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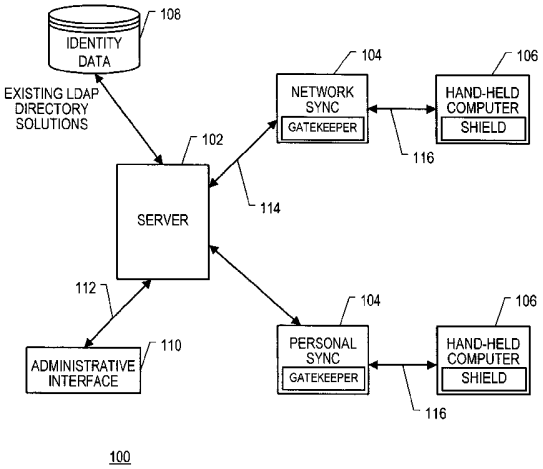
(54) Title: SERVER, COMPUTER MEMORY, AND METHOD TO SUPPORT SECURITY POLICY MAINTENANCE AND DISTRIBUTION



(57) Abstract: In a particular embodiment, a server module deployed on a server (102) is disclosed. The server module is connected to a wireless network access node (104). The server modules includes a database (108) containing user information for multiple wireless devices (106). Each element in the database (108) is attributable to at least one authorized wireless device (106) and contains at least one type of data file from the following group: (i) wireless connectivity permissions, (ii) authorized wireless device identification, and (iii) authorized network access node information.In another embodiment, a method of enforcing security policies at a mobile computing device (106) is provided. The method includes receiving a policy at the mobile computing device (106) and enforcing the policy at the mobile computing device (106) by disallowing a user of the mobile computing device (106) from engaging in the use precluded by the use limitation. The policy includes at least one device use limitation.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

SERVER, COMPUTER MEMORY, AND METHOD TO SUPPORT SECURITY POLICY MAINTENANCE AND DISTRIBUTION

BACKGROUND

Field of the Invention

The present application relates to systems and methods of distributing and enforcing security policies.

Description of the Related Art

The use of mobile devices, such as personal digital assistants (PDAs), in corporate environments is projected to grow significantly over the next 3-5 years. These smart devices are increasing in diversity and capability as well as number. These devices offer a unique blend of lightweight mobility, convenience and functionality providing an instant-on access to information such as email, calendar, address book and other documents. Many enterprises are developing or have deployed special applications for mobile devices that transform the platform into a mission critical tool and repository for sensitive corporate data.

As a result, mobile devices have become indispensable tools for business communications. The use of these devices is expected to grow rapidly according to industry experts.

The prevalence and power of mobile computing devices and the increasing availability of wireless connectivity represents a paradigm shift in how people will use computers and access data. The current use and diversity of these devices are impacting the integrity of corporate IT infrastructures in many ways. These devices connect to the corporate network in multiple, unsecured and difficult to monitor transient ways. Cradles are used to 'synch' the devices to laptops or desktops using serial or USB lines. Modems and wired or wireless networks are used. Cell phones are converging with PDAs to provide

a new generation of devices that may access corporate data in an expanding network of advanced cellular access points. Finally, since these devices have significant storage, computing power and operate in a connected and disconnected mode, security management and control of these devices remains an important challenge.

Mobile devices provide an "open door" into the enterprise, especially if lost or stolen. A variety of sensitive information may reside on these devices including passwords and access codes for most corporate databases, network files and applications. These pocket-size devices have become the "password sticky note" of the 21st century. In a wireless "always-on" world, these devices can enter and exit numerous unknown and ad hoc networks in a single day. At industry tradeshows, cyber-cafes or industry networking environments, corporate data is especially exposed to unauthorized access.

These devices have become large walking repositories for business confidential information. Mobile professionals frequently synch or copy proprietary corporate information from laptops, such as financial results, launch plans, personnel information, client records or application specific information. The large memory capacity of mobile devices and the plummeting price of after market memory cards make it more likely that users will store additional information on their devices.

The emerging corporate use and capabilities of these devices make unique challenges for an enterprise scale mobile security solution. Because mobile devices often operate in a disconnected mode, on-device policy enforcement is required.

The number of mobile devices entering the enterprise and the complexity of the security requirements is placing an increased demand on the enterprises ability to manage and enforce corporate security on mobile devices. Many information technology (IT) departments do not know how many non-company issued devices are currently being used by employees. They have no tools to restrict these devices from accessing corporate data. Simply put, current IT departments are not equipped to respond to the emerging computing standard of the mobile device.

Accordingly, there is a need for an improved system and method of handing security policies with respect to mobile devices.

SUMMARY

In a particular embodiment, a server module deployed on a server that is connected to a wireless network access node is disclosed. The server module includes a database containing user information for multiple wireless devices. Each element in the database is attributable to at least one authorized wireless device and contains at least one type of data file from the following group: (i) wireless connectivity permissions, (ii) authorized wireless device identification, and (iii) authorized network access node information.

In another embodiment, a computer memory is disclosed. The computer memory includes a plurality of operating keys for use in connection with security features of a mobile computing device and a root key. The root key is to encrypt the plurality of operating keys.

In another embodiment, a method of enforcing security policies at a mobile computing device is provided. The method includes receiving a policy at the mobile computing device and enforcing the policy at the mobile computing device by disallowing a user of the mobile computing device from engaging in the use precluded by the use limitation. The policy includes at least one device use limitation.

In another embodiment, a security method is provided. The security method includes receiving a password from a user of a mobile computing device; deriving a security code from the password by applying a non-linear function; and encrypting the security code using the password as an encryption key.

In another embodiment, a method of selectively providing a mobile computing device with access to a software application on a server is provided. The method includes receiving a request to access the software application from the mobile computing device and determining whether to grant access to the software application by checking whether the mobile computing device has an installed security program.

In a further embodiment, a method of updating policies and key materials is provided. The method includes providing a shared encryption key that is shared by a server and a client module; encrypting data on the client using the shared encryption key; authenticating a user of a mobile computing device by receiving a password, where the client is resident at the mobile computing device; decrypting the shared key using the

password; using the shared key to decrypt updated policies and key materials; and replacing policies and key materials at the mobile computing device with the updated and decrypted policies and key materials.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of an embodiment of a system for use in providing security policy distribution and mobile device management.

FIG. 2 is a block diagram of an embodiment of a server within the system of FIG. 1.

FIG. 3 is a general diagram that illustrates software layers within the server of FIG. 2.

FIG. 4 is an illustrative screen shot of an administrative user interface for use with the server of FIG. 2.

FIG. 5 is a block diagram that illustrates functional elements within the gatekeeper of FIG. 1.

FIG. 6 is block diagram that illustrates elements within the shield application of the system of FIG. 1.

FIG. 7 is a flow chart that illustrates installation of the shield security application onto mobile devices.

FIG. 8 is a flow chart that illustrates a method of updating policy information and distributing the updated policy information to a mobile device.

FIG. 9 is a flow chart that illustrates another method of updating policy information and distributing the updated policy information to a mobile device.

FIG. 10 is a diagram that illustrates key materials and specific key field formats for use with encryption of policy information.

The use of the same reference symbols in different drawings indicates similar or identical items.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring to FIG. 1, a system 100 for use in enterprise security management is disclosed. The system 100 includes a server 102, a gatekeeper 104, and a client device module 106. The client device module 106 that is used to provide security functionality is also referred to as a shield. The system 100 is a comprehensive enterprise security management software platform for diverse mobile operating systems, applications and devices. The system 100 enables an organization to secure and manage mobile devices easily and cost effectively. The server 102 integrates with existing security policy management systems and allows administrators to centrally create new mobile security policies by extending existing security policies and to distribute them to a diverse population of mobile devices. The server 102 and gatekeeper 104 work together to automatically and securely push these security policies to a specified mobile device. The shield 106 is a trusted computing environment on the mobile device that enacts and enforces the distributed security policies, controls access to the mobile device, and provides data security.

The server 102 may be implemented as a web-based application server that provides central creation and management of mobile security policies. The server 102 is preferably implemented with portability, scalability and maintainability in mind using industry standards such as Java, XML and other advanced web technologies. To provide easy control and accessibility, an administrative interface to the server 102 is provided through a secure browser interface allowing the simple delegation of responsibilities and access by any workstation or PC on a local network connected to the server 102.

A consolidated LDAP directory (CLD) technique may be used to integrate the server 102 with existing enterprise security infrastructure, such as an existing identity database 108. Existing policy and identity management systems are integrated through a real-time interface to directory resources. A layer in the server 102 provides a consolidated view of the external LDAP services and extends these services through policy inheritance and over-riding. As a result, existing identity directories, such as directory 108, can be used without copying data and without changing the data schemas of the existing enterprise security systems.

The data passed to the gatekeeper 104 and subsequent mobile devices 106 is derived from security role and is protected through a combination of secure socket layer (SSL) and data encryption. Mobile security policies are formed using the administration interface 110, which is coupled to the server 102 via interface 112, to set and extend policies in a consolidated directory (e.g., LDAP). Once policies are set, a policy package is generated for each user within a role, encrypted with the specific users' encryption key, and forwarded to the gatekeeper 104 for installation on the target mobile device 106. Policy package encryption forms a main pillar of system security. Additionally, SSL communication is used for added privacy and authentication between the server 102 and the gatekeeper 104 over the secure interface 114. The system 100 is designed for robust security management to provide many advanced security features including: centralized management of disconnected devices, automatic versioning and distribution of policies, role-based policy creation and management, seamless integration with existing role repositories and security infrastructure, delegated security management, separation of administrative duties, automatic retrieval of device audit logs, consolidation, alerting and reporting, and mobile device management.

The gatekeeper 104 may be implemented as a security management software agent that forms a virtual security layer on existing, third party synchronization systems, such as HotSync, ActiveSycn, and ScoutSync. A function of the gatekeeper 104 is to receive policy packages from the server 102 and install the packages on target mobile devices 106. The gatekeeper 104 operates in two modes to support local and network synchronization. In local mode, the gatekeeper 104 executable operates on desktop and laptop computers forming a security layer on top of personal synchronization tools. In network mode, the gatekeeper 104 executable operates on an enterprise server and forms a security layer on top of a network synchronization application. When the gatekeeper 104 is deployed, mobile devices 106, such as personal digital assistants (PDAs), are required to authenticate and to request permission to synchronize before the third party data synchronization tool is allowed to launch. Additionally, the gatekeeper 104 provides for automatic installation of the mobile shield on specified PDAs, application configuration, update and patch management, mobile device configuration management, monitoring, management, and control access to synchronization application, and distribution of device policies, permissions and configurations.

