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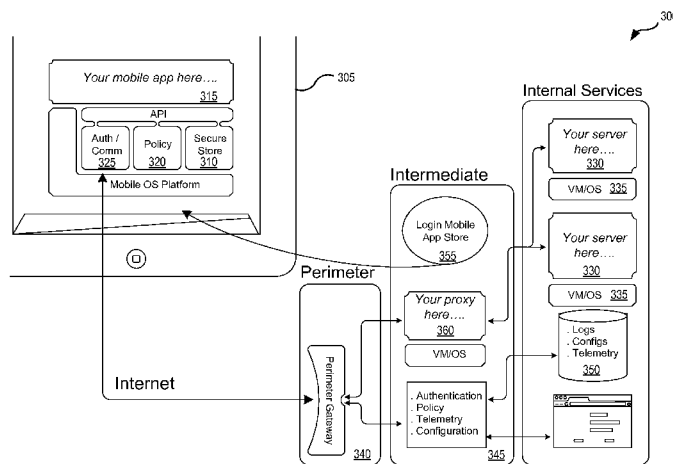


FIG. 3

(57) Abstract: Systems and methods for a secure mobile framework to securely connect applications running on mobile devices to services within an enterprise are provided. Various embodiments provide mechanisms of securitizing data and communication between mobile devices and end point services accessed from a gateway of responsible authorization, authentication, anomaly detection, fraud detection, and policy management. Some embodiments provide for the integration of server and client side security mechanisms, binding of a user/application/device to an endpoint service along with multiple encryption mechanisms. For example, the secure mobile framework provides a secure container on the mobile device, secure files, a virtual file system partition, a multiple level authentication approach (e.g., to access a secure container on the mobile device and to access enterprise services), and a server side fraud detection system.

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## SECURE MOBILE FRAMEWORK

### CROSS-REFERENCE TO RELATED APPLICATIONS

[001] This application claims priority to U.S. Provisional Application Serial No. 5 61/618,511 filed March 30, 2012 and U.S. Provisional Application Serial No. 61/806,763 filed March 29, 2013, the entire contents of both are incorporated herein by reference for all purposes.

### TECHNICAL FIELD

[002] Various embodiments of the present invention generally relate to mobile 10 devices. More specifically, some embodiments of the present invention relate to a secure mobile framework for securely connecting applications running on mobile devices to services within an enterprise.

### BACKGROUND

[003] Many companies or enterprises are either providing mobile devices (e.g., 15 smartphones, tablets, etc.) to employees or allowing employees to bring their own mobile device. However, allowing employees to access services within the company through a mobile device has increased the company's exposure to potential security breaches. For example, if an employee lost their mobile device, an unauthorized party could retrieve any unsecured data on the phone and potentially access 20 services within the company. As another example, if the employee leaves the company and does not give back the mobile device, the former employee could still potentially access sensitive data stored on the device or within the company.

[004] In order to mitigate this type of unauthorized access, many companies use 25 mobile device management (MDM) policies to restrict control of the mobile devices and thereby reduce potential security risks for mobile devices that are capable of connecting to services within the enterprise. The MDM policies that are set by the enterprise control and protect data through management of the configuration settings of the mobile devices. In order to manage the configuration settings, over-the-air programming (OTA) capabilities are often used. The use of OTA capabilities allows 30 the enterprise to remotely configure a single mobile device or an entire fleet of mobile devices, to send software and OS updates, and to remotely lock and wipe a device in order to protect the data stored on the device when it is lost or stolen, etc.

[005] However, the restrictions imposed by the MDM policies can be cumbersome to the user who may also be using the device in a personal capacity. For example, an MDM policy may require the mobile device to auto lock and prompt the user to provide a password with a particular set of characteristics before the mobile device is unlocked. The user may find these restrictions annoying. As such, there are a number of challenges and inefficiencies created in traditional mobile device management.

#### SUMMARY

[006] Systems and methods are described for a secure mobile framework capable of securely connecting applications running on mobile devices to services (e.g., an e-mail service, a trading service, or a reservation service) within an enterprise. In some embodiments, an authentication request from a remote device to access a service provided by an enterprise can be received at a gateway associated with the enterprise. The request can originate from an enterprise managed application running on the remote device. A framework authentication token and security policy (e.g., password structure, password duration, access controls for an application and/or secure container of data, etc.) can be generated.

[007] The security policy can be based on the service provided by the enterprise that the remote device is requesting to access. The framework authentication token and the security policy can then be transmitted to the remote device which ensures compliance with the security policy before generating a connection request to connect to the service within the enterprise. The connection request can be based on the framework authentication token and the security policy. A service authenticator determines if the application running on the remote device is authorized to access the service. Some embodiments monitor interactions between the enterprise managed application and the service. Upon detecting a violation of one or more fraud policies at the mobile device and/or gateway, an elevated authentication request can be generated.

[008] In some embodiments, a request can be received from an initiating device to establish a service connection between an enterprise managed application running on the initiating device and an enterprise service. The request includes authentication credentials associated with an end-user. A framework authentication

token can be generated and transmitted to the initiating device, wherein upon receipt the initiating device initiates a service connection request based on the authentication token. A secure connection can be created between the enterprise service and the initiating device upon successful validation (e.g., authorization and authentication) of the service connection request. Any data transmitted to the initiating device using the stored connection can be stored within a secure container that is only accessible by the enterprise managed application.

**[009]** Embodiments of the present invention also include computer-readable storage media containing sets of instructions to cause one or more processors to perform the methods, variations of the methods, and other operations described herein.

**[010]** In various embodiments, a system can include a gateway, an authenticator, a token generator, a communications module, a discovery service, and/or a fraud detection module. The gateway can be configured to provide remote devices access to services of an enterprise. In some embodiments, the gateway can include multiple levels, each of which provides isolated authentication protocols and activity logging. The remote devices can have stored thereon one or more applications managed by the enterprise. The authenticator can be configured to determine if a user is authorized to access the enterprise and to construct policies regarding the management of the one or more applications.

**[011]** The token generator can be configured to generate one or more tokens (e.g., authentication token, a user binding token, and/or a framework authentication token) for creating secure connections between one or more applications managed by the enterprise and servers. The tokens can be based on various identifiers such as, but not limited to the following: user identifier, device identifiers, device type identifiers, application family identifiers, etc. Some tokens may include a binding of other tokens. For example, in one embodiment, a framework authentication token can be based on an enterprise authentication token, a user binding token, and/or a framework authentication token expiration date. In some embodiments, one or more of the tokens may be cryptographically secured (e.g., digitally signed) that allow for the system to detect if the tokens have been tampered with or altered.

[012] The communications module can be configured to communicate the policies to the remote devices. The discovery service can be configured to determine which of the services of the enterprise to connect with the one or more applications. The anomaly detector can be configured to monitor activity between the remote devices  
5 and the servers and generate an indicator of anomalies in activity. For example, the anomaly detector may monitor the IP velocity of the user, failed log-in attempts, etc.

[013] While multiple embodiments are disclosed, still other embodiments of the present invention will become apparent to those skilled in the art from the following detailed description, which shows and describes illustrative embodiments of the  
10 invention. As will be realized, the invention is capable of modifications in various aspects, all without departing from the scope of the present invention. Accordingly, the drawings and detailed description are to be regarded as illustrative in nature and not restrictive.

#### BRIEF DESCRIPTION OF THE DRAWINGS

15 [014] Embodiments of the present invention will be described and explained through the use of the accompanying drawings in which:

[015] Fig. 1 illustrates an example of a network-based environment in which some embodiments of the present invention may be utilized;

[016] Fig. 2 is a flowchart with a set of exemplary operations for creating a binding  
20 between an enterprise managed application and an enterprise service in accordance with one or more embodiments of the present invention;

[017] Fig. 3 illustrates a general architecture for a secure framework which can be used in accordance with various embodiments of the present invention;

[018] Fig. 4 is a flowchart illustrating a set of exemplary operations for authorizing  
25 an enterprise managed application in accordance with some embodiments of the present invention;

[019] Fig. 5 is a flowchart illustrating a set of exemplary operations for creating a secure channel between an enterprise service and an enterprise managed application running on a remote device in accordance with one or more  
30 embodiments of the present invention;

[020] Fig. 6 is an example of an application built on a secure mobile framework which can be used with various embodiments of the present invention;

[021] Fig. 7 illustrates a remote device accessing a service within an enterprise in accordance with some embodiments of the present invention;

5 [022] Fig. 8 is a sequence diagram illustrating an initial authentication flow between a device application and an enterprise in accordance with one or more embodiments of the present invention;

[023] Fig. 9 is a sequence diagram illustrating a continuous authentication flow between a device application and an enterprise in accordance with various  
10 embodiments of the present invention; and

[024] Fig. 10 illustrates an example of a computer system with which some embodiments of the present invention may be utilized.

[025] The drawings have not necessarily been drawn to scale. For example, the dimensions of some of the elements in the figures may be expanded or reduced to help improve the understanding of the embodiments of the present invention.  
15 Similarly, some components and/or operations may be separated into different blocks or combined into a single block for the purposes of discussion of some of the embodiments of the present invention. Moreover, while the invention is amenable to various modifications and alternative forms, specific embodiments have been shown  
20 by way of example in the drawings and are described in detail below. The intention, however, is not to limit the invention to the particular embodiments described. On the contrary, the invention is intended to cover all modifications, equivalents, and alternatives falling within the scope of the invention as defined by the appended claims.

