HEADER 310
DATA 320
TYPE 321
SESSION ID 322
CERTIFICATE 323
SUBJECT NAME 326
KEY EXCHANGE 324
OTHER ENCRYPTION/
SECURITY FIELDS
325

FIG. 3

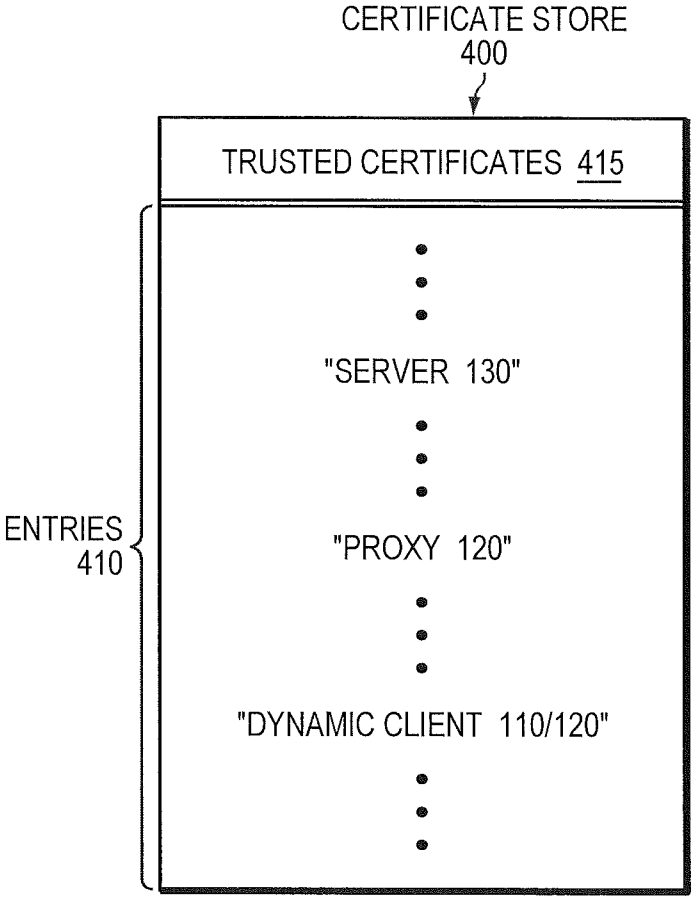

CERTIFICATE STORE
400
TRUSTED CERTIFICATES 415
"SERVER 130"
ENTRIES
410
"PROXY 120"
"DYNAMIC CLIENT 110/120"