The mobile device application, i.e., shield, 106, may be implemented as a trusted computing environment operating as a software layer on top of the mobile device operating system. Security policies are received from the gatekeeper 104 using a two-way authentication process. The policies are used by agent software at the mobile device to encrypt data, and to monitor and control device access, device peripherals, and device software and hardware operations. The mobile device trusted environment approach provides many security features, including: on-device policy enforcement whether connected or disconnected, mandatory access control, data encryption with secure recovery, mandatory synchronization authentication, controlled application access and use, control over hardware ports – infrared (IR), compact flash (CF), universal serial bus (USB), secure digital (SD), multiple profiles – personal and business, and secure audit logs. Sample devices that may accept shield software include personal devices made by Palm, Handspring, Sony, Compaq iPaq, and the HP Jornada 500 series.

To summarize, all three major components of the system 100 interoperate substantially seamlessly and transparently to the user to enable a secure mobile environment without materially deterring from the user's experience. The server 102 virtually consolidates external LDAP identity and policy data to integrate to existing security infrastructure. The administrative tools on the server 102 allow policy packages to be automatically formed and distributed to each mobile device 106. The gatekeeper 104 monitors synchronization and installs the shield software and policy packages on targeted devices. Finally, the shield forms a trusted computing environment by forming a security layer on the mobile operating system to enforce the policies originating from the server 102. The complete system 100 forms a comprehensive, enterprise scale mobile security management system.

The system 100 includes components that integrate to external systems. To support a large customer base, multiple platforms are supported for each component. The following sample list identifies illustrative devices and software platforms for integration. At the server 102, the windows2000 operating system, an LDAP of MS Active Directory System (ADS), Critical Path, or iPlanet flat files, and the Explorer version 5.0+ browser. At the gatekeeper 104, compatible operating systems include Win98, WinNT 4.0, Win2000, WinXP, compatible data synchronization software includes HotSync, ActiveSync version 3.1+, server operating system of Win2000, and the network synchronization of ScoutSync

version 3.5+. For the shield, the supported operating systems include PocketPC 2000, PocketPC 2002, and device OS version 3.5+.

The server 102 is constructed using enterprise scale server technology, such as federated webservices to provide scalability servers and portability of functions, model-view-controller (MVC) web interface techniques to provide maintainability and speed, and consolidated LDAP Directory (CLD) technology to provide compatibility and reduce installation and administrative costs in existing security infrastructures.

The server 102 architecture is integrated through a web service paradigm, as illustrated in FIG. 2. This paradigm is an industry recognized best practice for developing and integrating enterprise web applications. The web service paradigm is a loosely coupled architecture of processes that is flexible, allows additional functions, and allows replacement of servers as well as increased scale through load balancing and additional servers.

The core of the web services approach is in the ability to expose or advertise services through a consolidating interface. Referring to FIG 2 many of the key functions of the server 102 such as access control, audit log and security policy management are implemented as individual Java "applications" and advertised or exposed to the internal local area network (LAN) as services. These "applications" operate as web services. Each service can be run as a process or thread on a shared server, on separate servers or in combinations on fewer servers. Scalability and load balancing is achieved by running multiple threads of a service on a single server or on a cluster of servers. Maintenance is simplified by supporting the ability to move services between servers and to replace servers dynamically.

The federating web service in FIG. 2 is a proxy type of service that consolidates the internally advertised services and provides the corresponding service to an external user through a hyper-text transfer protocol (HTTP) interface. The federated web service consolidates internal services by proxying the functionality to external users. The location of the services is specified in a service table or configuration file formatted with eXtensible markup language (XML). Service management is an advantage to the federated services approach. Only a single URL needs to be maintained to provide service to a scalable cluster of servers and services. The federating service has the ability to route application calls

dynamically to perform load balancing. Scalability of the federating service is achieved using multiple federating service servers and standard load balancing routers such as Cisco's LocalDirector router.

The federating services and external users may be integrated through industry standard scripting protocols XML (eXtensible Markup Language) and SOAP (Simple Object Access Protocol). XML is a markup language similar to HTML for web pages, while SOAP is composed with structures or sentences written in XML. With web services, XML is the alphabet that represents data while SOAP is the grammar that defines the service call similar to a remote function call. Specifically, XML provides a tagged markup language that allows portable data representation between services. SOAP is an industry standard structure of XML tags that define calling sequences, parameter structures and result variables. These protocols are supported over the ubiquitous HTTP communication channels of the web.

As a result, XML/SOAP allows an external application, such as the gatekeeper 104, to request a service as a single federated web service URL, to proxy the result to the actual web service and to provide the result back to the gatekeeper 104. Privacy and authentication of the gatekeeper 104 can be achieved using SSL services by using the standard HTTPS protocol in place of HTTP.

The administrator interface 112 is provided through use of a lightweight HTTP or web interface. Benefits of this configuration includes wide availability of access from anywhere in the LAN, secure usage through SSL protocol, as well as simple delegation of responsibilities and separation of duties through authentication and access control.

The server 102 uses the industry recognized best practice of MVC programming model to implement the graphical user interfaces (GUI) of the administrator console. Model View Controller (MVC) is similar to web service in that it is a method of providing remote function calls. MVC leverages the federating web service to manage resources. However, MVC provides an additional capability to graphically represent the results of the service to provide a web page representation and a GUI.

MVC is the modern evolution of CGI for calling functions from web pages. The CGI approach used a myriad of println() calls to return HTTP data back to the browser for

display. Servlets are a server side Java application that perform a specific task and that do not have GUI capabilities. The servlets were used to manage flow while JSP managed the HTML formatting. The MVC model separates servlets into logic (or model) servlets and control servlets resulting in the acronym MVC.

The server 102 uses MVC to implement the GUI. A view component is used to format and represent GUI to the browser. JSP and HTML are used to implement the view component. A controller component is used to consolidate, delegate and manage control flow and may be implemented with a Java servlet controller using HTTPS with the federated web service. Finally, the controller delegates work to an appropriate model within the server 102. The model may be implemented as a servlet in Java. The models are used to control setting of policies, accessing roles stored in the LDAP and forming policy packages for distribution. The entire GUI including operation and logic is controlled and managed by the MVC framework. The framework is quickly implemented, and is easily modified, expanded and maintained.

Simplifying and lowering the total cost of ownership of the mobile security management system is a goal in the design of system 100. A challenge and cost of installation is integration with existing identity data management systems. LDAP is data directory structure that is commonly used to store identity information and security policies to support authentication and authorization systems. It is understandable that customers want to reuse existing LDAP repositories after investing the time and effort to create an LDAP role-based policy system and populate the system with every user in the company. Furthermore, customers may desire future security systems to use the existing LDAP repositories without compromising the integrity of the system by modifying any database schemas.

The server 102 uses a consolidated LDAP directory (CLD) technology to address this integration challenge. The server 102 uses a layering approach and places a virtual layer above external and internal LDAP systems to provide a federated view of LDAP repositories. FIG. 3 illustrates this approach.

The federation works with three layers. The bottom layer 302 is an adapter layer that is specific to a data store format and converts the store representation to a portable format. The middle layer 304 is a core directory engine that performs on-the-fly mapping to

transform top-level client requests into the context of each repository and results into federated representations. The top level 306 is a front-end listener that converts the directory engine results into proper LDAP format. The result is a powerful method for integrating disparate customer identity data stores into a unified view for simplified server installations.

An access control service provides authentication for administrator logins and for gatekeeper 104 communications. This service interfaces to the LDAP repository of identities and permissions to provide control for system and data access. Administrators are authenticated through a login screen presented by a browser with JSP. The JSP requests authentication with the user name and password through the servlet interface of the federated service. The request is proxied to the access control service for completion. The authentication may be performed with LDAP version 3 operations through the CLD and may alternatively be performed using private key encryption type authentication systems.

The gatekeeper 104 is authenticated using SSL server certificates and realm authentication. An SSL connection is created to provide communications between the server 102 and gatekeeper 104. Initially, the server 102 is authenticated to the gatekeeper 104 through SSL certificate authentication. Next, an SSL channel is constructed for privacy. Finally, a name/password pair (per realm authentication) is passed to through the federated service to the access control service for authentication. Successful match of name and password provides authentication of the gatekeeper 104 to the server 102.

A policy service provides management of the role-based policies as well as creation of the policy files. The policy management service is provided to the administration console and allows definition of the policy values for both roles (or groups) and individual users. Once the policies have been defined for a population of users, the administrator can select to publish the policies. The publication process is the act of forming the secure policy files and automatically pushing the policy files out to the individual shield application 106. An example screen shot of the policy management service is shown in FIG. 4.

The system 100 provides a key management service that generates and archives password keys for encryption operations in the shield 106. Symmetric encryption keys are generated using techniques such as industry standard X9.17. Symmetric keys are used to protect data on the mobile device. These data encryption keys are generated uniquely for

each mobile device and are stored on both the server 102 and the shield 106 to enable data protection while allowing secure data recovery with administrator intervention. Asymmetric or public/private key pairs are created with the elliptical curve cryptography (ECC) key algorithm and are used to encrypt policy files and audit log files. Separate key pairs are generated for each device and individually for the policy files and the audit logs. The key pairs are stored on the server 102 for secure data recovery through administrator intervention. The private audit log key is stored on the shield 106 to encrypt audit log information to support transference off of the device. The public policy file key is stored on the shield 106 to allow the software to authenticate and extract the policy items from the encrypted policy files. The opposite keys are used on the server 102 to decrypt audit log files and to encrypt policy files in support of the device.

A policy file is a collection of policy items combined into a single data package and formatted with XML. The policy file is transferred from the server 102 to the mobile device for security configuration and enforcement. The policy file is actually a number of files; one main index file and another for each category of policies defined. Each category file contains a series of policies that define the permissions and behavior of the shield 106. Three items define each policy: category, key and value name. A key may have zero or more name/value pairs associated with it.