25

#### DETAILED DESCRIPTION

[026] Various embodiments of the present invention relate generally to a secure mobile framework capable of securely connecting applications running on mobile devices to services within an enterprise. Some examples of services provided by an  
30 enterprise include, but are not limited to, an e-mail service, a trading service, a payment processing service, a customer relationship management service, an

inventory system service, a business intelligence service, a healthcare service, a student information service, a reservation service, secure services, and/or other services containing sensitive information. In accordance with some embodiments, the secure mobile framework provides a collection of software libraries and service  
5 components which provide software developers the ability to build secure applications on non-enterprise mobile devices. The secure mobile framework can be used in conjunction by enterprises that have firewalled content, services, and network from the public network through means of a DMZ type architecture. As a result, much of the enterprise's existing authentication and authorization systems  
10 can be utilized. Client and server libraries can be utilized or extended to provide secure storage and communication in both the client and server applications.

**[027]** There are a number of enterprises which through internal policy or regulation need to ensure that enterprise content and communication is protected, managed and monitored. Normally for devices managed by the enterprise, the  
15 aforementioned control requirements are directly implemented through device and operating system (OS) management. However, for devices which are not managed by the enterprise and cannot connect directly to the enterprise network, there is a need to ensure that the same controls are applied to enterprise applications running on these unmanaged devices.

**[028]** In accordance with various embodiments, the secure mobile framework can provide one or more of the following features to connect and utilize services within the enterprise: 1) mechanisms to store enterprise content on device in a protected manner whereby the enterprise content can only be accessed by authorized users, possibly offline, and be managed through enterprise policy; 2) mechanisms to  
25 provide multiple authentications against the gateway (i.e., framework authentication) and against the enterprise services (i.e., enterprise authentication) , provide secure connection to those enterprise services where authorized, and manage per service access through enterprise policy; 3) mechanism to manage and support connected applications and their dependent services; and 4) mechanisms to dynamically detect  
30 an undesirable or unsafe operating system environment and manage through a multi-step process (e.g., evaluating the policy, interrogation of the program, interrogation of the OS, and/or performing other checks in the client and/or server environments).

[029] The gateway can generate one or more tokens which can be used for authentication. For example, in some embodiments, an enterprise authentication token (EAT) can be generated representing a single or multi-factor credentials that can be used to authenticate with a given company as if single or multi factor  
5 credentials were presented, for a finite period of time. A user binding token (UBT) can also be used in one or more embodiments. The UBT can be an amalgamated, unique representation of a user (id), device (id), type of device, and app family. In addition, a framework authentication token (FAT) can be used in various embodiments. The FAT can be created by binding an EAT, UBT, and an expiration  
10 date used to authenticate with the framework. One advantage of this construction of the FAT is that the details cannot be tampered with by an unauthorized party.

[030] In some embodiments, secure mobile framework client and server components can be used to detect the integrity of the operational environment for the client application. Given the client application is executing within an unmanaged  
15 operating system environment it may need to ascertain, as best it can, if the environment is considered to be unsafe.

[031] In the following description, for the purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of embodiments of the present invention. It will be apparent, however, to one skilled in  
20 the art that embodiments of the present invention may be practiced without some of these specific details.

[032] While, for convenience, embodiments of the present invention are described with reference to dedicated enterprise-based setups, embodiments of the present invention are equally applicable to various other operational models such as cloud-  
25 based models. Moreover, the techniques introduced here can be embodied as special-purpose hardware (e.g., circuitry), as programmable circuitry appropriately programmed with software and/or firmware, or as a combination of special-purpose and programmable circuitry. Hence, embodiments may include a machine-readable medium having stored thereon instructions that may be used to program a computer  
30 (or other electronic devices) to perform a process. The machine-readable medium may include, but is not limited to, floppy diskettes, optical disks, compact disc read-only memories (CD-ROMs), magneto-optical disks, ROMs, random access memories (RAMs), erasable programmable read-only memories (EPROMs),

electrically erasable programmable read-only memories (EEPROMs), application-specific integrated circuits (ASICs), magnetic or optical cards, flash memory, or other type of media / machine-readable medium suitable for storing electronic instructions.

#### Terminology

5 **[033]** Brief definitions of terms, abbreviations, and phrases used throughout this application are given below.

**[034]** The terms “connected” or “coupled” and related terms are used in an operational sense and are not necessarily limited to a direct physical connection or coupling. Thus, for example, two devices may be coupled directly, or via one or  
10 more intermediary media or devices. As another example, devices (e.g., mobile devices, server machines, etc.) may be coupled in such a way that information can be passed therebetween, while not sharing any physical connection with one another. Based on the disclosure provided herein, one of ordinary skill in the art will appreciate a variety of ways in which connection or coupling exists in accordance  
15 with the aforementioned definition.

**[035]** The phrases “in some embodiments,” “according to some embodiments,” “in the embodiments shown,” “in other embodiments,” and the like generally mean the particular feature, structure, or characteristic following the phrase is included in at least one implementation of the present invention, and may be included in more than  
20 one implementation. In addition, such phrases do not necessarily refer to the same embodiments or different embodiments.

**[036]** If the specification states a component or feature “may”, “can”, “could”, or “might” be included or have a characteristic, that particular component or feature is not required to be included or have the characteristic.

25 **[037]** The term “module” refers broadly to a software, hardware, firmware, or service (or any combination thereof) component. Modules are typically functional components that can generate useful data or other output using specified input(s). A module may or may not be self-contained. An application program (also called an “application”) may include one or more modules, or a module can include one or  
30 more application programs.

#### General Description

**[038]** Fig. 1 illustrates an example of a network-based environment 100 in which some embodiments of the present invention may be utilized. As illustrated in Fig. 1, various enterprise managed applications 110A-110N can be running on user devices 120A-120N. In accordance with various embodiments of the present invention, user devices 120A-120N may or may not be managed by the enterprise. User devices 120A-120N can include enterprise managed applications 110A-110N that can be used to access services and data within the enterprise. User devices 120A-120N may use network 140 to submit and retrieve information from services within the enterprise. User devices 120A-120N can interact with various enterprise services through an application programming interface (API) that runs on the native operating system of the device, such as IOS® or ANDROID™.

**[039]** Gateway 130 manages the access of enterprise managed applications 110A-110N and user devices 120A-120N. Gateway 130 can be used to verify and establish a trust relationship between the enterprise managed applications 110A-110N and business specific services provided by the enterprise. For example, in some embodiments, the data and requests initially submitted by enterprise managed applications 110A-110N are transferred between the device and gateway 130 via network 140. Once gateway 130 is satisfied with the security of the device, then gateway 130 can open up a channel to some business specific service within the application management platform 150 and enterprise services 160. Gateway 130 and services within the application management platform 150 can have multiple independent layers of security and checks.

**[040]** User devices 120A-120N can be any computing device capable of receiving user input as well as transmitting and/or receiving data via the network 140. In one embodiment, user devices 120A-120N can be any device having computer functionality, such as a personal digital assistant (PDA), mobile telephone, smartphone, tablet, wearable types of mobile computers, body-mounted computers, or similar device. User devices 120A-120N can be configured to communicate via network 140, which may comprise any combination of local area and/or wide area networks, using wired and/or wireless communication systems. In one embodiment, network 140 uses standard communications technologies and/or protocols. Thus, network 140 may include links using technologies such as Ethernet, 802.11,

worldwide interoperability for microwave access (WiMAX), 3G, 4G, CDMA, digital subscriber line (DSL), etc.

**[041]** Similarly, the networking protocols used within the various layers of network 140 may include multiprotocol label switching (MPLS), transmission control  
5 protocol/Internet protocol (TCP/IP), User Datagram Protocol (UDP), hypertext transport protocol (HTTP), hypertext transport protocol secure (HTTPs), simple mail transfer protocol (SMTP), file transfer protocol (FTP), secure file transfer protocol (SFTP), and/or other networking protocols. Data exchanged over network 140 may be represented using technologies and/or formats including hypertext markup  
10 language (HTML) or extensible markup language (XML). In addition, all or some links can be encrypted using conventional encryption technologies such as secure sockets layer (SSL), transport layer security (TLS), and Internet Protocol security (IPsec).

**[042]** Fig. 2 is a flowchart with a set of exemplary operations 200 for creating a  
15 binding between an enterprise managed application and an enterprise service in accordance with one or more embodiments of the present invention. As illustrated in Fig. 2, installation operation 210 installs an enterprise controlled application on a remote device. The application may be installed by an end-user of the device, an individual from the enterprise, or other source. For example, in some embodiments,  
20 the application may be remotely installed or downloaded from an application store. Once the application is installed, authentication operation 220 can prompt a user of the remote device to provide a set of credentials which can be authenticated against the framework. A variety of security protocols and standards (e.g., passwords, passcodes, time-based tokens, encrypted data, auto-lock, etc.) may be used as part  
25 of the remote device and application security and authentication processes.

**[043]** A variety of authentication and security checks are performed at the enterprise during authentication operation 230. In some embodiments, for example, once the set of credentials are received from the user, an authorization request can be sent from the remote device (i.e., the client) to the gateway server. The gateway  
30 server can determine a current policy which should be applied at the remote device and send policy information from the gateway server to the remote device. Then, the device characteristics can be checked and new container credentials can be acquired if necessary. If the gateway determines that the application should have

access to one or more servers within the enterprise, creation operation 240 can be used to create a binding between the application and an enterprise service.

**[044]** Fig. 3 illustrates a general architecture 300 for a secure mobile framework in accordance with various embodiments of the present invention. The secure mobile framework components can be used to manage and protect enterprise content stored on mobile device 305. In some embodiments, mobile device 305 can include a secure storage 310, policy 320, and/or authentication store 325 for mobile application 315. Mobile application 315 can have a virtual file system that sits under the application. In some embodiments, mobile application 315 can use or generate one or more ephemeral keys, which can have multiple constituent components. The ephemeral keys can be assigned to each partition of the virtual file system to encrypt every file with its own key.

