Title: SYSTEM, METHOD AND COMPUTER PROGRAM PRODUCT FOR ENROLLING AND AUTHENTICATING COMMUNICATION PROTOCOL-ENABLED CLIENTS FOR ACCESS TO INFORMATION

Abstract: A system, method, and computer program product for allowing access to information, and more particularly to the enrollment and authentication of communication protocol-enabled clients for access to information, particularly confidential information, via the Internet is provided. The system includes client side components (210), a filter (206) coupled to the client side components and server side components (204) coupled to the filter (206). The client side components (210) include an authentication control component (208) that manages the process of capturing user credentials and communicates the result of the capturing process to the filter (206). The authentication server (202) receives the user credentials from the filter (206), attempts to authenticate the user by executing the user policy and communicates to the filter (206) whether the user is authenticated.
System, Method and Computer Program Product for Enrolling and Authenticating Communication Protocol-Enabled Clients for Access to Information

Background of the Invention

Field of the Invention

The present invention relates generally to a system, method and computer program product for allowing access to information, and more particularly to the enrollment and authentication of communication protocol-enabled clients for access to information, particularly confidential information, via a communication medium.

Related Art

The importance to the modern economy of rapid information access and exchange cannot be overstated. This explains the exponentially increasing popularity of the Internet, intranets, the wireless exchange of information, and so forth. The Internet is a world-wide set of interconnected computer networks that can be used to access a growing amount and variety of information electronically. The Internet today works especially well with the rapid access and exchange of public or non-confidential information.

One method of accessing information on the Internet is known as the World Wide Web (www, or the "web"). The web is a distributed, hypermedia system and functions as a client-server based information presentation system. The web supports documents that are formatted in a language called HyperText Markup Language (HTML). HTML documents support links to other documents, as well as graphics, audio, video files, and so forth. In addition, HTML controls how web pages are formatted and displayed. Computer users can access a web (or HTML) page using general-purpose computers, referred to as "clients," by specifying the uniform resource locator (URL) of the page. FIG. 1 is a network block diagram showing a plurality of clients and servers connected to the Internet.
The Internet’s popularity can be contributed in part to tools or protocols that have been developed to allow any user to take advantage of what the Internet has to offer. These include, but are not limited to, web browsers, HTTP, S-HTTP, cookies and SSL. Each of these are discussed in more detail below.

A web browser is a software application that makes it easy for users to locate and display web pages. Examples of web browsers include Netscape Navigator and Microsoft's Internet Explorer. A web browser is one example of a communication protocol-enabled client, as described herein. Other examples of a communication protocol-enabled client may include, but is not limited to, a TCP/IP client and a wireless client.

A common protocol used by the web is the HyperText Transfer Protocol (HTTP). HTTP defines how messages are formatted and transmitted, and what actions web servers and browsers should take in response to various commands. For example, when a user enters a URL in his or her browser, this actually sends an HTTP command to the web server directing it to fetch and transmit the requested web page.

HTTP is called a stateless protocol because each command is executed independently, without any knowledge of the commands that came before it or after it. This is one reason why it is difficult to implement web sites that react intelligently to user input. This feature of HTTP has been addressed in a number of new technologies that compliment HTTP, including ActiveX, Java, JavaScript and cookies.

A cookie, for example, is a message given to a web browser by a web server. Cookies are a general mechanism which server side connections can use to both store and retrieve information on the client side of the connection. This addition of a simple, persistent, client-side state significantly extends the capabilities of web-based client/server applications.

A server, when returning an HTTP object to a user, may also send a piece of state information which the user will store. Included in that state object is a description of the range of URLs for which that state is valid. Any future HTTP
requests made by the user which fall in that range will include a transmittal of the current value of the state object from the user back to the server. The state object is a cookie. This simple mechanism provides a powerful tool which enables a host of new types of applications to be written for web-based environments. Shopping applications can now store information about the currently selected user items, for-fee services can send back registration information and free the user from retyping a username (or user ID) on the next connection, sites can store per-user preferences on the user computer and have the user supply those preferences every time a connection is made to that site, and so forth.

Another common protocol used on the web is the Secure Sockets Layer (SSL) protocol. SSL is a protocol used for transmitting private documents via the Internet. SSL works by using a private session key that is known only to the web browser for that particular session. The session key changes for each session. The session key is used to encrypt data that is transferred over the SSL connection. Many web sites use the SSL protocol to obtain confidential user information, such as credit card numbers.

Another protocol for transmitting data securely over the web is Secure HTTP (S-HTTP). Whereas SSL creates a secure connection between a client and a server over which any amount of data can be sent securely, S-HTTP is designed to transmit individual messages securely. SSL and S-HTTP, therefore, can be seen as complementary rather than competing technologies.

As stated above, the importance to the modern economy of rapid information access and exchange cannot be overstated. The popularity of the Internet has been enhanced through web browsers and the various protocols mentioned above. (The popularity of intranets and wireless communication has also been enhanced through protocols specific to each.) The rapid exchange of non-confidential information via the Internet has served users well. However, there are some problems. One problem is the protection of confidential information via the Internet. Another problem is satisfying the comfort level in
individual users that their confidential information via the Internet remains confidential.

The importance of satisfying the comfort level of users increases as the applications or services provided to users via the Internet necessitates the access or exchange of confidential user information. Examples of such applications or services include business-to-business and business-consumer-e-commerce transactions, online applications such as banking, stock-trading, shopping, personalized content web sites, and so forth. To avoid providing confidential information to the wrong user, the user (or Communication protocol-enabled client such as a web browser) must be authenticated before the user accesses a web application. While the ease of information access and exchange is attractive to all users, most users are also concerned with the security of their confidential information accessible via the Internet an intranet, a wireless network, and so forth. Therefore, so as to not offset the increase in the popularity of the Internet for information access and exchange, an Internet provider of information needs to balance adequate confidential information protection with the ease of information access and exchange over the Internet.

**Summary of the Invention**

A system, method and computer program product for allowing access to information, and more particularly to the enrollment and authentication of Communication protocol-enabled clients for access to information, particularly confidential information, via a communication medium is provided.