The server 102 encodes the policy file with ECC asymmetric encryption and transfers the file to the mobile device. The key pair corresponding to the policy management of an individual mobile device is created and managed by the server 102. The private key is stored on the server 102 and used to encrypt the policy file. The public key is stored on the mobile device by the shield application 106. The policy file is transferred to the mobile device during synchronization, after authentication is performed. The public key stored in the shield is used to open the policy file. The public key is passed to the shield application in a secure manner. This method of policy file management provides private transfer to specific shield deployments, provides policy authentication and management, and is tamper resistant to enable consistent policy enforcement.

Policy data falls into the following categories: I/O, storage, applications, and authentication.

The following tables specify sample types of policy data:

Permission Policies

Name	ID (Category)	Value	Type	ReadOnly	Affects
IR_Enable	I/O	True/False	Boolean	True	Palm: Exchange Manager, IR Library CE:
TCPIP_Enable	I/O	True/False	Boolean	True	Palm: Network, INet Library CE:
NetBios_Enable	I/O	True/False	Boolean	True	Palm: N/A CE:
SyncAuthenticated_Required	I/O	True/False	Boolean	True	Palm: CE:
VolumeMount_Enable	Storage	True/False	Boolean	True	Palm: DB, VFS Manager (File system mounting) CE:
DateBook_Enable	Applications	True/False	Boolean	True	Palm: DateBook CE: Calendar
AddressBook_Enable	Applications	True/False	Boolean	True	Palm: AddressBook CE: Contacts
Todo_Enable	Applications	True/False	Boolean	True	Palm: Todo CE: Tasks
Memo_Enable	Applications	True/False	Boolean	True	Palm: Memo CE: Notes
Expense_Enable	Applications	True/False	Boolean	True	Palm: Expense CE: Money
Mail_Enable	Applications	True/False	Boolean	True	Palm: Mail CE: Inbox
Prefs_Enable	Applications	True/False	Boolean	True	Palm: Prefs CE: Settings
Security_Enable	Applications	True/False	Boolean	True	Palm: Security CE: N/A
FileExplorer_Enable	Applications	True/False	Boolean	True	Palm: N/A CE: File Explorer
InternetExplorer_Enable	Applications	True/False	Boolean	True	Palm: N/A CE: Internet Explorer
PocketWord_Enable	Applications	True/False	Boolean	True	Palm: N/A CE: Pocket Word
PocketExcel_Enable	Applications	True/False	Boolean	True	Palm: N/A CE: Pocket Excel
WindowsMedia_Enable	Applications	True/False	Boolean	True	Palm: N/A CE: Windows Media
Reader_Enable	Applications	True/False	Boolean	True	Palm: N/A CE: MS Reader

Rule Policies

Name	ID (Category)	Value	Type	ReadOnly	Description
PINEnable	Authentication	True/False	Boolean	True	Whether to include PIN authentication in the password hierarchy
PasswordEnable	Authentication	True/False	Boolean	True	Whether to include Password authentication in the password hierarchy
PassPhraseEnable	Authentication	True/False	Boolean	True	Whether to include Pass Phase authentication in the password hierarchy
ManAuthEnable	Authentication	True/False	Boolean	True	Whether to include PIN authentication in the password hierarchy
PasswordNumChars	Authentication	8-16 characters	Number	True	
PasswordAlphasRequired	Authentication	True/False	Boolean	True	
PasswordNumericRequired	Authentication	True/False	Boolean	True	
PasswordSpecialRequired	Authentication	True/False	Boolean	True	
PasswordUpperCaseRequired	Authentication	True/False	Boolean	True	
PassPhraseNumChars	Authentication	16-32 characters	Number	True	
NumPINAttempts	Authentication	1-4	Number	True	
NumPasswordAttempts	Authentication	1-4	Number	True	
NumPassPhraseAttempts	Authentication	1-4	Number	True	
NumManAuthAttempts	Authentication	1-4	Number	True	
UserSessionTimeout	Authentication	1-120 minutes	Number	True	Inactive time till user must re-authenticate
PowerOffTimeoutEnable	Authentication	True/False	Boolean	True	Requires user to re-authenticate after device has been turned off
AuthDataExpires	Authentication	1-365 days	Number	True	Time till user must reset authentication information

The system 100 also provides a logging service. Each event defined in the logging service has a corresponding registered policy. This will enable the administrator to control which events are written to the audit logs.

A log file is a record of events that is generated by the shield software 106. The shield 106 initially stores the file locally. During synchronization, the log file is automatically transferred through the gatekeeper 104 to the server 102. After synchronization, the shield 106 initializes a new file. The server 102 automatically appends the new log to the previous synchronized logs to form a consolidated log. Server access to the log is provided through an open database connectivity (ODBC) interface to allow custom or third party reporting tools to be used.

The log files are locally protected against tampering with elliptical curve algorithm asymmetric encryption. The key pair corresponding to the on-device audit logs of an individual mobile device is created and managed by the server 102. The public key is stored on the server and used to open the audit log after synchronization. The private key is stored on the mobile device by the shield application 106 and is used to add new event records to the event log. An initial value or seed is transferred from the server 102 to the mobile device in a secure mode during synchronization. This seed is updated through the encryption process as records are added to the audit log. This forms an encryption thread through the event recording process. Additionally, a time stamp from the server is used to initialize the file. The initial time stamp combined with periodic time events in the file allows monitoring of the mobile device clock to prevent time tampering. This method of on-device audit logging provides a secure and private audit log that is easily maintained by the server, detects gaps in time and in logging sequence, and is tamper resistant to provide a robust, on-device monitoring system.

Referring to FIG. 5, an illustrative functional diagram for the gatekeeper 104 is disclosed. The gatekeeper 104 includes a persistence network 502, a server interface 504, a client interface 506, an encryption module 508, an audit module 510, a synchronization plug-in module 512, and an authentication module 514. The gatekeeper 104 communicates with the server 102 using HTTPS and XML over the interface 114 and communicates with the mobile device 106 via the synchronization interface 116, such as with SKID3 and XML.

Referring to FIG. 6, an illustrative block diagram for the shield application 106 on a representative mobile device is shown. The shield application 106 includes a communication module 602, a storage area 604, a user interface 606, encryption module 608, audit and log module 610, policy rule engine 612, and system interface 614.

The communication module 602 communicates with external systems such as the gatekeeper. The communication module receives application data, personal information data (PIM), new key materials and policy data from the gatekeeper 104. The application data and PIM data are stored in the general device storage 604. This general storage may be encrypted by the encryption module 608. The new key materials are decrypted by the encryption module 608 and stored in the key data store in 608. The policy data is decrypted by the encryption module 608 and stored in the rules engine store 612.

The user interface module 606 communicates with the device user to authenticate the user and unlock the device. The user interface may retrieve any of a plurality of data such as PIN (personal identification number), password, answer to a question or response to a challenge. Authentication is tested by decrypting data in the encryption module 608 with the retrieved data. Upon successful decryption, authentication is approved. A similar authentication test can be hashing the retrieved information and comparing the information with data stored in the encryption module 608. The user interface 606 also displays alerts such as sync in progress or device is locked.

The audit log module 610 stores system event data, such as successful or unsuccessful authentication attempts, in the encrypted log store of 610. The events are encrypted by the encryption module 608 and transferred to the gatekeeper 104 by the communications module 602.

The rules engine 612 provides authorization based on the policy data in its store. The policies are retrieved from the communications module 602 during connectivity to the gatekeeper 104 and enforces the policies at all times whether connected or disconnected. The policy data is retrieved from the gatekeeper 104 by the communications module 602 in an encrypted form. The encryption module 608 decrypts the data prior to storage on the policy data store in 612. The rules engine receives authorization requests from a plurality of modules and responds with authorization based on the policies stored within. The policy engine can signal the user interface 606 to lock the device if a user action is denied or an unauthorized event occurs.

The rules engine 612 can enforce which devices to which the communications module 602 can communicate. The policy database may contain a list of devices that can be communicated with, a list of devices that cannot be communicated with or a list of keys

stored in the encryption module 608 with which can be used to authenticate devices. If an external device is included in the list of approved devices to communicate with, the rules engine 612 grants authorization to the communication module 602 to communicate with the external device. If an external device is included in the list of disapproved devices to communicate with, the rules engine denies authorization to the communications module 602 to communicate with the external device. If a plurality of keys is listed in the policy database, then the rules engine can request the encryption module 608 to perform a challenge response with an external device to determine authentication. If the authentication is successful, the rules engine 612 may grant authorization to the communications module 602 to communicate with the external device. Otherwise, the rules engine may deny authorization to the communications module 602 to communicate with an external device.

The rules engine 612 and user interface 606 can enforce a personal or business mode. The user interface 606 can authenticate a user in either personal mode or business mode. The mode is determined from the data retrieved from the user interface indicating which mode the user requests. The rules engine authorizes what actions can be performed in each mode. Additionally, the rules engine can authorize which data items in the general data store 604 can be displayed by the user interface 606, can be accessed by a plurality of modules, or can be transferred by the communications module 602.

The system interface 614 communicates using intercepted events with an external event handler, such as OS event handler 630 and communicates, by intercepting system calls, with external operating systems, such as OS 632. The system interface 614 authorizes system calls and events by intercepting the system calls and events, requesting authorization from the policy engine 612, and granting or denying the system calls or events.

Referring to FIG. 7, a method of distributing security software from the server 102 to a mobile computing device is illustrated. First, gatekeeper software 104, including network scripts, policies, and key materials, is installed from the server 102 to a desktop computer, or other suitable gatekeeper platform, at 702. When the mobile computing device connects to the gatekeeper 104 during a data synchronization event, the shield software application 106, i.e., security software for the mobile computing device, is installed from the gatekeeper 104 to the mobile computing device, at 704. The gatekeeper 104 requests a one-

time use password from the server 102, at 706. The server 102 emails the one-time use password to the user of the mobile computing device, at 708. The mobile computing device user can then use the one-time password to complete installation of the security shield application.