FIG. 4

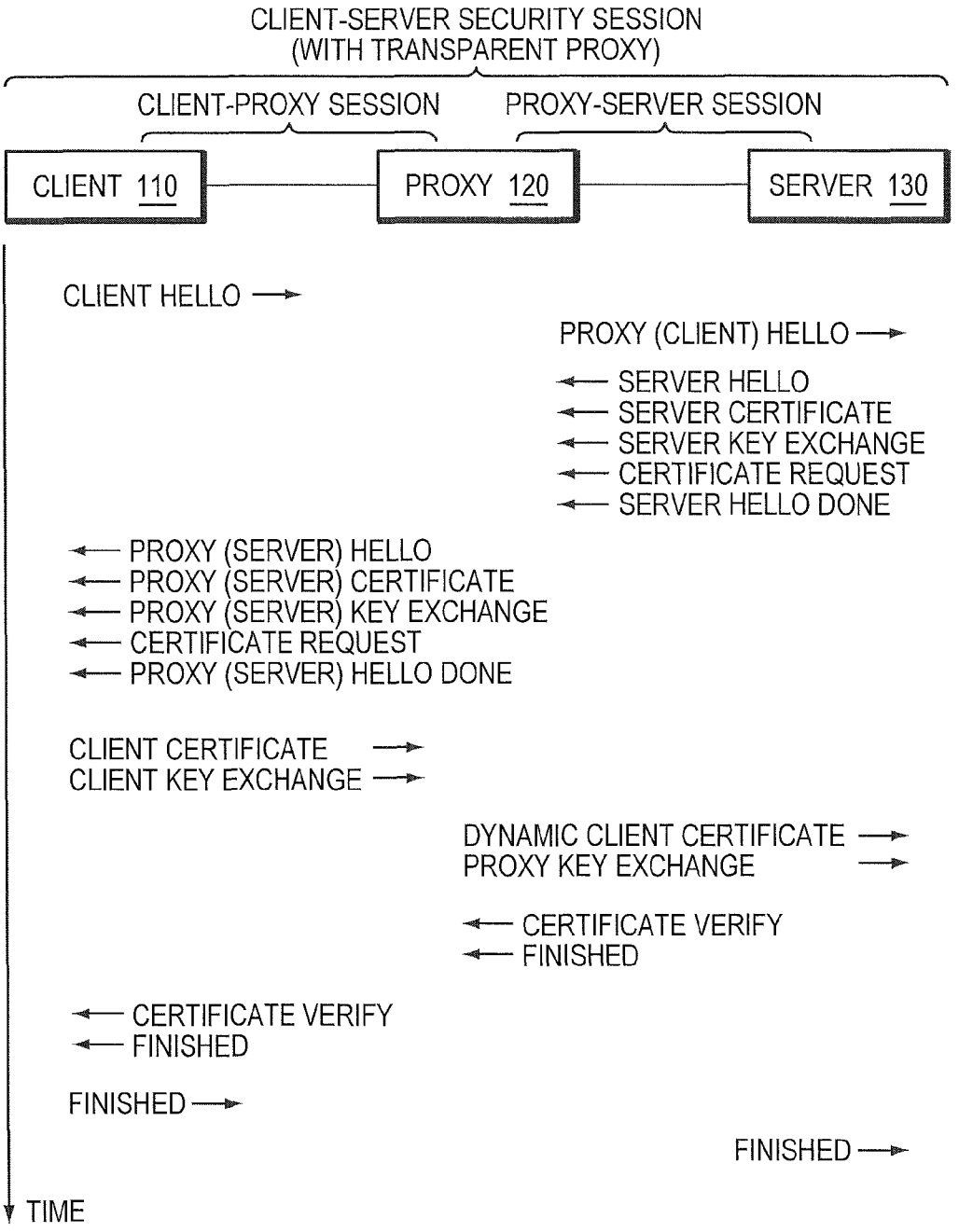

CLIENT-SERVER SECURITY SESSION
(WITH TRANSPARENT PROXY)
CLIENT-PROXY SESSION
PROXY-SERVER SESSION
CLIENT 110
PROXY 120
SERVER 130
CLIENT HELLO
PROXY (CLIENT) HELLO
SERVER HELLO
SERVER CERTIFICATE
SERVER KEY EXCHANGE
CERTIFICATE REQUEST
SERVER HELLO DONE
PROXY (SERVER) HELLO
PROXY (SERVER) CERTIFICATE
PROXY (SERVER) KEY EXCHANGE
CERTIFICATE REQUEST
PROXY (SERVER) HELLO DONE
CLIENT CERTIFICATE
CLIENT KEY EXCHANGE
DYNAMIC CLIENT CERTIFICATE
PROXY KEY EXCHANGE
CERTIFICATE VERIFY
FINISHED
CERTIFICATE VERIFY
FINISHED
FINISHED
FINISHED
TIME

FIG. 5

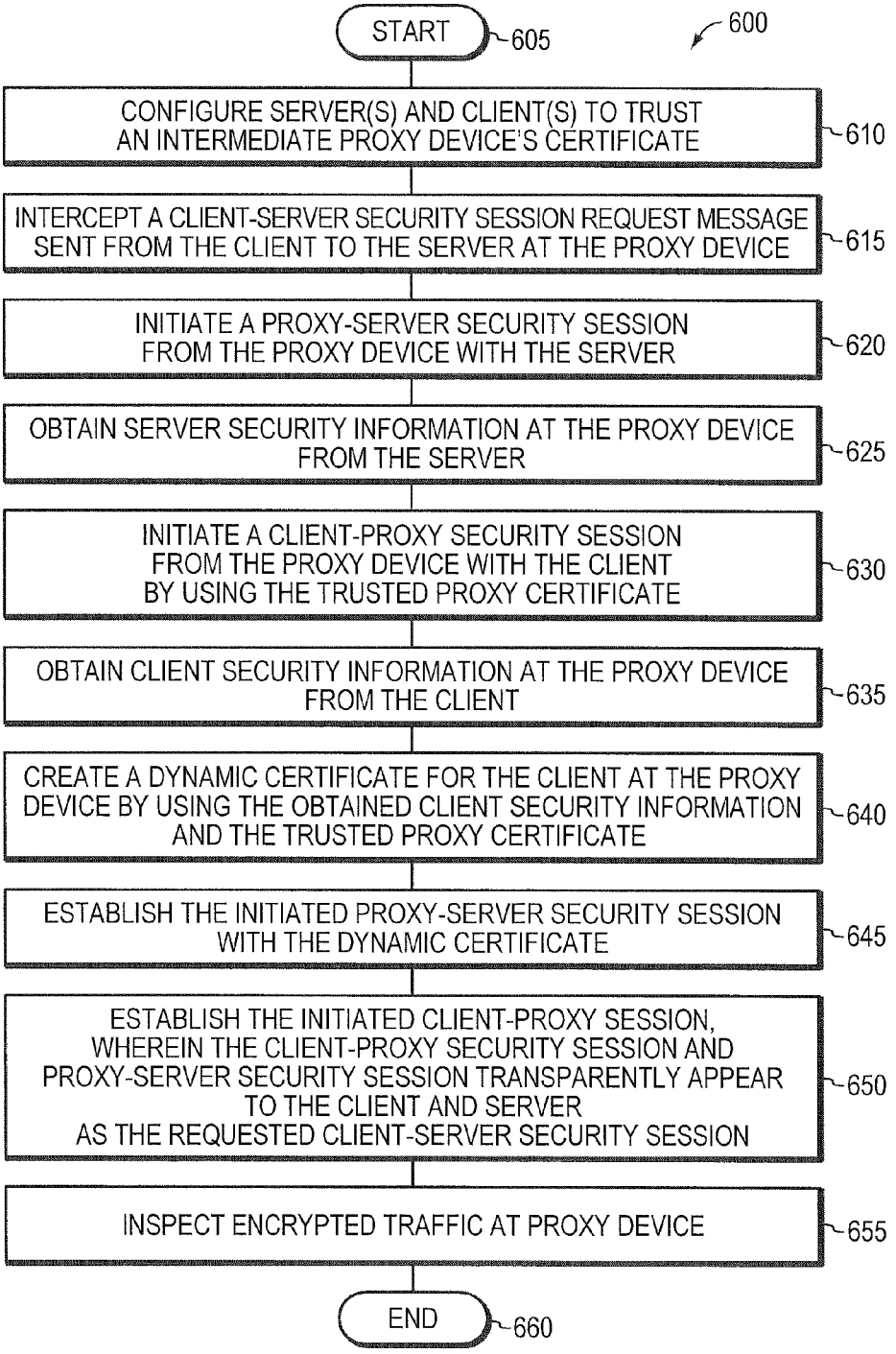

600
START
605
CONFIGURE SERVER(S) AND CLIENT(S) TO TRUST AN INTERMEDIATE PROXY DEVICE'S CERTIFICATE
610
INTERCEPT A CLIENT-SERVER SECURITY SESSION REQUEST MESSAGE SENT FROM THE CLIENT TO THE SERVER AT THE PROXY DEVICE
615
INITIATE A PROXY-SERVER SECURITY SESSION FROM THE PROXY DEVICE WITH THE SERVER
620
OBTAIN SERVER SECURITY INFORMATION AT THE PROXY DEVICE FROM THE SERVER
625
INITIATE A CLIENT-PROXY SECURITY SESSION FROM THE PROXY DEVICE WITH THE CLIENT BY USING THE TRUSTED PROXY CERTIFICATE
630
OBTAIN CLIENT SECURITY INFORMATION AT THE PROXY DEVICE FROM THE CLIENT
635
CREATE A DYNAMIC CERTIFICATE FOR THE CLIENT AT THE PROXY DEVICE BY USING THE OBTAINED CLIENT SECURITY INFORMATION AND THE TRUSTED PROXY CERTIFICATE
640
ESTABLISH THE INITIATED PROXY-SERVER SECURITY SESSION WITH THE DYNAMIC CERTIFICATE
645
ESTABLISH THE INITIATED CLIENT-PROXY SESSION, WHEREIN THE CLIENT-PROXY SECURITY SESSION AND PROXY-SERVER SECURITY SESSION TRANSPARENTLY APPEAR TO THE CLIENT AND SERVER AS THE REQUESTED CLIENT-SERVER SECURITY SESSION
650
INSPECT ENCRYPTED TRAFFIC AT PROXY DEVICE
655
END
660