**[045]** Secure storage 310 can securely store enterprise data locally on mobile device 305. Secure storage 310 can include a group of protected files managed as single unit through policy 320. In some embodiments, enterprise content can be stored in encrypted files and accessed via random access methods. In addition, various mechanisms can be used to set encryption block sizes on a per file basis and simultaneously maintain a sidecar index file used to aid with the synchronization content between client and service. The protected files are held within a secure partition which uses a single encrypted master file to hold per file encryption keys and a translation between applications file names and obfuscate file names. This secure file partition mechanism can be used to securitize not only application content directly but also used as a virtual file system for database servers hosted on the device, logging and telemetry data for customer support.

**[046]** Policy 320 can be an application specific (or application family) security policy set by the enterprise with which application 315 should comply. An application family generally refers to a grouping of applications governed by a common policy that share access to authorization and authentication information on a given device, for a given user. Policy 310 can include the value of security variables used in authorization, authentication, and securitizing data on the device. For example, policy 320 can include password structure, how long the device can remain disconnected from the gateway, how many times the user can fail to enter in a correct password, and other security variables.

[047] A further instance of a secure file partition is authentication store 325 which can contain authentication credentials (e.g., tokens and assertions), policy details, and a master encryption key used to encrypt all other secure file partitions master files. An authentication store master file store can be encrypted with an ephemeral  
5 key generated based on a user password or phrase. Furthermore, authentication store 325 can be shared among multiple applications on the device to form a common store for enterprise access and sharing encrypted content.

[048] Once application 315 and corresponding components are installed on mobile device 305, application 315 can request access to one or more internal services  
10 within an enterprise running on servers 330 or virtual machines 335 after passing one or more device security checks. The request from application 315 is first received at a perimeter gateway 340 where a first round of authentication is established before allowing application access to an intermediate layer 345. Intermediate layer 345 authenticates the user and ensures that the policy being  
15 enforced by application 315 is up-to-date. In addition, mobile device telemetry and configuration settings can be gathered, processed, analyzed, evaluated, and/or recorded within database 350. This information can be useful in creating (e.g., in real-time or in near real-time) various indicators of fraud or anomaly detection. Intermediate layer 345 also allows application 315 to log into mobile application store  
20 350. In addition, proxy 355 can be used as an intermediary between application 315 and the servers 330.

[049] Fig. 4 is a flowchart illustrating a set of exemplary operations 400 for authorizing an enterprise managed application in accordance with some embodiments of the present invention. During receiving operation 410, a request  
25 from an enterprise managed application can be received. The request can identify a named service within the enterprise to which the application would like to connect. Initiation operation 420 initiates a secure connection with a perimeter gateway. The perimeter gateway can then ensure the policy operating on the device is up to date using policy verification operation 430 and that the user is still authorized to access  
30 enterprise services during user verification operation 440.

[050] If the policy and user are successfully validated, then validation operation 450 validates the user's authentication credentials at the gateway. Enterprise credentials are then passed to the destination service during submission operation 460 where

authentication and authorization take place during verification operation 470. Upon successful authentication, binding operation 480 creates a binding between the application and the named service.

**[051]** Fig. 5 is a flowchart illustrating a set of exemplary operations 500 for creating a secure channel between an enterprise service and an enterprise managed application running on a remote device in accordance with one or more embodiments of the present invention. As illustrated in Fig. 5, the user causes an enterprise managed application running on a client device to launch during launch operation 510. The application prompts the user for a set of container credentials. Once the credentials are received from the user, the client device uses encryption operation 520 to encrypt the data and communication with a server gateway of the enterprise.

**[052]** The enterprise managed application can use a framework authentication token (FAT) to authenticate with the gateway, and an enterprise authentication token (EAT) to authenticate with a service. Validation operation 530 determines (e.g., using a framework authentication system) the validity of the FAT. A server authorizer can then construct one or more tokens for creating a secure connection to the enterprise service. For example, in some embodiments the server authorizer can create a User Binding Token (UBT) consisting of the user id, the application id, and the device id. In addition, the FAT can be created by binding the UBT, EAT, and an expiration date. In addition, the server authorizer may determine if the user is authorized to access the enterprise. A secure mobile framework server can construct a policy based on the enterprise services the user can interact with. The information in the policy can include the FAT expiration date, a type of enterprise authentication the user must perform when the FAT expires, and other policy information used to secure data on the mobile device. The secure mobile framework server gateway can then respond to the mobile device with the FAT and the policy.

**[053]** The calling client (e.g., the mobile device) can use an authentication store to save the FAT and policy content. The application can then use generation operation 540 to generate a connection request upon verification of the policy enforcement. Then creation operation 550 creates a secure channel between the enterprise managed application and the enterprise service. For example, the application can ask the client secure mobile framework to connect to a particular enterprise service

using some canonical name. Then, the framework can send the service name along with the UBT to the secure mobile framework server service authenticator over the same connection. The service authenticator determines if the UBT is allowed to connect to that destination.

5 [054] The secure mobile framework server service router can then map the canonical name to the real address of the service, and establish a connection. The mobile application can now communicate freely over a secured channel once the enterprise authentication is successfully completed. On subsequent requests for connections, the application may ask the secure mobile framework to connect to a particular service using some canonical name. The secure mobile framework can then send the service name along with the UBT and EAT to the secure mobile framework gateway. In some embodiments, the next time the application attempts to connect with the service, this information can be used rather than the user entered enterprise credentials, at least until the FAT expires.

15 [055] Fig. 6 is an example of an application built on a secure mobile framework which can be used with various embodiments of the present invention. As illustrated in Fig. 6, web browser 605 represents an implementation of a web browser capable of generating standard HTTP/S requests which may be wrapped in a custom protocol. Web browser 605 can use communications API 610 to establish a connection to the gateway. In some embodiments, communications API 610 can be built on top of secure socket layer (SSL) to access secure factory API 615 for authenticating the user. Typical web based applications require storage of data such as cookies shared with the server and historical URLs. The web browser implementation illustrated in Fig. 6 uses storage API 620 and a secure file partition manager to encrypt data before utilizing the operating system underlying file system  
25 625

[056] Communications API 610 obtains the user's raw credentials or stored token (FAT) to establish a connection with an enterprise gateway using secure key store 630. For example, upon receiving the user's credentials, a secure key can be retrieved from secure key store 630. This key can be used to access a key chain after which subcomponents of the framework can be initialized. System management 635 can receive, from the device/application, an identification of a current policy associated with the application. Using policy management 640 a  
30

determination can be made as to whether the policy associated with the application is up to date or needs to be updated. System management 635 can ensure that proper logging, virtual file system management, and page caching occur.

5 **[057]** Upon successful authorization and authentication, the gateway requests policy and device information from communications API 610. Upon successful validation, the gateway can bind a connection to a web browser proxy service, capable of making HTTP/S calls within the enterprise. Web browser 605 can then transmit the wrapped HTTP/S requests through this channel.

10 **[058]** Fig. 7 illustrates a remote device 705 accessing a server 710 within an enterprise in accordance with some embodiments of the present invention. As illustrated in Fig. 7, various embodiments of the present invention allow remote device 705 to access the enterprise through a multi-level authentication process. For example, in order to connect to an endpoint service running on server 710 within an enterprise, a container authentication, a framework authentication, and an enterprise authentication should all be successfully completed in some  
15 embodiments. Many traditional authentication systems would require that in order to use an application on a mobile device, a user typically enters a password to unlock the device and then supply a user name and password to authenticate against a remote service. In contrast, various embodiments of the present invention use  
20 multiple layers of security before allowing access to data on a device or connections to the remote services.

**[059]** Upon launching application 715, a request is sent to far mobile content gateway 720. Within the main stack 725 of far mobile content gateway 720, validation and authentication of the user and device can be confirmed. For example,  
25 in some embodiments, an enterprise authentication system 730 (e.g., RSA® or Kerberos™) can be used. In some embodiments, the authentication process can include a username, a whitelist check, a policy check, and/or a destination check. In addition, device telemetry and configurations can be monitored and transmitted to a second intermediate authentication layer. These allow for the user, device, and  
30 application to be authenticated.

**[060]** Once the user, device, and application have been authenticated, a connection can be established with server 710. Many embodiments use the various tokens

created during the authentication of the user, device, and application for establishing a connection with server 710. Far mobile content gateway 720 can connect with mobile gateway services 735 for additional authentication services for access to servers within the enterprise. For example, in some embodiments, a user can enter  
5 a password or other authentication credentials within application 715 that can be used to decrypt data stored locally on the device. Then, the user could present a FAT to a gateway process running on a remote environment. The gateway process uses the FAT to authorize and authenticate the user and the device. Then, to access any particular service, the user would present an EAT to the remote service.  
10 In some embodiments, the FAT and EAT can be stored locally on the device after performing one or more pluggable forms of authentication (e.g., time codes+pin, biometrics, passwords, etc.).

**[061]** In some embodiments, the form of authentication can be rotated on a predefined schedule (e.g., periodic) or upon detection of one or more events. For  
15 example, the gateway can securely transmit the current authentication form to the mobile device which can be stored in the secure store. While Fig. 7 illustrates examples, such as HTTPS and TLS, of secure connections which can be used, other embodiments of the present invention can use different protocols for creating connections for messaging and transferring data between system components.

**[062]** Fig. 8 is a sequence diagram illustrating an initial authentication flow between a device application and an enterprise in accordance with one or more embodiments of the present invention. As illustrated in Fig. 8, a user launches a device application. An integrity detection process is used to determine if the expected OS integrity is present. For example, the integrity detection process can determine if the  
25 device operating in an elevated unauthorized privilege (e.g., rooting or jailbreak) mode. The device application requests a node identifier (e.g., a Kerberos™ ID) and an authentication password. At which point the device identifier is obtained from the device. An initial authentication request can then be submitted (e.g., using a secure connection) to the far content gateway. The initial authentication request can include  
30 the authentication password, the device identifier, application family, the device type, and/or other information. The far content gateway can then send an authentication request to an authentication service. Once authentication service authenticates the user, a UBT is registered by the mobile authorization service.