The system for remotely enrolling and authenticating a user to access requested information via a communication medium includes client side components, a filter coupled to the client side components via the communication medium and server side components coupled to the filter via the communication medium. The client side components include an authentication control component that manages the process of capturing user credentials and
communicates the result of the capturing process to the filter. The server side components include an authentication server. The authentication server stores data related to a plurality of users and at least one policy that is associated with the user. The user policy defines an authentication level where the authentication level defines the probability that the user is authorized to access the requested information. In addition, the authentication server receives the user credentials from the filter, attempts to authenticate the user by executing the user policy and communicates to the filter whether the user is authenticated. Finally, the filter interacts with a server containing the requested information once the user is authenticated by the authentication server.

To allow for the remote enrollment of the user, the present invention provides client side components that include an authentication control component and an enroll application. The enroll application is responsible for driving presentation logic that interacts with the user when presenting user credentials. The authentication control component is responsible for managing the process of capturing user credentials and communicating the result of the capturing process to the server side components.

**Brief Description of the Figures**

The present invention will be described with reference to the accompanying drawings, wherein:

FIG. 1 is a network block diagram showing a plurality of clients and servers connected to the Internet;

FIG. 2 is a block diagram representing an example operating environment of the present invention according to an embodiment;

FIG. 3 illustrates an example computer that may be used to implement components of the present invention according to an embodiment;
FIG. 4 illustrates authentication components performing the necessary functions required when the communication protocol is a wireless communication protocol according to an embodiment of the present invention;

FIG. 5A illustrates authentication components performing the necessary functions required when the communication protocol is for a local network or an intranet according to an embodiment of the present invention;

FIG. 5B illustrates authentication components performing the necessary functions required when the communication protocol is for the Internet according to an embodiment of the present invention;

FIG. 6 illustrates tasks of the listen object of the authentication function according to an embodiment of the present invention;

FIG. 7 illustrates tasks of the comm object of the authentication function according to an embodiment of the present invention;

FIG. 8 illustrates tasks of the authenticate object of the authentication function according to an embodiment of the present invention;

FIG. 9 illustrates tasks of the listen object of the remote enrollment function according to an embodiment of the present invention;

FIG. 10 illustrates tasks of the enroll object of the remote enrollment function according to an embodiment of the present invention;

FIG. 11 illustrates a high level message flow between the components of the present invention for authenticating a user using a web browser according to an embodiment of the present invention; and

FIG. 12 illustrates a high level message flow between the components of the present invention for remotely enrolling a user using web browser 212 according to an embodiment of the present invention.
Detailed Description of the Preferred Embodiments

A. Overview of the Invention

The inventor of the present invention recognized that a solution did not exist that effectively balances the protection of confidential information with the ease of access to the same confidential information via a communication medium, such as the Internet. It is important to note that while the present invention is described with reference to the Internet, it is not meant to limit the present invention. The present invention also applies to intranets, wireless networks, and so forth.

The general solution of the present invention to the above stated problem is twofold. First, use as adequate an identification device as possible to protect confidential information available on the Internet. And second, provide a system, method and computer program product that utilizes the adequate identification device to provide effective authentication of the user to Internet-accessible applications and/or services that manage the confidential information. This system, method and computer program product for authentication must not decrease the popularity of the Internet in terms of the ease of rapid information access and exchange currently provided by the Internet. More specifically, the architecture of the system of the present invention must be a cross-platform, high performance, extensible, and highly scalable solution for authenticating communication protocol-enabled clients, as well as remotely enrolling the credentials of communication protocol-enabled clients.

Billions of dollars have been lost by thousands of E-commerce businesses, Internet data content providers, etc., due to inadequate authentication to, and thus inadequate protection of, confidential information. Many users do not feel comfortable with having their confidential information accessible via the Internet. Therefore, when it comes to confidential information, these users may give up the
ease of use of the Internet and resort to more traditional types of businesses or services that are not Internet-accessible.

Today, most web applications/services authenticate a user via a username and password only. Other identification devices include, but are not limited to, smart cards, tokens, and various biometric devices. In addition, most web applications reduce the cost and complexity of administering its confidential data protection by incorporating a process called "single sign-on" involving a password only. Single sign-on provides each user with one password to access all web application resources (including public or non-confidential information and confidential information). Most users can remember one password without writing it down. While this reduces the complexity and cost of administering information protection, it reduces the probability that the user gaining access to the information is authentic. While single sign-on using a password is acceptable to authenticate users who access non-confidential information, single sign-on using a password is not acceptable to authenticate users who access confidential information, in addition to other types of information. The probability that the user gaining access is authentic can be increased by forcing each user to use multiple passwords, tokens, smart cards or biometric devices to access different types of information (e.g., confidential versus non-confidential information).

B. **System Architecture Overview**

FIG. 2 is a block diagram representing an example operating environment of the present invention. It should be understood that the example operating environment in FIG. 2 is shown for illustrative purposes only and does not limit the invention. Other implementations of the operating environment described herein will be apparent to persons skilled in the relevant art(s) based on the teachings contained herein, and the invention is directed to such other implementations. Referring to FIG. 2, an authentication server 202, authentication components 204, a filter 206, an authentication control component
208, device specific components 210, a web browser 212 and a web/application server 214 is shown.

An embodiment of the functional modules or components of the present invention includes authentication server 202, authentication components 204, filter 206 and authentication control component 208. The components of the present invention can each be classified under the following categories including: client side components; filter component; server side components and remote enrollment components. Authentication server 202 and Authentication components 204 are classified as server side components. Authentication control component 208, along with device specific components 210 and web browser 212, is classified as client side components. Filter 206 is classified as a filter component. Finally, authentication control component 208 and authentication components 204 are classified as remote enrollment components. An embodiment of the present invention, the server side components and the remote enrollment components are designed to be platform independent and only require that the communication with them be done over a standard, published protocol (e.g., HTTP protocol (RFC 2068)). Note that authentication control component 208 is classified as both a client side component and a remote enrollment component. In addition, authentication components 204 are classified as both a server side component and a remote enrollment component. The reuse of these components in different classifications (or functions) of the present invention is the result of implementing the components in an object oriented programming language.

