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(54) **SECURING BLOCKCHAIN TRANSACTIONS AGAINST CYBERATTACKS**

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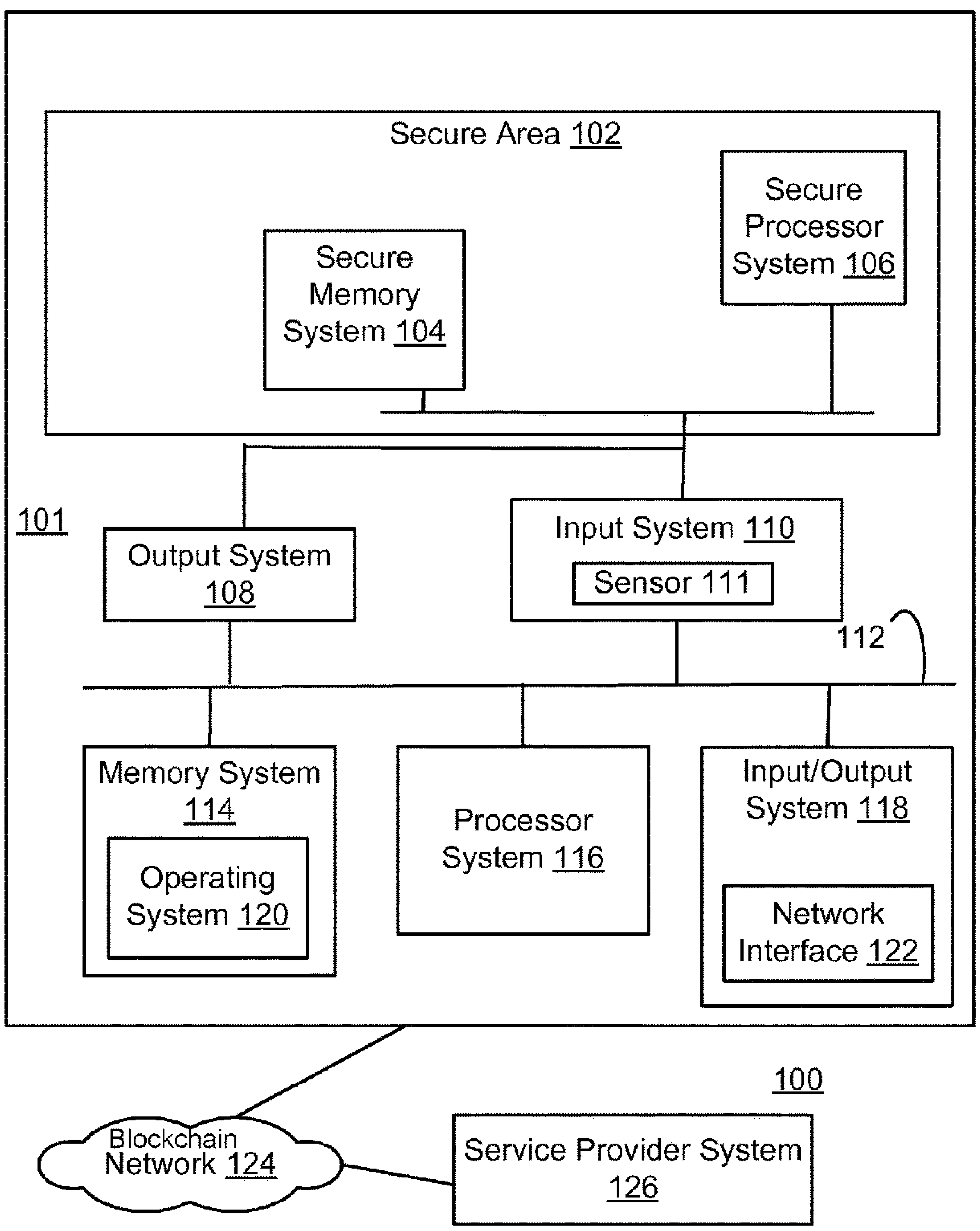
(57) **ABSTRACT**

Methods and systems are provided for performing a secure transaction. In an embodiment, users register biometric and/or other identifying user information. A private encryption key is generated from the biometric information and/or other user information and/or information obtained from a unpredictable physical process and are stored in a secure area of a device and a public key is transmitted to the blockchain network which acts as a service provider. In some embodiments, the private key depends upon at least partly on user information presented in the secure area. This hinders attacks like the Mt. Gox exchange. Each unique transaction passcode or transaction signature depends upon the transaction information and user information, so that on the next step of that transaction, only that unique transaction passcode will be valid. In some embodiments, if the transaction information has been altered relative to the transaction information stored in the device's secure area, then the transaction passcode sent to the blockchain network during this step will be invalid and the blockchain network may abort the transaction.



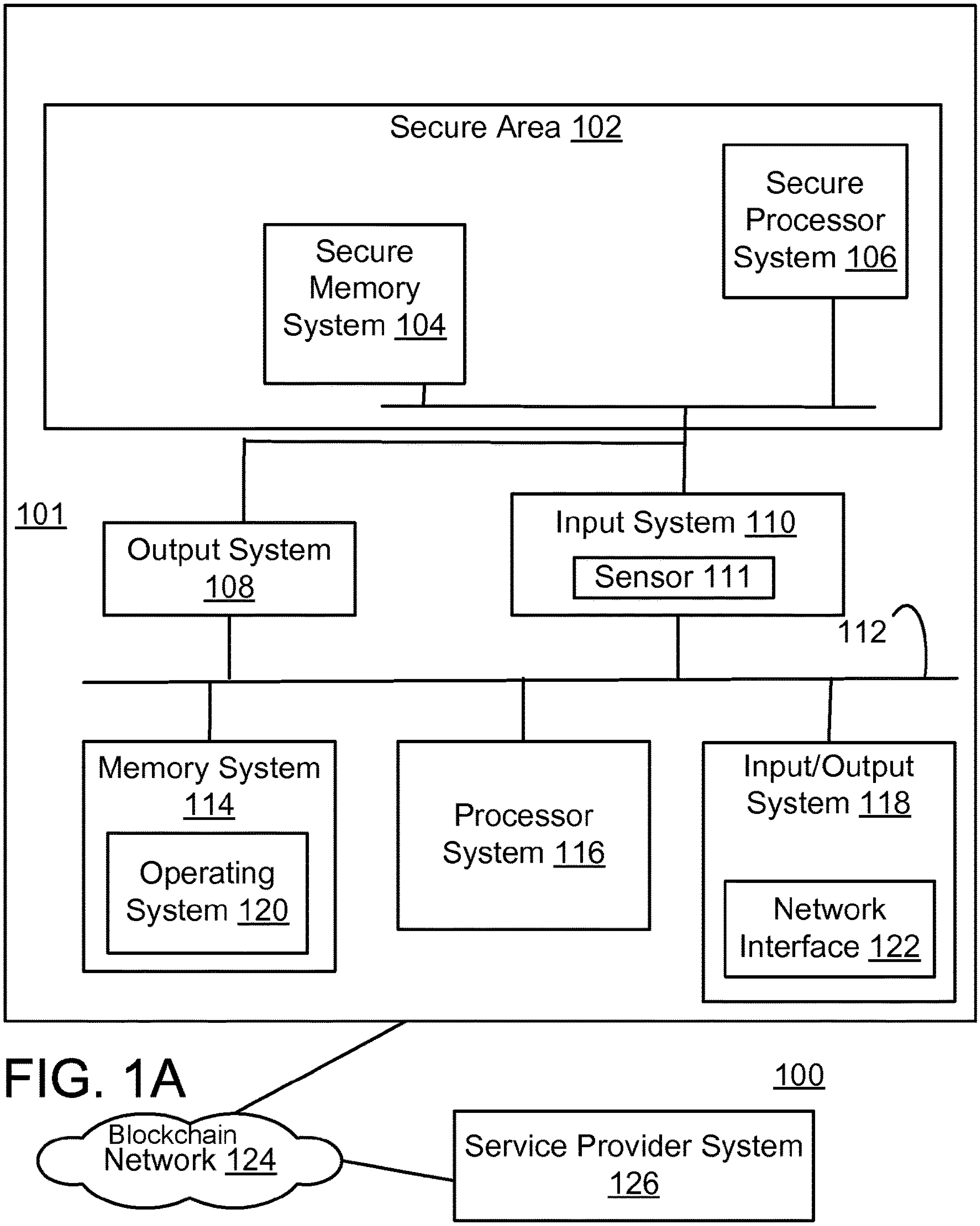

Secure Area 102
Secure Memory System 104
Secure Processor System 106
101
Output System 108
Input System 110
Sensor 111
112
Memory System 114
Operating System 120
Processor System 116
Input/Output System 118
Network Interface 122
100
Blockchain Network 124
Service Provider System 126

FIG. 1A

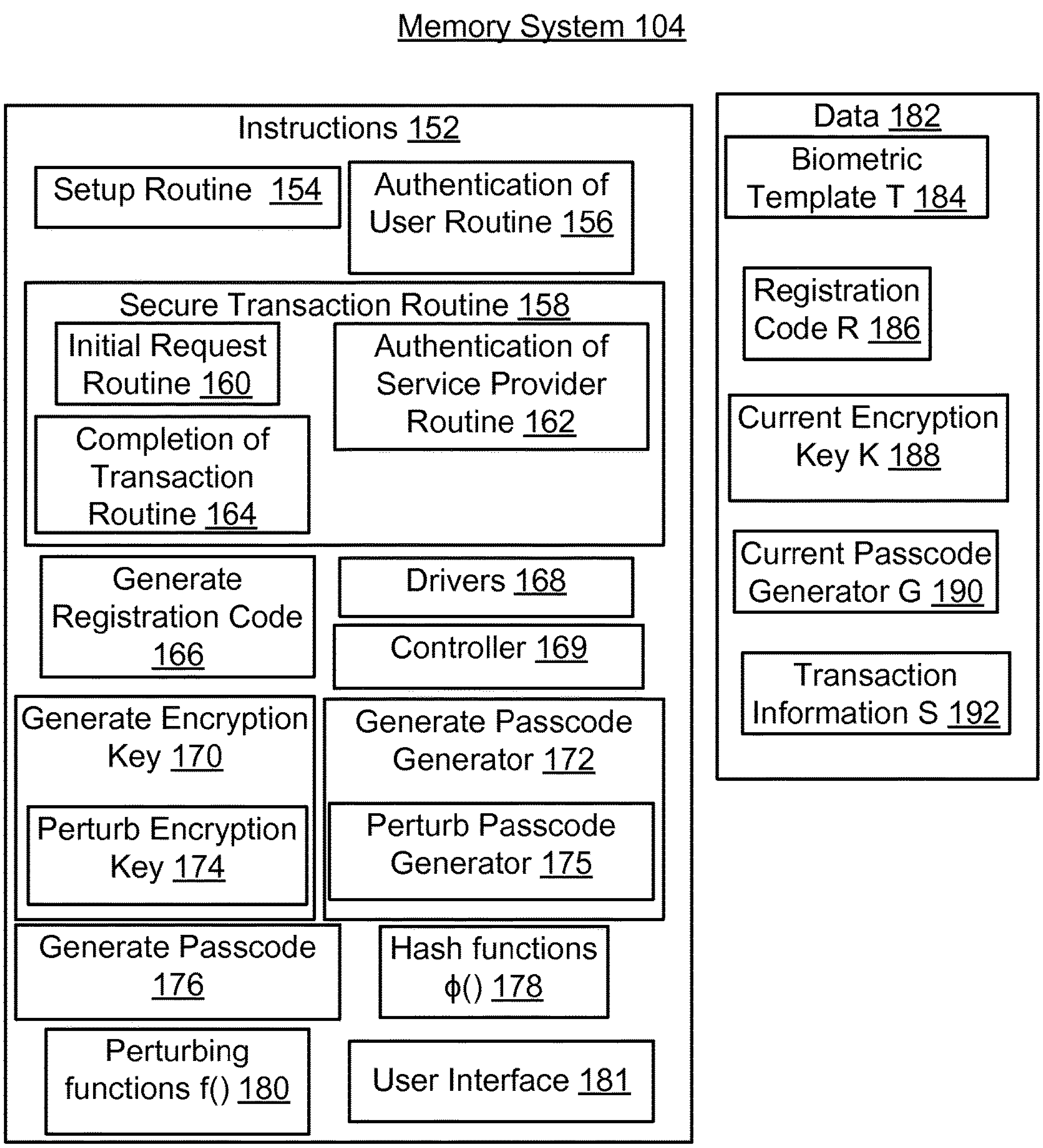

Memory System 104
Instructions 152
Setup Routine 154
Authentication of User Routine 156
Secure Transaction Routine 158
Initial Request Routine 160
Authentication of Service Provider Routine 162
Completion of Transaction Routine 164
Generate Registration Code 166
Drivers 168
Controller 169
Generate Encryption Key 170
Generate Passcode Generator 172
Perturb Encryption Key 174
Perturb Passcode Generator 175
Generate Passcode 176
Hash functions ϕ() 178
Perturbing functions f() 180
User Interface 181
Data 182
Biometric Template T 184
Registration Code R 186
Current Encryption Key K 188
Current Passcode Generator G 190
Transaction Information S 192