FIG. 6

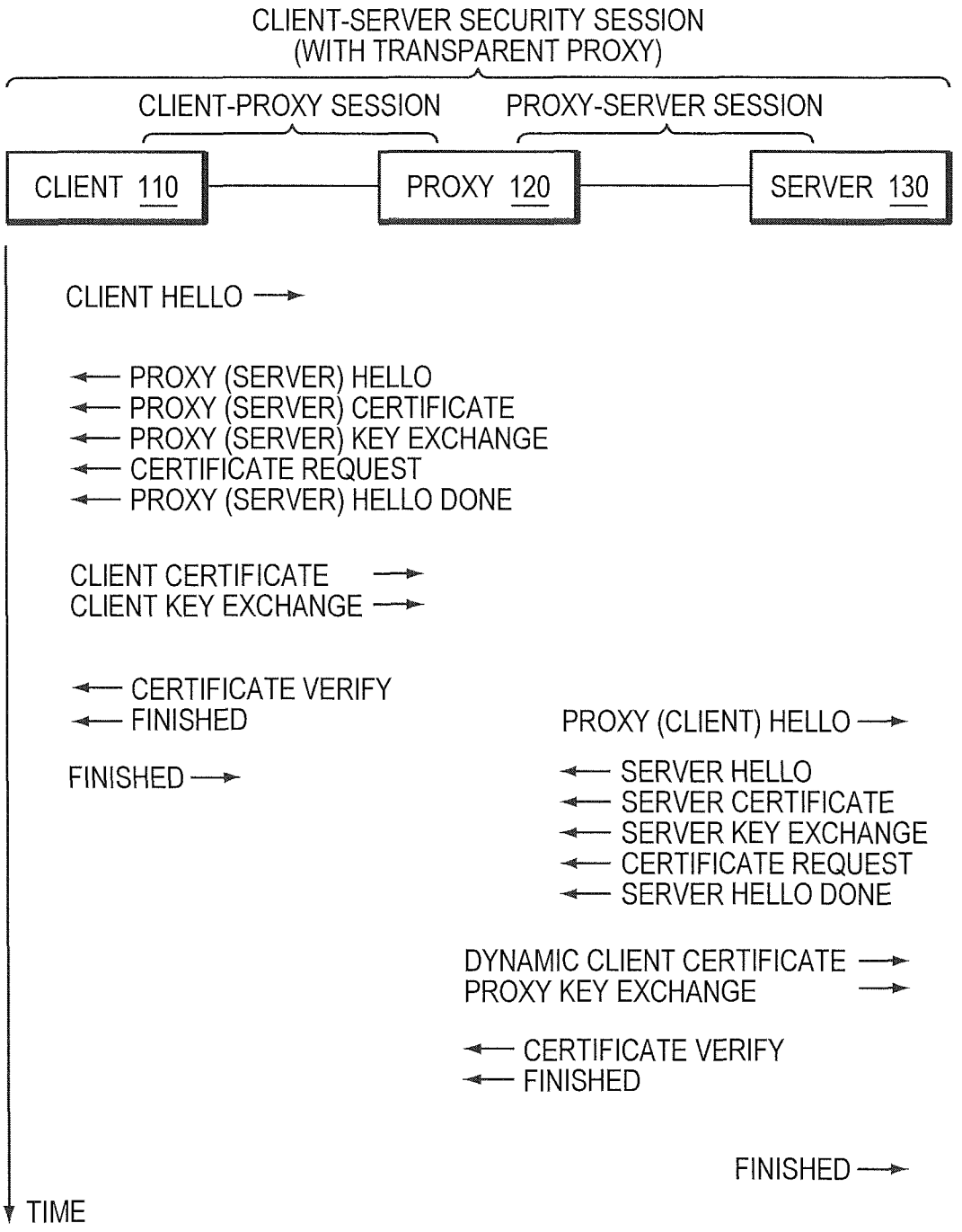

CLIENT-SERVER SECURITY SESSION
(WITH TRANSPARENT PROXY)
CLIENT-PROXY SESSION
PROXY-SERVER SESSION
CLIENT 110
PROXY 120
SERVER 130
CLIENT HELLO
PROXY (SERVER) HELLO
PROXY (SERVER) CERTIFICATE
PROXY (SERVER) KEY EXCHANGE
CERTIFICATE REQUEST
PROXY (SERVER) HELLO DONE
CLIENT CERTIFICATE
CLIENT KEY EXCHANGE
CERTIFICATE VERIFY
FINISHED
PROXY (CLIENT) HELLO
FINISHED
SERVER HELLO
SERVER CERTIFICATE
SERVER KEY EXCHANGE
CERTIFICATE REQUEST
SERVER HELLO DONE
DYNAMIC CLIENT CERTIFICATE
PROXY KEY EXCHANGE
CERTIFICATE VERIFY
FINISHED
FINISHED
TIME

FIG. 7

TRANSPARENT PROXY OF ENCRYPTED SESSIONS

RELATED APPLICATIONS

The present application is a continuation of U.S. patent application Ser. No. 11/605,087, filed on Nov. 28, 2006 by Jianxin Wang et al., titled "Transparent Proxy of Encrypted Sessions", the contents of which are incorporated by reference herein in their entirety.

TECHNICAL FIELD

The present disclosure relates generally to computer networks, and, more particularly, to security (e.g., encryption) sessions between a client and a server.