An advantage of any object-oriented program is that it enables programmers to create modules (that perform functions) that do not have to be changed when a new type of object is added. An object includes both the data and functions required to perform a task. Thus, by implementing the functions to be performed by the components of the present invention as objects, created modules do not need to be changed when a new type of object (or function) is added. This implementation of the present invention reduces complexity and thus
increases efficiency. The categories (and their respective components) of the present invention are described next.

1. **Server Side Components**

As stated above, authentication server 202 and authentication components 204 are classified as server side components. Authentication server 202 is connected to Authentication components 204 (see FIG. 2). Authentication server 202 is described in detail in related, co-pending U.S. Application No. 09/264,726 and U.S. Application No. 09/517,121 (see, “Cross-Reference to Related Applications” above). For convenience, authentication server 202 is briefly described next.

Authentication server 202 is the engine of the present invention and stores collections of data required by the present invention. Both the functions of the engine and the data stored in authentication server 202 will be discussed in further detail below. The types of data stored in authentication server 202 are partially determined through the operations of an enrollment station and an administration station (not shown). The enrollment station is used to enroll users that are to be authenticated by the present invention. The enrollment station has attached to it every type of device (e.g., biometric devices like fingerprint scanners, voice or face recognition systems, etc., or security tokens such as RSA tokens, VASCO tokens, and so forth) used by the present invention to enroll and ultimately authenticate users. When a user is enrolled into the present invention, the user may be enrolled with as many devices as the administrator deems necessary.

The administration station is used by the administrator of the present invention to perform overall management duties. The administrator can also use the administration station to generate various reports. The reports may include a list of different types of data stored in authentication server 202 (e.g., a list of the currently enrolled users in the present invention). In addition, the
administration station is typically used to setup the initial data in authentication server 202.

Another component that may be used by the present invention is the satellite enrollment station, also not shown in FIG. 2. The satellite enrollment station is used to enroll users into the present invention at remote locations. The satellite enrollment station may have as many devices attached to it as the administration station, but alternatively may also be a scaled down version of the administration station. As will be described in detail below, the present invention allows for web browsers (i.e., communication protocol-enabled clients) to act as remote enrollment stations.

As stated above, authentication server 202 is connected to authentication components 204. Authentication components 204 include different types of objects that perform specific functions, including a listen object, a comm object and an authentication object (which are described below). These types of objects are used by the present invention when the user is attempting to be authenticated.

As stated above, the present invention provides a solution that effectively balances the protection of confidential information with the ease of access to the same confidential information via a communication medium, such as the Internet. It is important to note that while the present invention is described with reference to the Internet, it is not meant to limit the present invention. The present invention also applies to intranets, wireless networks, and so forth. Depending on the type of communication medium, authentication components 204 perform the necessary functions to authenticate the user via that particular medium. This is shown with reference to FIGs. 4, 5A and 5B.

In FIG. 4, authentication components 204 perform the necessary functions for a wireless network. FIG. 5A illustrates authentication components 204 performing the necessary functions for a local network or intranet. Finally, FIG. 5B illustrates authentication components 204 performing the necessary functions for the Internet. Authentication components 204 will be described next with the
communication medium being the internet, although the present invention is not limited to the Internet.

a. **Listen object**

The listen object is instantiated by authentication server 202 at the time it starts up. The listen object is responsible for the following tasks as illustrated by FIG. 6. In FIG. 6 the flowchart starts at step 602. Once instantiated, the listen object acts like a HTTP daemon listening on the standard SSL port (i.e., port 443) for incoming SSL connection requests, as illustrated by step 602. Control then passes to step 604.

In step 604, once the listen object receives a SSL connection request, the listen object ensures that the request is processed by the comm object and/or authenticate object, as described below. Control then passes back to step 602, where the listen object listens for incoming SSL connection requests. The listen object is only destroyed once authentication server 202 is turned off.

There are different ways in which the listen object ensures that the request is processed in step 604. For example, in an embodiment of the present invention the listen object may be implemented as a standard daemon-thread, worker-thread-pool model where a single daemon thread accepts all incoming connection requests and hands off the newly created socket (for each connection) to one of the worker threads in the pool. The daemon thread can then go back to listening for more incoming connections. The number of threads in the pool may be a configurable parameter. Threads are well known in the relevant art.

In another embodiment of the present invention, the listen object may use an IO Completion Port to provide a single point of receiving requests from and transmitting responses to clients. This technique also lends naturally to asynchronous communication mechanisms, which have been shown to improve performance of IO centric processes. IO Completion Ports and asynchronous
communication mechanisms are also well known in the relevant art. The comm object of the present invention will be discussed next.

b. Comm object

A comm object is instantiated for each new client session. A client session results when a user at web browser 212 attempts to access web/application server 214. Once the authentication process is completed, an error occurs, or a timeout occurs, the corresponding comm object is destroyed. The comm object is responsible for the following tasks as illustrated by FIG. 7. In FIG. 7, the flow begins at step 702. In step 702, the comm object negotiates a session key with web browser 212 for symmetric encryption/decryption of data. This may involve exchanging of server-side certificates as well as client-side certificates. Control then passes to step 704.

In step 704, the comm object receives data from web browser 212 encrypted with the session key. Control then passes to step 706.

In step 706, the comm object decrypts the data received in step 704. Control then passes to step 708.

In step 708, the comm object parses the HTTP headers and content in the decrypted data. Control then passes to step 710.

In step 710, the comm object creates a data object conforming to a specific format from the received data and hands it off to the authenticate object or a policy object and formats it according to HTTP specifications. Policy objects are explained in detail in related, co-pending U.S. Application No. 09/264,726 and U.S. Application No. 09/517,121. A policy object differs depending on the specific policy being used. It is policy that determines the method or way in which a user is to be authenticated by authentication server 202. It is important to note that a user is not authenticated until he or she passes the appropriate policy. In the present invention, a user is never authenticated by solely passing
one or more devices without also passing his or her policy. Policies will be discussed further below. Control then passes to step 712.

In step 712, the comm object receives the data object back from the authenticate object or the policy object and formats it according to HTTP specifications. Control then passes to step 714.