FIG. 1B

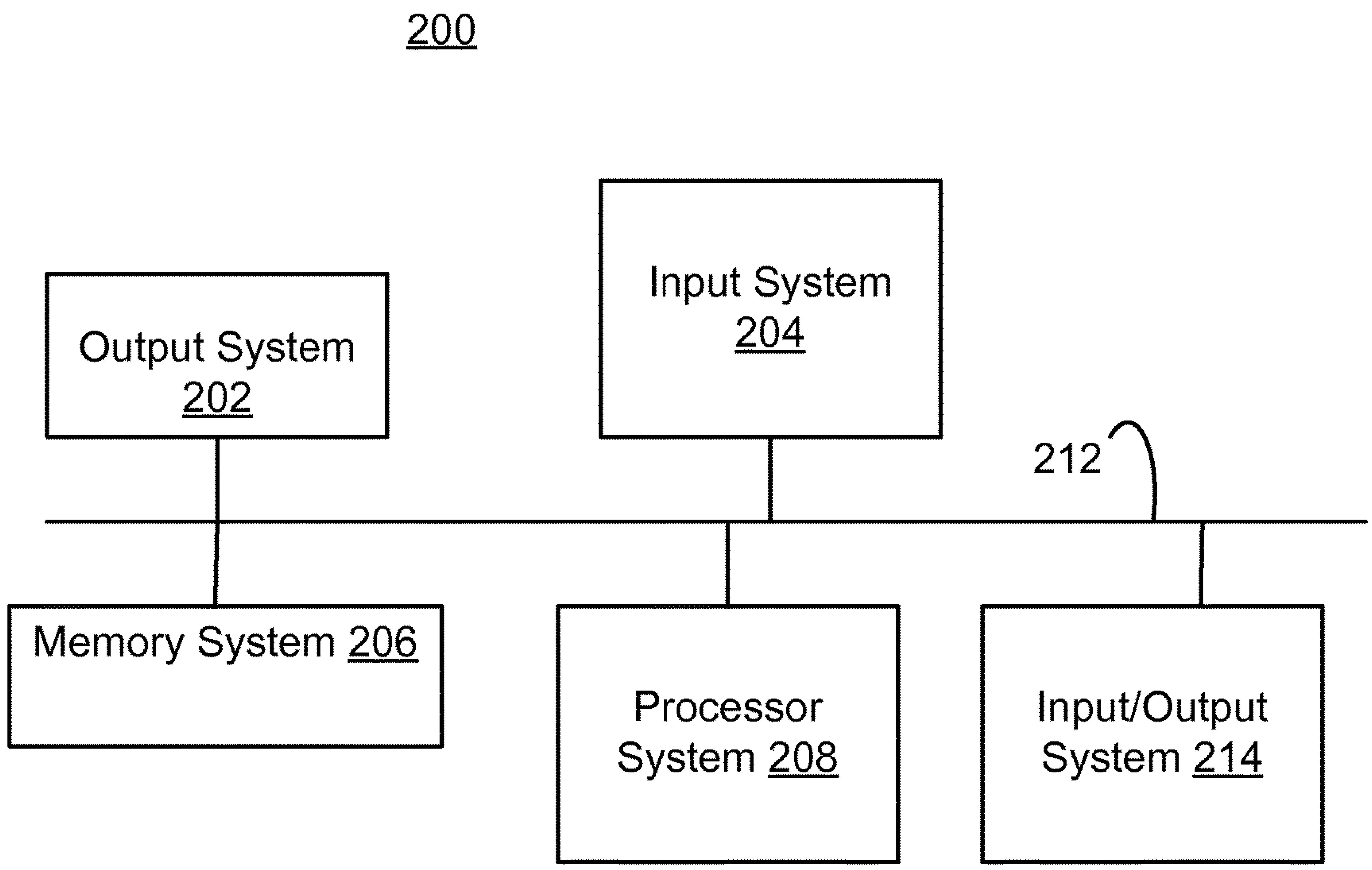

200
Output System 202
Input System 204
212
Memory System 206
Processor System 208
Input/Output System 214

FIG. 2A

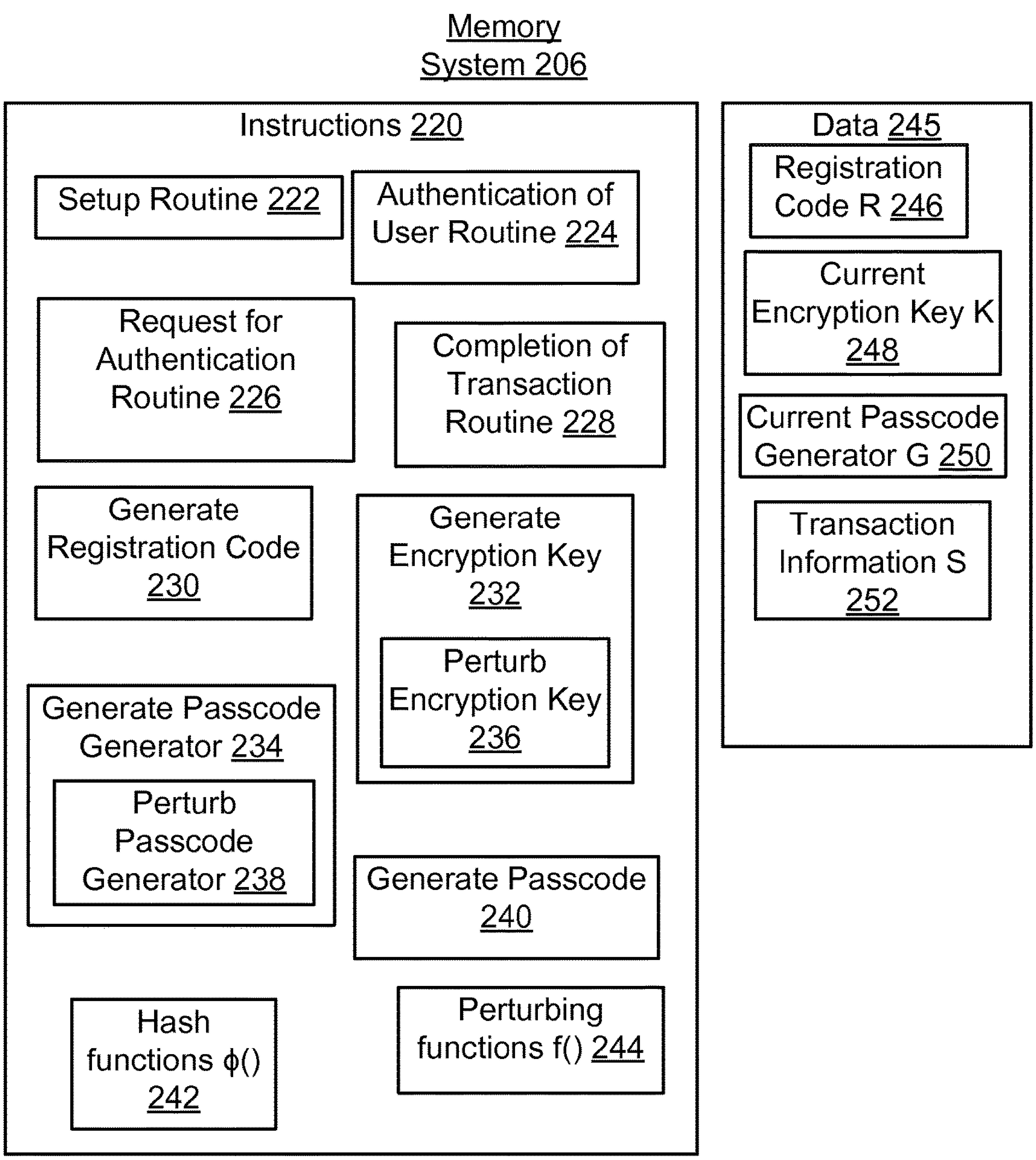

Memory
System 206
Instructions 220
Setup Routine 222
Authentication of User Routine 224
Request for Authentication Routine 226
Completion of Transaction Routine 228
Generate Registration Code 230
Generate Encryption Key 232
Perturb Encryption Key 236
Generate Passcode Generator 234
Perturb Passcode Generator 238
Generate Passcode 240
Hash functions ϕ() 242
Perturbing functions f() 244
Data 245
Registration Code R 246
Current Encryption Key K 248
Current Passcode Generator G 250
Transaction Information S 252

FIG. 2B

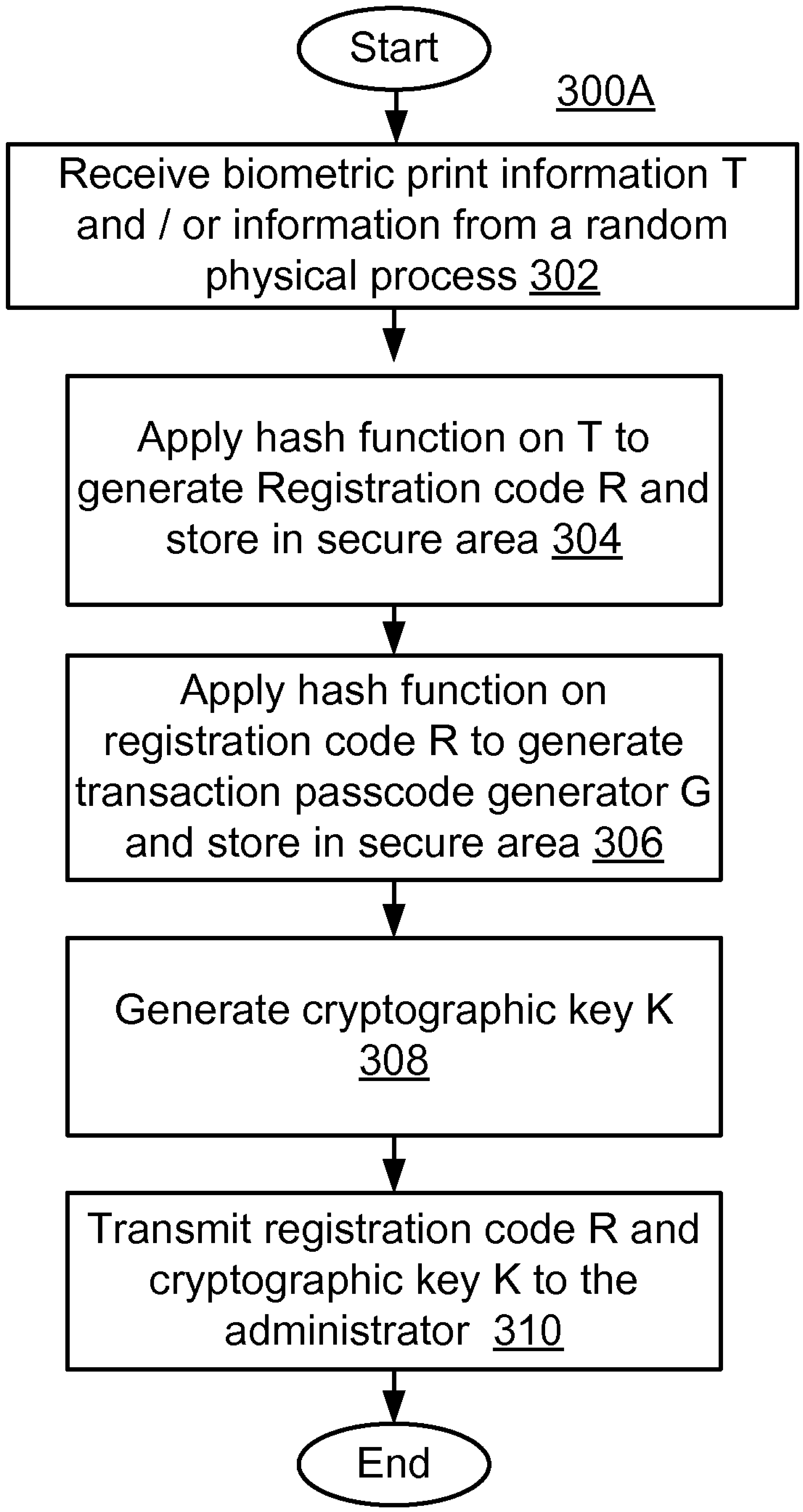

Start
300A
Receive biometric print information T and / or information from a random physical process 302
Apply hash function on T to generate Registration code R and store in secure area 304
Apply hash function on registration code R to generate transaction passcode generator G and store in secure area 306
Generate cryptographic key K 308
Transmit registration code R and cryptographic key K to the administrator 310
End

FIG. 3A

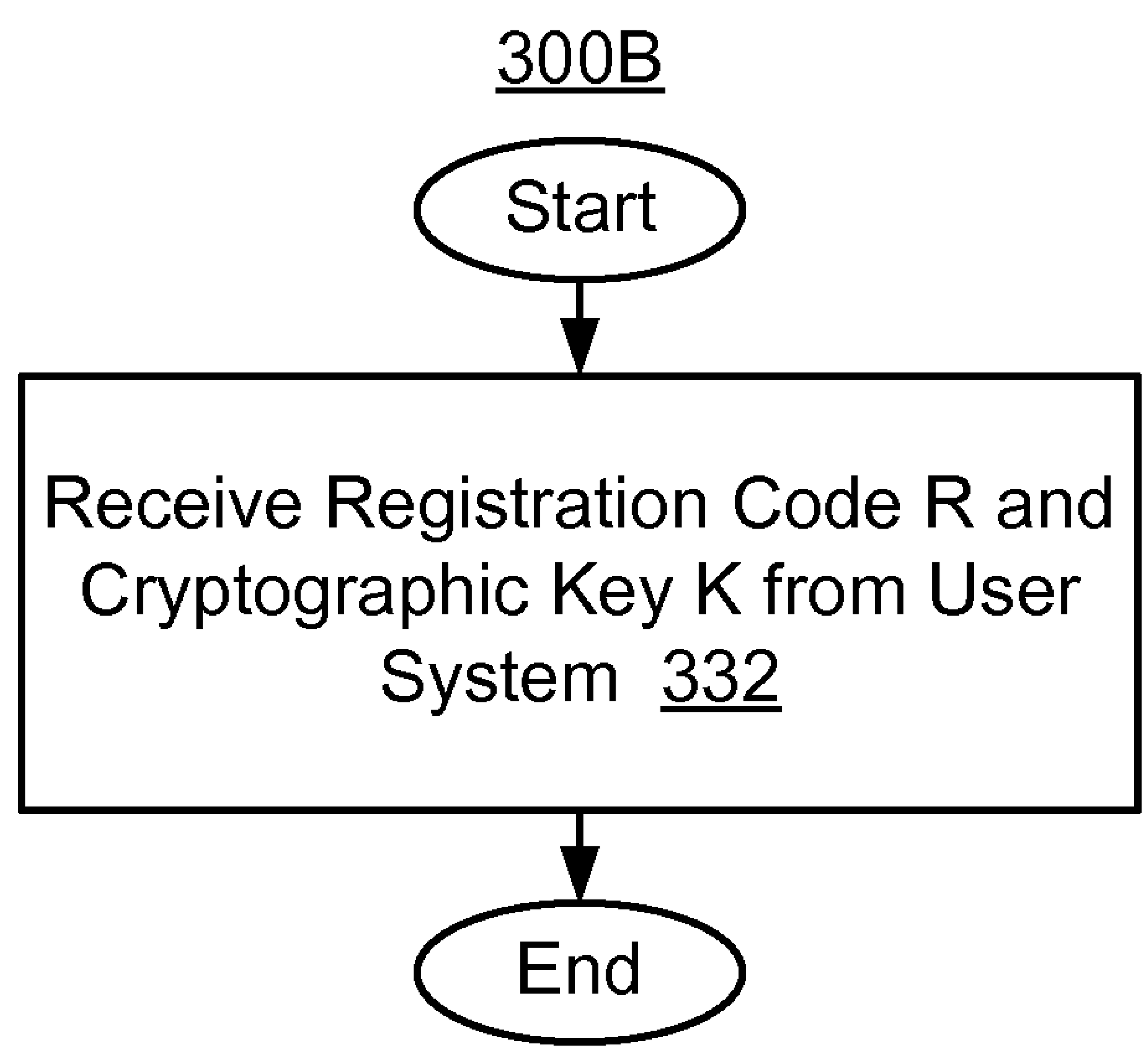

300B
Start
Receive Registration Code R and Cryptographic Key K from User System 332
End

FIG. 3B

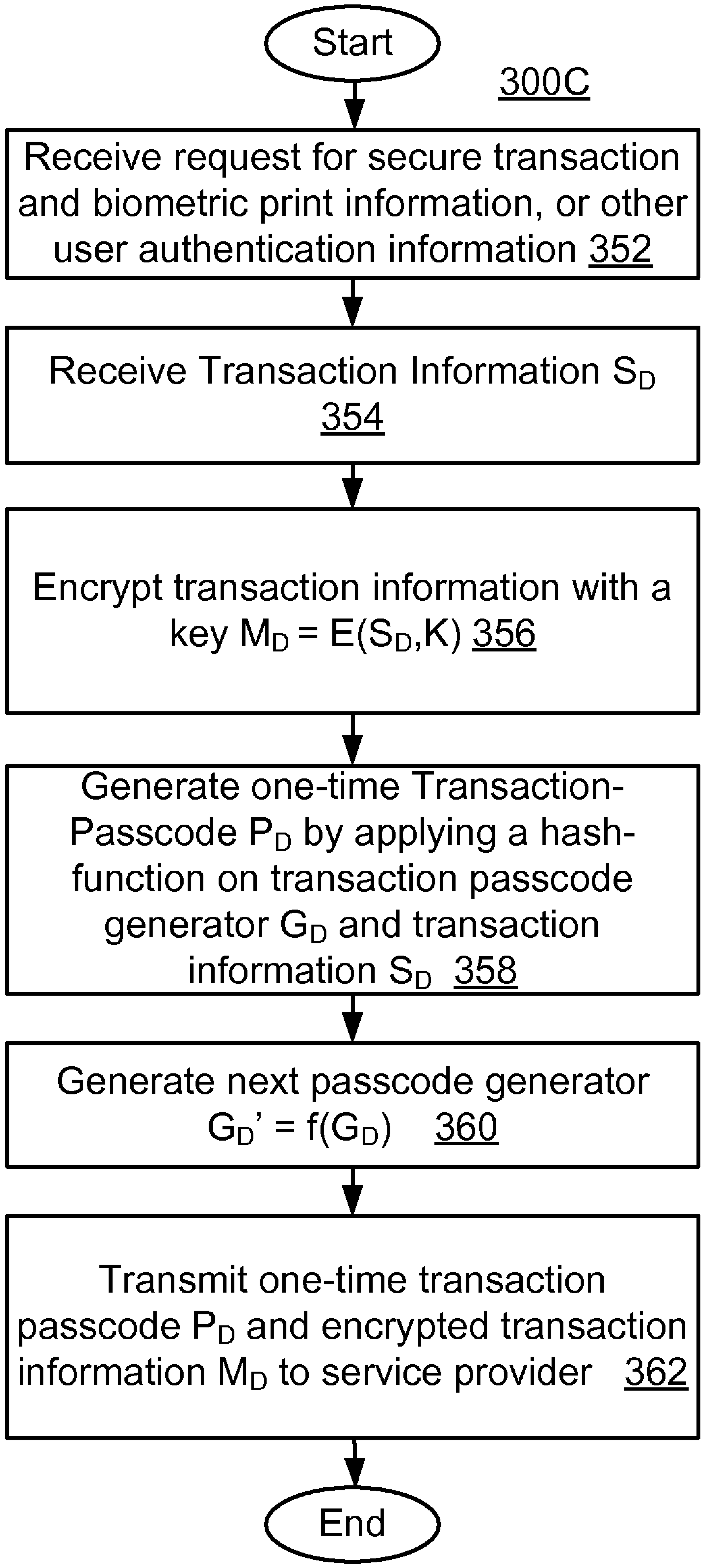
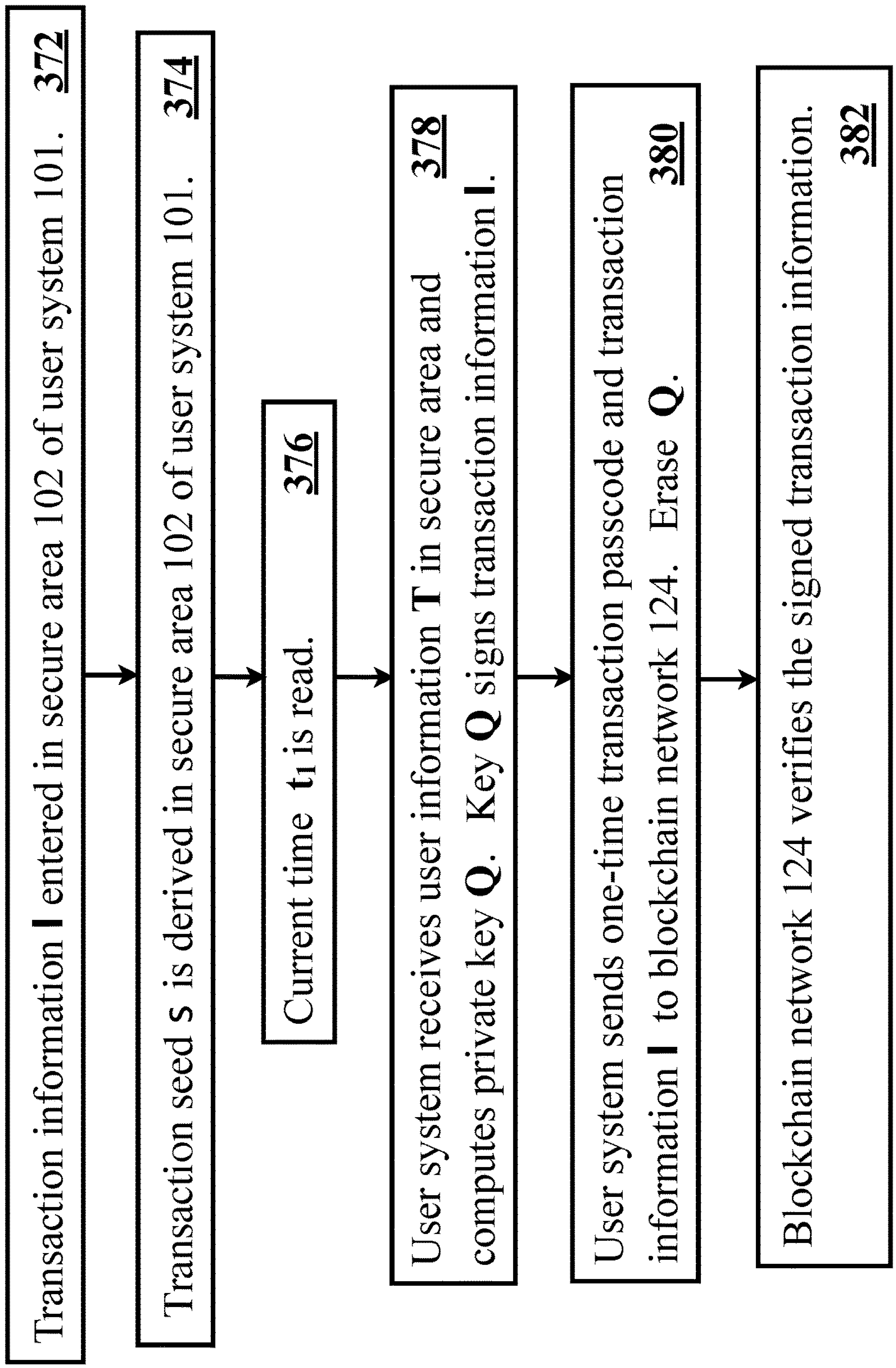