**[063]** The mobile authorization service can authorize access, generate a UBT, and store the device identifier, the user name, application family, and the UBT. The mobile authorization service signs the UBT and authentication token before returning a policy, a UBT, and a digital signature to the far content gateway. The far content gateway then generates a FAT which is returned along with the policy, UBT and digital signature to the device application. In some cases, the policy may require the device application to request a new password for the secure container. The FAT, UBT, and digital signature can then be stored in the secure container which can be locked with the password.

**[064]** Fig. 9 is a sequence diagram illustrating a continuous authentication flow between a device application and an enterprise in accordance with various embodiments of the present invention. In the embodiments illustrated in Fig. 9, a user launches a device application. An operating system integrity check (e.g., a jail break detection process) can then be used to determine if the integrity of the operating system has been compromised. If the operating system integrity check determines that the operating system is not as expected, then the application will not be allowed to connect with the gateway. If integrity of the operating system is as expected, the device application retrieves the secure container password from the user and unlocks the secure container to retrieve the current policy. The device application checks the enforcement of the policy and connects to the far content gateway. The far content gateway checks the digital signature of the UBT and authentication token. The far content gateway can also check a directory to determine the status of the username and if the UBT is on a whitelist.

**[065]** The device application submits the canonical name of the enterprise service to which the device application wants to connect. The far content gateway uses a destination service module to determine if the UBT is allowed to connect to that service. If the UBT is allowed to connect, the far content gateway binds a connection to the enterprise service, or a proxy to that service. A success code is returned from the far content gateway to the device application along with the latest policy version. The device application checks to see if the policy version just returned is greater than the policy retrieved from the secure container. If the policy version is greater, then the new policy is applied. The FAT can then be retrieved

form the secure container and the conversation with the far content gateway can be initiated.

#### Exemplary Computer System Overview

**[066]** Embodiments of the present invention include various steps and operations, which have been described above. A variety of these steps and operations may be performed by hardware components which are part of a mobile device, server, or other computer system used within embodiments of the present invention. In some embodiments, these steps and operations may be embodied in machine-executable instructions, which may be used to cause a general-purpose or special-purpose processor programmed with the instructions to perform the steps. Alternatively, the steps may be performed by a combination of hardware, software, and/or firmware. As such, Fig. 10 illustrates some components which may be used as part of a computer system 1000 with which embodiments of the present invention may be utilized. As illustrated in Fig. 10, the computer system may include a bus 1010, at least one processor 1020, at least one communication port 1030, a main memory 1040, a removable storage media 1050, a read only memory 1060, and a mass storage 1070. In some cases, computer system 1000 may not include any local storage such as removable storage media 1050, mass storage 1070, and the like.

**[067]** Processor(s) 1020 can be any known processor, such as, but not limited to, an Intel® Itanium® or Itanium 2® processor(s); AMD® Opteron® or Athlon MP® processor(s); ARM-based processors; or Motorola® lines of processors. Communication port(s) 1030 can be any of an RS-232 port for use with a modem-based dialup connection, a 10/100 Ethernet port, or a Gigabit port using copper or fiber. Communication port(s) 1030 may be chosen depending on a network such as a Local Area Network (LAN), Wide Area Network (WAN), or any network to which the computer system 1000 connects.

**[068]** Main memory 1040 can be Random Access Memory (RAM) or any other dynamic storage device(s) commonly known in the art. Read only memory 1060 can be any static storage device(s) such as Programmable Read Only Memory (PROM) chips for storing static information such as instructions for processor 1020.

**[069]** Mass storage 1070 can be used to store information and instructions. For example, hard disks such as the Adaptec® family of SCSI drives, an optical disc, an

array of disks such as RAID, such as the Adaptec family of RAID drives, or any other mass storage devices may be used.

**[070]** Bus 1010 communicatively couples processor(s) 1020 with the other memory, storage and communication blocks. Bus 1010 can be a PCI /PCI-X or SCSI based  
5 system bus depending on the storage devices used.

**[071]** Removable storage media 1050 can be any kind of external hard-drives, floppy drives, IOMEGA® Zip Drives, Compact Disc – Read Only Memory (CD-ROM), Compact Disc – Re-Writable (CD-RW), and/or Digital Video Disk – Read Only Memory (DVD-ROM).

10 **[072]** The components described above are meant to exemplify some types of possibilities. In no way should the aforementioned examples limit the scope of the invention, as they are only exemplary embodiments. Moreover, some of the computer systems (e.g., servers, clients, mobile devices, etc.) contemplated by  
15 embodiments of the present invention may not include all of these components. In addition, some of the computer systems may include different configurations and/or additional components from those illustrated in Fig. 10. For example, some computer systems (e.g., mobile devices) may include a GPS unit and various types of I/O devices (e.g., touchscreens, eye tracking modules, natural language processors, LCD, keyboards, etc.).

20 **[073]** In conclusion, the present invention provides novel systems, methods and arrangements for a secure mobile framework for enterprise managed applications. While detailed descriptions of one or more embodiments of the invention have been given above, various alternatives, modifications, and equivalents will be apparent to those skilled in the art without varying from the spirit of the invention. For example,  
25 while the embodiments described above refer to particular features, the scope of this invention also includes embodiments having different combinations of features and embodiments that do not include all of the described features.

## CLAIMS

What is claimed is

1. A method comprising:

5 receiving, at a gateway associated with an enterprise, an authentication request from a remote device to access a service provided by the enterprise, wherein the request originates from an enterprise managed application running on the remote device;

10 generating a framework authentication token and a security policy based on the service provided by the enterprise that the remote device is requesting to access;

transmitting the framework authentication token and the security policy to the remote device, wherein the remote device ensures compliance with the security policy before generating a connection request to connect to the service; and

15 receiving, from the remote device, the connection request based on the framework authentication token and the security policy, wherein a service authenticator determines if the remote device is authorized to access the service.

20 2. The method of claim 1, further comprising generating a user binding token based on a user identifier and an application identifier.

3. The method of claim 2, wherein generating the framework authentication token includes binding the enterprise authentication token, the user binding token, and a framework authentication token expiration date.

25 4. The method of claim 3, further comprising digitally signing the framework authentication token.

5. The method of claim 1, further comprising:

performing an operating system integrity check to determine if an expected operating system integrity is present; and

denying the remote device access to the gateway if the expected operating system integrity is not present.

- 5 6. The method of claim 1, wherein the remote device includes a secure container for storing data related to the service and the security policy provides a set of requirements indicating access controls for the application and secure container.
7. The method of claim 6, wherein the framework authentication token is stored in the secure container.
- 10 8. The method of claim 6, wherein access to the secure container is dependent on successful validation of a user credential and a successful operating system integrity check.
9. The method of claim 1, wherein the security policy identifies a password structure and a password duration based on the service.
10. The method of claim 1, further comprising:
- 15 monitoring interactions between the enterprise managed application and the service; and
- generating, upon violation of one or more fraud policies, an elevated authentication request or a termination of access to the gateway and the service.
- 20 11. The method of claim 1, wherein the service includes an e-mail service, a trading service, a payment processing service, a customer relationship management service, an inventory system service, a business intelligence service, a healthcare service, a student information service, or a reservation service.
12. The method of claim 1, wherein the service includes a secure service or a service containing sensitive information.
- 25 13. A system comprising:
- a gateway configured to provide remote devices access to services of an enterprise, wherein the remote devices have stored thereon one or more applications managed by the enterprise;

an authenticator, accessible by the gateway, configured to determine if a user is authorized to access the enterprise and to construct policies regarding the management of the one or more applications;

5 a token generator, accessible by the gateway, configured to generate one or more tokens for creating secure connections between the one or more applications managed by the enterprise and the services; and

a communications module configured to communicate the policies to the remote devices.

10 14. The system of claim 13, further comprising a discovery service configured to determine which of the services of the enterprise to connect with the one or more applications.

15. The system of claim 14, wherein the discovery service selects which of the services to connect with the one or more applications is based on the user and a set of associated privileges.

15 16. The system of claim 13, wherein the token generator generates an enterprise authentication token, a user binding token, and a framework authentication token.

17. The system of claim 16, wherein framework authentication token includes the enterprise authentication token, the user binding token, and a framework authentication token expiration date.

20 18. The system of claim 16, wherein the user binding token is generated based on a user identifier, a device identifier, device type identifier, and an application family identifier.

25 19. The system of claim 13, further comprising an anomaly detector configured to monitor activity between the remote devices and the services and generate an anomaly indicator, and wherein the anomaly detector further determines a reaction to the anomaly indicator.

20. The system of claim 13, wherein the gateway includes multiple levels each of which provides isolated authentication protocols and activity logging.

21. A method comprising:

receiving, at a gateway, a request from an initiating device to establish a service connection between an enterprise managed application running on the initiating device and an enterprise service, wherein  
5 the request includes authentication credentials associated with an end-user;

generating a framework authentication token;

transmitting the framework authentication token to the initiating device, wherein upon receipt the initiating device initiates a service  
10 connection request based on the authentication token; and

creating a secure connection between the enterprise service and the initiating device upon successful validation of the service connection request.

22. The method of claim 21, wherein any data transmitted to the initiating device is  
15 stored within a secure container only accessible by the enterprise managed application.

23. The method of claim 21, further comprising gathering information about the initiating device and the enterprise managed application.

24. The method of claim 21, further comprising determining a policy that the initiating  
20 device should enact in managing the enterprise managed application.

25. The method of claim 24, wherein the secure connection will not be created if the enterprise cannot verify the initiating device is enacting the policy.