At this point, the root key for the key pack is decrypted using the one-time password, allowing access for the user to enter a new password, a personal identification number (PIN), and a password phrase, and optionally other user identification information, such as the user's mothers maiden name or pet name, at 710. The root key is then encrypted using each of the above user information entries, including the new password, the PIN, the phrase, and the user's answers to key questions, at 712. The above process of having a mobile computing device user initiate security operations may be accomplished using user interface software, such as by providing prompting screens to facilitate entry of the user information.

Referring to FIG. 8, a method for distributing a new or modified security policy information to a mobile device is illustrated. At 802, a policy change or a new policy is added by an administrator connected to the server 102 and the server 102, in response to the administrator request, creates a new policy package. The policy package contains the new or modified policy. To distribute the new policy package to the mobile computing device, the server 102 authenticates a connection with the gatekeeper 104 and upon successful authentication, sends the policy package to the gatekeeper 104, at 804.

The authentication between the device and gatekeeper may be implemented using a mutual challenge-response algorithm that uses a shared key as a shared secret for determining authentication. The process is a two step challenge-response that may begin with ether the device or the gatekeeper. Consider an example where the device initiates the challenge. A random number is calculated by the device and sent to the gatekeeper as a challenge. The gatekeeper and the device compute the expected answer in parallel and in private. The answer can be calculated by any one way function of the shared key and challenge value. For example, the key can be appended to the challenge and input to a hashing algorithm such as MD5 for calculation of a message digest. The gatekeeper responds to the device by returning the computed response. If the response matches the expected answer, the first step or phase of the mutual challenge response is completed successfully and the gatekeeper calculates a random number for the return challenge. The

next step repeats the first step but in reverse roles. The gatekeeper challenges the device with the random number. Each computes the expected response privately. The device returns the calculated value as the response. If the values match, then the second phase is passed. If either phase fails, then the entire process is failed. Both steps must pass in order to be successful.

The gatekeeper 104 receives the policy package and waits for the next data synchronization communication with the mobile computing device, at 806. When the mobile computing device initiates data synchronization, at 808, the gatekeeper 104 authenticates the mobile computing device. The gatekeeper 104, upon successful authentication of the mobile computing device, pushes the policy package to the mobile computing device, at 810. The mobile computing device then decrypts the policies and activates the new or modified security policies, at 812. If authentication of either the gatekeeper 104, from the server 102, or the mobile computing device from the gatekeeper 104 fails, then the updated policy package is not distributed and the administrator may be notified.

Referring to FIG. 9, a method where a mobile computing device requests policy updates is shown. In this method, the mobile computing device initiates synchronization with the gatekeeper 104, at 902. The connections between the mobile computing device and the gatekeeper 104 and between the gatekeeper 104 and the server 102 is authenticated, at 904. After successful authentication, the gatekeeper 104 checks the server 102 for new policies, at 906. The server 102 creates a policy package based on new and modified policies and sends the policy package to the gatekeeper 104, at 908. The gatekeeper 104 installs the new and/or modified policies onto the mobile computing device, at 910. At the mobile computing device, the security application (i.e., the shield application 106) decrypts the policy package and activates the new or modified policies on the mobile computing device, at 912.

Referring to FIG. 10, the key materials and the use of the key materials to provide for security applications is illustrated. A sample key 1002 with a plurality of fields, including the software field 1004, the date field 1006, the owner field 1008, the length field 1010, the key ID 1012, and a cyclic redundancy check field 1014 is shown. Also shown is a root key 1016. The root key 1016 is encrypted using a user's PIN 1018, password 1020,

phrase 1022, and challenge 1024 (i.e., answer to key questions). The root key 1016 is then used to encrypt a set of operating keys 1036 referred to as a key ring. The operating keys 1036 include a data key 1038, a policy key 1040, a log key 1042, a gatekeeper authentication element 1044, an updating key 1046, and a heartbeat log key 1048. The data key 1038 is linked to unlock data storage 1054 within the mobile computing device. The policy key 1040 is used to access policies 1050 and the log key 1042 is used to access log files 1052 that track historical mobile device user activities.

The log key is the public key used with a public key encryption algorithm to encrypt data into the event log that tracks historical mobile device user activities.

The gatekeeper authentication key is used by the device in a challenge-response algorithm to prove its identity with the gatekeeper. The key is used as a shared secret to compute the response to a challenge. The update key is used to decrypt new keys sent by the server to the device as replacements to any of the plurality of keys. The heartbeat key is used similar to the gatekeeper authentication key for authenticating between the device and the server. The challenge and response between the device and server is used as a heartbeat to monitor the device.

Also illustrated, is the policy package that includes the policy pack 1056, encrypted using the policy key, and a key material pack 1058 that has been encrypted using the root key 1016. The policy package may be pushed from the server 102, via the gatekeeper 104, to the mobile computing device 106 or may be pulled from the mobile computing device from the server 102, via the gatekeeper 104. Methods for distributing the policy package were described above with respect to FIGs. 8 and 9.

The above disclosed subject matter is to be considered illustrative and the appended claims are intended to cover all such modifications and other embodiments which fall within the true spirit and scope of the present invention. Thus, to the maximum extent allowed by law, the scope of the present invention is to be determined by the broadest permissible interpretation of the following claims and their equivalents, and shall not be restricted or limited by the foregoing detailed description.

WHAT IS CLAIMED IS

1. A server module deployed on a server that is connected to a wireless network access node, comprising:

a database containing user information for multiple wireless devices, each element in the database attributable to at least one authorized wireless device and containing at least one type of data file from the group consisting of: (i) wireless connectivity permissions, (ii) authorized wireless device identification, and (iii) authorized network access node information.

2. A computer memory comprising:

a plurality of operating keys for use in connection with security features of a mobile computing device; and

a root key, the root key to encrypt the plurality of operating keys.

3. A method of enforcing security policies at a mobile computing device, the method comprising:

receiving a policy at the mobile computing device, the policy including at least one device use limitation;

enforcing the policy at the mobile computing device by disallowing a user of the mobile computing device from engaging in the use precluded by the use limitation.

4. A security method comprising:

receiving a password from a user of a mobile computing device;

deriving a security code from the password by applying a non-linear function; and

encrypting the security code using the password as an encryption key.

5. A method of selectively providing a mobile computing device with access to a software application on a server, the method comprising:

receiving a request to access the software application from the mobile computing device;

determining whether to grant access to the software application by checking whether the mobile computing device has an installed security program.

6. A method of updating policies and key materials, the method comprising:

providing a shared encryption key that is shared by a server and a client module;

encrypting data on the client using the shared encryption key;

authenticating a user of a mobile computing device by receiving a password, the client resident at the mobile computing device;

decrypting the shared key using the password;

using the shared key to decrypt updated policies and key materials; and

replacing policies and key materials at the mobile computing device with the updated and decrypted policies and key materials.

7. A wireless security system, comprising:

a client module deployed on a wireless device;

a network module selectively coupled to the client module during synchronization; and

a server module coupled to the network module,

wherein the client module is adapted to authenticate use of a wireless computing device independent of the network module and the server module.

8. A method of installing a security software application from a network module to a mobile computing device, the method comprising:

providing a network module, the network module including security policies and key material, the security policies and key material communicated to the network module from a server;

when the mobile device is synchronizing with the network module, initiating installation of a security software program onto the mobile security device;

requesting a one-time password;

receiving the one-time password at the mobile computing device; and

using the one-time password to decrypt a root key associated with the key materials.

9. A method of distributing security policy information from a server to a mobile computing device, the method comprising:

authenticating a connection between the server and a gatekeeper;

sending a policy package to the gatekeeper;

initiating data synchronization between the mobile computing device and the gatekeeper;

authenticating the mobile computing device; and

sending the policy package from the gatekeeper to the mobile computing device.

10. A client module deployed on a wireless device, comprising:

a policy database including a list of authorized devices to which the wireless device may communicate.

11. A client module deployed on a wireless device, comprising:

a policy database containing at least two user profiles on the wireless device.

12. A client module deployed on a wireless device, comprising:
a policy database including rules related to wireless connectivity permissions; and
an intelligent agent for enforcing the policy database rules.

13. A client module deployed on a wireless device, comprising:
a policy database; and
an agent responsive to the policy database, the agent configured to monitor unauthorized use of the wireless device.

14. A client module deployed on a wireless device, comprising:
a policy database including at least one type of data file from the group consisting of: (i) multiple profile data, (ii) connectivity permissions, (iii) authorized wireless device identification, and (iv) authorized network access node information;
an intelligent agent for enforcing rules of the policy database; and
an activity log containing wireless connectivity history information.

15. A network module deployed at a wireless network access node, comprising:
a policy database including a list of authorized wireless mobile devices; and
an agent for enforcing rules of the policy database.