In step 714, the comm object encrypts the data with the session key to be sent back to web browser 212. Control then passes to step 716.

In step 716, the comm object sends the encrypted data to web browser 212. It is important to note that some or all of the above steps may be repeated several times if the policy requires multi-factored authentication. The flowchart in FIG. 7 ends at this point. As stated above, the comm object is destroyed once the authentication process is completed, if an error occurs, or if a timeout occurs. The authenticate object of the present invention is described next.

c. **Authenticate object**

The authenticate object is also instantiated for each new client session. The tasks of the authenticate object is illustrated in FIG. 8. In FIG. 8, control starts at step 802. In step 802, the authenticate object retrieves the policy (or policy object) from the database (or database object) that is to be used to authenticate the user. Control then passes to step 804.

In step 804, the authenticate object then manages the exchange of all necessary messages that are required for communication with web browser 212 (via filter 206 and via authentication control component 208). Once the authentication message exchange is complete, control passes to step 806.

In step 806, the authenticate object returns the final result to filter 206, which in turn interacts with server/web application 214 to allow (or disallow) access to the user. The interaction between filter 206 and server/web application 214 to hand-off control of the access with the user is referred to by the present
invention as integration. The flowchart in FIG. 8 ends at this point. The client side components of the present invention are described next.

2. **Client Side Components**

Authentication control component 208, along with device specific components 210 and web browser 212, are classified as client side components by the present invention. Device specific components 210 are software libraries and other components that are specific to an identification device (e.g., biometric devices like fingerprint scanners, voice or face recognition systems, etc., or security tokens such as RSA tokens, VASCO tokens, and so forth). Device specific components 210 are typically shipped by the device manufacturers and usually include an Application Programming Interface (API) that can be used to interface with the device. API's are well known in the relevant art.

Authentication control component 208 works in conjunction with device specific components 210 to manage the process of capturing a user credential, doing any local processing that is necessary and communicating the result of this processing to filter 206. For example, authentication control component 208 can be implemented as ActiveX control for certain web browsers (e.g., Internet Explorer) and implemented as a plug-in that contains the same logic as the Active X control for other web browsers (e.g., Netscape).

The client side components of the present invention provide two features including software integrity and one-time download. Once authentication control component 208 is downloaded on the client computer or machine, malicious users may tamper with it. To prevent this, client software integrity is checked each time before authentication control component 208 is used. This may be accomplished by performing a hash on the code for authentication control component 208, as well as the code for device specific components 210. If any changes are discovered, then the original code for authentication control
component 208 and/or device specific components 210 are downloaded before
the authentication of the present invention proceeds.

The one-time download feature of the present invention deals with the fact
that a particular version of authentication control component 208 is downloaded
only once on a user’s computer, either at enrollment time or the first time the user
tries to authenticate from a computer that does not have authentication control
component 208. Thereafter, each new version of authentication control
component 208 is also downloaded only once on the user’s computer. The filter
component is described next.

3. Filter Component

Filter 206 is a lightweight component that resides with web/application
server 214 (i.e., any web server or application server that requires the
authentication services of the present invention). The code for filter 206 is
preferably written in the native language (e.g., C, C++, Java, etc) of
web/application server 214 for optimum performance. In one embodiment of the
present invention, filter 206 looks at all requests sent from web browser 212 and
intercepts any request for authentication from web browser 212. Filter then
forwards the authentication requests to authentication server 202.

Filter 206 is designed to interoperate with existing web servers including,
but not limited to, Netscape Enterprise Server (NES), Microsoft Internet
Information Server (MS IS), Apache, etc., to provide authentication services for
accessing web sites. Filter 206 may also be used with application servers
including, but not limited to, BEA WebLogic, SilverStream Application Server,
Oracle AppServer, Sun NetDynamics, Microsoft Site Server, etc., to provide
authentication services for web applications including online banking, online
stock trading, and so forth. As shown in FIG. 2, filter 206 is connected to
web/application server 214. Web/application 412 represents both a web server
and an application server as mentioned above. Remote enrollment components of the present invention are described next.

4. Remote Enrollment Components

The present invention allows users to register their credentials remotely (over the Internet, an intranet, wireless networks, and so forth). The remote enrollment components of the present invention include authentication control component 208, authentication components 204 and a middle-tier enroll application. As mentioned above, authentication control component 208 may also be used for enrollment as well as authentication (client side component). The authentication components 204 include a listen object, a comm object and an enroll object (which is the counterpart of authentication object described above). This allows “one-time” download of authentication control component 208 either at the time of enrollment, or if the user moves to a different computer than the one they enrolled on, authentication control component 208 is downloaded the first time the user tries to authenticate from that different computer. In addition, authentication components 204 may be used for enrollment as well as authentication (server side component).

The remote enrollment functionality of the present invention requires authentication control component 208 to capture the user’s credentials (e.g., biometric measurement, password, etc.) and send the credentials to the enroll object to be stored in the database of authentication server 202 for future authentication of the user by the present invention.

The enroll application drives the presentation logic of the remote enrollment process. The enroll application is responsible for creating the user visible HTML that is viewed in web browser 212. Several technologies may be used to implement the user visible HTML including, but not limited to, Active Server Pages (ASP), Java Server Pages (JSP), JAVA Servlets, Microsoft ISAPI and Netscape NSAPI. The enroll application acts as the go-between
authentication control component 208 on one side and the listen object, the comm object and the enroll object on the other side. The tasks of the listen object, the comm object and the enroll object are described next.

a. **Listen object**

As explained above, the listen object is instantiated by authentication server 202 at the time authentication server 202 starts up. The listen object is responsible for the following tasks as illustrated by FIG. 9. In FIG. 9 the flowchart starts at step 902. Once instantiated, the listen object acts like a HTTP daemon listening on the standard SSL port (i.e., port 443) for incoming SSL connection requests, as illustrated by step 902. Control then passes to step 904.

In step 904, once the listen object receives a SSL connection request, the listen object looks at the parameters of the request and determines whether control should be transferred to the enroll object, the comm object, or any other functional object the present invention supports. Note that FIG. 6 illustrates the case where there is only one type of request possible (i.e., an authentication request). Control then passes to step 906.