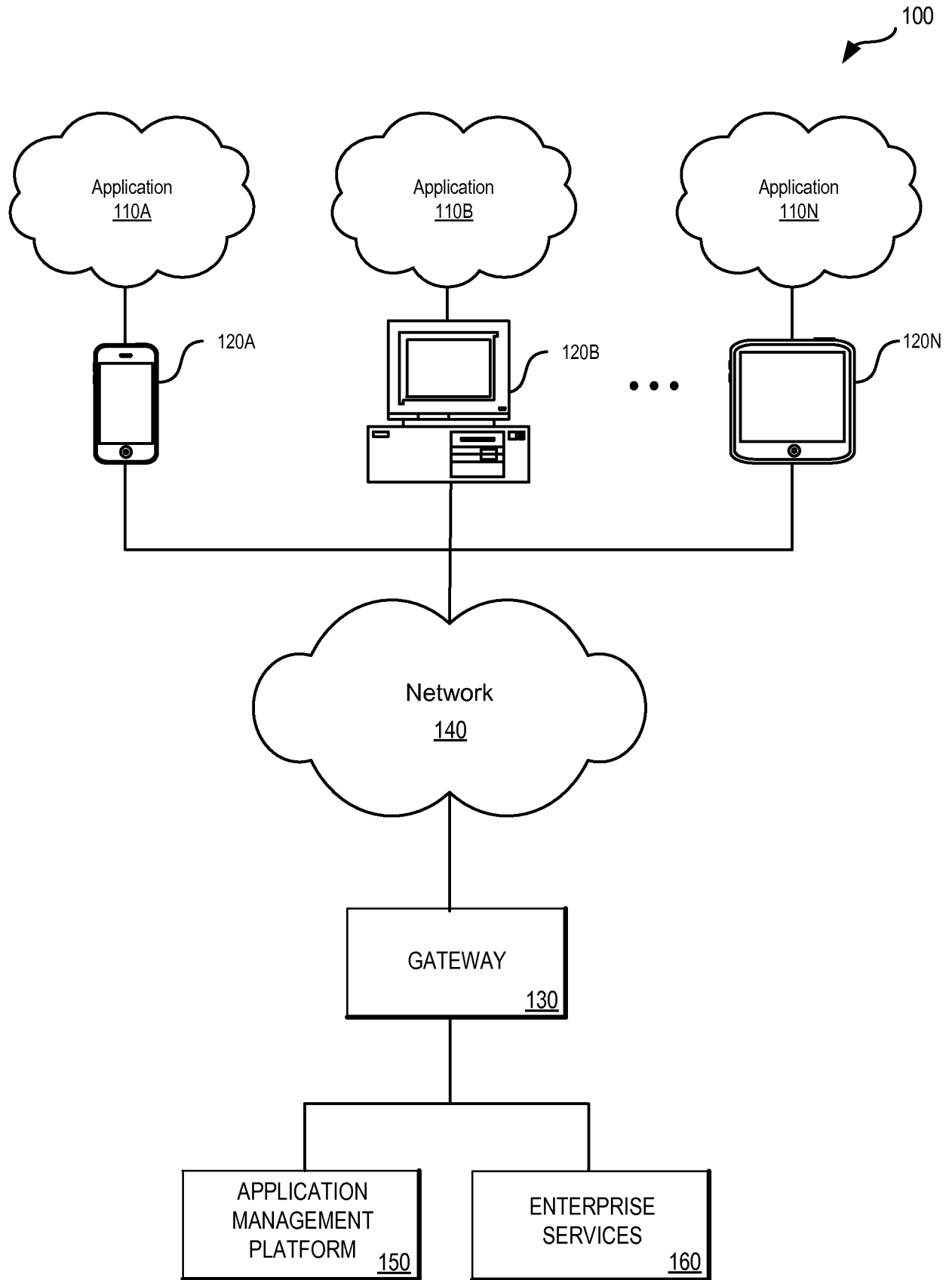


FIG. 1

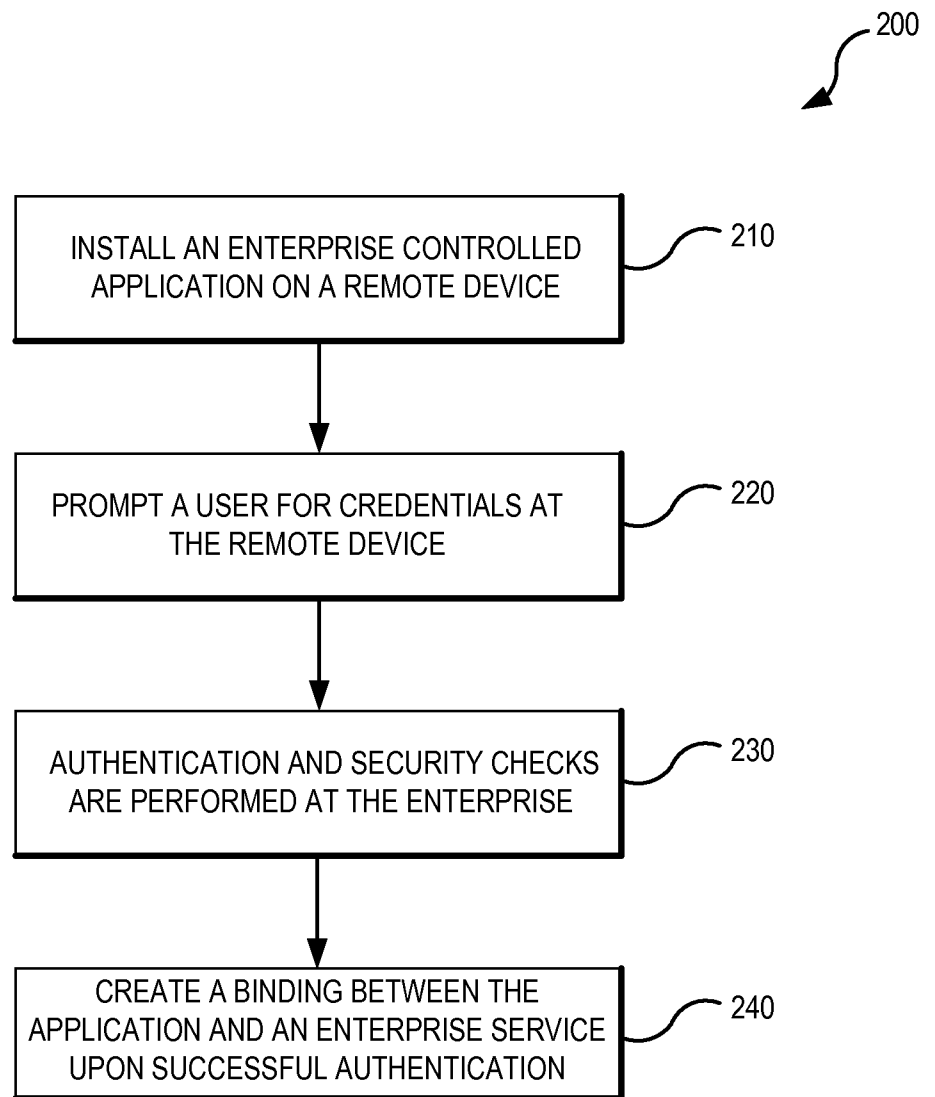


FIG. 2

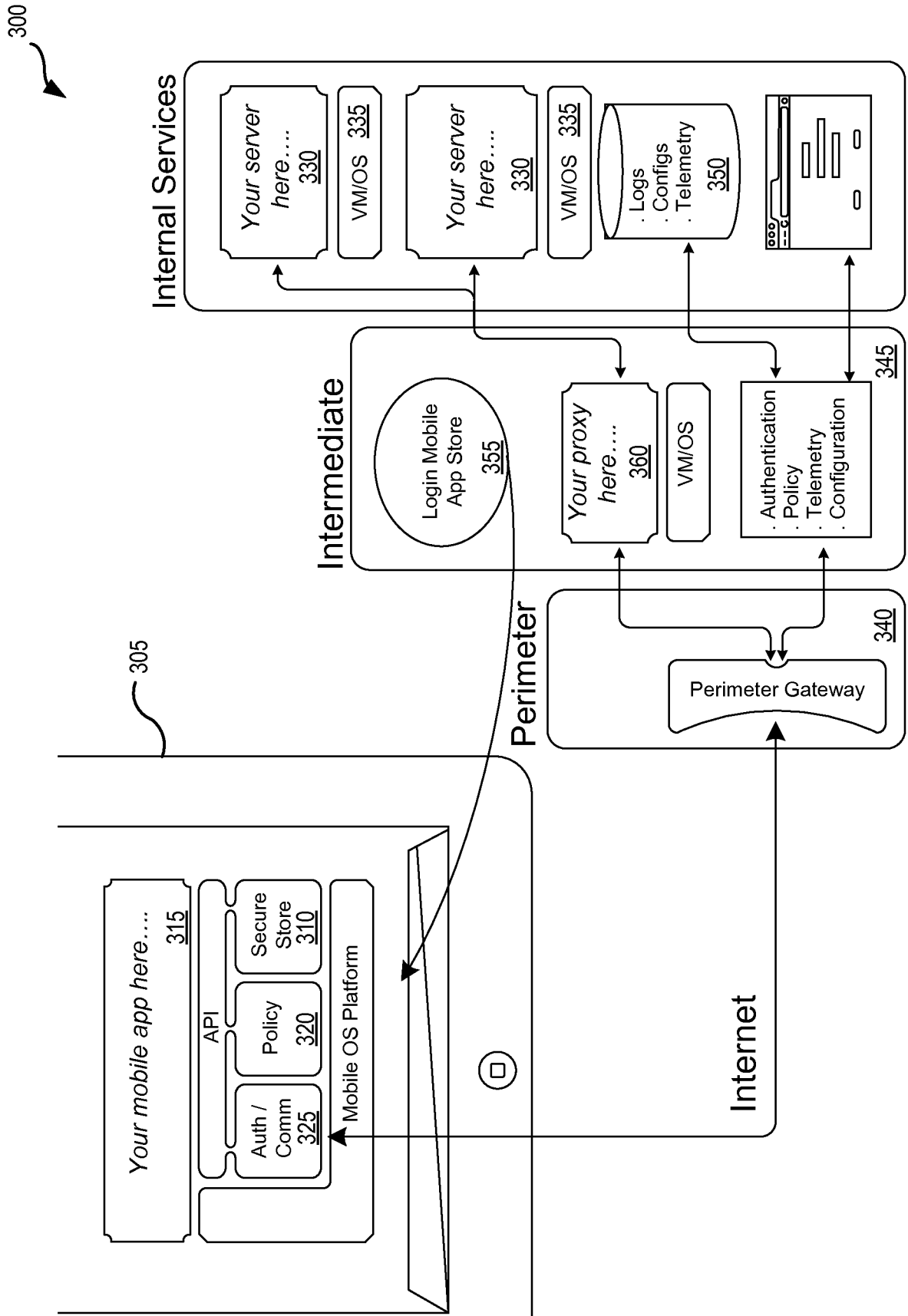


FIG. 3

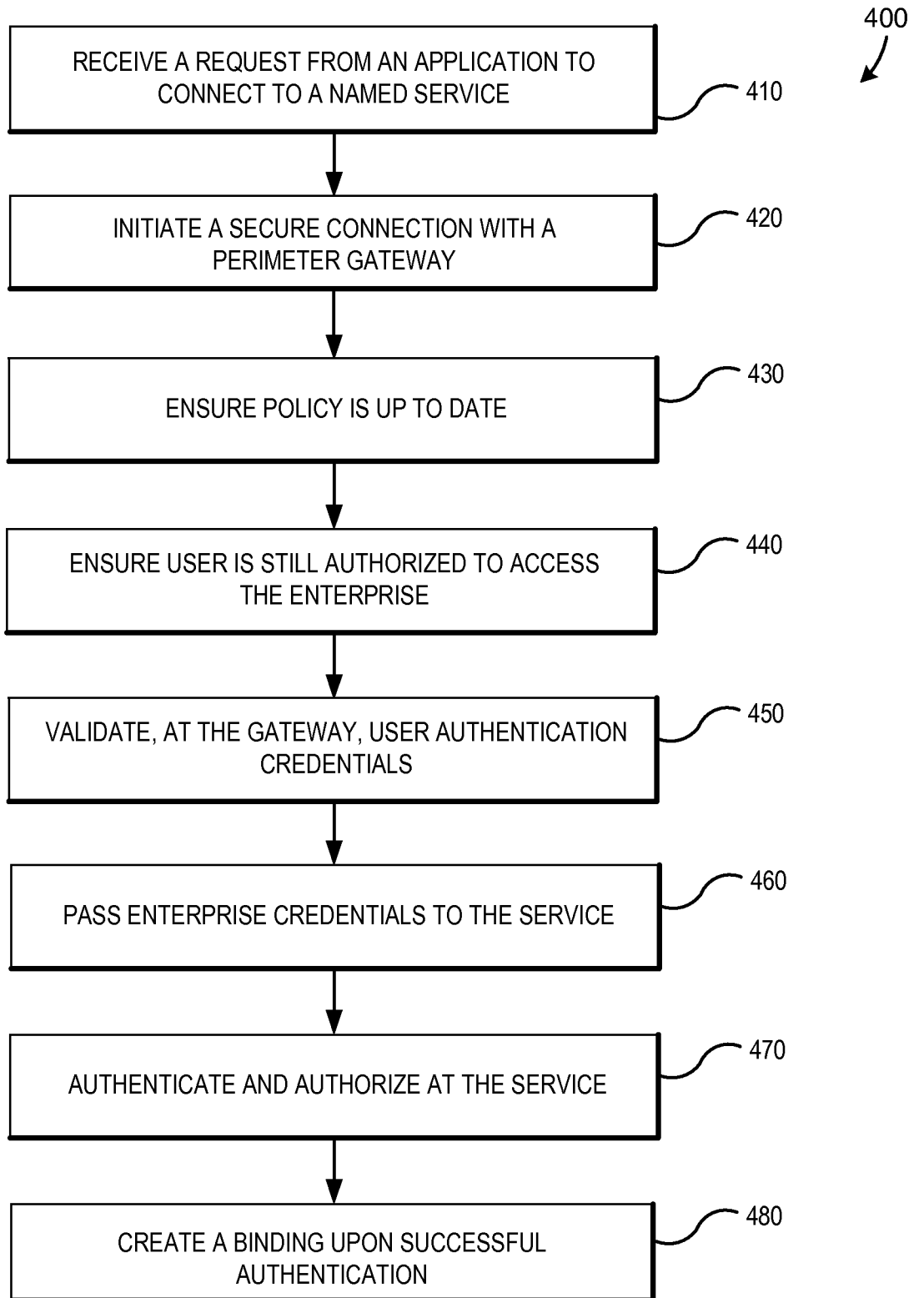


FIG. 4

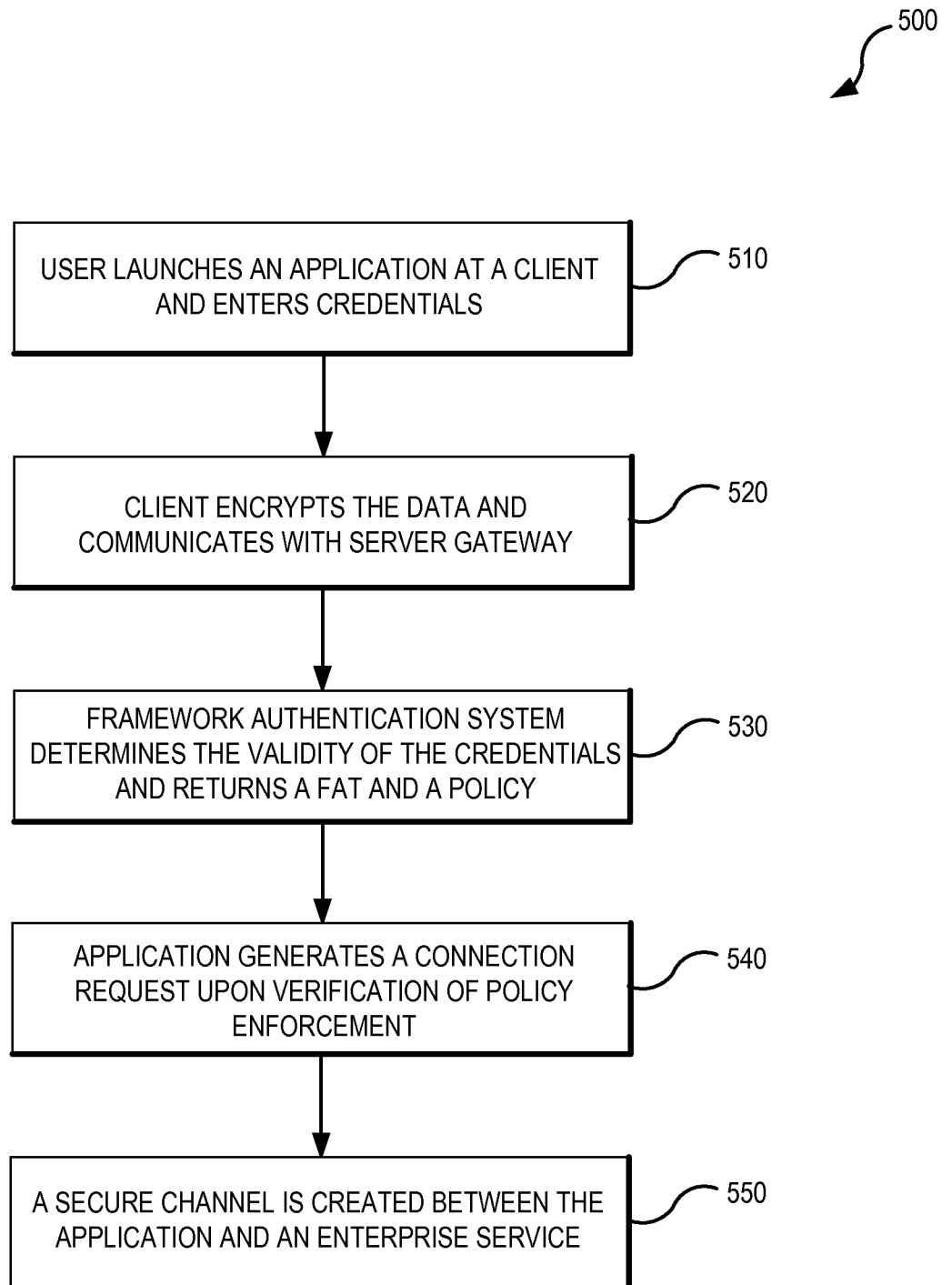


FIG. 5

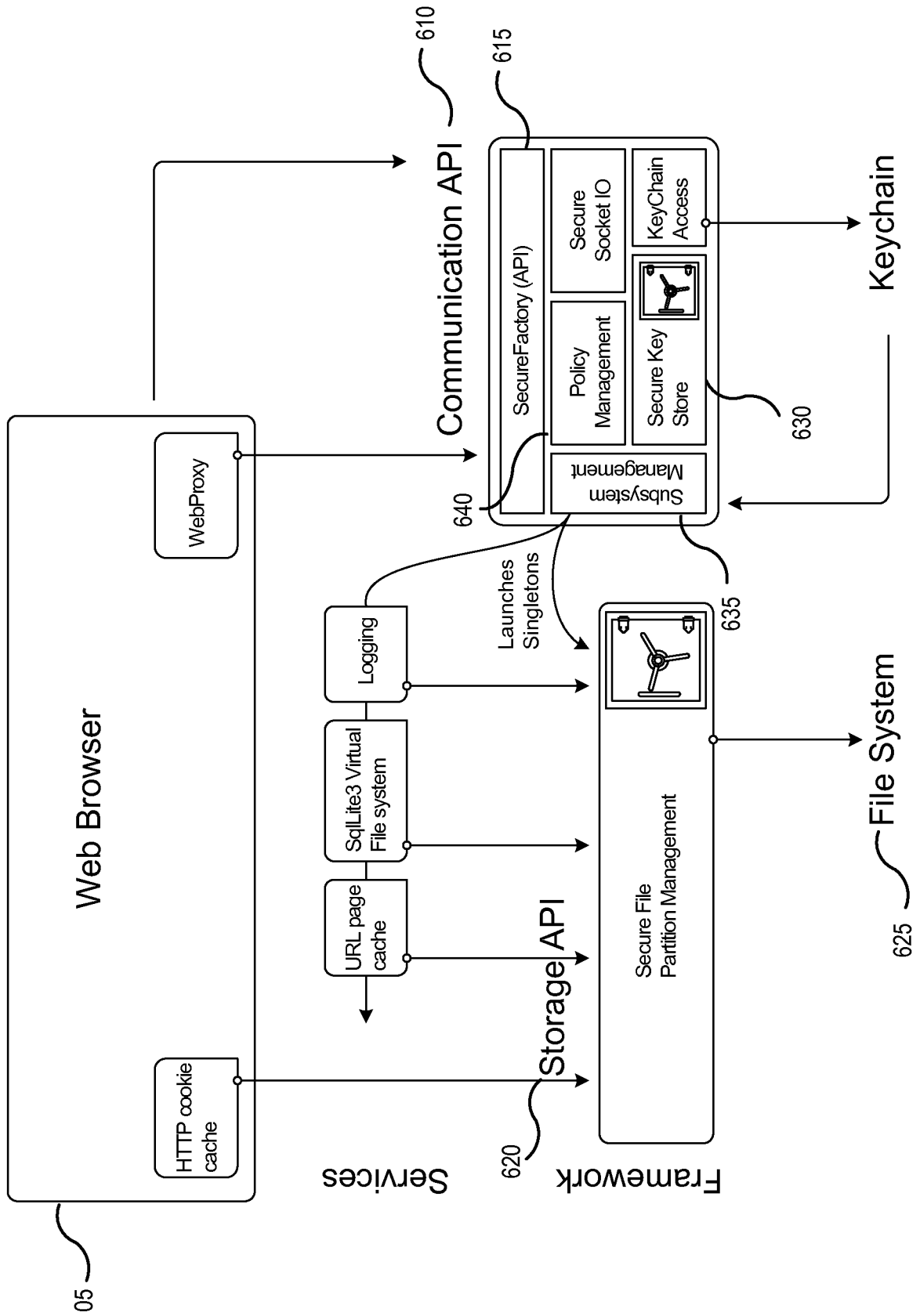


FIG. 6

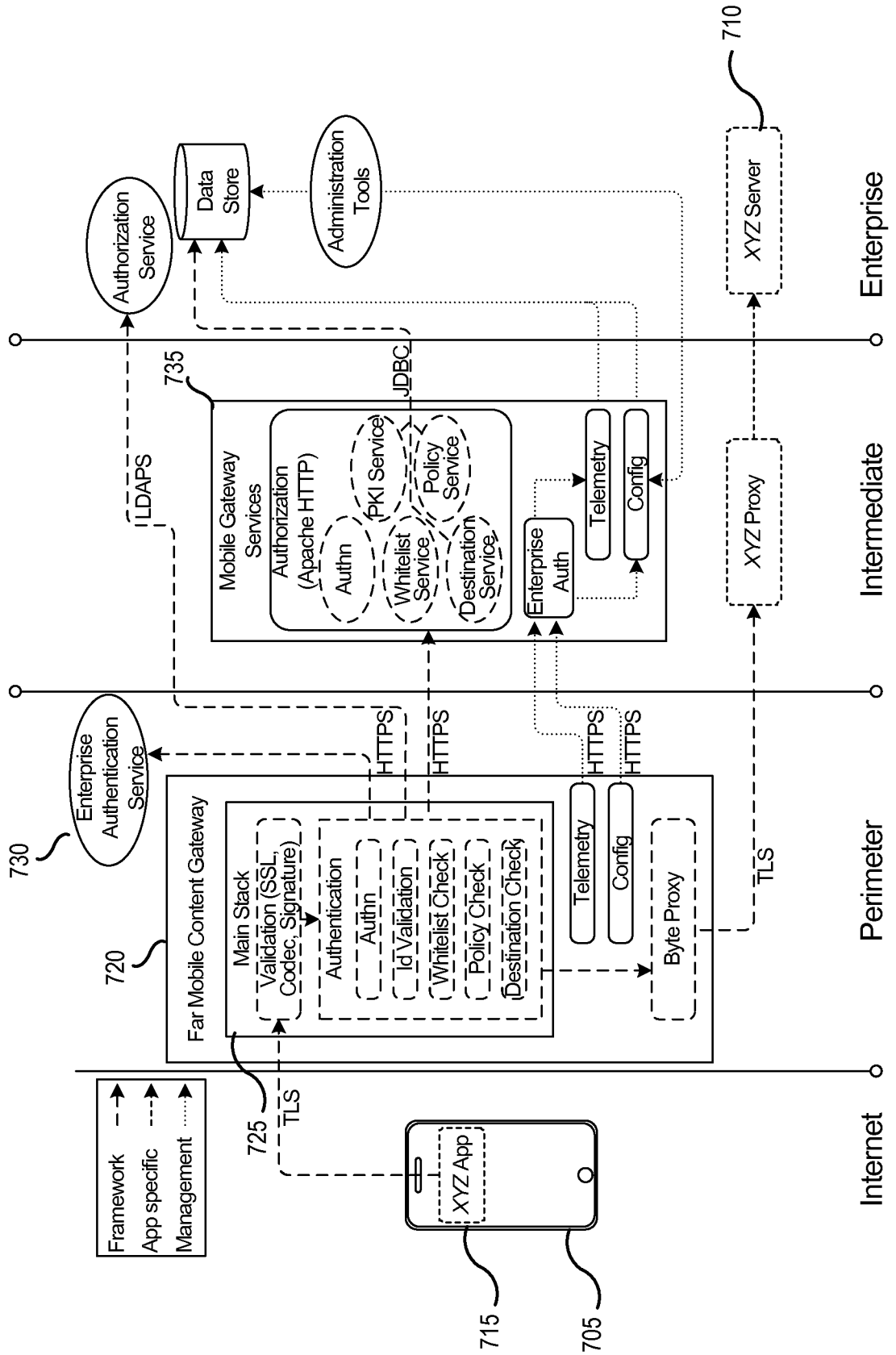


FIG. 7

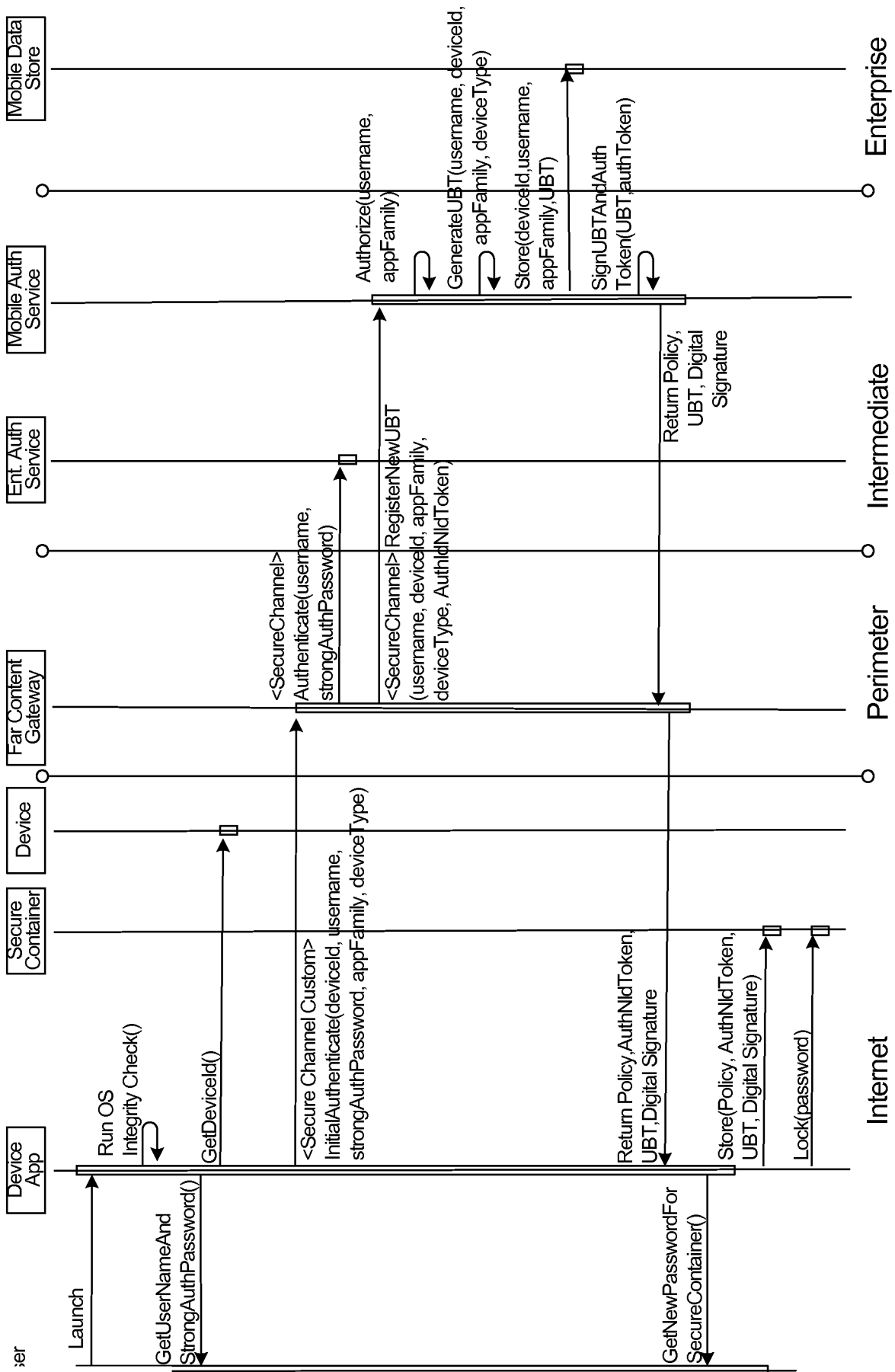


FIG. 8

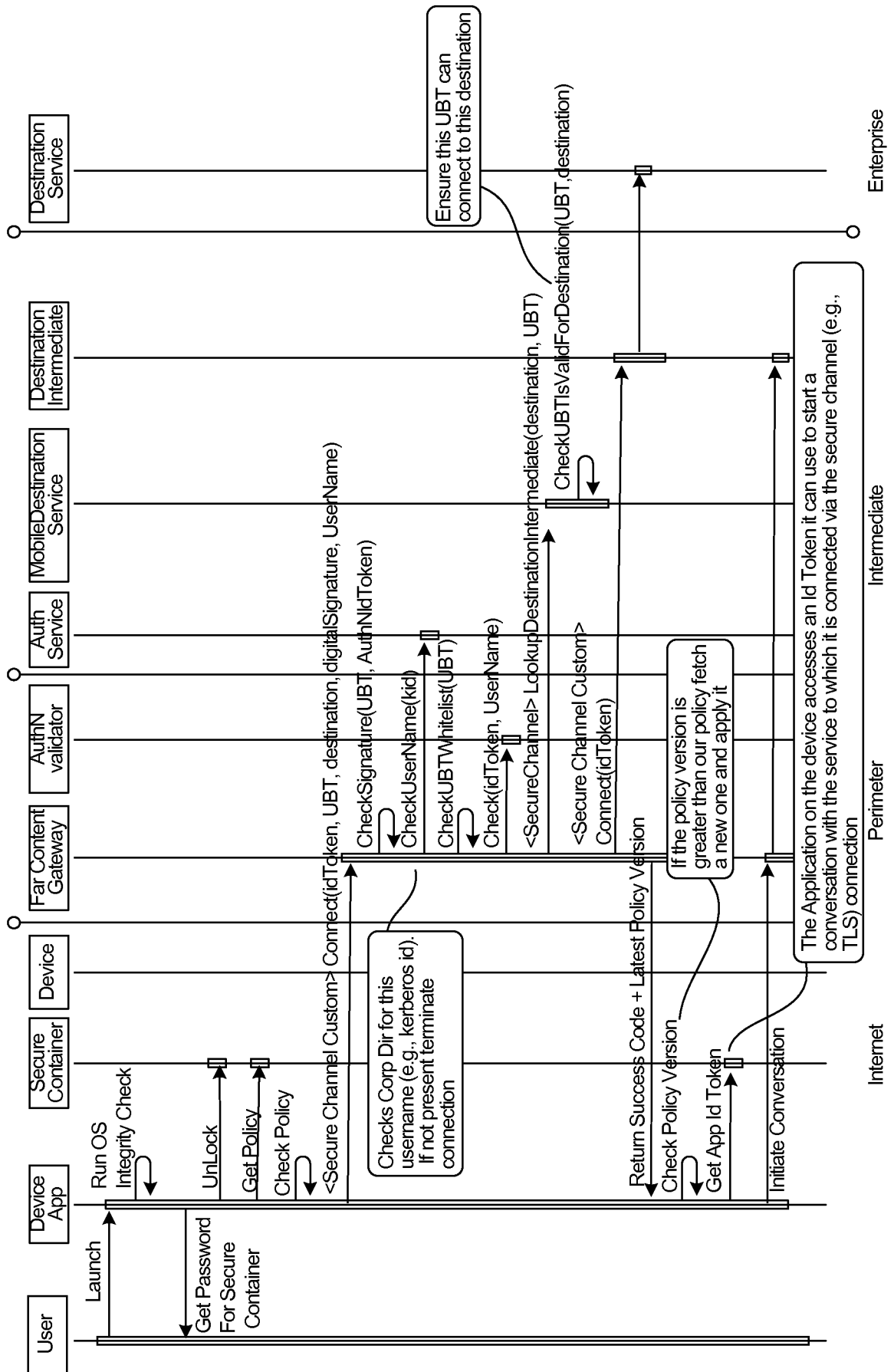


FIG. 9

1000 ↘

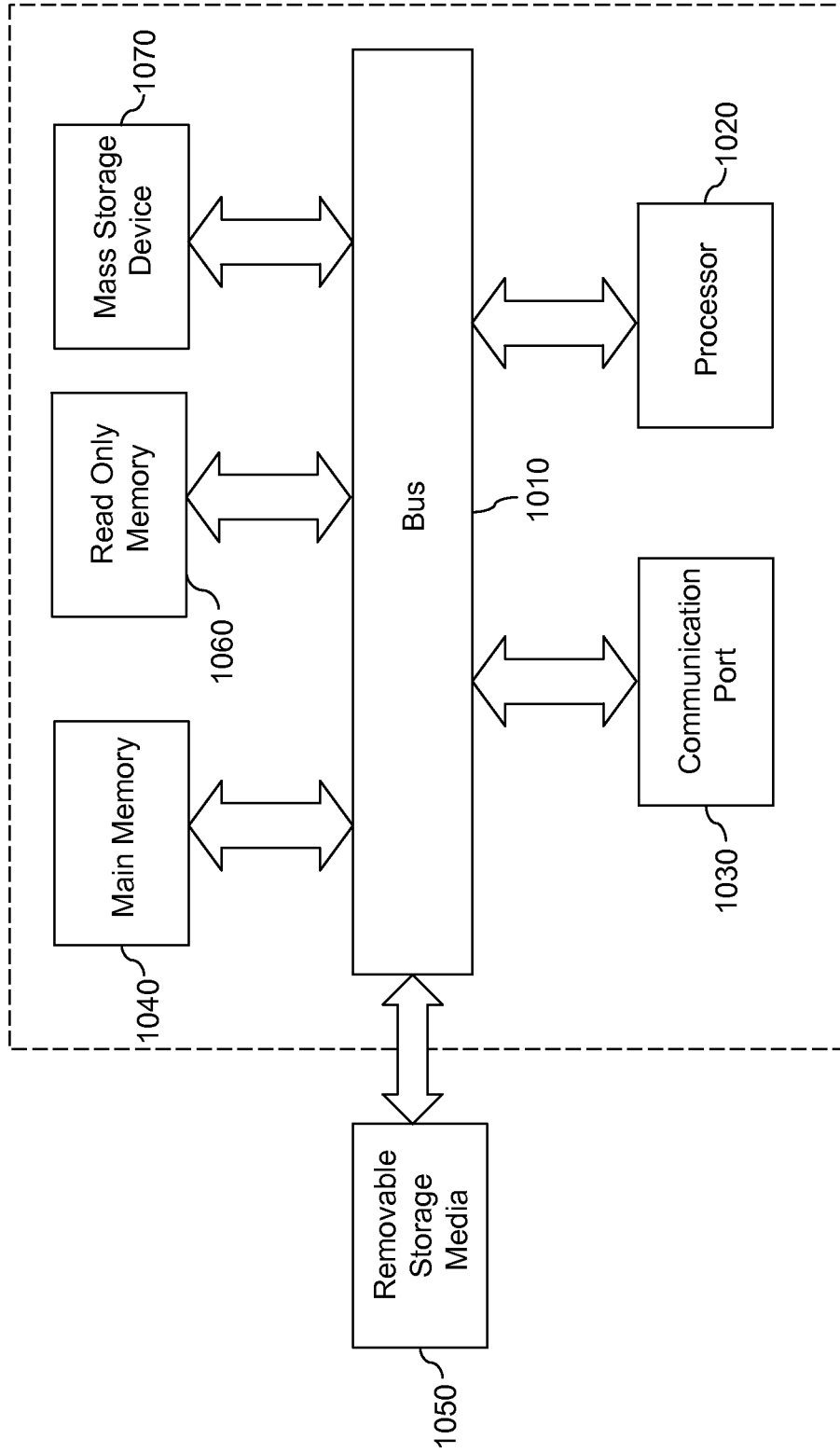