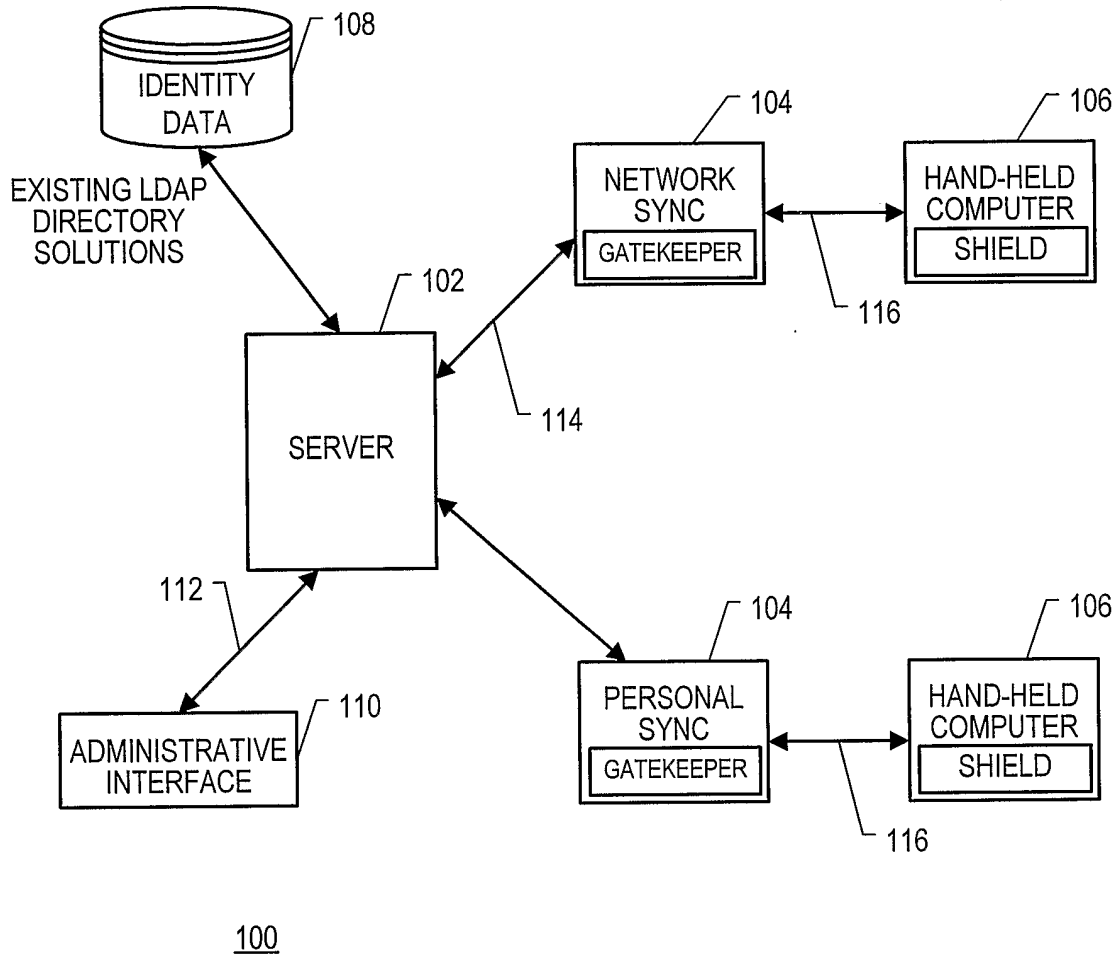
108
IDENTITY DATA
EXISTING LDAP DIRECTORY SOLUTIONS
104
NETWORK SYNC
GATEKEEPER
106
HAND-HELD COMPUTER
SHIELD
116
102
SERVER
114
112
ADMINISTRATIVE INTERFACE
110
104
PERSONAL SYNC
GATEKEEPER
106
HAND-HELD COMPUTER
SHIELD
116
100

FIG. 1

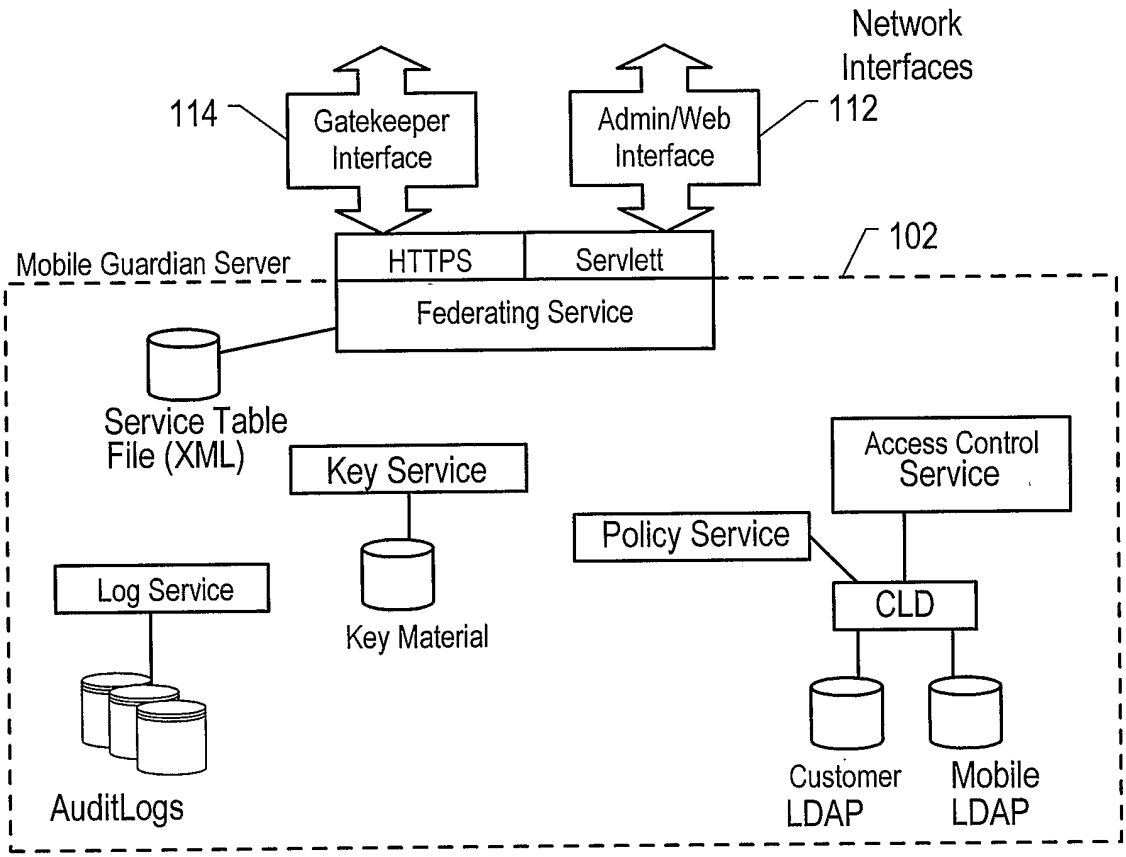
Network
Interfaces
114
Gatekeeper
Interface
Admin/Web
Interface
112
102
Mobile Guardian Server
HTTPS
Servlett
Federating Service
Service Table
File (XML)
Key Service
Access Control
Service
Policy Service
Log Service
Key Material
CLD
AuditLogs
Customer
LDAP
Mobile
LDAP

FIG. 2

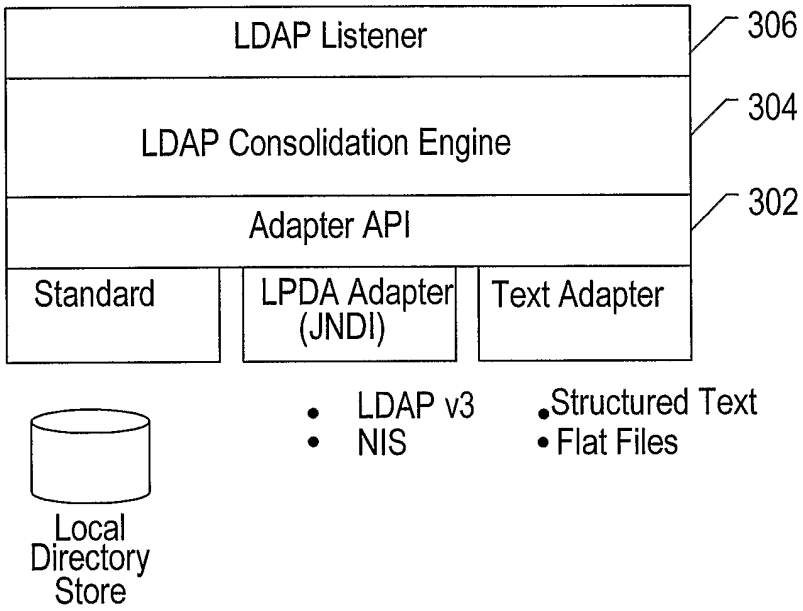
LDAP Listener
306
LDAP Consolidation Engine
304
Adapter API
302
Standard
LPDA Adapter (JNDI)
Text Adapter
• LDAP v3
• NIS
• Structured Text
• Flat Files
Local Directory Store

FIG. 3

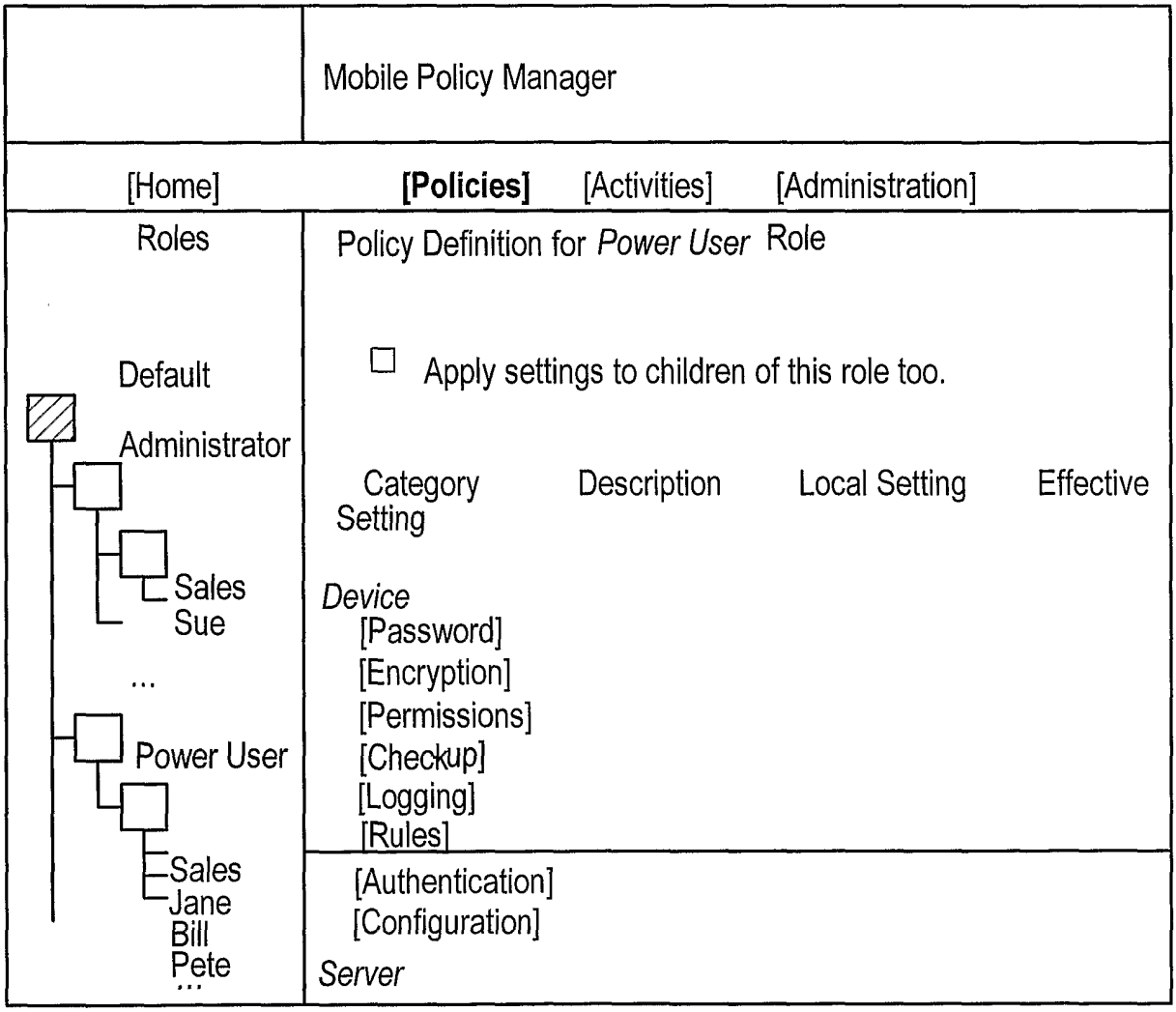
Mobile Policy Manager
[Home]
[Policies]
[Activities]
[Administration]
Roles
Default
Administrator
Sales
Sue
...
Power User
Sales
Jane
Bill
Pete
...
Policy Definition for Power User Role
Apply settings to children of this role too.
Category
Description
Local Setting
Effective Setting
Device
[Password]
[Encryption]
[Permissions]
[Checkup]
[Logging]
[Rules]
[Authentication]
[Configuration]
Server