Start
300C
Receive request for secure transaction and biometric print information, or other user authentication information 352
Receive Transaction Information S_D 354
Encrypt transaction information with a key $M_D = E(S_D,K)$ 356
Generate one-time Transaction-Passcode P_D by applying a hash-function on transaction passcode generator G_D and transaction information S_D 358
Generate next passcode generator $G_D' = f(G_D)$ 360
Transmit one-time transaction passcode P_D and encrypted transaction information M_D to service provider 362
End

FIG. 3C

370 Figure 3D



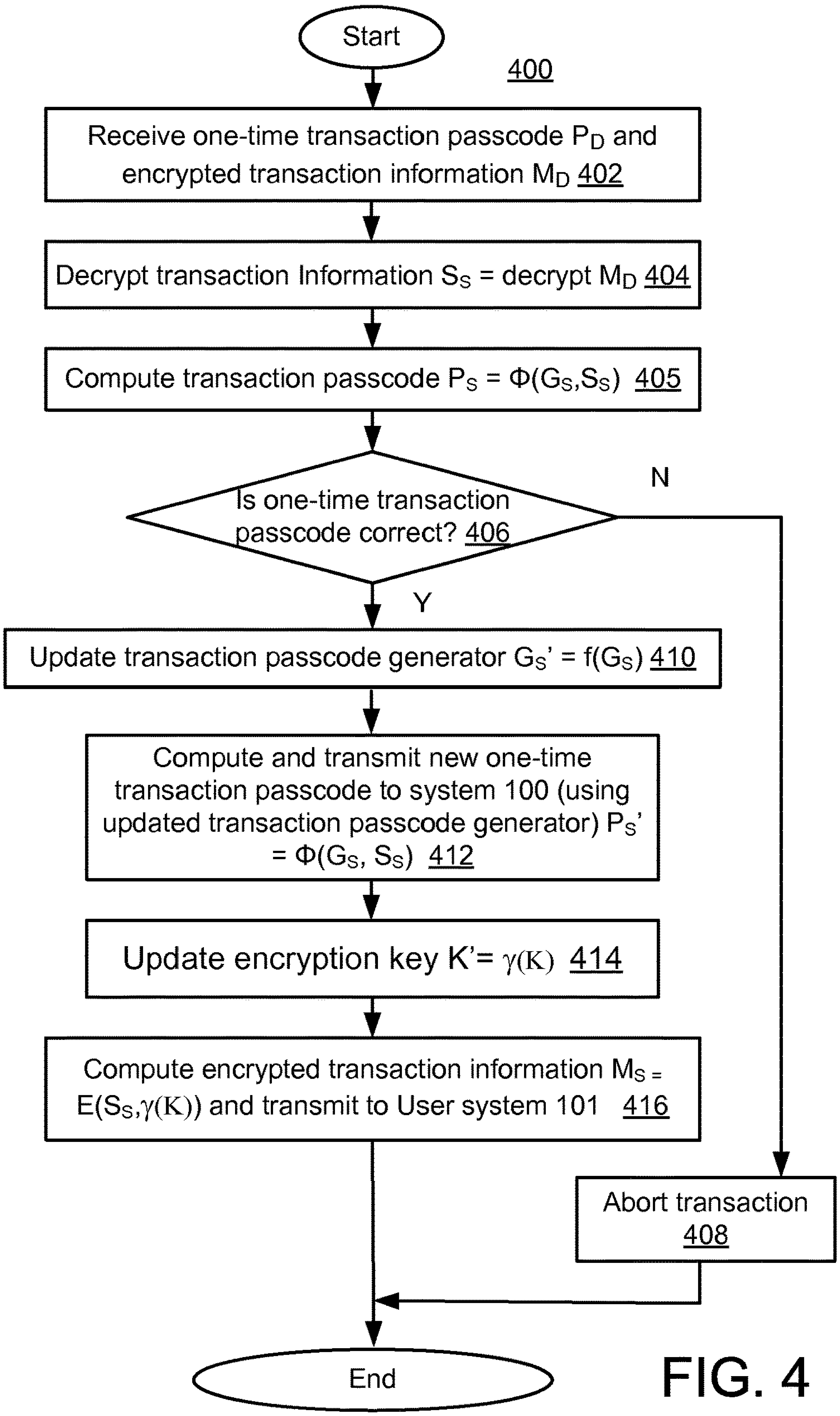

Start
400
Receive one-time transaction passcode P_D and encrypted transaction information M_D 402
Decrypt transaction Information S_S = decrypt M_D 404
Compute transaction passcode $P_S = \Phi(G_S,S_S)$ 405
Is one-time transaction passcode correct? 406
N
Y
Update transaction passcode generator $G_S' = f(G_S)$ 410
Compute and transmit new one-time transaction passcode to system 100 (using updated transaction passcode generator) $P_S' = \Phi(G_S, S_S)$ 412
Update encryption key $K' = \gamma(K)$ 414
Compute encrypted transaction information $M_S = E(S_S,\gamma(K))$ and transmit to User system 101 416
Abort transaction 408
End

FIG. 4

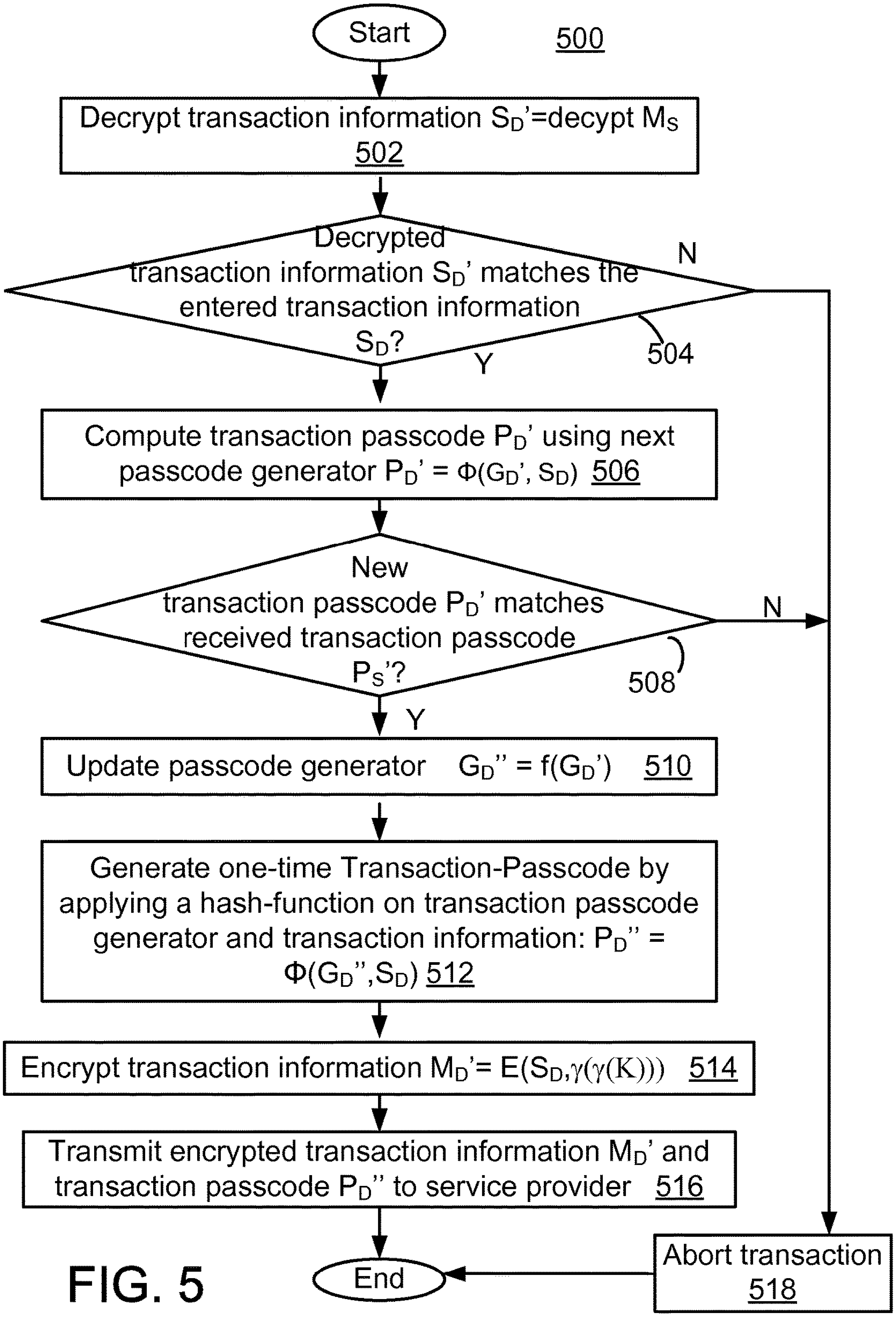
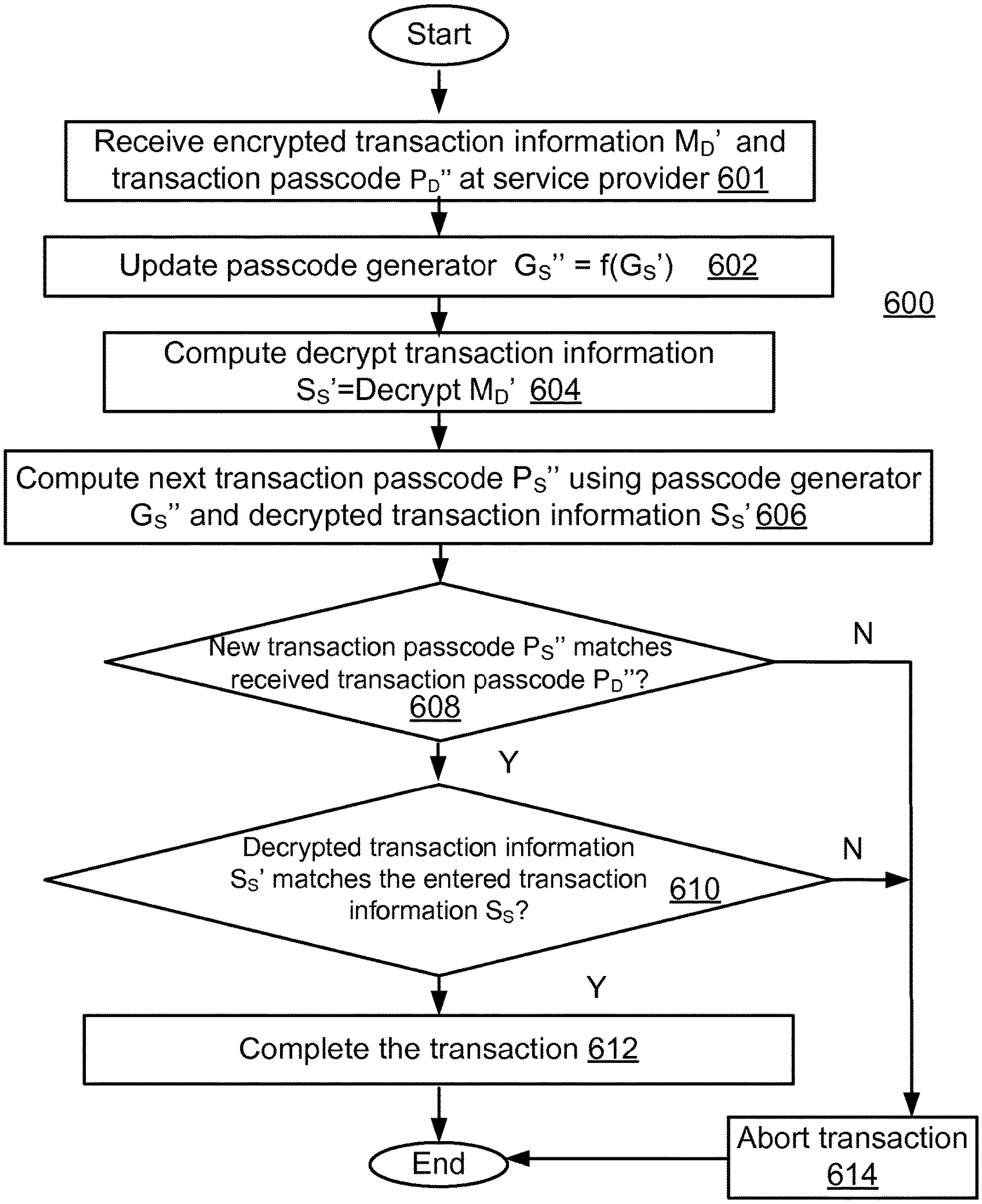

Start
500
Decrypt transaction information S_D'=decypt M_S 502
Decrypted transaction information S_D' matches the entered transaction information S_D?
N
Y
504
Compute transaction passcode P_D' using next passcode generator P_D' = Φ(G_D', S_D) 506
New transaction passcode P_D' matches received transaction passcode P_S'?
N
Y
508
Update passcode generator G_D'' = f(G_D') 510
Generate one-time Transaction-Passcode by applying a hash-function on transaction passcode generator and transaction information: P_D'' = Φ(G_D'',S_D) 512
Encrypt transaction information M_D'= E(S_D,γ(γ(K))) 514
Transmit encrypted transaction information M_D' and transaction passcode P_D'' to service provider 516
Abort transaction 518
End

FIG. 5



Start
Receive encrypted transaction information M_D' and transaction passcode P_D'' at service provider 601
Update passcode generator G_S'' = f(G_S') 602
600
Compute decrypt transaction information S_S'=Decrypt M_D' 604
Compute next transaction passcode P_S'' using passcode generator G_S'' and decrypted transaction information S_S' 606
New transaction passcode P_S'' matches received transaction passcode P_D''? 608
N
Y
Decrypted transaction information S_S' matches the entered transaction information S_S? 610
N
Y
Complete the transaction 612
Abort transaction 614
End

FIG. 6

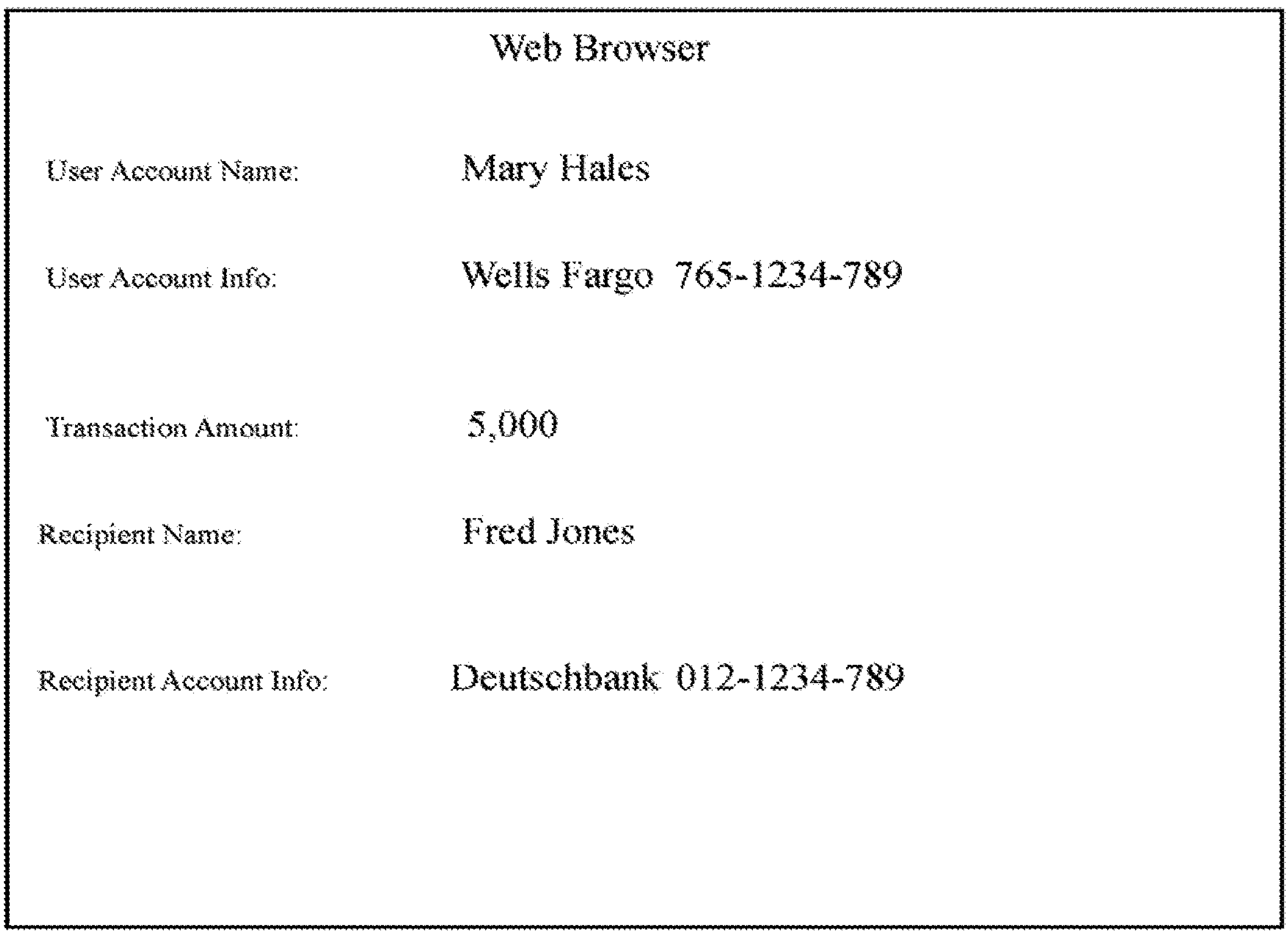

Web Browser
User Account Name: Mary Hales
User Account Info: Wells Fargo 765-1234-789
Transaction Amount: 5,000
Recipient Name: Fred Jones
Recipient Account Info: Deutschbank 012-1234-789