BACKGROUND

Generally, firewalls are devices in computer networks that are configured to apply one or more policies to traffic (e.g., data packets) that traverse the firewalls. For instance, the firewalls may inspect the traffic at a basic level, e.g., at source and destination addresses of packet headers, to permit or deny traversal of the packets based on access lists corresponding to the addresses. Often, the firewalls may also be configured to perform deep packet inspection on the traffic, wherein the firewalls inspect the packets further than simply the headers, e.g., to the data contained within the packets ("payload"). For example, firewalls are often utilized to inspect the payloads of packets for Voice over Internet Protocol (VoIP) or Video over IP applications (e.g., "Layer 7" application layer data), as well as for Network Address Translation (NAT) functionality and dynamic pinhole (access) control, as will be understood by those skilled in the art. Notably, packet inspection is not limited to simply reading the payload contents of packets, but also to modification of the packets, such as rewriting portions of the packets that contain address/port information (e.g., for NAT).

As more traffic within computer networks (e.g., the Internet) moves toward a secured mode of transport (e.g., authenticated and/or encrypted), traditional firewalls lose their ability to look into the packet payload, and particularly their ability to modify the packets. In other words, the firewalls are unable to deeply inspect the traffic payload because of their inability to decrypt the traffic. Accordingly, one option is to allow all secured traffic to traverse the firewalls without inspection. However, this option negates the use of the firewalls to inspect traffic, thereby potentially allowing illegitimate and/or harmful traffic to pass through freely, particularly for the Session Initiation Protocol (SIP) for VoIP traffic. Also, NAT functionality is generally unavailable when signaling is encrypted, as will be understood by those skilled in the art.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and further advantages of the invention may be better understood by referring to the following description in conjunction with the accompanying drawings in which like reference numerals indicate identically or functionally similar elements, of which:

FIG. **1** illustrates an example computer network;

FIG. **2** illustrates an example network device/node;

FIG. **3** illustrates an example security message;

FIG. **4** illustrates an example certificate store;

FIG. **5** illustrates an example message exchange between a client and server through an intermediate proxy device;

FIG. **6** illustrates an example procedure for proxying a security session between a client and a server; and

FIG. **7** illustrates another example message exchange between a client and server through an intermediate proxy device.

DESCRIPTION OF EXAMPLE EMBODIMENTS

Overview

According to embodiments of the disclosure, at least one server and at least one client are configured to trust a proxy certificate of an intermediate proxy device. The proxy device intercepts a client-server security session request message sent from the client to the server. In response, the proxy device initiates a proxy-server security session with the server and obtains server security information from the server. Then, the proxy device initiates a client-proxy security session with the client using the trusted proxy certificate, and obtains client security information from the client. Upon obtaining the client security information, the proxy device creates a dynamic certificate using the obtained client security information and the trusted proxy certificate, and establishes the initiated proxy-server security session with the dynamic certificate. The proxy device then establishes the initiated client-proxy session, wherein the client-proxy security session and proxy-server security session transparently appear to the client and server as the requested client-server security session.

Description

FIG. **1** is a schematic block diagram of an example computer network **100** illustratively comprising nodes/devices, such as one or more clients **110***a-c* and one or more servers **130** interconnected by links as shown. Also, an intermediate proxy device **120** is located between the client **110** and the server **130** in accordance with one or more embodiments described herein. Illustratively, as described herein, an example embodiment of the client **110**, proxy **120**, and server **130** may be a Voice over Internet Protocol (VoIP) configuration. As such, the client may be an IP phone, the server may be a call controller, and the proxy device may be a firewall. Those skilled in the art will understand that any number of nodes, devices, links, etc. may be used in the computer network, and that the view shown herein is for simplicity. Those skilled in the art will also understand that while the embodiments herein are described generally, they may apply to any network configuration (particularly, to network configurations other than for VoIP sessions) within a single Autonomous System (AS) or area, or throughout multiple ASes or areas, etc.

Data packets **140** (e.g., traffic sent between the client and server) may be exchanged among the nodes/devices of the computer network **100** using predefined network communication protocols such as the Transmission Control Protocol/Internet Protocol (TCP/IP), User Datagram Protocol (UDP), Asynchronous Transfer Mode (ATM) protocol, Frame Relay protocol, Internet Packet Exchange (IPX) protocol, etc.

FIG. **2** is a schematic block diagram of an example node/device **200** that may be advantageously used with one or more embodiments described herein, e.g., as a proxy device **120** (or client **110** or server **130**). The device comprises a plurality of network interfaces **210**, one or more processors **220**, and a memory **240** interconnected by a system bus **250**. The network interfaces **210** contain the mechanical, electrical, and signaling circuitry for communicating data over physical links coupled to the network **100**. The network interfaces may

be configured to transmit and/or receive data using a variety of different communication protocols, including, inter alia, TCP/IP, UDP, ATM, synchronous optical networks (SONET), wireless protocols, Frame Relay, Ethernet, Fiber Distributed Data Interface (FDDI), etc. Notably, a physical network interface **210** may also be used to implement one or more virtual network interfaces, such as for Virtual Private Network (VPN) access, known to those skilled in the art.

The memory **240** comprises a plurality of storage locations that are addressable by the processor(s) **220** and the network interfaces **210** for storing software programs and data structures associated with the embodiments described herein. The processor **220** may comprise necessary elements or logic adapted to execute the software programs and manipulate the data structures, such as a certificate store **400**. An operating system **242**, portions of which is typically resident in memory **240** and executed by the processor(s), functionally organizes the node by, inter alia, invoking network operations in support of software processes and/or services executing on the device. These software processes and/or services may comprise client/server/proxy services **244** (e.g., depending upon the particular device **200**) and security process/services **245** and, for an illustrative proxy device **200**, firewall services **247** and Network Address Translation (NAT) services **248**. It will be apparent to those skilled in the art that other processor and memory means, including various computer-readable media, may be used to store and execute program instructions pertaining to the inventive technique described herein.

Client services **244** (i.e., for clients **110**) contain computer executable instructions executed by processor(s) **220** to perform functions related to client device functionality. For example, in an illustrative embodiment, client services **244** provides for the signaling and transmission of VoIP traffic, such as where the client **110** is an IP phone, as will be understood by those skilled in the art.