In step 906, the listen object ensures that the request is processed. Control then passes back to step 902, where the listen object listens for incoming SSL connection requests. The listen object is only destroyed once authentication server 202 is turned off.

b. **Comm object**

A comm object is instantiated for each new client session. A client session results when a user at web browser 212 attempts to access web/application server 214. Once the enrollment process is completed, an error occurs, or a timeout occurs, the corresponding comm object is destroyed. The comm object is responsible for the same tasks as illustrated by FIG. 7.
c. **Enroll object**

The enroll object is the counterpart of the authentication object described above, in that it implements the logic for and drives the message exchange with authentication control component 208 (through the enroll application). A new instance of the enroll object is also instantiated for each new client session. The tasks of the enroll object are illustrated in FIG. 10. In FIG. 10, control starts at step 1002. In step 1002, the enroll object creates the policy (or policy object) for the user. Control then passes to step 1004.

In step 1004, based on the created policy, the enroll object requests the necessary credentials from the user to be stored as a template. For example, if the policy requires that the user be tested on both a fingerprint device and a handprint device, the enroll object requests the biometric measurements of the user’s fingerprint and hand-print. Control then passes to step 1006.

In step 1006, the enroll object stores the policy and credentials (or templates) in the database of authentication server 202. The flowchart in FIG. 10 ends at this point.

Although an embodiment of the present invention includes all of the functional components of the present invention discussed above, several (or all) components may be combined as long as the functionality of each component still exists within the present invention as described above.

C. **An Example Implementation of the Present Invention**

1. **An Example Environment**

Authentication server 202, authentication components 204, filter 206, authentication control component 208, enrollment station, administration station and satellite enrollment station could be implemented using computer 300 as
shown in FIG. 3. Obviously, more than one of these functional components could be implemented on a single computer 300.

The present invention may be implemented using hardware, software or a combination thereof and may be implemented in a computer system or other processing system. In fact, in one embodiment, the invention is directed toward one or more computer systems capable of carrying out the functionality described herein. The computer system 300 includes one or more processors, such as processor 304. The processor 304 is connected to a communication bus 306. Various software embodiments are described in terms of this example computer system. After reading this description, it will become apparent to a person skilled in the relevant art how to implement the invention using other computer systems and/or computer architectures.

Computer system 300 also includes a main memory 308, preferably random access memory (RAM), and can also include a secondary memory 310. The secondary memory 310 can include, for example, a hard disk drive 312 and/or a removable storage drive 314, representing a floppy disk drive, a magnetic tape drive, an optical disk drive, etc. The removable storage drive 314 reads from and/or writes to a removable storage unit 318 in a well known manner. Removable storage unit 318, represents a floppy disk, magnetic tape, optical disk, etc. which is read by and written to by removable storage drive 314. As will be appreciated, the removable storage unit 318 includes a computer usable storage medium having stored therein computer software and/or data.

In alternative embodiments, secondary memory 310 may include other similar means for allowing computer programs or other instructions to be loaded into computer system 300. Such means can include, for example, a removable storage unit 322 and an interface 320. Examples of such can include a program cartridge and cartridge interface (such as that found in video game devices), a removable memory chip (such as an EPROM, or PROM) and associated socket, and other removable storage units 322 and interfaces 320 which allow software
and data to be transferred from the removable storage unit 318 to computer system 300.

Computer system 300 can also include a communications interface 324. Communications interface 324 allows software and data to be transferred between computer system 300 and external devices. Examples of communications interface 324 can include a modem, a network interface (such as an Ethernet card), a communications port, a PCMCIA slot and card, etc. Software and data transferred via communications interface 324 are in the form of signals which can be electronic, electromagnetic, optical or other signals capable of being received by communications interface 324. These signals 326 are provided to communications interface via a channel 328. This channel 328 carries signals 326 and can be implemented using wire or cable, fiber optics, a phone line, a cellular phone link, an RF link and other communications channels.

In this document, the terms "computer program medium" and "computer usable medium" are used to generally refer to media such as removable storage device 318, a hard disk installed in hard disk drive 312, and signals 326. These computer program products are means for providing software to computer system 300.

Computer programs (also called computer control logic) are stored in main memory and/or secondary memory 310. Computer programs can also be received via communications interface 324. Such computer programs, when executed, enable the computer system 300 to perform the features of the present invention as discussed herein. In particular, the computer programs, when executed, enable the processor 304 to perform the features of the present invention. Accordingly, such computer programs represent controllers of the computer system 300.

In an embodiment where the invention is implemented using software, the software may be stored in a computer program product and loaded into computer system 300 using removable storage drive 314, hard drive 312 or communications interface 324. The control logic (software), when executed by the processor 304,
causes the processor 304 to perform the functions of the invention as described herein.

In another embodiment, the invention is implemented primarily in hardware using, for example, hardware components such as application specific integrated circuits (ASICs). Implementation of the hardware state machine so as to perform the functions described herein will be apparent to persons skilled in the relevant art(s). In yet another embodiment, the invention is implemented using a combination of both hardware and software.

2. An Example Network Architecture and Programming Language

As discussed above, computer programs when executed, enable computer 302 to perform the functions of the present invention as discussed herein. In an embodiment, the present invention is implemented using computer programs written in an object-oriented programming language. Object-oriented programming is a type of programming in which programmers define not only the data type of a data structure, but also the types of operations (functions) that can be applied to the data structure. In this way, the data structure becomes an object that includes both data and functions. In addition, programmers can create relationships between one object and another. For example, objects can inherit characteristics from other objects.

One of the principal advantages of object-oriented programming techniques over procedural programming techniques is that they enable programmers to create modules that do not need to be changed when a new type of object is added. A programmer can simply create a new object that inherits many of its features from existing objects. This makes object-oriented programs easier to modify. To perform object-oriented programming, one needs an object-oriented programming language (OOPL). C++ and Smalltalk are two of the more popular languages, and there are also object-oriented versions of Pascal.
While an embodiment of the present invention is implemented using computer programs written in an object-oriented programming language, the present invention can also be implemented using procedural programming languages, etc.