FIG. 7

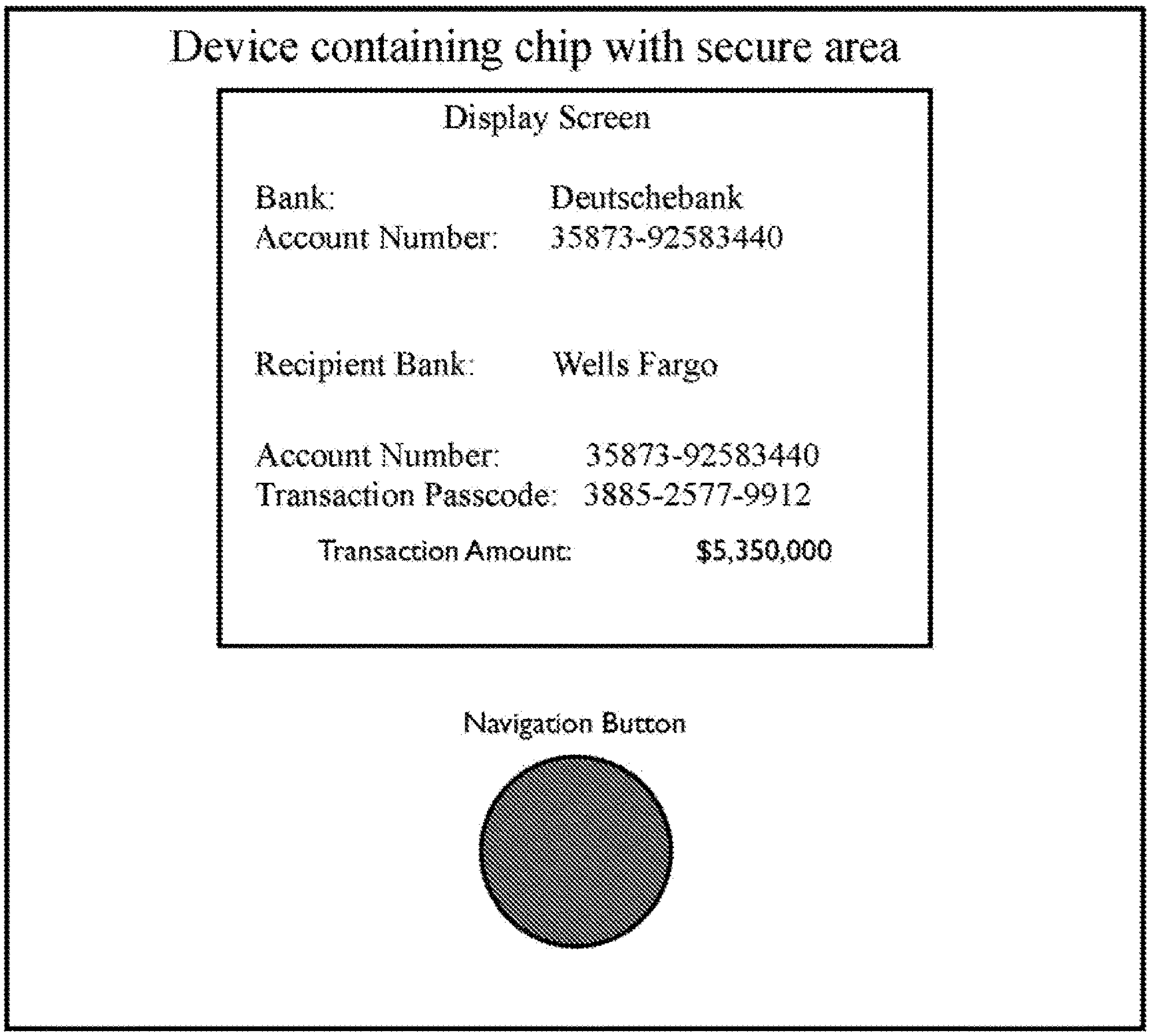

Device containing chip with secure area
Display Screen
Bank: Deutschebank
Account Number: 35873-92583440
Recipient Bank: Wells Fargo
Account Number: 35873-92583440
Transaction Passcode: 3885-2577-9912
Transaction Amount: $5,350,000
Navigation Button

FIG. 8

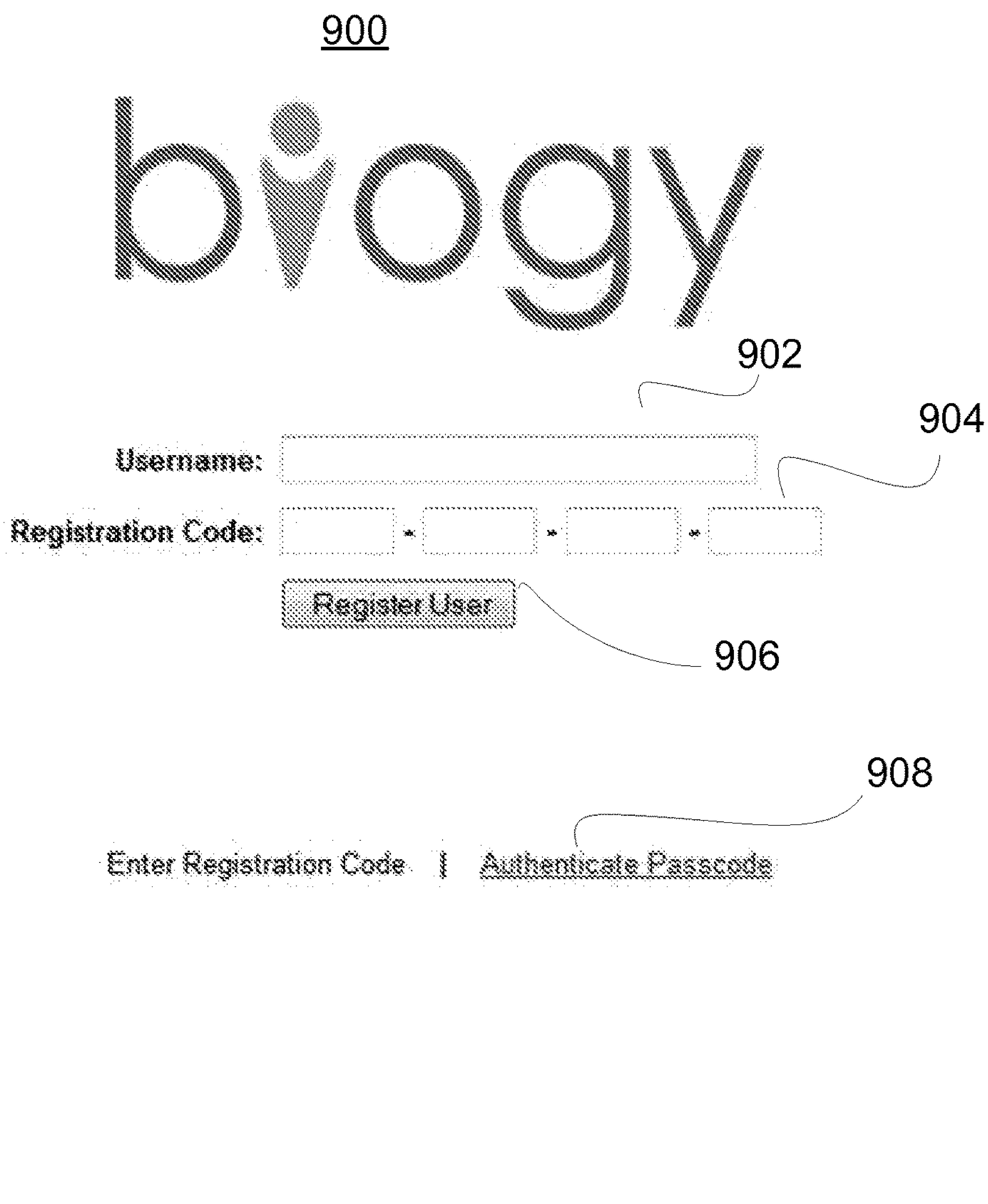

900
biogy
902
904
Username:
Registration Code:
Register User
906
908
Enter Registration Code | Authenticate Passcode

FIG. 9

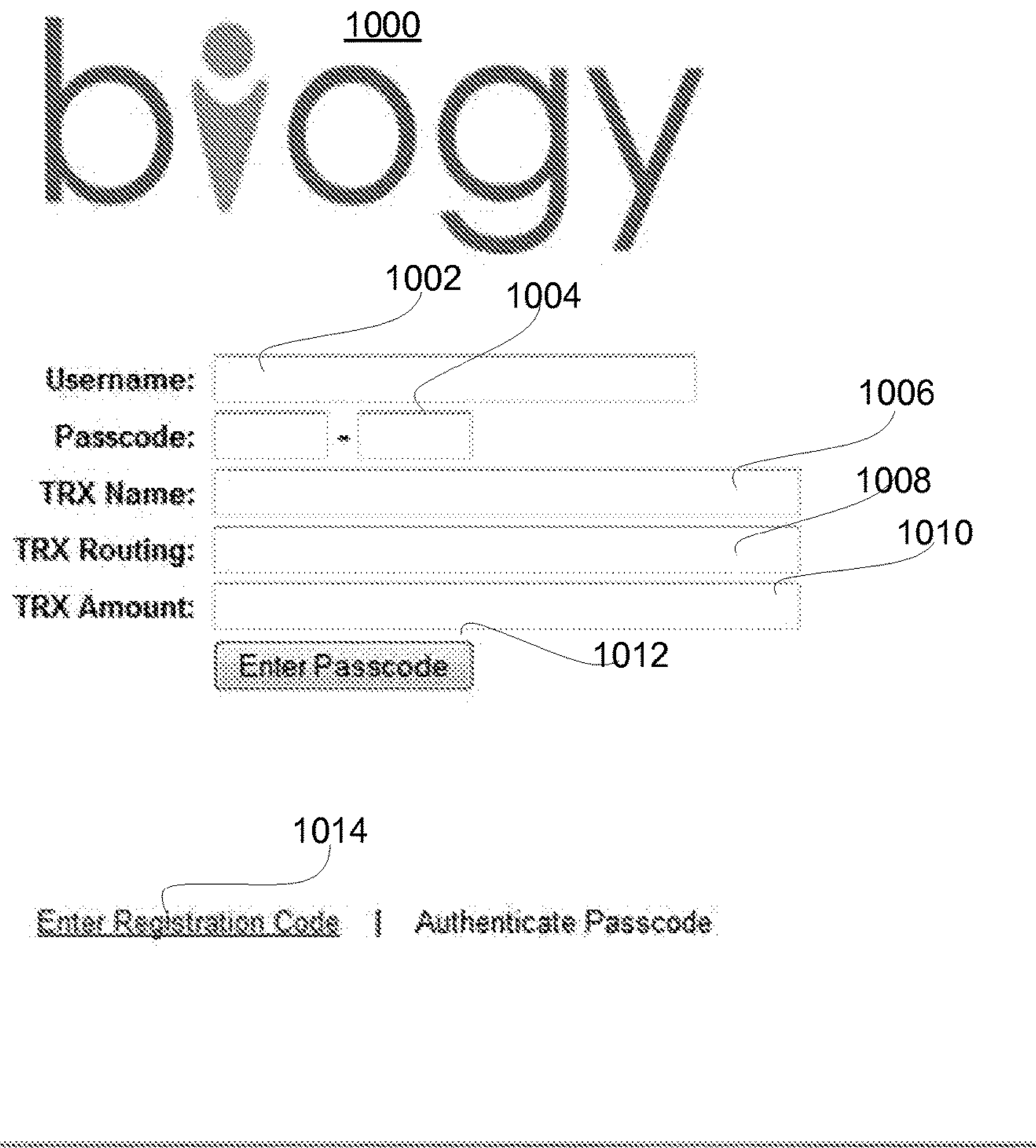

1000
1002
1004
Username:
Passcode:
1006
TRX Name:
1008
TRX Routing:
1010
TRX Amount:
Enter Passcode
1012
1014
Enter Registration Code | Authenticate Passcode

FIG. 10

SECURING BLOCKCHAIN TRANSACTIONS AGAINST CYBERATTACKS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Patent Application 61/574,752 entitled, SECURING TRANSACTIONS AGAINST CYBERATTACKS, by Michael Stephen Fiske, filed Aug. 9, 2011, the entire contents of which are incorporated herein by reference; this application claims the benefit of U.S. Provisional Patent Application 61/626,485 entitled, SECURING FINANCIAL TRANSACTIONS AGAINST CYBERATTACKS, by Michael Stephen Fiske, filed Sep. 25, 2011, the entire contents of which are incorporated herein by reference. This claims the benefit of U.S. Provisional Patent Application 61/659,376 entitled, SECURING FINANCIAL TRANSACTIONS AGAINST CYBERATTACKS, by Michael Stephen Fiske, filed Jun. 13, 2012, the entire contents of which are incorporated herein by reference. This application is a continuation-in-part of U.S. patent application Ser. No. 13/541,733 entitled, SECURING FINANCIAL TRANSACTIONS AGAINST CYBERATTACKS, filed Jul. 4, 2012; the entire contents of U.S. patent application Ser. No. 13/541,733 are incorporated herein by reference.

FIELD OF THE INVENTION

[0002] This specification relates to computer security.

BACKGROUND

[0003] The subject matter discussed in the background section should not be assumed to be prior art merely as a result of its mention in the background section. Similarly, a problem mentioned in the background section or associated with the subject matter of the background section should not be assumed to have been previously recognized in the prior art. The subject matter in the background section merely represents different approaches, which in and of themselves may also be inventions. A shortcoming in the prior art, recognized by this specification, is that there is a lack of a secure integration of the identity of the user to the protection of the user's data and the control of the user's wallet. A critical part of the computer instructions for an action or a transaction are usually executed on the host domain machine (e.g., the user's wallet). Some examples of the user's wallet are a Mac Book Pro, a Dell desktop computer, an IPhone, a Blackberry or an Android phone. Currently cryptography keys are stored on the user's wallet or a chip executing the operating system, which is not secure. For example, when Bob's computer communicates with Mary's computer, even when using well-implemented Public Key Infrastructure (PKI), Bob's computer can only be sure that it is communicating with Mary's computer. Bob can not be sure that he is communicating with Mary and vice versa. Similarly, even Bob cannot be certain that the communications he sends Mary the same as the communications that Mary receives as coming from him.

[0004] Sending a secure communication using Public Key Infrastructure (PKI) from one user machine to another user machine ensures communication between the user machines, but may not ensure secure communication between the users of the machines. Continuing, with the above example, as a result of the use of a Public Key Infrastructure, although Mary may be reasonably sure that Mary's machine is communicating with Bob's machine, Boris may be operating one or more computers in Russia and may have remotely broken into Bob's computer and may be using Bob's machine and pretending to be Bob.

[0005] In the prior art, each computer cannot be assured of who controls the other computer. For example, even when a user is present, an intruder (e.g., a hacker) may be physically located thousands of miles away, but is remotely logged onto the user's machine and hijacking the user's intended action (s). Even the Trusted Platform Module (TPM) has the fundamental cyber security weakness of not knowing who controls the other computer with which a user may be in communication with or who controls the computer which contains the Trusted Platform Module. Not knowing the other computer with which a current computer is in communication with may be a weakness that is significant when the operating system can directly access the TPM. If the user's wallet is compromised, then the attacker can access the TPM. Another limitation and weakness of the TPM is that there is no mechanism for binding the identity of the user to the user's cryptography keys and other confidential information that should be bound to the user's true identity.

[0006] Another shortcoming of cyber security is that a secure link is missing between the authentication of a valid user, and the authorization of an action. The authorization of an action could be the execution of a financial transaction from a user's bitcoin account, a stock trade in a user's brokerage account, the execution of an important functionality on the electrical grid, or access to important data on a private network such as SIPRnet (e.g. WikiLeaks). The authorization of an action typically occurs through the web browser since the web browser presents a convenient interface for a person. However, the web browser is where the important connection between authentication of a user and authorization of an action may be broken. Existing systems have the user authenticating the user's wallet, and then the same user's wallet also authorizes (and may also execute) the action. Since the user's wallet can be hacked, the lack of a secure and direct link between authenticating the user's wallet and authorizing the action may render the act of user verification irrelevant.

[0007] Part of the vulnerability between authenticating the user and authorizing the user's action occurs, because authentication (e.g., biometric authentication) is typically and naively represented as an on/off switch. That is, after the user has been authenticated and the initial transaction approved, the remainder of the session is assumed to be secure and all actions after authentication are assumed to be legitimate, without performing any further checks. In the same way, if this on/off implementation occurs in an untrusted computing environment, then outstanding biometric algorithms and sensor(s) become irrelevant because the biometric authentication can be circumvented between the user authentication and the authorization or confidentiality part of the security system.

[0008] The use of biometrics can be advantageous for security, because biometrics offers a reliable method for verifying who (the person) is that is actually initiating a transaction. However, even with the use of biometrics, if the handling of the biometric information, the storage of the biometric data, or the control of actions based on a biometric verification is done on an unsecured user's wallet, the value of the biometrics may be greatly reduced or nullified.

[0009] An additional aspect of the weakness of current authentication and authorization processes (such as those using biometrics) is that the action can be hijacked by executing a Trojan attack on the user's wallet, for example. A Trojan attack is an attack in which the attacker pretends to be the user and/or the other system to which the user is communicating with. In other words, a valid, authorized user cannot verify that the action he or she is trying to execute is what is actually being executed, because a third party may be masquerading as the other system.

[0010] An example of this weakness is the untrusted browser attack used to divert money from a user's bank account. Mary's web browser may display to her that she is about to send $500 to Bob's account, but in reality her untrusted browser is configured to send $50,000 to a thief's bank account.