Server services **244** (i.e., for servers) contain computer executable instructions executed by processor(s) **220** to perform functions related to server device functionality. For example, in an illustrative embodiment, server services **244** also provides for the signaling (control) and transmission of VoIP traffic, such as where the server **110** is a call controller to interact with the client IP phones, as will also be understood by those skilled in the art.

Security process/services **245** (e.g., for clients **110**, proxy devices **120**, and/or servers **130**) contain computer executable instructions executed by processor(s) **220** to perform functions related to security and security protocols. For example, the Transport Layer Security (TLS) protocol is a security protocol that may be run on top of TCP/IP, and involves security handshakes, key exchanges, etc. TLS is further described in RFC (Request for Comments) 4346, entitled *The Transport Layer Security (TLS) Protocol Version* 1.1 dated April 2006, the contents of which are hereby incorporated by reference as though fully set forth herein. Notably, other security protocols, such as the Secure Socket Layer (SSL) protocol (of Netscape Communications Corp.), IP Security (IPSec), etc., may also be advantageously used herein.

Generally, two devices interested in establishing a security session (e.g., for encryption of traffic between a client **110** and server **130**) may send session initiation request/reply messages ("security messages") to exchange security information, as will be understood by those skilled in the art. For instance, each device may have its own corresponding public-private key pair, e.g., according to a public key infrastructure (PKI). Public and private keys are well known in the art. For instance, devices within a network **100** are allowed to see anyone's public key, while each device's private key is not disclosed. Traffic may be encrypted using a public key of the recipient, which then decrypts the traffic with its own private key. A private key may also be used to generate a "certificate" for a particular device, such as a digital signature used to authenticate the device to a recipient. For example, a device may "sign" a certificate by encrypting various information, such as a "subject name" of the device (e.g., an identification of the device, such as a Media Access Control, or "MAC" address of the device), using the private key of the device (to which only that device has access). A device receiving the certificate may verify the identity of the sending device using the sending device's public key and the certificate issuer information (e.g., the trusted certificate authority that signs the certificate). A device may also send certain randomly generated numbers (e.g., session ID) to uniquely identify the security session under negotiation. The exchange of security information between the two devices (e.g., client and server) may thus include the exchange of the keys, the certificates, and the random numbers. The devices may also extract a shared session-specific key from the exchanged information.

FIG. **3** is a schematic block diagram of an example security message **300** that may be used in accordance with one or more embodiments described herein. Notably, while the security message **300** is illustratively shown as a TLS handshake message, those skilled in the art will understand that other types of security messages (e.g., for TLS or other protocols such as SSL, etc.) may be used in accordance with the embodiments described herein. Security message **300** may comprise a conventional header information field **310**, such as an IP header and/or other suitable encapsulation protocol header, as will be understood by those skilled in the art. A data field **320** contains the payload data of the message ("security information"), generally relevant to the particular type of security message.

Illustratively, data field **320** (e.g., of a TLS handshake) may comprise a type field **321**, a session identifier (ID) field **322**, a certificate field **323**, a key exchange field **324**, and other security/encryption fields **325** (e.g., data field **320** may have a particular one of these fields per corresponding handshake message). Certificate field **323** may be used to carry the sending device's certificate, along with a corresponding "subject name" field **326** as described above (which, illustratively, need not be a separate field within the certificate **323**, but rather a portion of the information contained within the certificate, as will be understood by those skilled in the art). Also, key exchange field **324** may be used to carry/advertise the sending device's public key (or secret key, if secret key encryption is used), which may be a separate field or included within the certificate. Other security/encryption fields **325** will be understood by those skilled in the art (e.g., as defined in the various security protocols and extensions thereto).

Trusted certificates **323** may be pre-installed in a certificate store of a device **200** (e.g., described herein). FIG. **4** illustrates an example certificate store **400** that may be advantageously used in accordance with one or more embodiments described herein. Certificate store **400** is illustratively stored in volatile or non-volatile memory (e.g., flash memory) **240** and may include one or more entries **410**, each comprising a field for storing a trusted certificate **415**. The certificate store **400** is illustratively maintained and managed by security services **245**. To that end, the security services **245** may be configured with a list of trusted certificates, and receive and authenticate certificates from security messages **300**, as will be understood by those skilled in the art. Notably, a "certificate authority" (or "certification authority") (CA) may be used as an independent third-party to issue trusted certificates, as will also be understood by those skilled in the art. That is, any device that

is configured to trust the CA can assume that the certificates issued by the CA may also be trusted.

Returning to FIG. **2**, firewall services **247** (i.e., for proxy device/firewall **120**) contain computer executable instructions executed by processor(s) **220** to perform functions related to firewall functionality. For example, firewall services **247** may inspect traffic (e.g., data, packets, etc.) received on one or more network interfaces **210** of the device **200**. Based on one or more policies applied to traffic (e.g., information contained within the traffic from a physical Layer **1** to an application Layer **7**, as will be understood by those skilled in the art), the firewall services **247** may permit forwarding of the traffic or deny the traffic from being forwarded accordingly. Example firewall devices **200** are the Cisco PIX 500 Series firewalls and the Cisco ASA 5500 Series firewalls, both available from Cisco Systems, Inc. of San Jose, Calif. Illustratively, as mentioned above, the firewall/proxy **120** may be located between a client and a server (e.g., between an IP phone and a call controller of a VoIP session).

NAT services **248** (i.e., for proxy device **120**) contain computer executable instructions executed by processor(s) **220** to perform functions related to Network Address Translation (NAT). For example, devices **200** performing NAT (e.g., a proxy/firewall **120**) may receive traffic having certain network addresses (e.g., source and/or destination addresses) that may require translation before being forwarded any further. For instance, certain networks may assign a particular network address to a device, e.g., a private network address, which when leaving the private network may require modification by a NAT device **200**, e.g., into a public network address. Other NAT services will be understood by those skilled in the art (such as, e.g., changing a network port address), wherein each service possibly requires modification of the traffic sent through the NAT device **200** (e.g., proxy/firewall **120**).