As discussed above, one or more of computers 302 is connected by a network. An embodiment of the present invention uses a type of network architecture called a peer-to-peer object architecture. Before peer-to-peer object architecture can be understood, a type of network architecture called client/server architecture must be described. Client/server architecture is a network architecture in which each computer or process on the network is either a client or a server. Servers are computers or processes dedicated to managing disk drives (file servers), printers (print servers), applications/functions or network traffic (network servers). In fact, a server is any computer or device that allocates resources for an application. Clients are personal computers or workstations on which users run applications. Clients rely on servers for resources, such as files, devices, execution of functions and even processing power.

As stated above, an embodiment of the present invention uses a type of network architecture called a peer-to-peer object architecture. A peer-to-peer object architecture is when each computer in the network has equivalent capabilities and responsibilities. This differs from client/server architectures, in which some computers are dedicated to serving the others. Therefore, in an embodiment of the present invention, all computers 302 can operate as either a server or a client. The engine and data stored in authentication server 202 is described next.

D. Engine and Data of the Present Invention

As stated above, authentication server 202 of FIG. 2 is the engine of the present invention. In an embodiment of the present invention, it is this engine (executing a policy) that ultimately determines whether or not a user is
authenticated by the present invention. In addition, authentication server 202 stores data accessed by the present invention. The ways in which the data stored in authentication server 202 can be configured include as a database and as a directory. Both the database and directory configurations are described in detail in related, co-pending U.S. Application No. 09/264,726 and U.S. Application No. 09/517,121.

The various collections of data stored in authentication server 202, along with a typical sequence of steps an administrator may take to initially setup authentication server 202, are also described in detail in related, co-pending U.S. Application No. 09/264,726 and U.S. Application No. 09/517,121. Typical data stored in authentication server 202 include, but are not limited to, templates, policies, groups, device IDs, user IDs, computer IDs and application IDs.

One or more unique templates is created and stored in authentication server 202 each time a user enrolls on a different identification device. A template stores the user's unique measurement for a particular biometric device (which is then used to match against the user's "live" measurement when the device is attempting to identify the user) or password, etc., for a non-biometric device.

Policies of the present invention determine the method or way in which a user is to be authenticated by authentication server 202. Specific examples of pre-defined policies provided by the present invention include an OR policy, an AND policy, a CONTINGENT policy, a RANDOM policy, a THRESHOLD policy, a multi-user policy, a multi-location policy, a multi-template policy, a user dependent policy, a location restriction policy, and a computer/device specific policy. The present invention also allows the administrator to define or configure other policies. These policies are described in more detail in related, co-pending U.S. Application No. 09/264,726 and U.S. Application No. 09/517,121.

Each pre-defined policy has a list of devices associated with it. The list of devices identifies the identification devices that are used to execute the particular policy. Each device in the list of devices may have a threshold value
and a timeout value associated with it (this is typically true with biometric devices). The threshold value (e.g., false acceptance rate) indicates the level of identification the device must determine for the user to pass the device. The timeout value indicates the time in which the device has to identify the user to the level of identification indicated by the threshold value.

Groups in the present invention are a logical way of combining one or more users that need access to the same set of information stored on web/application server 214. For example, all users in the Internet may be allowed to access the login page of an online application that allows users to trade stocks. For the same online application, the user and only other users specific by the user would be in the group that is allowed to access confidential information of the user. Therefore, one of the groups can be defined as "USR24458 group." Here, when a user is put into "USR24458 group," that user (once authenticated by the present invention) has access to the same resources as all the other users in "USR24458 group."

Each user can be put into one or more groups. When the user attempts to gain access to information in a particular group, the user must be authenticated by whichever policy is associated with that particular group.

A device ID identifies an identification device. Each identification device has a unique ID. Thus, the collection of device IDs allows the present invention to uniquely identify each identification device attached to Communication protocol-enabled clients (web browsers) in the Internet. Similarly, a user ID uniquely identifies a user utilizing the present invention. The message flows between the components of the present invention to authenticate the user and to remotely enroll the user are described next in Section E and Section F, respectively.
E. Message Flow Between Components for Authentication by the Present Invention

FIG. 11 illustrates a high level message flow between the components of the present invention for authenticating a user using web browser 212 according to an embodiment of the present invention. When the user tries to access a website or a web application that is using the services of the present invention, the user is prompted to enter the “username” (or any unique user ID that identifies the user) that the user registered with during the enrollment process. This “username” is sent to filter 206, as shown by flow line 1102.

Once filter 206 receives the “username,” filter 206 then sends a request to authentication server 202 (via authentication components 204) to retrieve the “username” policy and templates (or credentials) stored in its database, as shown by flow line 1104.

Authentication server 202 retrieves the “username” policy and templates and returns them to filter 206 (via authentication components 204), as shown by flow line 1106.

Based on the policy and templates, filter 206 challenges the user to present the user’s credentials, as shown by flow line 1108. Here, authentication control component 208 guides the user through any necessary biometric measurement capture and matching processes.

Authentication control component 208 then sends the results of the challenge to filter 206 who forwards those results to authentication server 202 (via authentication components 204), as shown by flow lines 1110 and 1112, respectively.

Based on the user policy, authentication server 202 then decides whether the match was good enough and if additional credentials are required (as in the case of multi factored authentications or policies) to access the particular information requested by the user. If multi factored authentication is required, then flow lines 1106 through 1112 are repeated as many times as necessary.
Once authentication server is able to execute the user’s policy and determines whether the user has been authenticated, authentication components 204 forwards the result to filter 206, as shown by flow line 1114. Here, if the user has been authenticated, then filter 206 interacts with web/application server 214 to allow the user access to its requested information.

The user can use the web application or web site for the duration of that session (i.e., until the user closes web browser 212). Thus, filter 206 either allows or denies the user access to the requested information, as shown by flow line 1116. The message flow between components for remote enrollment of the present invention will be described next.