[0011] Since the web browser is executed on the user's wallet, the browser cannot be trusted even when using PKI and one-time passcodes! A recent untrusted browser attack on the gold standard of security, RSA SecurID, demonstrates this surprising fact. The consequences of this particular cyberattack were that $447,000 was stolen from a company bank account in a matter of minutes, even though the valid user was using one-time passcodes to make the transaction more secure. The details of this cyberattack are quoted below in a MIT Technology Review, entitled "Real-Time Hackers Foil Two-Factor Security," Sep. 18, 2009, which states, "In mid-July, an account manager at Ferma, a construction firm in Mountain View, Calif., logged into the company's bank account to pay bills, using a one-time password to make the transactions more secure. Yet the manager's computer had a hitchhiker. A forensic analysis performed later would reveal that an earlier visit to another website had allowed a malicious program to invade his computer. While the manager issued legitimate payments, the program initiated 27 transactions to various bank accounts, siphoning off $447,000 in a matter of minutes. "They not only got into my system here, they were able to ascertain how much they could draw, so they drew the limit," says Roy Ferrari, Ferma's president. The theft happened despite Ferma's use of a one-time password, a six-digit code issued by a small electronic device every 30 or 60 seconds. Online thieves have adapted to this additional security by creating special programs--real-time Trojan horses—that can issue transactions to a bank while the account holder is online, turning the one-time password into a weak link in the financial security chain. "I think it's a broken model," Ferrari says. Security experts say that banks and consumers alike need to adapt—that banks should offer their account holders more security and consumers should take more steps to stay secure, especially protecting the computers they use for financial transactions. 'We have to fundamentally rethink how customers interact with their banks online,' says Joe Stewart, director of malware research for security firm SecureWorks, in Atlanta, Ga. 'Putting all the issues with the technology aside, if [attackers] can run their code on your system, they can do anything you can do on your computer. They can become you."

[0012] In a more recent example, the Bitcoin exchange Mt. Gox was hacked and Mt. Gox users lost hundreds of millions of dollars of bitcoins. The user's wallets did not have a secure area for the private keys and conduction of bitcoin transactions.

[0013] A third fundamental shortcoming of current cybersecurity solutions is the fact that static authentication factors, such as passwords, PINs and biometrics, are entered directly into the user's wallet or stored on computers that can be accessed in the network domain. The host domain and network are untrusted environments. This weakness makes static authentication factors vulnerable to phishing attacks in the host domain or security breaches in the network domain. Furthermore, some biometric factors are immutable, and if an immutable biometric factor is compromised, then the reuse of the compromised biometric factor reduces the security of the system.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] In the following drawings like reference numbers are used to refer to like elements. Although the following figures depict various examples, the one or more implementations are not limited to the examples depicted in the figures.

[0015] FIG. **1**A shows a block diagram of an embodiment of a system for secure transactions where the transactions are stored publicly and distributed across a blockchain network;

[0016] FIG. **1**B shows a memory system that is a component of the system shown in **1**A.

[0017] FIG. **2**A shows a block diagram of an embodiment of a service provider system;

[0018] FIG. **2**B shows memory system that is a component of the system in FIG. **2**A.

[0019] FIG. **3**A shows a flow diagram of an embodiment of a user-side method of setting up a system before starting a secure transaction;

[0020] FIG. **3**B shows a flow diagram of an embodiment of a service provider-side method of setting up a system before starting a secure transaction; FIG. **3**C shows a flow diagram of an embodiment of a user-side method of initiating a secure transaction;

[0021] FIG. **3**D shows a flow diagram of an embodiment of user-side method or user wallet initiating a blockchain transaction;

[0022] FIG. **4** shows a flow diagram of an embodiment of a service provider-side method of authenticating the user and requesting authentication;

[0023] FIG. **5** shows a flow diagram of an embodiment of a user system-side method of authenticating the service provider and requesting completion of the transaction;

[0024] FIG. **6** shows a flow diagram of an embodiment of a service provider system-side method of completing the transaction;

[0025] FIG. **7** shows a diagram of an embodiment of a browser with the recipient information being entered into the web browser;

[0026] FIG. **8** shows an embodiment of a display screen that may use an LCD;

[0027] FIG. **9** shows a screenshot of an embodiment of user interface for entering the registration code of a user;

[0028] FIG. **10** shows an example of a user interface for performing a secure transaction.

DETAILED DESCRIPTION

[0029] Although the issues discussed in the background or elsewhere may have motivated some of the subject matter disclosed below, nonetheless, the embodiments disclosed below do not necessarily solve all of the problems associated with the subject matter discussed in the background or elsewhere. Some embodiments only address one of the problems, and some embodiments do not solve any of the problems associated with the subject matter discussed in the background or elsewhere. In general, the word "embodiment" is used to specify an optional feature and/or configuration.

[0030] Security solutions are provided for secure transactions against untrusted browser attacks and other cyberattacks. In some embodiments, the solution(s) described in the specification secure payment transactions. In some embodiments, they secure blockchain transactions. In other embodiments, the solution(s) may secure access and use of private networks such as Secret Internet Protocol Router Network (SIPRnet) or resources on a public infrastructure such as the electrical grid.

The System

[0031] FIG. **1**A shows an embodiment of a system **100** for providing secure transactions. In an embodiment, system **100** may include user system **101**, and user system **101** may include secure area **102**, secure memory system **104**, secure processor system **106**, output system **108**, input system **110**, sensor **111**, communication system **112**, memory system **114**, processor system **116**, input/output system **118**, operating system **120**, and network interface **122**. System **100** may also include network **124** and service provider system **126**. In other embodiments, system **100** may not have all of the elements or features listed and/or may have other elements or features instead of, or in addition to, those listed.

[0032] System **100** is a system within which a secure transaction takes place (FIGS. **1**A-**3**B discuss various details of system **100** and FIGS. **3**C-**6** discuss various methods for using system **100**). In this specification the word system refers to any device or system of devices that communicate with one another. User system **101** is one that has a secure area that is dedicated for performing secure transactions over a network. User system **101** may be a single device or a combination of multiple devices. User system **101** may be a portable device, personal computer, laptop, tablet computer, handheld computer, mobile phone, or other network system, for example (in this specification a network system is any device or system that is capable of sending and/or receiving communications via a network). In an embodiment, a secure area **102** may be provided for performing secure transactions. In this specification, authentication information references to any form of information used for authenticating a user. In an embodiment, within secure area **102**, authentication information, such as a biometric authentication and/or another form of authentication is bound to the authorization of an action. In other words, the authentication information is in some way combined with the information for performing the action, such as by being concatenated together and then applying a hash function to the result of the concatenation. In this specification, the words "action" and "transaction" may be switched one with another to obtain different embodiments. Throughout this specification, when ever information is disclosed as being combined, the information may be concatenated, added together (e.g., in a binary addition of the binary values of information), be different inputs to the same function, and/or combined in another manner.

[0033] A hash function, denoted by Φ, is a function that accepts as its input argument an arbitrarily long string of bits (or bytes) and produces a fixed-size output. In other words, a hash function maps a variable length message m to a fixed-sized output, $\Phi(m)$. Typical output sizes range from 160 bits, 256 bits, 512 bits, or can also be substantially larger.

[0034] An ideal hash function is a function Φ whose output is uniformly distributed in the following way: Suppose the output size of Φ is n bits. If the message m is chosen randomly, then for each of the 2^n possible outputs z, the probability that $\Phi(m)=z$ is 2^{-n}. In an embodiment, the hash functions that are used are one-way. A one-way function Φ has the property that given an output value z, it is computationally extremely difficult to find a message m_z such that $\Phi(m_z)=z$. In other words, a one-way function Φ is a function that can be easily computed, but that its inverse Φ^{-1} is extremely difficult to compute. Other types of one way functions may be used in place of a hash function.

[0035] Any of a number of hash functions may be used. In an embodiment, hash functions that conform with the standard SHA-256, which produces output values of 256 bits, and SHA-512, which produces output values of 512 bits, [NIST_STANDARDS_2001]. A hash function could be one of the SHA-3 candidates: an embodiment of a hash function is BLAKE; another embodiment of a hash function is Grøstl; another embodiment of a hash function is JH; another embodiment of a hash function is Keccak; another example of a hash function is Skein.

[0036] In an embodiment, secure area **102** may have its own secure processor system and secure memory system, which are not accessible by the rest of user system **101**. Secure area **102** may be capable of taking over and/or blocking access to other parts of user system **101**.

[0037] Secure memory system **104** may be a dedicated memory for securing transactions. In an embodiment, secure memory system **104** may not be accessed by the other processor systems of user system **101**. Memory system **104** may include, for example, any one of, some of, any combination of, or all of a long-term storage system, such as a hard drive; a short-term storage system, such as random access memory; a removable storage system, such as a floppy drive or a removable drive; and/or flash memory. Memory system **104** may include one or more machine-readable mediums that may store a variety of different types of information. Secure memory system **104** may store methods and information needed to perform the secure transaction, such as a method for generating a passcode generator, user information, a method of generating a registration code generator, and encryption/decryption code. Secure memory system **104** may include one or more memory units that each write and/or read to one or more machine readable media. The term machine-readable medium is used to refer to any non-transient medium capable carrying information that is readable by a machine. One example of a machine-readable medium is a computer-readable medium. Another example of a machine-readable medium is paper having holes that are detected that trigger different mechanical, electrical, and/or logic responses. The content of secure memory **104** is discussed further in FIG. **1**B, below.

[0038] Secure processor system **106** may include one or more processors. Processor system **116** may include any one of, some of, any combination of, or all of multiple parallel processors, a single processor, a system of processors having one or more central processors and/or one or more specialized processors dedicated to specific tasks. Processor system **116** implements the machine instructions stored in memory **114**. Secure processor system **106** may include one or more processors that cannot be accessed by the main processor of the user system **101**. For example, in an embodiment all of the processors of secure processor system **106** cannot be accessed by the main processor of system **101**. In an embodiment, the operating system of user system **101** may have no access to secure area **102**, and in an embodiment, secure area **102** may be programmed without benefit of an operating system, so that there is no standard manner of programming secure area **102**, which thwarts hackers from sending read and/or write commands (or any other commands) to secure area **102**, because secure area does not use standard read and write commands (and does not use any other standard commands). As a consequence, providing secure area **102** addresses the weakness of biometric authentication and other authentication methods. Secure memory system **104** may store a transaction passcode generator (which will be described later in conjunction with FIG. **3**A).

[0039] Output system **108** may include any one of, some of, any combination of, or all of a monitor system, a handheld display system, a printer system, a speaker system, a connection or interface system to a sound system, an interface system to peripheral devices and/or a connection and/or interface system to a computer system, intranet, and/or internet, for example. In an embodiment, secure processor system **106** may be capable of taking over and using any portion of and/or all of output system **108**. In an embodiment, a portion of the output system may be a dedicated display system that may be accessed only by secure area **102**. In an embodiment, secure processor **106** may be capable of receiving input from input system **110** and/or blocking access to output system **108** by the main processor system and/or other devices.

[0040] Input system **110** may include any one of, some of, any combination of, or all of a biometric sensor **111**, a keyboard system, a touch sensitive screen, a tablet pen, a stylus, a mouse system, a track ball system, a track pad system, buttons on a handheld system, character entry such as letters and numbers a scanner system, a microphone system, a connection to a sound system, and/or a connection and/or interface system to a computer system, intranet, and/or internet (e.g. IrDA, USB). In an embodiment, character entry may be performed on a touch sensitive screen such as an IPhone, IPad or Android phone. In an embodiment, biometric sensor **111** may be a finger print scanner or a retinal scanner. In an embodiment, user system **101** stores the processed data from user information **104**B during registration. In an embodiment user system **101** retrieves user information **104**B and compares the scanned output of sensor **111** to user information **104**B to authenticate a user. In an embodiment secure processor **106** may be capable of receiving input from input system **110** and/or blocking access to input system **110** by the main processor system and/or other devices.

[0041] Communication system **112** communicatively links output system **108**, input system **110**, memory system **114**, processor system **116**, and/or input/output system **118** to each other. Communications system **112** may include any one of, some of, any combination of, or all of electrical cables, fiber optic cables, and/or means of sending signals through air or water (e.g. wireless communications), or the like. Some examples of means of sending signals through air and/or water include systems for transmitting electromagnetic waves such as infrared and/or radio waves and/or systems for sending sound waves.

[0042] Memory system **114** may include, for example, any one of, some of, any combination of, or all of a long-term storage system, such as a hard drive; a short-term storage system, such as random access memory; a removable storage system, such as a floppy drive or a removable drive; and/or flash memory. Memory system **114** may include one or more machine-readable mediums that may store a variety of different types of information. Memory system **114** and memory system **104** may use the same type memory units and/or machine readable media. Memory system **114** may also store the operating system of user system **101** and/or a web browser (which may also be referred to as an HTTP client). In embodiment, memory system **114** may also store instructions for input system **110** to read in biometric data and send the biometric data to secure area **102**.

[0043] Processor system **116** may include one or more processors. Processor system **116** may include any one of, some of, any combination of, or all of multiple parallel processors, a single processor, a system of processors having one or more central processors and/or one or more specialized processors dedicated to specific tasks. Processor system **116** implements the machine instructions stored in memory **114**. In an embodiment, processor **116** does not have access to secure area **102**.

[0044] In an alternative embodiment, processor **116** only communicates to secure area **102** when secure area **102** authorizes processor **116** to communicate with secure area **102**. Secure area **102** may prevent processor **116** from communicating to secure **102** during the secure area's execution of critical operations such as setup, generation of keys, registration code, biometric authentication or decryption of transaction information.

[0045] Input/output system **118** may include devices that have the dual function as input and output devices. For example, input/output system **118** may include one or more touch sensitive screens, which display an image and therefore are an output device and accept input when the screens are pressed by a finger or stylus, for example. The touch sensitive screen may be sensitive to heat and/or pressure. One or more of the input/output devices may be sensitive to a voltage or current produced by a stylus, for example. Input/output system **118** is optional, and may be used in addition to or in place of output system **108** and/or input device **110**. In an embodiment, a portion of the input/output system **118** may be dedicated to secure transactions providing access only to secure area **102**. In an embodiment, secure processor **106** may be capable of receiving/sending input/output from/via input system **110** and/or blocking access to input system **110** by the main processor system and/or other devices. Restricting access to a portion of and/or all of the input/output system **118** denies access to third party systems trying to hijack the secure transaction.

[0046] Operating system **120** may be a set of machine instructions, stored in memory system **110**, to manage output system **108**, input system **110**, memory system **114**, input/output system **118** and processor system **116**. Operating system **120** may not have access to secure area **102**. Network interface **122** may be an interface that connects user system **101** with the block chain network **124**. Network interface **122** may be part of input/output system **118**.

[0047] Blockchain network **124** may be any network and/or combination of networks of devices that communicate with one another (e.g., and combination of the Internet, telephone networks, and/or mobile phone networks) in a peer-to-peer decentralized architecture, storing all transactions publicly using a blockchain. Blockchain network **124** may make up service provider system **126** (which will be discussed further in conjunction with FIG. **2**A) which records and validates the transactions. The recipient of the transaction may be the final recipient or an intermediary recipient of transactions. In some embodiments, the recipient is anonymous except for their address which is at least partly comprised of a public cryptographic key. In an embodiment, the public key cryptography is based on elliptic curves.

[0048] Service provider system **126** may be a financial institution or a recipient of a secure transaction. User system **101** may interact with any of a variety of service provider systems, such as service provider system **126**, via a network **124**, using a network interface **122**. Service provider system **126** may be a system of one or more computers or another electronic device, and may be operated by a person that grants a particular user access to its resources or enables a particular event (e.g., a financial transaction, a stock trade, or landing a plane at an airport, and so on).

[0049] Methods for securing transactions are disclosed in this specification, which may be implemented using system **100**. A financial transaction may be an instance or embodiment of a blockchain transaction. Further, a stock trade is one embodiment of a financial transaction; a bank wire transfer is an embodiment of a financial transaction and an online credit card payment is an embodiment of a financial transaction. Any operation(s) that runs in a trusted environment, which may be secure area **102** may be treated as a secure transaction. In an embodiment, every secure transaction may include one or more atomic operations and the use of the word transaction is generic to both financial transactions and operations including atomic operations unless stated otherwise. In this specification, the word transactions is also generic to an individual or indivisible set of operations that must succeed or fail atomically (i.e., as a complete unit that cannot remain in an intermediate state). Operations that require security may include operations that make use of, or rely on, the confidentiality, integrity, authenticity, authority, and/or accountability of a system should be executed in a trusted environment (e.g., in a secure area, such as secure area **102**). Types of operations that require security may be treated as secure transactions. Further, a successful transaction other than logging information alters a system (e.g., of service provider **126**) from one known, good state to another, while a failed transaction does not. To be sure that a transaction results in a change of state only when the transaction is successful—particularly in systems that handle simultaneous actions—rollbacks, rollforwards, and deadlock handling mechanisms may be employed to assure atomicity and system state integrity, so that if there is an error in the transaction, the transaction does not take effect or does not cause an unacceptable state to occur.

[0050] In at least one embodiment, a secure transaction assures the following properties:

[0051] A. Availability: Having timely and reliable access to a transactional resource.

[0052] B. Confidentiality: Ensuring that transactional information is accessible only to those authorized to use the transactional information.

[0053] C. Integrity: Ensuring that transactional information is protected from unauthorized modification.

[0054] D. Authentication: Ensuring that transactional resources and users accessing the transactional resources are correctly labeled (identified).

[0055] E. Authorization: Ensuring that only authorized users have access rights to transactional resources.

[0056] F. Accounting: Ensuring that a transaction cannot be repudiated. Any operation that handles or provides access to data deemed too sensitive for an untrusted environment (e.g., any private data) may be treated as a secure transaction to ensure that information leakage does not occur.

[0057] In at least one embodiment, a unique passcode is bound to, and depends upon, the transaction information. In an embodiment, each step of the transaction uses a different transaction passcode that is dependent on the transaction information and user verification information. In other words, in an embodiment, the passcode includes the transaction information. Furthermore, in at least one embodiment, if the transaction information has been altered relative to the transaction information initiated in the user's secure area **102**, then the unique passcode sent following the alteration will be invalid (an example, of a manner in which the transaction being altered is the dollar amount and account number of the recipient could be altered in an untrusted browser). Since an alteration of the transaction alters the passcode, the execution of the transaction would fail due to the incorrect unique passcode during that transaction step.