As noted, however, encrypted traffic (e.g., encrypted VoIP traffic) generally may not be inspected by a firewall. That is, because of its inability to decrypt the traffic, the firewall is unable to deeply inspect the traffic payload. In addition, a proxy (e.g., firewall) is also unable to modify the traffic (e.g., for NAT services **248**), since the modified encrypted traffic would (most likely) not match an encryption hash expected at the receiving device, since the firewall is also unable to properly encrypt the modified traffic, as will be understood by those skilled in the art.

Transparent Proxy of Security Sessions

According to embodiments of the disclosure, at least one server **130** and at least one client **110** are configured to trust a proxy certificate of an intermediate proxy device (e.g., for proxy device **120**). To establish the trust relationship, one or more proxy certificates may be installed (e.g., through offline provisioning/manual configuration) into the server's certificate store **400**. For example, the proxy certificate may be a CA certificate that is capable of signing other proxy certificates, and may be at least a "root" certificate and, optionally, one or more other non-root proxy certificates issued by a "root" CA, as will be understood by those skilled in the art and further described herein. By installing the proxy certificate on the server **130**, the server is thus configured to trust the proxy device **120** accordingly.

Illustratively, to establish the trust relationship on the clients **110**, the certificate store **400** of the clients may be populated by the server **130** (i.e., the server "pushes" the certificates to the client), e.g., particularly where the client is an IP phone and the server is a call controller, as will be understood by those skilled in the art. For instance, VoIP endpoints (clients/IP phones **110**) are generally provisioned centrally via the call controller (server **130**), where the provisioning of trust is carried out on the call controller, and the results are pushed down to the clients. This effectively removes the need for human/user intervention/configuration on each endpoint to accept the proxy device's certificate. Illustratively, the proxy certificate pushed to the clients need not be the proxy device's root or CA certificate, but may be any certificate that may be generated by the proxy device **120** (e.g., with the subject name and public key of the proxy device, signed by the private key of the proxy device) and used with the clients **110**, as described below. This proxy certificate may be issued by the proxy device (e.g., to the one or more servers **130**) to be used on behalf of a particular server (e.g., call controller) or a plurality of servers (e.g., call controller cluster), also as described below.

Once the trust relationship is established at both the client and the server, the proxy device **120** may intercept a client-server security session request message **300** sent from the client **110** to the server **130**. FIG. **5** illustrates an example message exchange between the client **110** and server **130** through an intermediate proxy device **120** in accordance with one or more embodiments described herein. For instance, when the client wishes to initiate a security session (e.g., an encrypted session), such as a VoIP "call" from an IP phone to a call controller, the client may send a requesting handshake (e.g., TLS "Hello") to the server. The intermediate proxy device **120** receives the handshake (message **300**), and intercepts it accordingly.

In response to intercepting the message **300**, the proxy device **120** apportions the requested client-server security session into two separate sessions, namely a client-proxy session and a proxy-server session. To do this, the proxy device initiates the proxy-server security session with the server **130** through a new security session request message **300**, where the proxy acts as a "client" for the server. Upon receiving the proxy (client) request from the proxy device, the server returns server security information (e.g., in one or more response messages **300**). For instance, the server security information may begin and end with a "Hello" and "Hello done" indication, and may comprise the server's certificate **323**, key exchange **324**, and optionally a certificate request (e.g., field **325**).

Prior to responding to the server (as the client would conventionally do), the proxy device **120** may initiate (or, e.g., continue unbeknownst to the client) the client-proxy security session with the client **110** using the trusted proxy certificate, where the proxy acts as the "server" for the client. In other words, the proxy device **120** may send "server" security information to the client in a similar manner to the actual server **130**, but with security information of the proxy. Because the proxy certificate is already trusted by the client (e.g., not necessarily the root certificate of the proxy), the proxy device **120** may be authenticated by the client as a proper server for the client-proxy security session (which, notably, appears to the client as the requested client-server security session). Alternatively, the proxy device may create a "dynamic certificate" (as described below) and contain the dynamic certificate in the "server" security information to the client.

Upon receiving the proxy device's "server" security information, the client **110** responds with client security information, e.g., in a response message **300**. For instance, the proxy device **120** obtains from the client **110** the client's certificate, which comprises the client's subject name (e.g., "client") and a signature generated (signed) by the client certificate issuer (e.g., a trusted CA). The client security information may also

include the client's public key, which is used by the proxy to authenticate the client certificate, as will be understood by those skilled in the art.

Once the client security information is obtained, particularly the client's subject name extracted from the decrypted certificate, the proxy device **120** may create a "dynamic certificate" using the obtained client security information (e.g., the subject name) and the trusted proxy certificate accordingly. That is, the proxy device **120** may generate a dynamic (client) certificate by signing the client's subject name ("client") using the proxy device's private key (e.g., for the CA certificate of the proxy device). This newly created dynamic certificate effectively mimics the properties of the original client certificate (i.e., it appears as the client to the server through the trusted proxy CA certificate), without compromising the security measures in place at the client (e.g., the proxy device does not need the client's private key). For instance, the dynamic certificate may be created using the client's signature algorithm and/or certificate extensions, as will be appreciated by those skilled in the art.

Accordingly, the proxy device **120** may then establish the initiated proxy-server security session with the dynamic certificate. The server **130** authenticates the "client" (i.e., the proxy device acting as the client) by verifying the dynamic certificate with the public key of the proxy device (e.g., the CA of the proxy device). For instance, once the proxy device's CA certificate is installed in the certificate store **400** of the server **130**, certificates signed by the CA of the proxy device may also be trusted at the server in a "chained" certificate manner, as will be understood by those skilled in the art. For example, if the server trusts the CA certificate of the proxy device, the server may also trust other certificates signed by the CA of the proxy device. In this manner, the proxy device **120** transparently appears as the client to the server **130** in the proxy-server security session (i.e., for any client **110***a-c* connected to the proxy device). The server then responds to the proxy device (as though it were the client) with a certificate verification and finish message **300** to establish the proxy-server security session.