**F. Message Flow Between Components for Remote Enrollment by the Present Invention**

FIG.12 illustrates a high level message flow between the components of the present invention for remotely enrolling a user using web browser 212 according to an embodiment of the present invention. The message flow for remote enrollment is very similar to the message flow for authentication. The enroll application manages the interaction with the user. For authenticating the user to use the enroll application itself, several techniques may be used by the present invention. For example, the existing username-password combination that a user uses to access the application or web site today may be used. Another example is a one-time password or PIN may be generated and mailed (electronically or otherwise) to the user. In either case, the enroll object (described above with reference to FIG. 10) performs the one-time authentication of the user before proceeding to download authentication control component 208 on the user’s computer.

Referring to FIG.12, the user submits the one-time password or PIN to filter 206, as shown in flow line1202.

Filter 206 then requests one-time authentication for the user by the enroll object, as shown by flow line1204.
The result of the on-time authentication is returned to filter 206, as shown by flow line 1206.

Filter 206 forwards this request to authentication control component 208, as shown by flow line 1208.

Authentication control component 208 (via the enroll application) captures the necessary biometric measurements from the user and then posts the results of this capture to filter 206, as shown by flow line 1210.

The results of this capture are then forwarded from filter 206 to the enroll object to store the results in authentication server 202, as shown by flow line 1212.

The user at this point has been enrolled in the present invention. The component API and extensibility of the present invention are described next.

G. Component API and Extensibility of the Present Invention

The server side components (i.e., authentication server 202 and authentication components 204), filter 206 and enroll application present a well-defined interface to web-enabled clients. These interfaces consist of a set of URLs that can be requested using HTTP GET or POST methods. The API and related conventions shown below are only examples of how to implement these interactions. These examples are not meant to limit the present invention. All URL requests could be required to follow the syntax below:

- **METHOD**: Type of HTTP method. Can be GET or POST
- **HEADER**: HTTP header. Format is name=value
- **BODY**: Body of the HTTP request. Can be a series of name=value pairs, binary data, or both
- `<foobar>`: Denotes an optional element.
- `foo|bar`: Denotes “foo” OR “bar”.

...
The server-side components, filter 206 and the enroll application expect requests in a specific format. The responses to these requests also follow a specific format. This allows for an extensible architecture and enables the plugging in of new web-enabled services to the existing infrastructure. BNF is an acronym for “Backus-Naur Form,” which is a metasyntactic notation used to specify the syntax of programming languages, command sets, and the like. Following is a BNF of a request of the present invention that includes an identification of the type of object that needs to be created and the data to send to the object.

\[
\begin{align*}
<\text{request}> & ::= \quad <\text{function}> \mid <\text{request}><\text{connector}><\text{request}> \\
<\text{function}> & ::= \quad <\text{identifier}> \{ <\text{parameter}> \} \\
<\text{parameter}> & ::= \quad <\text{identifier}> \mid <\text{identifier}> \\
<\text{identifier}> & ::= \quad <\text{letter}> \{ <\text{letter}> \mid <\text{digit}> \} \\
<\text{letter}> & ::= \quad \text{A} \mid \text{B} \mid \text{C} \mid \text{D} \mid \text{E} \mid \text{F} \mid \text{G} \mid \text{H} \mid \text{I} \mid \text{J} \mid \text{K} \mid \text{L} \mid \text{M} \mid \text{N} \mid \text{O} \mid \text{P} \mid \text{Q} \mid \text{R} \mid \text{S} \mid \text{T} \mid \text{U} \mid \text{V} \mid \text{W} \mid \text{X} \mid \text{Y} \mid \text{Z} \\
<\text{digit}> & ::= \quad 0 \mid 1 \mid 2 \mid 3 \mid 4 \mid 5 \mid 6 \mid 7 \mid 8 \mid 9 \\
<\text{connector}> & ::= \quad \text{AND} \mid \text{OR}
\end{align*}
\]

Using the same method described here, albeit a different set of URLs, the architecture can easily be extended to allow other web functionality to be added to authentication server 202. Such an example of another functionality includes remote administration of authentication server 202.
H. Conclusion

While various embodiments of the present invention have been described above, it should be understood that they have been presented by way of example, and not limitation. It will be apparent to persons skilled in the relevant art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention. This is especially true in light of technology and terms within the relevant art(s) that may be later developed. Thus, the present invention should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims and their equivalents.
What Is Claimed Is:

1. A system for authenticating a user to access requested information via a communication medium, comprising:
   client side components;
   a filter coupled to said client side components via the communication medium; and
   server side components coupled to said filter via the communication medium,
   wherein said client side components include an authentication control component that manages the process of capturing user credentials and communicates the result of capturing said user credentials to said filter,
   wherein said server side components include an authentication server, wherein said authentication server stores therein data related to a plurality of users and at least one policy that the user is associated with, said policy defining an authentication level, said authentication level defining a probability that the user is authorized to access the requested information, and wherein said authentication server receives said user credentials from said filter, attempts to authenticate the user by executing said policy and communicates to said filter whether the user is authenticated, and
   wherein said filter interacts with a server containing the requested information once the user is authenticated by said authentication server.

2. The system of claim 1, wherein the communication medium is the Internet.

3. The system of claim 1, wherein the communication medium is a local network.
4. The system of claim 1, wherein the communication medium is a wireless network.

5. The system of claim 1, wherein said server is a web server.

6. The system of claim 1, wherein said server is an application server.

7. The system of claim 1, wherein said authentication control component is checked for integrity each time it is invoked.

8. A system for allowing a user to remotely enroll user credentials via a communication medium in order to access requested information, comprising:
   - client side components;
   - a filter coupled to said client side components via the communication medium; and
   - server side components coupled to said filter via the communication medium,
   wherein said client side components include an authentication control component and an enroll application, said enroll application is responsible for driving presentation logic that interacts with the user when presenting user credentials, said authentication control component is responsible for managing the process of capturing user credentials and communicating the result of capturing said user credentials to said server side components;
   wherein said server side components include an authentication server, wherein said authentication server stores therein data related to a plurality of users and at least one policy that the user is associated with, said policy defining an authentication level, said authentication level defining a probability that the user is authorized to access the requested information, and wherein said authentication server stores said user credentials.
9. The system of claim 8, wherein the communication medium is the Internet.