[0058] In addition, the secure transaction solution can be executed on a standalone portable device—e.g., a secure flash drive, portable token, or in a secure chip or a secure separate part of a chip, and the use of a standalone portable device makes it difficult for an attacker to gain access. In at least one embodiment, the secure chip or secure part of the chip may reside in a mobile phone. Some examples of a mobile phone are an Android phone, the iPhone and the Blackberry. In at least one embodiment, the secure chip or secure part of the chip may reside in a personal computer. In at least one embodiment involving a mobile phone or computer, the secure chip may be temporarily or permanently disconnected from the rest of the system so that the operating system **120** does not have access to critical information entered into and received (e.g., read or heard) from the secure area's user interface. In at least one embodiment, this critical information may be authentication information, biometric information, passwords, passcodes, passcode generators, PINS, other kinds of authentication factors, transaction information, and/or other user credentials.

[0059] In at least one embodiment in which user system **101** is a portable device, the portable device may have a user interface with one or more buttons or a navigation button, which may offer the user five choices (e.g., up, down, left, right, select). In at least one embodiment, the buttons or navigation button may be used to enter a PIN into the secure area. In at least one embodiment, the buttons or navigation buttons may be used to select one or more images stored in the secure area. In an embodiment, character entry of letters, numbers and other symbols may be performed on a touch sensitive screen: some devices that have touch sensitive screens are IPhones, IPads and Android smartphones. In at least one embodiment, the user interface may enable the user's wallet to enter transaction information directly to the secure area or secure part of the chip.

[0060] Portable embodiments of user system **101** enable users to execute secure transactions in remote places such as inside a jet, on a golf course, inside a moving automobile, from a hotel room, in a satellite, at a military gate, and/or other isolated places.

[0061] Although some embodiments of user system **101** below may be described using fingerprints as an example, other items or a combination of these items may be used for verifying the true identity of the person such as face prints, iris scans, finger veins, DNA, toe prints, palm prints, handprints, voice prints and/or footprints. Any place, the expression "biometric prints" occurs any of the above listed different specific types of biometrics may be substituted to get specific embodiments. In terms of what a person knows, the authentication items may be PINs, passwords, sequences, collections of images that are easy to remember, and/or even psychometrics. In an embodiment, the item used to verify the person may be any item that is unique. In an embodiment, the item(s) used to verify the person may be one or more items that as a combination are difficult to fabricate, guess, find by trial and error, and/or compute. In an embodiment, the item(s) used to verify the person are uniquely associated with this person. In an embodiment, the item used to verify the person has an unpredictable element. For example, in one instance, a transaction may require a fingerprint and the person selecting an apple image as user verification where the secure area indicates, via the user interface, to the user to choose their favorite food. In another instance at a later time, a transaction may require a fingerprint and the person selecting a correct image or collection of images from a display screen. Example images could be a picture or photo of an orange, a train, a specific pattern such as a peace sign or a diagram or a logo, a Mercedes, a house, a candle, or a pen. In at least one embodiment, the person may add his or her own images during registration, which are then used for user verification during the transaction. When images are a part of the user verification process, a display screen that is a part of the secure area **102** and/or controlled by secure area **102** is used.

[0062] In at least one embodiment, secure area **102** may be a specialized part of the chip (e.g., a microprocessor), where the operating system **120** and web browser software do not have access to this specialized part of the chip. In at least one embodiment, a specialized part of the chip may be able to turn off the operating system **120**'s access to presses of the buttons or finger presses of the screen of a mobile phone (or other computing device), preventing malware and key or screen logging software from intercepting a PIN, character entry of letters, numbers or other symbols or the selection of one or more images. In at least one embodiment, a specialized part of the chip may be able to temporarily disconnect the rest of the chip's access to the screen (e.g., by preventing the execution of the operating system **120** and web browser). In at least one embodiment, part of the display screen may be permanently disconnected from the part of the chip (e.g., from the microprocessor of the chip) that executes the operating system **120** and web browser. In at least one embodiment, a part of the chip may only have access to the biometric sensor, while the rest of the chip—executing the operating system **120** and web browser—is permanently disconnected from the biometric sensor.

[0063] At least one embodiment uses a secure device that produces unique passcodes from biometric prints that can be used as one-time passwords. For each acquired biometric print, the derived passcodes created from the biometric print and the transaction information for that particular transaction is unique.

[0064] Another embodiment includes a secure area, such as secure area **102**, that executes the biometric acquisition and storage of a registration code, passcode generator, seed, cryptography key(s) and other user credentials, which may be created from the biometric prints or created from unpredictable physical processes in secure area **102**, or created from a combination of the biometric prints and unpredictable processes In at least one embodiment, photons may be produced by the hardware as a part of the unpredictable process. In least one embodiment, the unpredictable process may be produced by a specialized circuit in the secure area.

[0065] In yet another embodiment of the invention, biometric prints and/or unpredictable information from unpredictable physical processs are used to generate a registration code in the secure area **102**. The secure area **102** may include embedded software. In at least one embodiment, the embedded software is on a chip with a physical barrier around the chip to hinder reverse engineering of the chip, and/or hinder access to passcode generators, keys, transaction information, and/or possibly other user credentials. The use of biometric prints to create one-time passcodes within a secure area may eliminate the use of static passwords that need to be memorized and need to be stored on the host computer or need to be stored on an insecure part of the chip executing the operating system **120** and web browser. The use of other biometric information entered into the secure area may eliminate a person entering a static password into an insecure part of the system.

[0066] By executing the fingerprint software or other type of biometric software on a secure embedded device, the fingerprints (or other biometric prints) are less susceptible to theft, the biometric prints are not transmitted to the insecure part of the system, nor is there any need to have encrypted templates of the biometric prints transmitted to an insecure device. Each of the above embodiments may be used separately from one another in combination with any of the other embodiments. All of the embodiments of this specification may be used together or separately.

Secure Area in a Device or a Chip

[0067] The secure area **102** may be part of user system **101** or a special part of the chip that is able to acquire biometric prints, store authentication information, and/or authenticate the newly acquired items. The authentication information may include templates of biometric prints, images, pins, and/or passwords. The secure area may also be a part of the device where critical transaction information may be entered or verified on a display that the secure area only has access to. In at least one embodiment, the host computer (domain) and the network have no access to the transaction information, no access to the keys, no access to biometrics, no access to passcode generators, and/or no access to other critical user credentials (the transaction information, the keys, the biometrics, passcode generators, and/or other critical user credentials may be the contained and processed by the secure area).

[0068] For a payment transaction, one item of transaction information may be the name of the person or entity sending the money. One item of transaction information may be the user's bitcoin address. Another item of transaction information may be the name of the person or entity receiving the money. Another item of transaction information, may be the date or time of day. Another item of transaction information may be the sending person's (or entity's) account number. Another item of transaction information may be the receiving person's (or entity's) bank account number (the sending person or entity is the person or entity that sends a message that is part of the transaction and the receiving person or entity is the person or entity that receives the message that is part of the transaction. Another item of transaction information may be the sending person's (or entity's) routing number. Another item of transaction information may be the receiving person's (or entity's) routing number. Another item of transaction information may be the amount of money that may be expressed in dollars, Euros, yen, francs, deutschmark, yuan or another currency.

[0069] During setup, one or more biometric prints may be acquired, and one or more unique registration codes and in at least one embodiment encryption keys may be generated from the one or more of the biometric prints (items) or generated from an unpredictable physical process or both. In at least one embodiment, the unpredictable physical process may come from a hardware chip or hardware circuit that uses photons as a part of the unpredictable process to create the encryption keys. During authentication, if the acquired biometric print is an acceptable match, then a sequence of transaction steps that make up the complete transaction may be initiated.

[0070] The software that secure area **102** executes may be embedded in secure memory **104**. In an embodiment, there is no operating system on the device or on secure area **102** of user system **101**. In an alternative embodiment, there is an operating system. The secure biometric print device has a number of components, which are described later. The security of the secure area **102** may be enhanced by any one of, any combination or of, or all of (1) the use of embedded software, (2) the lack of an operating system, and (3) the secure area being at least part of a self-contained device not connected to a computer or the internet. For example, the unit that includes the secure area may contain its own processor. In an embodiment, the secure area may not have any of these security enhancing features. The biometric sensor enables user system **101** to read biometric prints. The biometric sensor may include a fingerprint area sensor or a fingerprint sweep sensor, for example. In at least one embodiment, the biometric sensor may contain an optical sensor that may acquire one or more types of biometrics. In at least one embodiment, the biometric sensor may be a microphone or other kind of sensor that receives acoustic information, such as a person's voice. In at least one embodiment, the sensor may be a device that acquires DNA or RNA. In an embodiment, secure processor system **106** may execute the software instructions, such as acquiring a biometric print from the sensor, matching an acquired biometric print against a stored biometric print, sending communication and control commands to a display, and/or encrypting the registration code and transmitting the registration code to the blockchain network when the user and blockchain network are not in the same physical location. By including processor system **106** in secure area **102**, the security is enhanced, because the external processor is given fewer chances to inspect contents of secure area **102**. Alternatively, secure area **102** may store software instructions that are run by secure processor system **106**. Processor system **106** performs the biometric print acquisition, the encryption, and/or generation of the passcode. Alternatively, a specialized logic circuit is built that carries out the functions that the software causes the processors to perform, such as driving sensor **111** (which may be an acquisition unit, such as a biometric sensor).

[0071] Secure memory system **104** may contain non-volatile memory in addition to volatile memory. Non-volatile memory enables the device to permanently store information for generating passcodes, encryption keys, and passcode generators. In another embodiment, secure memory system **104** may include memory on secure processor system **106**. In another embodiment, the sensor or input system **110** and secure processor system **106** may be integrated into a single chip. Alternatively, in another embodiment, the sensor in input system **110** and secure processor system **106** may be two separate chips.

Content of Memory in Secure Area

[0072] FIG. **1**B shows an embodiment of a block diagram of the contents of memory system **104** of FIG. **1**A, Memory system **104** may include instructions **152**, which in turn may include a setup routine **154**, an authentication of user routine **156**, a secure transaction routine **158**, having an initial request routine **160**, a service provider authentication routine **162**, and a completion of transaction routine **164**. Instructions **154** (of memory **104**) may also include registration code generator **166**, drivers **168**, controller **169**, generate encryption key **170**, generate passcode generator **172**, perturb encryption key **174**, perturb passcode generator **175**, generate passcode **176**, hash functions **178**, perturbing functions **180**, and user interface **181**. Memory system **104** may also store data **182**, which may include biometric template T **184**, registration key R **186**, current encryption key K **188**, current passcode generator G **190**, and transaction information S **192**. In other embodiments, memory system **104** may not have all of the elements or features listed and/or may have other elements or features instead of, or in addition to, those listed.

[0073] Instructions **152** may include machine instructions implemented by processor **106**. Setup routine **154** is a routine that handles the setting up of the user system **101**, so that user system **101** may be used for performing secure transactions. Setup routine **104** may collect a new user's biometric print, and apply a hash function to the biometric print (and/or to other user information) to generate a registration key R. In at least one embodiment, there may be specialized hardware in the secure area to help create unpredictableness used for the generation of key(s), seed(s), and/or registration code(s). Alternatively, the registration code, seed, or key may be generated by applying the hash function to the raw biometric print data, for example. Similarly, setup routine **154** may apply a hash function to authentication information, such as a biometric print, to hardware noise produced by a phototransistor, and/or other user information or a combination of these to generate an initial encryption key. The setup routine **154** may also send the registration code and/or a public encryption key to the service provider system **126**. In another embodiment, the registration code R and/or the initial encryption key may be received from service provider **126**.

[0074] Authentication of user routine **156** may authenticate the user each time the user attempts to use user system **101**. For example, user system **101** may include a biometric sensor (e.g., as sensor **111**) that scans the user's biometric print, reduces the biometric print to a template, and matches the newly derived biometric template to a stored template (which was obtain by setup routine **154**). Then, if the stored template and the newly derived template match, the user is allowed to use user system **101**.

[0075] In an alternative embodiment, a biometric print acquired may be directly matched with a stored template. Alternatively or additionally, authentication of user routine **156** may require the user to enter a password. If the password received and the password stored match, the user is allowed to use user system **101**.

[0076] Secure transaction routine **158** is a routine that implements the secure transaction. The initial request routine **160** is a first phase of secure transaction routine **158**. One purpose of initial request routine **160** is to generate a passcode from a combination of the current passcode generator and transaction information. In some embodiments, the current passcode generator is implemented with the user's private key. The transaction information and the passcode are sent to the service provider. In an embodiment, the private encryption key is not changed each time. In an alternative embodiment, during initial request routine **160**, the passcode generator is perturbed and the encryption key is perturbed to obtain a new passcode generator and a new encryption key, respectively. In an embodiment, each passcode is generated from the same private encryption key or passcode generator. In an embodiment, the passcode is generated from the passcode generator after generating the prior passcode, which may be generated any time after generating the prior passcode and before generating the current passcode, such as just after generating the prior passcode or just before generating the current passcode. After initial request routine **160** sends the passcode and transaction information to service provider system **126**, secure transaction routine **158** waits for a reply, which will include a passcode that is dependent on the passcode generator and transaction information.

[0077] Service provider authentication routine **162** authenticates the information provided by the service provider. The transaction passcode sent by the service provider **126** to system **101** in reply to initial request **160** may be authenticated by service provider authentication routine **162** (throughout this specification, the word passcode and the phrase transaction may be substituted one for another to obtain different embodiments). If the service provider that sent the passcode is the wrong service provider, it is unlikely that the service provider will have the correct transaction information and the correct passcode generator, and consequently the passcode returned will be incorrect.

[0078] Completion of transaction routine **164** completes the portion of the transaction performed by system **101**. If the service provider is authenticated, completion of transaction routine **164** generates yet another passcode from the passcode generator and transaction information and sends the passcode to the service provider.

[0079] Registration code generator **166** may be an algorithm for generating a registration code from biometric data, unpredictableness generated by an unpredictable process in the hardware in the secure area of the chip, and/or other information. Instructions **154** (of memory system **104**) may also include registration code generator **166**. Drivers **168** may include drivers for controlling input and output devices, such as the keyboard, a monitor, a pointing device (e.g., a mouse and/or a touch pad), a biometric print sensor (for collecting biometric prints). Controller **169** may include one or more machine instructions for taking control of the keypad, monitor and/or network interface, so the transaction may be performed securely, without fear of the processor system **116** compromising security as a result of being taken over by malware sent from another machine.

[0080] Generate encryption key **170** are machine instructions that generate a new private encryption key (e.g., by applying a function) and public encryption key pair. In at least one embodiment, the private encryption key is not updated after the initial step. Generate passcode generator **172** may include machine instructions that generate a new passcode generator from a prior passcode generator. In other words, generate passcode generator **172** may be an algorithm for generating a passcode generator from previous passcode generator. Generate passcode generator **172** may combine (e.g., concatenate) the prior passcode generator with current transaction information and apply a one-way function (e.g., a one-way hash) to the combination or may perturb the prior passcode generator. Perturb encryption key **174** perturbs the current encryption key to thereby generate the next encryption key. Perturb passcode generator **175** perturbs the current passcode generator to thereby generate the next passcode generator. The perturbing function could apply a one-way function to the passcode generator and other information. Generate passcode **176** generates a new passcode. Generate passcode **176** may generate the passcode by applying a hash function to a combination of (e.g., a concatenation of) the passcode generator and transaction information.

[0081] Hash functions **178** may use one or more one-way functions, which may be used by generate registration code **166** for generating a registration from a biometric print and/or other user information. Alternatively or additionally, hash functions **178** may use a one-way function, which may be used by generate passcode **176** for generating a new passcode from the combination of a passcode generator and transaction information. Optionally, hash functions **178** may include a different function for generate registration code **166** and generate passcode **176**. Those hash function(s) of hash functions **178** that are used by initial request **160**, authentication of service provider routine **162**, and completion of transaction routine **164** may be the same as one another or different from one another.

[0082] Perturbing functions **180** may include one or more perturbing functions, which may be used by perturb encryption key **174** and perturb passcode generator **175** generate passcode generator **176**. The perturbing functions in perturbing functions **180** used by perturb encryption key **174** and perturb passcode generator **176** may be the same or different from one another. Different perturbing functions of perturbing functions **180** may be used during each initial request **160**, authentication of service provider routine **162**, and/or completion of transaction routine **164**. Although perturbing functions **180** and hash functions **178** are indicated as separate storage areas in perturb encryption key **174** and perturb passcode generator **175**, the perturbing functions may just be stored as part of the code for perturb encryption key **174** and perturb passcode generator **175**. In this specification anytime a hash function is mentioned or a perturbing function is mentioned any other function may be substituted (e.g., any perturbing function may be replaced with a hash function and any hash function may be replaced with a perturbing function) to obtain another embodiment. Optionally, any perturbing function and/or hash function mentioned in this specification may be a one way function.

[0083] User interface **181** provides a page, or another method of displaying and entering information so that the user interface may provide the following functionalities, labeled with the letters A-F.

[0084] A. The user may view the transaction information being sent. B. The user may enter instructions for sending transaction information. C. The user may receive information about whether or not the biometric print was acceptable. D. The user may determine whether it is necessary to enter another biometric print or another type of user authentication such as a PIN or a sequence of images known by the user. E. The user may determine the current state in the transaction process. F. The user may read or enter directions for the next step in the transaction process.

[0085] Data **182** may include any data that is needed for implementing any of the routines stored in memory **104**. Biometric template T **184** may include templates, such as minutiae and/or other information characterizing biometric prints of users, which may be used to authenticate the user each time the user would like to use secure area **102** and/or system **101**. Registration key R **186** may be generated by applying a hash function to biometric print(s) and/or information derived from an unpredictable physical process, and may be used for generating passcode generators by perturbing the registration code or applying a hash code to the registration code. In one embodiment, the unpredictable physical process may use one or more phototransistors, each of which senses photons.

[0086] Current encryption key K **188** is the current encryption key, which may be stored long enough for the next encryption key to be generated from the current encryption key. Similarly, current passcode generator G **190** may stored long enough for generating the current passcode and the next passcode generator. The passcode generator is a value (e.g., a combination of various symbols and characters) that is combined with the transaction information, and a function may be applied to the combination to generate a passcode. Transaction information S **192** may include information about a transaction that the user would like to perform. Transaction information **190** may combined with the current passcode generator and to generate the current transaction passcode.