The proxy device **120** may then establish the initiated client-proxy session by sending a similar certificate verification and finish message **300** to the client **110** (the proxy device now acting as the server). The client **110** and proxy device **120** may each send a return finish message **300** to the proxy device and server **130**, respectively, to complete the establishment of the client-proxy and proxy-server security sessions. The proxy device **120** (e.g., proxy services **244**) thus transparently proxies the connection between the client/server endpoints of a client-server security session. In other words, the client-proxy security session and proxy-server security session transparently appear to the client **110** and server **130** as the requested client-server security session.

Accordingly, neither the client nor the server is required to be provisioned to specifically communicate with the proxy device, and instead may simply attempt to directly connect to the peer (server or client, respectively) over an apparent client-server security session. The two actual security sessions, i.e., the client-proxy and proxy-server, may be coordinated by the proxy, such as for handshakes, resume handshakes, authentication, etc., as will be appreciated by those skilled in the art. For instance, in response to receiving a client-server security session tear-down request, the proxy device **120** may correspondingly tear down each security session. Notably, the dynamic certificates may be scoped by session, i.e., may only be valid during the particular client-server (proxy-server) session. Once the session is "torn down" (terminated), the dynamic certificates may be removed from the server and proxy device. (Also, to further regulate security measures, the dynamic certificates may not be issued to any host enrolled with the CA, and the dynamic certificates may be illustratively constrained to a proxy type, as will be understood by those skilled in the art.)

In accordance with one or more embodiments described herein, the proxy device **120** may be illustratively configured as a firewall and/or NAT device. As such, the firewall services **247** (or NAT services **248**) may advantageously utilize the techniques described above to decrypt received traffic from the client **110** and server **130**, and to re-encrypt the traffic accordingly. In particular, because the proxy device **120** is a transparent intermediary to the client-server security session, the proxy device is able to decrypt the received traffic/packets (e.g., using the session key negotiated for the client-proxy or proxy-server session, as appropriate) from each sending end device, and may re-encrypt the traffic prior to forwarding it on using the respective session key with the receiving end device. In this manner, the traffic is decrypted solely for the proxy device, and deep packet inspection (e.g., for firewalls) may be performed appropriately. The proxy device may then re-encrypt the deeply inspected traffic prior to forwarding it to the receiving end device. Also, when modifying the packets (e.g., for NAT), the newly re-encrypted traffic will match the expected encryption algorithm's hash at the receiving end device because the proxy device is now the expected (re-) encrypting device.

FIG. **6** illustrates an example procedure for proxying a security session between a client and a server in accordance with one or more embodiments described herein. The procedure **600** starts at step **605**, and continues to step **610**, where at least one client **110** (e.g., an IP phone) and at least one server **130** (e.g., a call manager) are configured to trust a certificate of an intermediate proxy device **120** (e.g., a firewall). For instance, the server **130** is configured to trust the proxy certificate (e.g., through off-line provisioning), and that trust relationship is pushed down to the one or more clients **110**, as described above. Once the trust relationship is established, the proxy device **120** may intercept a client-server security session request message sent from the client **110** to the server **130** in step **615**.

Upon intercepting the client-server security session request message, the proxy device **120** initiates a proxy-server security session with the server **130** in step **620**. During the proxy-server session, the proxy device obtains server security information (e.g., a certificate **323** and/or public key **324**) from the server in step **625**, such as from the server's response to the session request message (e.g., a security message **300**). Based on the server's response, the proxy device initiates a client-proxy security session with the client in step **630** using the trusted proxy certificate of the proxy device as described above (e.g., a proxy certificate stored in the client's certificate store **400**).

In response to the initiated client-proxy security session, the proxy device **120** obtains client security information from the client in step **635** (e.g., a certificate **323** and/or public key **324**). Using the obtained client security information (e.g., the subject name **326**) and the trusted proxy certificate as described above, the proxy device creates a dynamic certificate for the client's subject name in step **640**, and establishes the previously initiated proxy-server security session in step **645** by sending the dynamic (client) certificate to the server. The proxy device **120** may then establish the initiated client-proxy session in step **650**, wherein the client-proxy security session and proxy-server security session transparently appear to the client and server as the requested client-server security session. With the established client-proxy and proxy-

server security sessions acting transparently as a client-server security session, the proxy device may be allowed to inspect the traffic between the client and the server in step **655**, such as by decrypting and re-encrypting the traffic accordingly. As mentioned above, the proxy device may also tear down the security sessions in response to either the client or the server requesting a tear-down of the client-server security session. The procedure **600** ends in step **660**.

Advantageously, the novel techniques described herein proxy a security session between a client and a server in a computer network. By proxying the security session, the novel techniques allow for the proxy (e.g., a firewall) to inspect the encrypted traffic of the session and to perform other services that require decryption of the traffic (e.g., NAT services). In particular, the techniques described above allow for transparent operation of proxied security sessions between the client (e.g., an IP phone) and the server (e.g., a call controller) as though the client and server were communicating over a client-server security session. In addition, the dynamic aspects of one or more embodiments described herein alleviate the need for cumbersome and inefficient manual configuration. For instance, IP phone operation (e.g., for VoIP communications) does not require end-user intervention, particularly to establish trust for the proxy/firewall or to configure the IP phone to communicate with the firewall.

While there have been shown and described illustrative embodiments that proxy a security session between a client and a server in a computer network, it is to be understood that various other adaptations and modifications may be made within the spirit and scope of the present invention. For example, the embodiments have been shown and described herein with reference to an illustrative TLS security session. However, the embodiments of the invention in their broader sense are not so limited, and may, in fact, be s used with other sessions (e.g., SSL and IPSec as mentioned above), and the exact order of the messages/exchange shown (e.g., in FIG. **5**) may be modified within the scope of the present invention. For instance, the proxy device need not initiate the proxy-server security session until after the client-proxy security session is established (as illustrated in FIG. **7**). This alternative has the advantage of preventing attacks from the client side and avoiding the overhead of initiating unnecessary proxy-server security sessions. Note that the proxy (client) "hello" message may be sent from the proxy **120** to the server **130** along with the "finished" message from the proxy to the client **110** as shown, or instead may be sent following a received "finished" message from the client to the proxy. As another instance, provided that the proxy device **120** has the client's subject name, the proxy device need not wait for a client response prior to creating the dynamic certificate and establishing the proxy-server security session, as will be appreciated by those skilled in the art after understanding the techniques described above. Further, while one or more illustrative embodiments show one client and one server, other embodiments may be possible with more than one client and/or more than one server interconnected with an intermediate proxy device, as will be understood by those skilled in the art. Also, while in one or more embodiments the proxy device **120** is a firewall and/or NAT device, the proxy device may be embodied as other network devices that would benefit from the advantages provided by a proxied security session.