FIG. 4

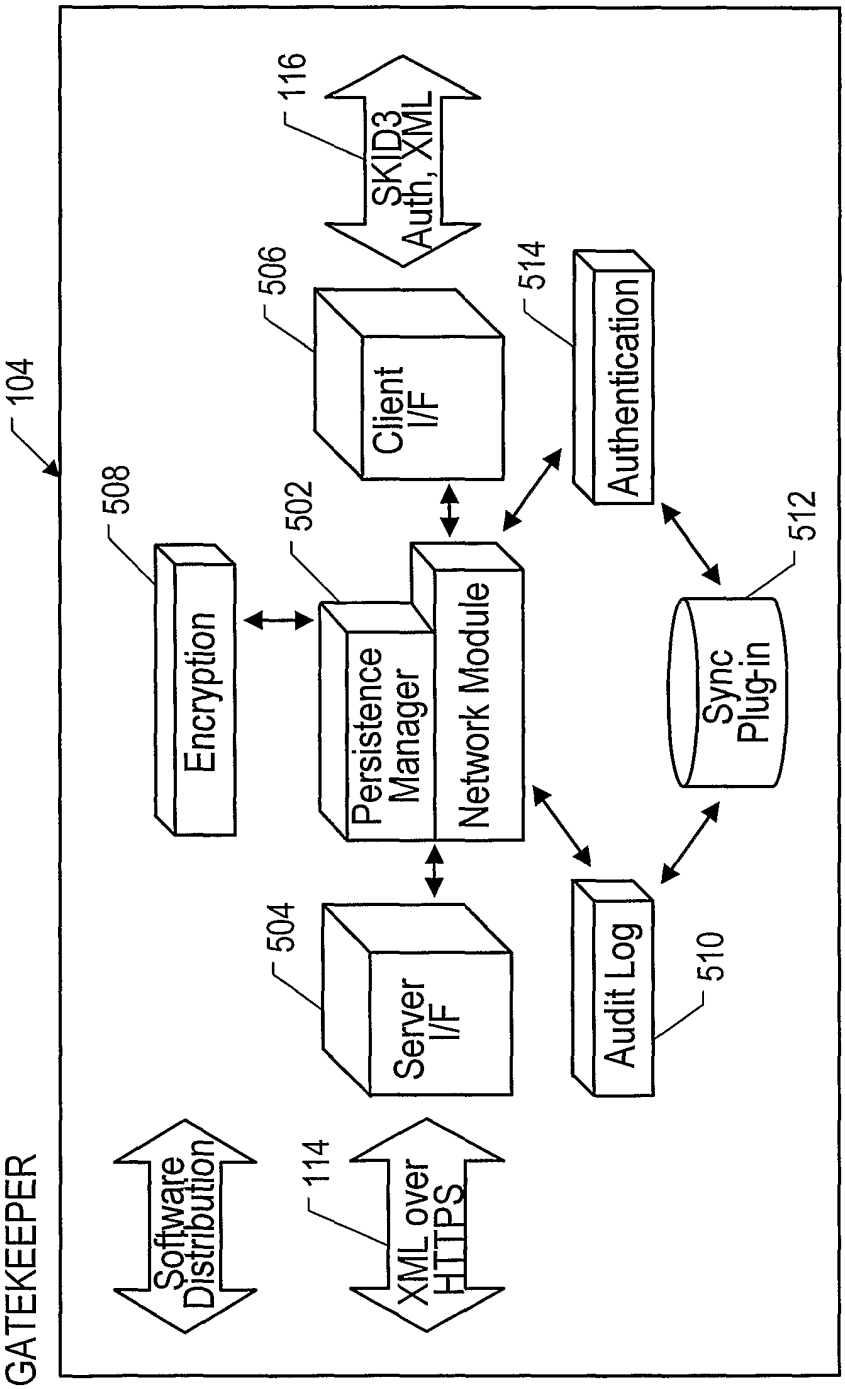
GATEKEEPER
104
Software Distribution
XML over HTTPS
114
Server I/F
504
Persistence Manager
Network Module
502
Encryption
508
Client I/F
506
SKID3 Auth, XML
116
Audit Log
510
Sync Plug-in
512
Authentication
514

FIG. 5

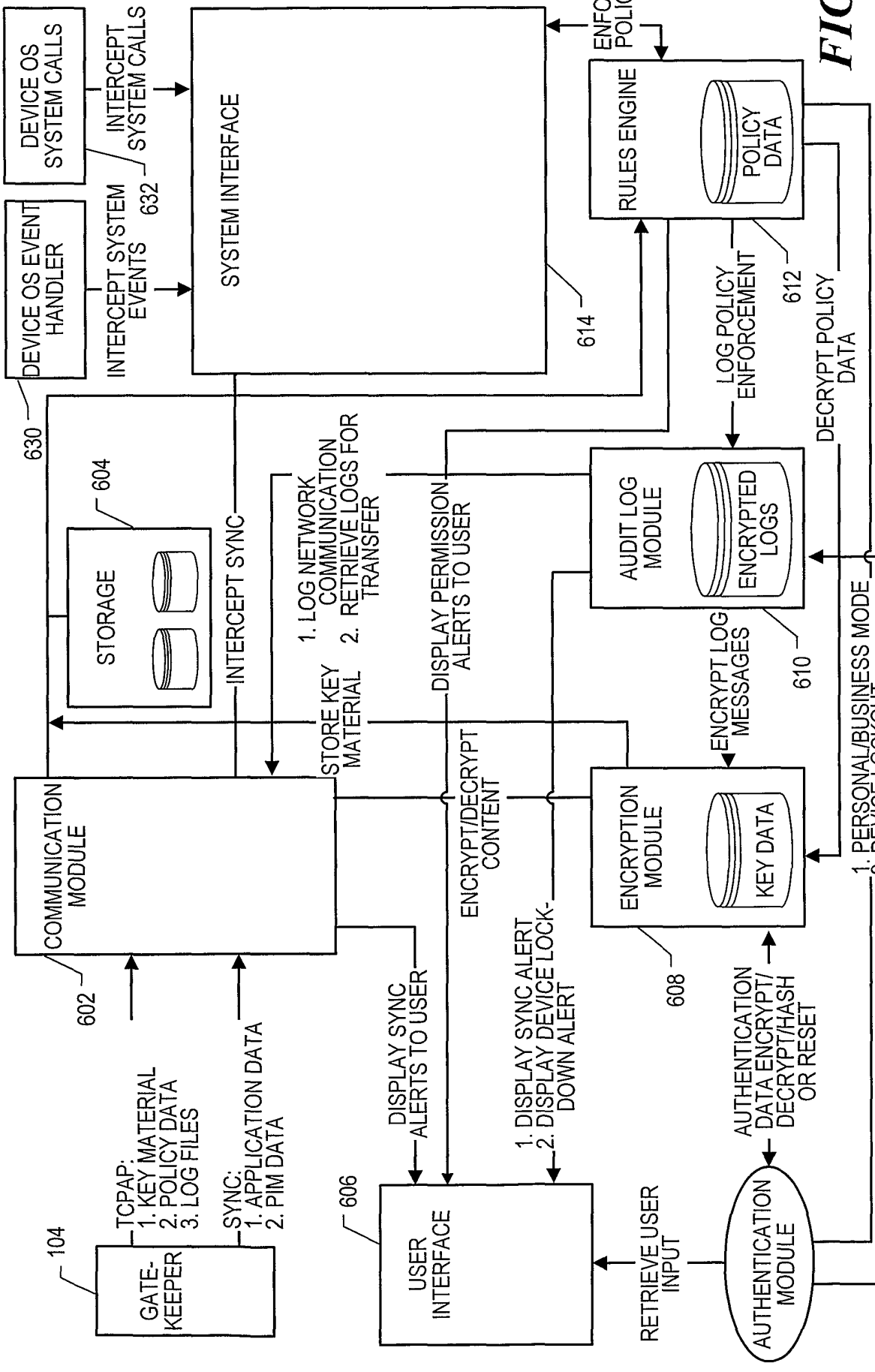
DEVICE OS SYSTEM CALLS
INTERCEPT SYSTEM CALLS
632
DEVICE OS EVENT HANDLER
INTERCEPT SYSTEM EVENTS
SYSTEM INTERFACE
614
ENFORCE POLICIES
RULES ENGINE
POLICY DATA
612
LOG POLICY ENFORCEMENT
DECRYPT POLICY DATA
630
604
STORAGE
INTERCEPT SYNC
1. LOG NETWORK COMMUNICATION 2. RETRIEVE LOGS FOR TRANSFER
DISPLAY PERMISSION ALERTS TO USER
AUDIT LOG MODULE
ENCRYPTED LOGS
610
STORE KEY MATERIAL
ENCRYPT LOG MESSAGES
1. PERSONAL/BUSINESS MODE 2. DEVICE LOCKOUT
COMMUNICATION MODULE
ENCRYPT/DECRYPT CONTENT
ENCRYPTION MODULE
KEY DATA
602
608
DISPLAY SYNC ALERTS TO USER
1. DISPLAY SYNC ALERT 2. DISPLAY DEVICE LOCK-DOWN ALERT
AUTHENTICATION DATA ENCRYPT/ DECRYPT/HASH OR RESET
TCPAP: 1. KEY MATERIAL 2. POLICY DATA 3. LOG FILES
SYNC: 1. APPLICATION DATA 2. PIM DATA
606
USER INTERFACE
RETRIEVE USER INPUT
AUTHENTICATION MODULE
LOG USER AUTHENTICATION
104
GATE-KEEPER