FIG. 10

**INTERNATIONAL SEARCH REPORT**

International application No.

PCT/US13/34853

<b>A. CLASSIFICATION OF SUBJECT MATTER</b> IPC(8) - G06F 7/04 (2013.01) USPC - 726/9 According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b> Minimum documentation searched (classification system followed by classification symbols) IPC(8) Classification(s): G06F 15/16, 11/30, 09/44, 12/14, 17/00, 7/04 (2013.01) USPC Classification(s): 709/218; 726/1, 12, 9; 713/185, 168 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) MicroPatent (US-G, US-A, EP-A, EP-B, WO, JP-bib, DE-C,B, DE-A, DE-T, DE-U, GB-A, FR-A); DialogPRO; IEEE/IEEExplore; Google/Google Scholar; IP.com; Search Terms: gateway, intermediary, proxy, proxies, rely, request, authenticate, device, client, mobile, remote, enterprise, application, program, agent, resident, plugin, applet, api, token, cookie		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2011/0307947 A1 (KARIV, A et al.) December 15, 2011; entire document	1-25
A	US 2008/0244724 A1 (CHOE, C et al.) October 2, 2008; entire document	1-25
A	US 2007/0101418 A1 (WOOD, D et al.) May 3, 2007; entire document	1-25
<input type="checkbox"/> Further documents are listed in the continuation of Box C.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 28 June 2013 (28.06.2013)	Date of mailing of the international search report  <b>16 JUL 2013</b>	
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer:  Shane Thomas  PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774	