The foregoing description has been directed to specific embodiments of this invention. It will be apparent, however, that other variations and modifications may be made to the described embodiments, with the attainment of some or all of their advantages. For instance, it is expressly contemplated that the components and/or elements described herein can be implemented as software, including a computer-readable medium having program instructions executing on a computer, hardware, firmware, or a combination thereof. Also, electromagnetic signals may be generated to carry computer executable instructions that implement aspects of the present invention over, e.g., a wireless data link or a data network, such as the Internet. Accordingly this description is to be taken only by way of example and not to otherwise limit the scope of the invention. Therefore, it is the object of the appended claims to cover all such variations and modifications as come within the true spirit and scope of the invention.

What is claimed is:

1. A method, comprising:

intercepting, at a proxy device locate between a first device and a second device in a computer network, a security session request for a security session between the first device and the second device;

obtaining, at the proxy device, security information from the first device, the security information from the first device including at least a subject name of the first device;

creating a dynamic certificate using the subject name of the first device and a trusted proxy certificate of the proxy device;

establishing a security session between the proxy device and the second device using the dynamic certificate; and

establishing a security session between the first device and the proxy device using the trusted proxy certificate of the proxy device, wherein the security session between the first device and the proxy device and the security session between the proxy device and the second device collectively operate as a security session between the first device and the second device.

2. The method of claim **1**, wherein creating a dynamic certificate comprises:

signing the subject name of the first device using a private key of the proxy device.

3. The method of claim **1**, wherein establishing a security session between the proxy device and the second device comprises:

verifying the dynamic certificate using a public key of the proxy device.

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

subsequent to establishing a security session between the first device and the proxy device, inspecting, at the proxy device, encrypted traffic between the first device and the second device.

5. The method of claim **4**, wherein the inspecting comprises:

decrypting, at the proxy device, the encrypted traffic;

inspecting the decrypted traffic;

re-encrypting the decrypted traffic; and

forwarding the re-encrypted traffic from the proxy device to the first device or the second device.

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

configuring the first device and the second device to trust the proxy certificate by installing the proxy certificate on the first device and the second device.

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

initiating the security session between the proxy device and the second device;

obtaining security information for the second device at the proxy device; and

initiating the security session between the first device and the proxy device.

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

receiving a security session tear down request for either the security session between the proxy device and the second device or the security session between the first device and the proxy device; and

in response to the receiving, tearing down both the security session between the proxy device and the second device and the security session between the first device and the proxy device.

9. The method of claim **1**, wherein the security session between the first device and the proxy device and the security session between the proxy device and the second device include a Transparent Layer Security (TLS) session or a Secure Socket Layer (SSL) session.

10. The method of claim **1**, wherein the first device is a client and the second device is a server.

11. An apparatus comprising:

one or more network interfaces configured to communicate with a plurality of devices in a computer network, the plurality of devices including a first device and a second device;

one or more processors coupled to the network interfaces and configured to execute one or more processes; and

a memory configured to store a proxy security process executable by the one or more processors, the proxy security process, when executed, operable to:

intercept a security session request for a security session between the first device and the second device,

obtain security information from the first device, the security information from the first device including at least a subject name of the first device,

create a dynamic certificate using the subject name of the first device and a trusted certificate of the apparatus,

establish a security session between the apparatus and the second device using the dynamic certificate, and

establish a security session between the first device and the apparatus using the trusted certificate of the apparatus.

12. The apparatus of claim **11**, wherein the proxy security process is further, when executed, operable to:

sign the subject name of the first device using a private key of the apparatus to create the dynamic certificate.

13. The apparatus of claim **11**, wherein the proxy security process is further, when executed, operable to:

inspect encrypted traffic between the first device and the second device.

14. The apparatus of claim **13**, wherein the proxy security process is further, when executed, operable to:

decrypt the encrypted traffic;

inspect the decrypted traffic;

re-encrypt the decrypted traffic; and

forward the re-encrypted traffic from the one or more network interfaces of the apparatus to the first device or the second device.

15. The apparatus of claim **11**, wherein the proxy security process is further, when executed, operable to:

initiate the security session between the apparatus and the second device;

obtain security information for the second device; and

initiate the security session between the first device and the apparatus.

16. The apparatus of claim **11**, wherein the proxy security process is further, when executed, operable to:

in response to a security session tear down request for either the security session between the apparatus and the second device or the security session between the first des vice and the apparatus, tear down both the security session between the apparatus and the second device and the security session between the first device and the apparatus.

17. The apparatus of claim **11**, wherein the security session between the first device and the apparatus and the security session between the apparatus and the second device include a Transparent Layer Security (TLS) session or a Secure Socket Layer (SSL) session.

18. The apparatus of claim **11**, wherein the apparatus is a proxy device, the first device is a client and the second device is a server.

19. A non-transitory computer-readable medium including software encoded thereon that, when executed, is operable to:

intercept a security session request for a security session between a first device and a second device;

obtain security information from the first device, the security information from the first device including at least a subject name of the first device;

create a dynamic certificate using the subject name of the first device and a trusted proxy certificate of a proxy device;

establish a security session with the second device using the dynamic certificate; and

establish a security session with the first device using the trusted proxy certificate of the proxy device, wherein the security session with the first device and the security session with the second device collectively operate as a security session between the first device and the second device.

20. The non-transitory computer readable medium of claim **19**, wherein the first device is a client, the second device is a server, and the security session with the first device and the security session with the second device include a Transparent Layer Security (TLS) session or a Secure Socket Layer (SSL) session.

* * * * *