FIG. 6

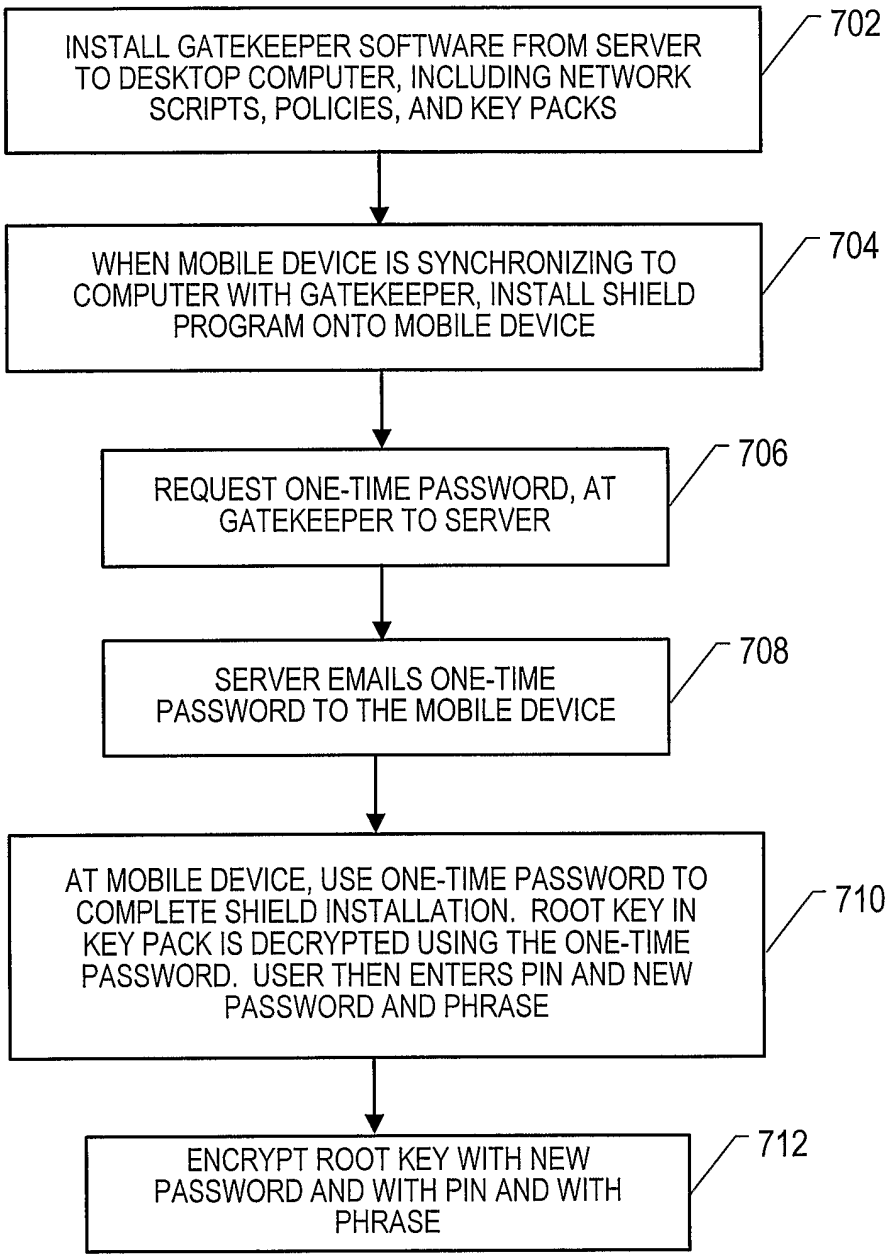
INSTALL GATEKEEPER SOFTWARE FROM SERVER TO DESKTOP COMPUTER, INCLUDING NETWORK SCRIPTS, POLICIES, AND KEY PACKS
702
WHEN MOBILE DEVICE IS SYNCHRONIZING TO COMPUTER WITH GATEKEEPER, INSTALL SHIELD PROGRAM ONTO MOBILE DEVICE
704
REQUEST ONE-TIME PASSWORD, AT GATEKEEPER TO SERVER
706
SERVER EMAILS ONE-TIME PASSWORD TO THE MOBILE DEVICE
708
AT MOBILE DEVICE, USE ONE-TIME PASSWORD TO COMPLETE SHIELD INSTALLATION. ROOT KEY IN KEY PACK IS DECRYPTED USING THE ONE-TIME PASSWORD. USER THEN ENTERS PIN AND NEW PASSWORD AND PHRASE
710
ENCRYPT ROOT KEY WITH NEW PASSWORD AND WITH PIN AND WITH PHRASE
712

FIG. 7

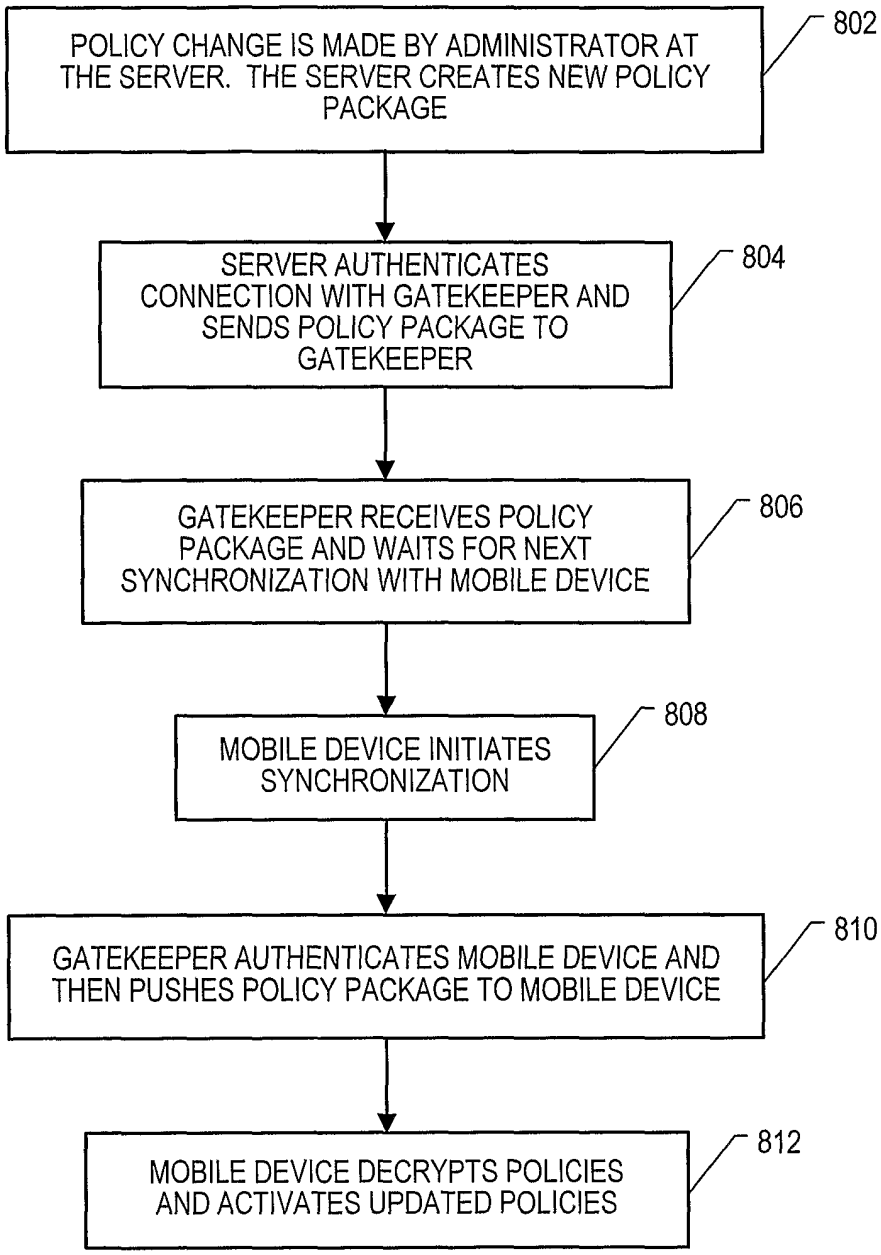
POLICY CHANGE IS MADE BY ADMINISTRATOR AT THE SERVER. THE SERVER CREATES NEW POLICY PACKAGE
802
SERVER AUTHENTICATES CONNECTION WITH GATEKEEPER AND SENDS POLICY PACKAGE TO GATEKEEPER
804
GATEKEEPER RECEIVES POLICY PACKAGE AND WAITS FOR NEXT SYNCHRONIZATION WITH MOBILE DEVICE
806
MOBILE DEVICE INITIATES SYNCHRONIZATION
808
GATEKEEPER AUTHENTICATES MOBILE DEVICE AND THEN PUSHES POLICY PACKAGE TO MOBILE DEVICE
810
MOBILE DEVICE DECRYPTS POLICIES AND ACTIVATES UPDATED POLICIES
812