Service Provider System (Blockchain Network System)

[0087] FIG. **2**A shows a block diagram of an embodiment of a service provider system **200** in a system for securing transactions against cyber attacks. In an embodiment, service provider system **200** may include output system **202**, input system **204**, memory system **206**, processor system **208**, communication system **212**, and input/output system **214**. In other embodiments, the service provider system **200** may not have all the components and/or may have other embodiments in addition to or instead of the components listed above.

[0088] Service provider system **200** may be a financial institution or any other system such as a power plant, a power grid, or a nuclear plant or any other system requiring secure access. In an embodiment, service provider system **200** may be an embodiment of service provider system **126**. Any place in this specification where service provider **126** is mentioned service provider **200** may be substituted. Any place in this specification where service provider **200** is mentioned service provider **126** may be substituted. Service provider system **200** may include one or more webservers, applications servers, and/or databases, which may be part of a financial institution, for example.

[0089] Output system **202** may include any one of, some of, any combination of, or all of a monitor system, a handheld display system, a printer system, a speaker system, a connection or interface system to a sound system, an interface system to peripheral devices and/or a connection and/or interface system to a computer system, intranet, and/or internet, for example.

[0090] Input system **204** may include any one of, some of, any combination of, or all of a keyboard system, a touch sensitive screen, a tablet pen, a stylus, a mouse system, a track ball system, a track pad system, buttons on a handheld system, character entry of letters, numbers or other symbols on a touch sensitive screen, a scanner system, a microphone system, a connection to a sound system, and/or a connection and/or interface system to a computer system, intranet, and/or internet (e.g. IrDA, USB).

[0091] Memory system **206** may include may include, for example, any one of, some of, any combination of, or all of a long term storage system, such as a hard drive; a short term storage system, such as random access memory; a removable storage system, such as a floppy drive or a removable drive; and/or flash memory. Memory system **206** may include one or more machine-readable mediums that may store a variety of different types of information. The term machine-readable medium is used to refer to any medium capable carrying information that is readable by a machine. One example of a machine-readable medium is a computer-readable medium. Another example of a machine-readable medium is paper having holes that are detected that trigger different mechanical, electrical, and/or logic responses. Memory **206** may include encryption/decryption code, generate passcode generator, and algorithms for authenticating transaction information, for example (memory **206** is discussed further in conjunction with FIG. **2**B).

[0092] Processor system **208** executes the secure transactions on system **200**. Processor system **208** may include any one of, some of, any combination of, or all of multiple parallel processors, a single processor, a system of processors having one or more central processors and/or one or more specialized processors dedicated to specific tasks. In an embodiment, processor system **208** may include a network interface to connect system **200** to user system **101** via network **124**. In an embodiment, processor **208** may decrypt secure messages from user system **101** and/or encrypt messages sent to user system **101**.

[0093] Communication system **212** communicatively links output system **202**, input system **204**, memory system **206**, processor system **208**, and/or input/output system **214** to each other. Communications system **212** may include any one of, some of, any combination of, or all of electrical cables, fiber optic cables, and/or means of sending signals through air or water (e.g. wireless communications), or the like. Some examples of means of sending signals through air and/or water include systems for transmitting electromagnetic waves such as infrared and/or radio waves and/or systems for sending sound waves. In embodiment, memory system **206** may store instructions for system **200** to receive authenticated secure transaction information from user system **101**.

[0094] Input/output system **214** may include devices that have the dual function as input and output devices. For example, input/output system **214** may include one or more touch sensitive screens, which display an image and therefore are an output device and accept input when the screens are pressed by a finger or stylus, for example. The touch sensitive screen may be sensitive to heat and/or pressure. One or more of the input/output devices may be sensitive to a voltage or current produced by a stylus, for example. Input/output system **118** is optional, and may be used in addition to or in place of output system **202** and/or input device **204**.

[0095] FIG. 2B shows an embodiment of a block diagram of the contents of memory system **206** of FIG. 2A, Memory system **206** may include instructions **220**, which in turn may include a setup routine **222**, an authentication of user routine **224**, a request for authentication routine **226**, completion of transaction routine **228**, generate registration code **230**, generate encryption key **232**, generate passcode generator **234**, perturb encryption key **236**, perturb passcode generator **238**, generate passcode **240**, hash functions **242**, and perturbing functions **244**. Memory system **206** may also store data **245**, which may include registration code R **246**, current encryption key K **248**, current passcode generator G **250** , and transaction information S **252**. In other embodiments, memory system **206** may not have all of the elements or features listed and/or may have other elements or features instead of, or in addition to, those listed.

[0096] Setup routine **222** is a routine that handles the setting up of the service provider system **200**, so that service provider system **200** may be used for performing secure transactions. Setup routine **222** may receive a registration code from the user system, which in turn may be used for generating the initial passcode and/or initial encryption key.

[0097] In an alternative embodiment, the user may send the biometric print or template of the biometric print to service provider system **200**, and service provider system **200** may generate the registration code from the biometric print in the same manner that user system **101** generates the registration code from the template of the biometric print or from the biometric print and/or information obtained from an unpredictable physical process (e.g., by setup routine **222** applying a hash function to the biometric print and/or information derived from an unpredictable physical process).

[0098] In another embodiment, the user may visit the location of service provider, where the service provider may collect the biometric print or the user, which is used by service provider system **200** for creating the template of the biometric print, the registration code, and/or the initial encryption key. In this embodiment, user system **101** may obtain the biometric template, initial encryption key, and/or the registration code from service provider system **200** instead of the user system **101** collecting the biometric print, creating the biometric template, initial encryption key, and/or creating the registration code.

[0099] Authentication of user routine **224** may optionally receive and may process the initial request from initial request routine **160** of user system **101** to perform the transaction, which includes a passcode. Authentication of user routine **224** may decrypt the transaction information with the encryption key and generate the passcode from a combination of the current passcode generator and transaction information. If the passcode generated by service provider system **200** and the passcode received match from user system **101**, then the user has been authenticated. If the passcode received and the passcode generated do not match, the process is terminated, and optionally an error message is sent to user system **101**. During authentication of user routine **224**, the passcode generator is perturbed (stored at service provider system **200**) and the encryption key (stored at service provider system **200**) is perturbed to obtain a new passcode generator and a new encryption key, respectively, so that the passcode generator and encryption key used by service provide system **200** is the same as (or sted differently is synchronized with) the passcode generator and encryption key used by user system **101**. As with user system **101**, an embodiment, each passcode is generated from a different passcode generator. In an embodiment, the passcode is generated from the passcode generator generated after generating the prior passcode, which may be generated any time after generating the prior passcode and before generating the current passcode, such as just after generating the prior passcode or just before generating the current passcode, so long as the passcode generator and encryption key of the service provider system **200** is the same as used by user system **101** for creating the passcode being authenticated.

[0100] After authentication of user routine **224** authenticates the passcode sent from user system **101**, service provider system **200** needs to be authenticated by user system **101** (e.g., so that the user knows that the service provider is not an imposter and thereby protect against man-in-the-middle attacks). Authentication of service provider routine **226** creates a new passcode, which is sent to the user system **101** for authentication. As part of authentication of user routine **224**, service provider **200** perturbs the passcode generator, and applies a function (e.g., a one-way hash function) the combination of the passcode generator and the transaction information (which generates the new passcode). In order for service provider system **200** to be authenticated, both service provider system **200** and user system **101** generate the new passcode from the same passcode generator and transaction information, and since the passcode generator is indirectly derived from the biometric print and in some embodiments indirectly derived from an unpredictable physical process. Since the transaction information is likely to vary with every transaction, the passcode is likely to be hard to duplicate by someone posing as the user or service provider.

[0101] After sending the passcode for authenticating the service provider, service provider system **200** waits for a reply, including a new passcode and transaction information, to complete the transaction. Upon receipt of the passcode and an encrypted message, user authentication routine **224** again authenticates user system **101** by decrypting the encrypted message to obtain the new transaction information, perturbing the generating of the new passcode by applying a one way function to the combination of the passcode generator and the transaction information, and comparing the new passcode generated and the new passcode received. If the passcode is determined to be authentic, completion of transaction routine **228** completes the transaction using the transaction information sent from user system **101** by initial request routine **160** and/or completion of transaction routine **164**. The transaction information sent by initial request routine **160** and completion of transaction routine **164** may be the same or different. In an embodiment, the transaction information sent from user system **101** to service provider system **200** are not known in advance. In another embodiment, the transaction information used and/or sent during initial request routine **160** may be information that is already known by service provider system **200**, while the transaction information sent during transaction routine **164** (which is after user system **101** and service provider system **200** authenticated one another) may include some transaction information that was previously unknown to the service provider **200**. Initial request routine **160** may send a perturbation of a hash of an initial passcode and transaction information, to service provider system **200**, and secure transaction routine **158** may wait for a reply, which will include a passcode that is dependent on the passcode generator and transaction information.

[0102] Generate registration code **230** is optional and may be the same as generate registration code **166**. In an embodiment, both generate registration code **166** and **230** are present, and both user system **101** and service provider system **200** generate the registration code separately. Only one of generate registration code **230** and **166** is necessary, the registration code may be generated in one of user system **101** and service provider system **200**, and sent to the other of user system **101** and service provider system **166**, and in an embodiment of user system **101** and service provider system **166** does not generate the registration code.

[0103] Generate encryption key **232** are machine instructions that generate a new encryption key from (e.g., by applying a function, such as a perturbing function to) a prior encryption key. Generate encryption key **232** may be the same routine as generate encryption key **170** except that generate encryption key **232** is implemented at service provider **200** and generate encryption key **170** is implemented at user system **101**. Generate passcode generator **234**, which may be the same as generate passcode generator **172**, are machine instructions that generate a new passcode generator from a prior passcode generator. In other words, generate passcode generator **234** may be an algorithm for generating a passcode generator from previous passcode generator. Generate passcode generator **234** may combine (e.g., concatenate) the prior passcode generator with current transaction information and apply a one-way function (e.g., a one-way hash function) to the combination or may perturb the prior passcode generator. Perturb encryption key **236** may be the same as perturb encryption key **174**, and perturb encryption key **236** perturbs the current encryption key to thereby generate the next encryption key. Perturb passcode generator **238** may be the same as perturb encryption key **175**, and perturb passcode generator **238** perturbs the current passcode generator to thereby generate the next passcode generator. Generate passcode **240** may be the same as generate passcode **176**, and generate passcode **240** may generate a new passcode. Generate passcode **240** may generate the passcode by applying a hash function to a combination of (e.g., a concatenation of) the passcode generator and transaction information. Hash functions **242** may be the same as hash functions **178**. Hash functions **242** may be one a way functions, which may be used by generate registration code **230**. Hash functions **242** may be used to generate passcode **240**. Hash functions **242** may be used for generating a registration code from a biometric print and/or information from an unpredictable physical process and/or other user information. Hash functions **242** may be used for generating a new passcode from the combination of a prior passcode and transaction. Optionally, hash functions **242** may include a different function for generate registration code **230** and generate passcode **240**. Those hash function(s) of hash functions **242** that are used by authentication of user routine **224**, request for authentication routine **226**, and completion of transaction routine **228** may be the same as one another or different from one another. The perturbing functions in perturbing functions **244** used by perturb encryption key **236** and perturb passcode generator **238**, and may be the same or different from one another. Different perturbing functions of perturbing functions **244** may be used during each of authentication of user routine **224**, request for authentication routine **226**, and completion of transaction routine **228**. Although perturbing functions **244** and hash functions **242** are indicated as separate storage areas in from perturb encryption key **236** and perturb passcode generator **238**, the perturbing functions may just be stored as part of the code for perturb encryption key **236** and perturb passcode generator **238**.

[0104] Data **245** may include any data that is needed for implementing any of the routines stored in memory **206**. Registration key R **246** may be the same as registration code **186** and may be generated by applying a hash function to biometric print(s) and/or information from an unpredictable physical process, and may be used for generating passcode generators by perturbing the registration code or applying a hash code to the registration code.

[0105] Current encryption key K **248** may be the same as current encryption key **188**, and may be the current encryption key, which may be stored long enough for the next encryption key to be generated from the current encryption key. Similarly, current passcode generator G **250** may be the same as passcode generator G **190** and may stored long enough for generating the current passcode and the next passcode generator. The passcode generator is a value (e.g., a combination of various symbols and characters) that is combined with the transaction information, and a function may be applied to the combination to generate a passcode. Transaction information S **252** may be the same as transaction **192**, and may include information about a transaction that the user would like to perform. Transaction information S **252** may combined with the current passcode generator and to generate the current passcode. Transaction information S **252** may be received from user system **101** and may be used to perform a transaction at service provider system **200** on behalf of user system **101**.

[0106] FIGS. **3**A, **3**B, **3**C and **4**-**6** show methods for different parts of a secure transaction. The methods of FIGS. **3**A-**3**C and **4**-**6** may be implemented on system **100**.

Setup of User System or Wallet

[0107] FIG. **3**A shows a flowchart of an embodiment of method **300**A of setting up user system **101** for securing transactions against cyber attacks. User system method **300**A may be the setup performed by user system **101** before starting a secure transaction.

[0108] In step **302**, the biometric print information may be obtained from the user from a biometric sensor **111** in input system **110**. Method **300**A may also collect other setup information, such as a Personal Identification Number

(PIN), a password, and/or a sequence or collection of images that are easy to remember. The setup data that was collected may be denoted as a T.

[0109] In step **304**, a hash function Φ or any other one way method is applied on the biometric print information and other collected data T. A hash function Φ is applied to T, one or more times denoted as $\Phi^k(T)$, to create the registration code R which may be stored in secure area **102**. In other words, $R=\Phi^k(T)$. The registration code is a sequence of symbols. An example of a registration code with 16 symbols is "1Ae58GnZbk3T4pcQ". A registration code in hex format maybe used: "32DE0FA3908F100BBCEFFE3E4CB2382E376629E34A11478291A09B2A3DFFEF." A registration code with punctuation and other symbols may also be used. An example of a registration code with 32 symbols is "1!56hs#KUD3_4xP*7:y2iW=K;r.+4vN?". There is at least one unique registration code for each passcode generator. In at least one embodiment, more than one different hash function may be used so for example, SHA-512 may be applied to U one or more times and Keccak may be applied to W one or more times.

[0110] In step **306**, transaction passcode generator G is computed. For example, transaction passcode generator G may be generated by applying a hash function Φ to registration code R. In other words, G=Φ(R). In an embodiment, in step **306** transaction passcode generator G may be stored in secure memory system **104**. In this specification, passcode generator and transaction passcode generator may be used interchangeably. The transaction passcode generator G may be stored in secure memory system **104** and is a value (e.g., a number or sequence of symbols, such as alphanumeric characters) from which user system **101** may generate a one-time transaction passcode. For example, a one-way function may be applied to a combination of the transaction passcode generator G and transaction information to generate the one-time passcode. Each transaction code generator may be generated from a prior transaction passcode generator, by applying a function to the prior passcode generator. In an embodiment, both the user system **101** and service provider system **126** separately generate each transaction passcode generator G and each one-way passcode.

[0111] In an alternative embodiment, the application of hash function Φ in step **306** may be skipped and the registration code is stored as an initial passcode generator.

[0112] In step **308**, a cryptographic key K may be generated. In at least one embodiment, the biometric print information T is divided into two parts U,W. U may be used to generate the registration code R and W is used to help generate an encryption key K that the user's secure area and a valid blockchain network only have access to. Similarly, the registration code may be generated as $R=\Phi^k(U, I)$ and the encryption key may be generated as $K=\Phi^k(W, I)$ where I is information created from an unpredictable physical process. Alternatively, the registration R code may be generated from the biometric print, the initial transaction passcode generator may be generated from the registration code and each subsequent passcode generator may be generated from the prior transaction passcode generator. The transaction passcode generator may be used as the encryption key or may be generated by applying yet another one way function to the transaction passcode generator.

[0113] In step **310**, the registration code R generated in step **306** and the cryptographic key K generated in step **308** may be securely transferred to service provider system **126**. In an embodiment, the secure distribution of R and K may be performed by a Diffie-Hellman key exchange.

[0114] A Diffie-Hellman key exchange is a key exchange method where two parties (Alice and Bob) that have no prior knowledge of each other jointly establish a shared secret key over an unsecure communications channel. Before the Diffie-Hellman key exchange is described it is helpful to review the mathematical notion of a group. A group G is a set with a binary operation *, (g*g is denoted as g^2; g*g*g*g*g is denoted as g^5), such that the following four properties hold:

[0115] (i.) The binary operation * is closed on G. In other words, a*b lies in G for all elements a and b in G.

[0116] (ii.) The binary operation * is associative on G. a*(b*c)=(a*b)*c for all elements a, b, and c in G

[0117] (iii.) There is a unique identity element e in G. a*e=e*a=a.

[0118] (iv). Each element a in G has a unique inverse denoted as a^{-1}. $a*a^{-1}=a^{-1}*a=e$.

[0119] The integers {. . ., −2, −1, 0, 1, 2, . . .} with respect to the binary operation + are an example of an infinite group. 0 is the identity element. For example, the inverse of 5 is −5 and the inverse of −107 is 107.

[0120] The set of permutations on n elements {1, 2, . . . , n}, denoted as S_n, is an example of a finite group with n! elements where the binary operation is function composition. Each element of S_n is a function p:{1, 2, . . . , n}→{1, 2, . . . , n} that is 1 to 1 and onto. In this context, p is called a permutation The identity permutation e is the identity element in S_n, where e(k)=k for each k in {1, 2, . . . , n}.

[0121] If H is a non-empty subset of a group G and H is a group with respect to the binary group operation * of G, then H is called a subgroup of G. H is a proper subgroup of G if H is not equal to G (i.e., H is a proper subset of G). G is a cyclic group if G has no proper subgroups.

[0122] The integers modulo n (i.e., Z_n={[0], [1], . . . [n-1]} are an example of a finite group with respect to addition modulo n. If n=5, [4]+[4]=[3] in Z_5 because 5 divides (4+4)−3. Similarly, [3]+[4]=[3] in Z_5. Observe that Z_5 is a cyclic group because 5 is a prime number. When p is a prime number, Z_p is a cyclic group containing p elements {[0], [1], . . . [p-1]}. [1] is called a generating element for cyclic group Z since $[1]^m=[m]$ where m is a natural number such that 0<m<p and $[1]^p=[0]$. This multiplicative notation works as follows: $[1]^2=[1]+[1]$; $[1]^3=[1]+[1]+[1]$; and so on. This multiplicative notation (i.e. using superscripts) is used in the description of the Diffie-Hillman key exchange protocol described below.