10. The system of claim 8, wherein the communication medium is a local network.

11. The system of claim 8, wherein the communication medium is a wireless network.

12. A method for authenticating a user to access requested information via a communication medium, comprising the steps of:

   storing, in an authentication server, data related to a plurality of users and at least one policy that the user is associated with, said policy defining an authentication level, said authentication level defining a probability that the user is authorized to access the requested information;

   managing, via an authentication control component, the process of capturing user credentials;

   communicating, from said authentication control component to a filter via the communication medium, the result of capturing said user credentials;

   communicating, from said filter to said authentication server via the communication medium, said user credentials;

   determining, by said authentication server, whether the user is authenticated by executing said policy;

   communicating, from said authentication server to said filter via the communication medium, whether the user has been authenticated; and

   interacting, by said filter, with a server containing the requested information if the user was authenticated by said authentication server.

13. The method of claim 12, wherein the communication medium is the Internet.
14. The method of claim 12, wherein the communication medium is a local network.

15. The method of claim 12, wherein the communication medium is a wireless network.

16. The method of claim 12, wherein said server is a web server.

17. The method of claim 12, wherein said server is an application server.

18. The method of claim 12, wherein said authentication control component is checked for integrity each time it is invoked.

19. A method for allowing a user to remotely enroll user credentials via a communication medium in order to access requested information, comprising the steps of:

   storing, in an authentication server, data related to a plurality of users and at least one policy that the user is associated with, said policy defining an authentication level, said authentication level defining a probability that the user is authorized to access the requested information;

   driving presentation logic, by an enroll application, that interacts with the user when presenting user credentials;

   managing, via an authentication control component, the process of capturing user credentials;

   communicating, from said authentication control component to said authentication server via the communication medium, the result of capturing said user credentials; and

   storing in said authentication server said user credentials.
20. The method of claim 19, wherein the communication medium is the Internet.

21. The method of claim 19, wherein the communication medium is a local network.

22. The method of claim 19, wherein the communication medium is a wireless network.

23. A system for authenticating a user to access requested information via a communication medium, comprising:
   client side components; and
   server side components coupled to said client side components via the communication medium,
   wherein said client side components include an authentication control component that manages the process of capturing user credentials and communicates the result of capturing said user credentials to said server side components, and
   wherein said server side components include an authentication server and a filter, wherein said authentication server stores therein data related to a plurality of users and at least one policy that the user is associated with, said policy defining an authentication level, said authentication level defining a probability that the user is authorized to access the requested information, and wherein said authentication server receives said user credentials from said filter, attempts to authenticate the user by executing said policy and communicates to said filter whether the user is authenticated, and wherein said filter interacts with a server containing the requested information once the user is authenticated by said authentication server.
24. A method for authenticating a user to access requested information via a communication medium, comprising the steps of:

- storing, in an authentication server, data related to a plurality of users and at least one policy that the user is associated with, said policy defining an authentication level, said authentication level defining a probability that the user is authorized to access the requested information;
- managing, via an authentication control component, the process of capturing user credentials;
- communicating, from said authentication control component to said authentication server via the communication medium, the result of capturing said user credentials;
- determining, by said authentication server, whether the user is authenticated by executing said policy; and
- communicating, from said authentication server to a server containing the requested information via the communication medium, whether the user has been authenticated.
FIG. 4

Wireless Authentication Object

Wireless Authentication Object

Wireless Authentication Object

Wireless Listen Object

Wireless Comm Object

Wireless Comm Object

Wireless Comm Object

Wireless Comm Object
Listen object listens for incoming SSL connection requests

Once the listen object receives an SSL connection request, the listen object ensures that the request is processed

FIG. 6
702 The comm object negotiates a session key with the web browser

704 The comm object receives data from the web browser encrypted with the session key

706 The comm object decrypts the received encrypted data

708 The comm object parses the headers and content in the decrypted data

710 The comm object creates a data object and hands it off to either the authenticate object or the policy object

712 The comm object receives the data object back from either the authenticate object or the policy object

714 The comm object encrypts the data with the session key

716 The comm object sends the encrypted data to the web browser

FIG. 7

SUBSTITUTE SHEET (RULE 26)
The authenticate object retrieves the policy used to authenticate the user.

The authenticate object manages the exchange of messages between the web browser (via the filter and via the authentication control component).

The authenticate object returns the final result to the filter.

FIG. 8
The listen object listens for incoming SSL connection requests

The listen object receives a request and looks at the parameters of the request

Once the listen object determines the type of request, the listen object ensures that the request is processed

FIG. 9
1002: The enroll object creates the authentication policy for the user.

1004: Based on the policy, the enroll object requests the necessary credentials from the user.

1006: The enroll object stores the policy and credentials in the database of the authentication server.

FIG.10
INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/03541

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) : Please See Extra Sheet.
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. : 713/200, 201, 202; 705/52, 52, 54; 709/217, 219, 226, 227, 228, 229

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 Extra Sheet.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>US 6,003,084A (GREEN ET AL) 14 DECEMBER 1999, SEE ENTIRE DOCUMENT</td>
<td>1-24N</td>
</tr>
<tr>
<td>X,P</td>
<td>US 6,070,243 A (SEE ET AL) 30 MAY 2000, SEE ENTIRE DOCUMENT</td>
<td>1-24</td>
</tr>
</tbody>
</table>

* 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 document 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
&S* document member of the same patent family

Date of the actual completion of the international search
20 MARCH 2001

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Form PCT/ISA/210 (second sheet) (July 1998)
A. CLASSIFICATION OF SUBJECT MATTER:
IPC (T):
G06F 11/30, 12/14, 15/16, 15/173, 17/60; H04L 9/00, 9/32; H04K 1/00

A. CLASSIFICATION OF SUBJECT MATTER:
US CL:
713/200, 201, 202; 705/52, 52, 54; 709/217, 219, 226, 227, 228, 229

B. FIELDS SEARCHED
Electronic data bases consulted (Name of data base and where practicable terms used):
BRS (FILES: USPAT, DERWENT, JPO, EPO, IBM TDB'S)

search terms: policy, filter, filters, filtering, filtered, id, credential, identity, identification, identifying, identified, password, authorize, authority, authorized, authorizing, authenticate, authenticated, authentication, authenticating, request, requesting, requested, access, accessing, accessed, firewall