FIG. 8

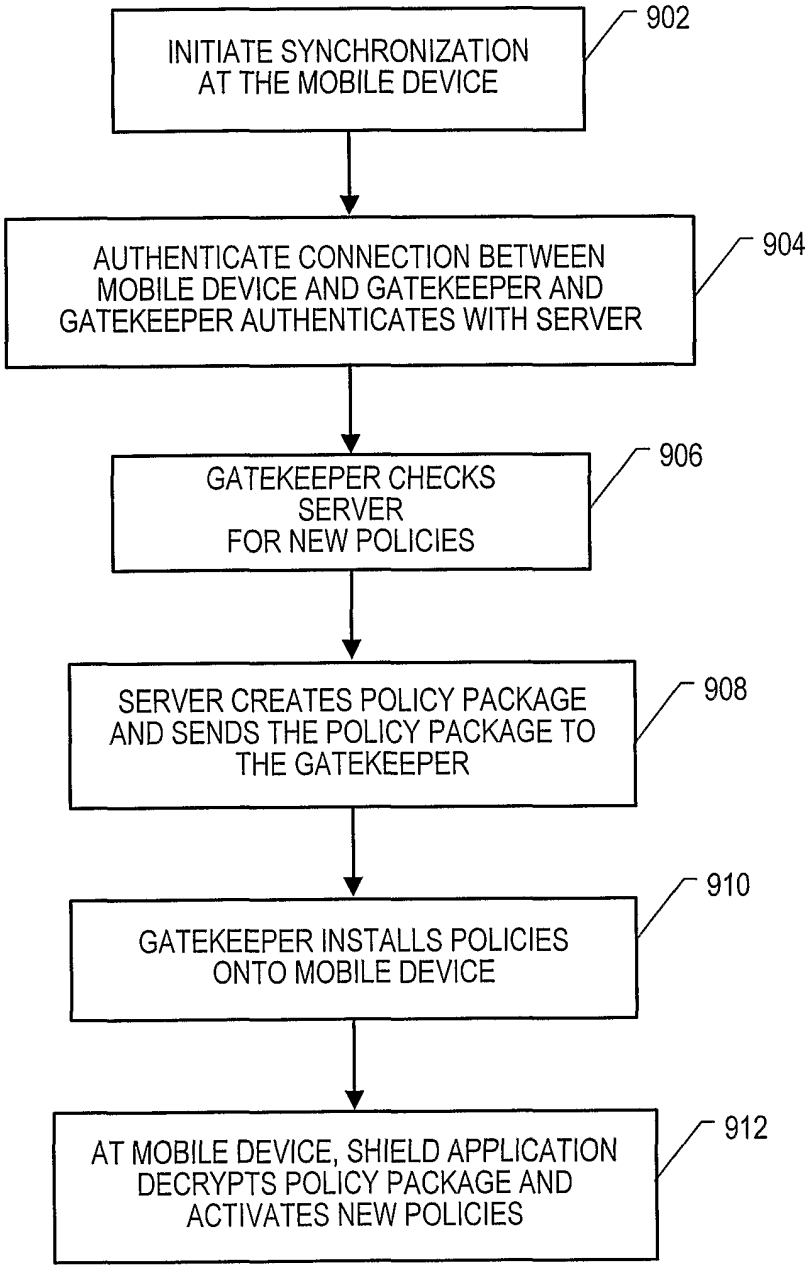
INITIATE SYNCHRONIZATION AT THE MOBILE DEVICE
902
AUTHENTICATE CONNECTION BETWEEN MOBILE DEVICE AND GATEKEEPER AND GATEKEEPER AUTHENTICATES WITH SERVER
904
GATEKEEPER CHECKS SERVER FOR NEW POLICIES
906
SERVER CREATES POLICY PACKAGE AND SENDS THE POLICY PACKAGE TO THE GATEKEEPER
908
GATEKEEPER INSTALLS POLICIES ONTO MOBILE DEVICE
910
AT MOBILE DEVICE, SHIELD APPLICATION DECRYPTS POLICY PACKAGE AND ACTIVATES NEW POLICIES
912

FIG. 9

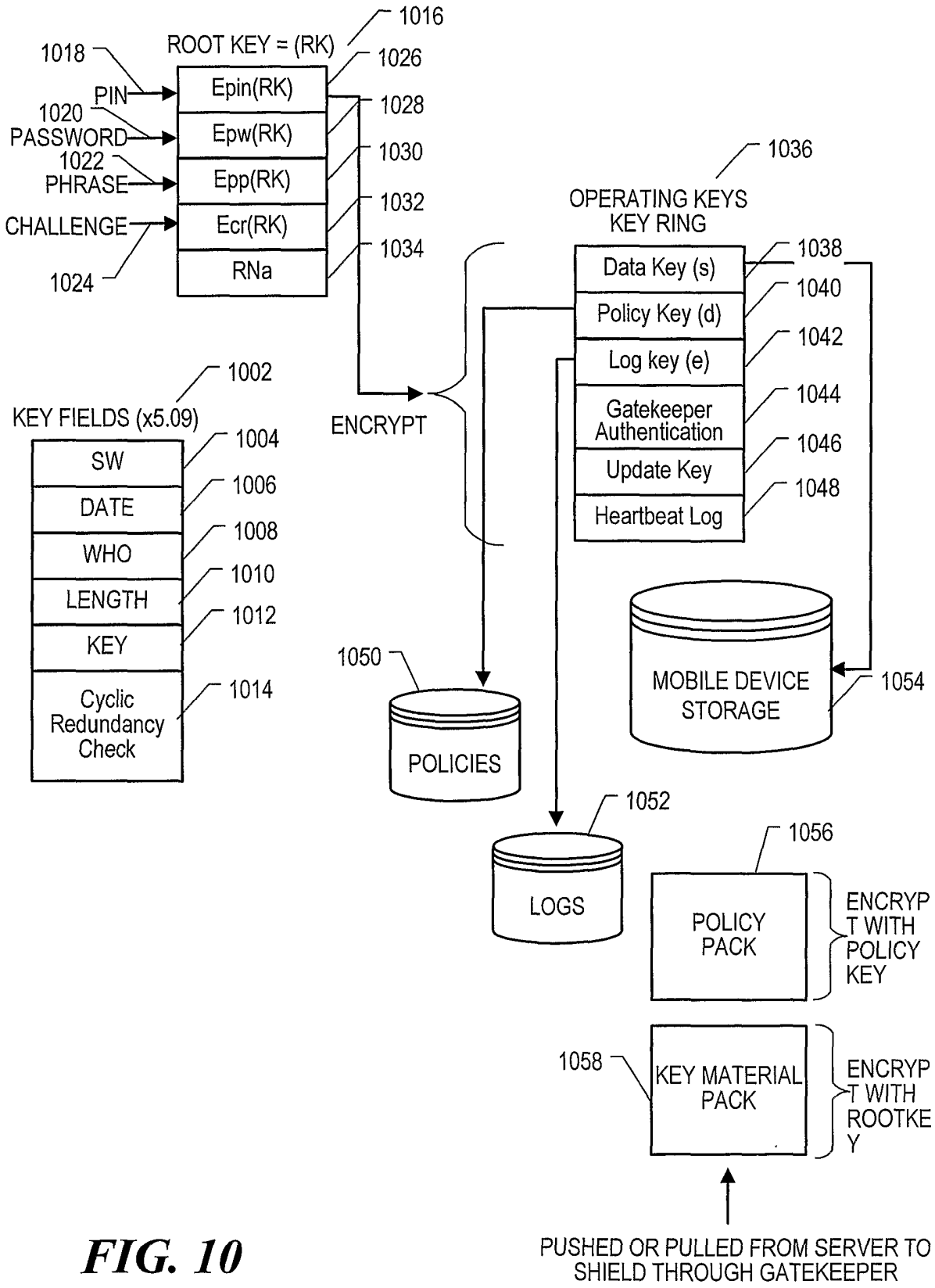
1016
ROOT KEY = (RK)
1018
PIN
1020
PASSWORD
1022
PHRASE
CHALLENGE
1024
Epin(RK)
Epw(RK)
Epp(RK)
Ecr(RK)
RNa
1026
1028
1030
1032
1034
1036
OPERATING KEYS
KEY RING
Data Key (s)
Policy Key (d)
Log key (e)
Gatekeeper Authentication
Update Key
Heartbeat Log
1038
1040
1042
1044
1046
1048
1002
KEY FIELDS (x5.09)
SW
DATE
WHO
LENGTH
KEY
Cyclic Redundancy Check
1004
1006
1008
1010
1012
1014
ENCRYPT
1050
POLICIES
MOBILE DEVICE STORAGE
1054
1052
LOGS
1056
POLICY PACK
ENCRYPT WITH POLICY KEY
1058
KEY MATERIAL PACK
ENCRYPT WITH ROOTKEY
PUSHED OR PULLED FROM SERVER TO SHIELD THROUGH GATEKEEPER

FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US03/29347

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : H04L 9/00, 9/32
US CL : 713/150, 200-202; 380/255, 270, 277, 278, 279, 281, 283, 284

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 713/150, 200-202; 380/255, 270, 277, 278, 279, 281, 283, 284

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)
Please See Continuation Sheet

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6,236,852 B1 (VEERASAMY et al) 22 May 2001, see abstract, col. 2, lines 4-36, col. 5, lines 14-40, col. 8, lines 19-55, col. 9, lines 23-46, col. 11, lines 5-11	1,3,5,9-15
X	US 5,850,444 A (RUNE) 15 December 1998, see abstract, col. 3, lines 12-50, col. 4, lines 16-38, col. 5, lines 54-61	2,8
X	US 6,178,506 B1 (QUICK, JR.) 23 January 2001, see col. 2, lines 46-60, col. 4, line 45-col. 5, line 8, col. 6, lines 11-40	4,6

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* 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 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	Date of mailing of the international search report
04 December 2003 (04.12.2003)	23 DEC 2003
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. (703)305-3230	Authorized officer Ayaz Sheikh Telephone No. 703-305-3900

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

PCT/US03/29347

Continuation of B. FIELDS SEARCHED Item 3:
BRS TEXT SEARCH (files: USPAT, DERWENT, JPO, EPO, IBM TDB, US PGPUB)

search terms: wireless, cell, cellular, policy, root, key, encrypt, encrypting, password, authentic, authenticate, authentication, authenticating, authenticated, authorize, authorizing, authorization, authorized