[0123] There are an infinite number of cyclic groups and an infinite number of these cyclic groups are extremely large. The notion of extremely large means the following: if 2^{1024} is considered to be an extremely large number based on the computing power of current computers, then there are still an infinite number of finite cyclic groups with each cyclic group containing more than 2^{1024} elements.

[0124] Steps 1, 2, 3, 4, and 5 describe the Diffie-Hellman key exchange.

[0125] 1. Alice and Bob agree on an extremely large, finite, cyclic group G and a generating element g in G. (Alice and Bob sometimes agree on finite, cyclic group G and element g long before the rest of the key exchange protocol; g is assumed to be known by all attackers.) The group G is written multiplicatively as explained previously.

[0126] 2. Alice picks a random natural number a and sends g^a to Bob.

[0127] 3. Bob picks a random natural number b and sends g^b to Alice.

[0128] 4. Alice computes $(g^b)^a$.

[0129] 5. Bob computes $(g^a)^b$.

[0130] Both Alice and Bob are now in possession of the group element g^{ab}, which can serve as the shared secret key. The values of $(g^b)^a$ and $(g^a)^b$ are the same because g is an element of group G.

[0131] Alice can encrypt a message m, as mg^{ab}, and sends $mg^{ab}$to Bob. Bob knows |G|, b, and g^a. A result from group theory implies that the order of every element of a group divides the number of elements in the group, denoted as |G|. This means $x^{|G|}=1$ for all x in G where 1 is the identity element in G. Bob calculates $(g^a)^{|G|-b}=(g^{|G|})^a g^{-ab}=(g^{ab})^{-1}$. After Bob receives the encrypted message mg^{ab} from Alice, then Bob applies $(g^{ab})^{-1}$ and decrypts the encrypted message by computing $mg^{ab}\ (g^{ab})^{-1}=m$.

Embodiment Using Time (Implemented in System **100**): Setup

[0132] During setup, in the secure area **102**, biometric print information obtained from the user and in at least one embodiment unpredictable noise received from the hardware in the secure area **102** is passed to a one-way hash function Φ or another one way method. In one embodiment, the unpredictable noise may come from a physical process using one or more phototransistors or another type of hardware in the secure area of the chip in the wallet. In an embodiment, the unpredictable noise and/or biometric data is used by the user system **101** to a private K and in some embodiments to generate a separate seed s. Public key cryptography algorithms are executed on K to compute a public key P. In some embodiments, public cryptographic key P may computed with elliptic curve operations. Subsequently, P can be used to derive an address A that may be transmitted to the blockchain network. In at least one embodiment, the distribution and transmission of public cryptographic key P may implemented with elliptic curve cryptography for signing transactions and subsequent verification by block chain network **124**.

[0133] In an embodiment, the public key P or address A may be electronically transmitted to the blockchain network **124**—for example, using TCP/IP infrastructure. In at least one embodiment, the public key P or address A may be given to the blockchain network **124** in the same physical place, such as at a bank or financial exchange location, or it may be mailed or electronically transmitted to the blockchain network when setup is accomplished remotely. Throughout this specification the term blockchain network **124** and service provider **126** may be interchanged to obtain different embodiments and terms of use. Throughout this specification user system **101** and user wallet may be substituted one for another to obtain different embodiments except in discussion of the user interacting with user system **101**.

Setup (User Registration)

[0134] During setup, the user presents user information. Setup may request the user to present information that he or she knows. The information that the user knows may be a PIN, password, or a sequence or collection of images that are easy to remember. In an embodiment, the user information may be a PIN or password that is entered via a secure interface into the secure area of the user's wallet. In another embodiment, setup may request something that the user is and use a sensor to acquire his / her biometric attributes one or more times. These biometric attributes may be fingerprints, or a voice command or sentence or a face. In another embodiment, at the end of setup, the following steps are executed:

[0135] Step 1.) Biometric print information, unpredictable noise from hardware in the secure area and other items (e.g., images, PIN, password, etc.) obtained from the setup, denoted as user information T, are used to create a seed s. A hash function D is applied to user information T, one or more times denoted as $\Phi^k(T)$, to create the seed s. In other words, $s=\Phi^k(T)$. In at least one embodiment, user information T is divided into two parts U, W as described in the previous section and U is used to generate the seed and W is used to generate a private encryption key pair (K, P) , which the user's secure area and the blockchain network. Similarly, the private encryption key may be generated by applying the hash function one or more times to the other part of the user information W one or more times (which may be written as $K=\Phi^j(W)$). In at least one embodiment, more than one type of hash function may be used so for example, SHA-512 may be applied to one part of the user information U one or more times and Keccak may be applied to the other part of the user information W one or more times.

[0136] Step 2.) A hash function is applied to the public key P one or more times. That is, $\Phi^1((P)$ where k is greater than or equal to 1. The hash output $\Phi^k(P)$ may be truncated to an address A and this address is transmitted to the blockchain network.

[0137] Step 3.) To prevent massive thefts that occurred at Mt. Gox and others, there is an additional measure. A distinct transient private key Q can be dynamically generated in the secure area by combining the seed s and the user information entered into the secure area. In an embodiment, Q is computed as Φ^k (s, T) where the user information is never stored in the secure area. In another embodiment, Q is computed as Φ^k (s, Φ(T)). If the wallet is stolen or broken into remotely over the Internet, the hacker cannot capture Q because the private user information T is never stored in the secure area. Q is used to compute a distinct public key R, which is sent to the blockchain network.

Securely Executing a Transaction Using a Blockchain Network

[0138] When a transaction is requested by the person, after a valid biometric print match occurs or a valid verification of other user items such as password, PIN, or images at user system **101**, in at least one embodiment, there are transaction steps A, B, and C, which make up a successful transaction. Steps A, B, and C help prevent an untrusted browser attack or other cyberattack from compromising the transaction.

[0139] BLOCKCHAIN TRANSACTION. The person (user) securely enters transaction information into the secure area **102** of his device or wallet (e.g., user system **101**) and the transaction information is transmitted to the service provider **126**. In an embodiment, service provider **126** is performed in a decentralized peer to peer manner by blockchain network **124**. FIG. **3**D covers steps of a user system in a blockchain transaction.

[0140] A.1 In **370** of FIG. **3**D, the person selects and enters transaction information I into the secure area **102** of user system **101**.

[0141] A.2. In **372** of FIG. **3**D, the transaction seed s is retrieved or reconstructed from secure area **102** of user system **101**.

[0142] A.3 In **374** of FIG. **3**D, the current time t_1 is read.

[0143] A.4 In **376** of FIG. **3**D, the user system receives the private user information T into the secure area and transiently computes private key Q as described before and then signs the transaction information I with its private key Q.

[0144] In an embodiment, the current time t_1 is part of the transaction information. In another embodiment, the transaction information I and current time t_1 are distinct and concatenated and then the concatenation is signed with private key Q. The signing produces a one-time transaction passcode (signature) that the block chain network **124** can verify with public key R.

[0145] A.5 In **378** of FIG. **3**D, the user system sends the one-time transaction passcode (or signature produced by Q) and the transaction information I to blockchain network **124**.

[0146] A.6 In **380** of FIG. **3**D, the user system erases or deletes private key Q from its secure area.

[0147] In an embodiment, during a transaction, Q exists for less than 1 second. In another embodiment, Q exists for less than **10** milliseconds. In some embodiments, Q existing for less than a second is what it means to say that the private key Q is transient. The advantage of a transient nature Q is that it is never stored on the user system **101** and thus Mt. Gox types of cyberattacks on blockchain transactions will be hindered.

[0148] There are many different methods for transmitting the one-time transaction passcode and transaction information I to the service provider system **126**. In a one method, the user may transmit the passcode via a mobile phone to service provider system **126**. In a second method, the user may submit the passcode and transaction information to the web browser of user system **101** and use the Internet for transmission to service provider system **126**. In many other methods, the user may submit the transaction passcode (signature) and transaction information by some other electronic means, such as a fax machine or an ATM machine. In one method, the transaction passcode and transaction information may be displayed on the blockchain network, when the user is in the same physical location as the service provider system.

[0149] A.7 In **382** of FIG. **3**D, the blockchain network **124** attempts to verify the signed transaction information. If the verification of the one-time transaction passcode is successful and the miners verify that the user's crypto currency (bitcoin other cryptocurrency) has not been already spent, the blockchain network adds the user's transaction to the pending block which the miners will eventually add to the new block that is appended to the blockchain.

[0150] In at least one embodiment, the current time t_1 is determined and rounded to the nearest minute, for example. Optionally, the sender and receiver may compute the difference in time between the clock of the sender and the clock of the receiver prior to sending a message in case the two clocks are not sufficiently synchronized. In other embodiments, the time may be rounded to the nearest 5 minutes, the nearest, 10 minute, or the nearest hour, for example. For example, if the exact time is 19:05 and 45 seconds, then t_1 is set to is 19:06 pm. In some embodiments, the timestamp may be synchronized across timezones based on the Coordinated Universal time (UTC time).

[0151] In other embodiments, the current time t_1 is determined and rounded to the nearest 90 second. In other embodiments, the current time t_1 is determined and rounded to the nearest 5 minutes. In these embodiments, if the exact time is 6:07 and 57 seconds, then t_1 is set to 6:10. In at least one embodiment, the blockchain network (e.g., via service provider system **126**) verifies the transaction passcode and verifies the transaction information and then executes this transaction if the transaction passcode is valid based on the decrypted transaction information, the same seed and the current time. In this specification the words "valid" and "authenticated" and their conjugations may be substituted one for another to obtain different embodiments. If the transaction passcode is determined to not be correct, or the decrypted transaction information is unreadable, then the transaction is aborted.

[0152] In other embodiments, the blockchain network continues with transaction steps B and C before the transaction is executed. These steps involve an exchange between the user (sender) and the recipient. The block chain network acts as the intermediate trusted party.

[0153] TRANSACTION STEP B. Blockchain network **124** serves as a service provider system **126** and receives the transaction information and one-time transaction passcode. The blockchain network checks the transaction information and checks that the one-time transaction passcode is correct (e.g., the transaction information, the seed, and the time at which the passcode was generated are encrypted with a one-way hash function thereby computing the passcode, and the computed passcode is compared to a newly sent passcode to determine if there is a match.). If the one-time transaction passcode received from the user is not correct (e.g., if the sent passcode does not match the computed passcode), the transaction is aborted, and no transaction occurs. If the one-time transaction passcode received from the user is correct (e.g., if the sent passcode matches the computed passcode), then the blockchain network sends a new transaction passcode back to the user that is generated by the recipient. The new passcode may be computed by the recipient applying her private key to the transaction information I and the new time t_2 where t_2 is the new current time read by the blockchain network **124** (at service provider system **126**) or recipient's wallet.

[0154] In at least one embodiment, the private encryption key K may be updated, denoted as h(K), using similar methods to the update of the transaction passcode generator. Then the transaction information is sent from the blockchain network **124** back to the user. (Updating the private encryption key K may help address sniffing and replay attacks.)

[0155] TRANSACTION STEP C. The user, system **101**, via the block chain network **124**, checks the recipient's signing of the transaction information. Otherwise, the block chain network acting as the service provider system **126**, aborts the transaction.

Alternative Embodiments Using Transaction Passcodes

[0156] In alternative embodiments, the user and the service provider **126** agree upon a common key for the registration key. The user then encrypts one of the common keys with the registration key. The service provider **126** encrypts the common key with other information, which may be information specific to the user or a random number, for example. Then the user sends the encrypted common key (that was encrypted by the user with the registration) to the service provider **126**, and the service provider **126** sends the encrypted common key that the service provider **126** encrypted to the user. Next, the user encrypts the encrypted common keys that was received from the service provider **126** with the registration key, and the service provider **126** encrypts the encrypted common key received from the user (which was encrypted with the registration key) with the same information that was used to encrypt the original copy of the common key of the service provider **126**. Thus, both the user and the service provider **126** will now have the common encrypted key derived from the registration key supplied by the user and the information supplied by the service provider **126**. The resulting encrypted common key may be used as the registration key (instead of the original registration key).

[0157] Optionally, the user system **101** and the service provider **126** may also agree upon a common key for the encryption key. The common key of the encryption key and registration key may be the same as one another or different. The user system **101** then encrypts one of the common keys and the encryption key. The server encrypts the common key with other information, which may be information specific to the user or a random number for example (as was done for the registration key). Then the user system **101** sends the encrypted common key (that was encrypted by the user with the encryption key) to the service provider **126**, and the service provider **126** sends the encrypted common keys (which was encrypted service provider **126**) to the user. Next, the user encrypts the encrypted common key that were received from the service provider **126** with the encryption key, and the service provider **126** encrypts the encrypted common keys received from the user (which was already encrypted with the encryption key by the user) with the same information that was used to encrypt the original copy of the common keys of the service provider **126**. Thus, both the user and the service provider **126** will now have the common key encrypted by the encryption key supplied by the user and the information supplied by the service provider **126**. The resulting encrypted common key may be used as the encryption key (instead of the original encryption key). Alternatively, the encryption key may be derived from the registration key by both the service provider **126** and user.

[0158] In other embodiments, the secure transmission may use elliptic curve cryptography which is similar to the Diffie-Hellman exchange described previously. In other embodiments, the secure transmission R and K may use a camera that reads a proprietary pattern that the portable device is able to display after setup is complete. In at least one embodiment, the registration code R may be given to the blockchain network in the same physical place, such as at a bank, or the registration code may be mailed or electronically transmitted to the blockchain network if setup is accomplished remotely. In some applications, the registration code may be encrypted first and then electronically transmitted or sent by mail. The service provider system **126** uses the registration code R to generate the encryption key (that service provider system **126** received), and is used to compute the passcode generator G as $G=\Phi^k(R)$ where $k \geq 0$ and stores transaction passcode generator G and encryption key K for a particular user in a secure area **102**. The number k in the operator $\Phi^k(\,)$ is the number of times that the operator $\Phi()$ is applied to R. In an embodiment, prior to creating each passcode a new passcode generator is generated from which the new passcode is generated by applying $\Phi()$ to the prior value of the passcode generator and transaction information S_k. In other words, $G_n=f(G_{n-1})=f^2(G_{n-2})=f^3(G_{n-3})= \ldots =f^n(G_0)=f^n(\Phi^k(R))$, and $P_n=\psi(G_n, S_n)$ is the nth transaction passcode, where ψ is another function, which may be the same or different than Φ.

[0159] In an embodiment, each of the steps of method **300**A may be a distinct step. In other embodiments, method **300**A may not have all of the above steps and/or may have other steps in addition to or instead of those listed above. The steps of method **300**A may be performed in another order. Subsets of the steps listed above as part of method **300**A may be used to form their own method. In an embodiment, there could be multiple instances of method **300**A, each performed in response to performing another transaction or another part of the same transaction. The multiple instances of method **300**A may be performed sequentially (e.g., each sequential instance performing the next part of a sequence of transactions or of a sequence of operations making up a single transaction) or in parallel.

Setup of Service Provider

[0160] FIG. **3**B shows a flowchart of an embodiment of method **300**B of setting up service provider system **126** for secure transactions against cyber attacks. Service provider setup method **300**B may be the setup performed by service provider **126** before starting a secure transaction procedure.

[0161] In a step **332**, service provider **126** may receive registration code R, cryptographic key K along with user information such as name and account number. In another embodiment, service provider **126** generates the passcode and/or encryption key in parallel with user system **101** or instead of service provider **126**.

[0162] In an embodiment, each of the steps of method **300**B may be a distinct step. In other embodiments, method **300**B may not have all of the above steps and/or may have other steps in addition to or instead of those listed above. The steps of method **300**B may be performed in another order. Subsets of the steps listed above as part of method **300**B may be used to form their own method. In an embodiment, there could be multiple instances of method **300**B.

User System Method of Initiating the Transaction and Requesting Authentication

[0163] FIG. **3**C shows a flowchart of an embodiment of method **300**C in system **100** for secure transactions against cyberattacks. User system method **300**C may be performed by user system **101** after the setup described in method **300**A. Method **300**C may be an embodiment of initial request routine **160** (FIG. **1**B).

[0164] In step **352**, user system **101** may receive a request from a user (via an interface on the user system **101**) to start a secure transaction with service provider system **126**. User system **101** may also receive biometric print information or other information from the user to authenticate the user. Processor system **116** may send a request to secure processor system **106** to authenticate the user with the information stored during setup. In this specification, the terms authenticate, verify, and validate (and their conjugations) may be interchanged with one another to obtain different embodiments.

[0165] In step **354**, user system **101** receives transaction information from the user. The transaction information S_D may be stored either in secure memory system **104**. In an embodiment, the transaction information is only stored in encrypted form in secure memory system **104**, and nowhere else. In another embodiment, the transaction information may be stored unencrypted in the secure area **102** and/or elsewhere. In this specification, transaction information refers to one or more items of information that describe the transaction. For a payment transaction, one item may be the name of the person or entity sending the money. Another item may be the name of the person or entity receiving the money. Another item may be the date. Another item may be the sender's (entity's) account number. Another item may the receiving person's (entity's) bank account number. Another item may be the sender's (entity's) routing number. Another item may be the receiving person's (entity's) routing number. Another item may the amount of money which may be expressed in dollars, Euros, Yen, Francs, Deutschmark or another currency.

[0166] In at least one embodiment, the transaction may be a stock trade. In these embodiments, the stock account number may be part of the transaction information. In at least one embodiment, the ticker symbol of the stock—for example, GOOG—being bought or sold may be part of the transaction information (or the name of a commodity or other item being purchased). The number of shares may be part of the transaction information. The price per share (or unit price) at which the person wishes to buy or sell the shares may be an item of the transaction information. If the stock purchase (or sale) is a limit order, then an indication that the stock purchase is a limit order may be an item of the transaction information. If the stock purchase (or sale) is a market order, then an indication that the purchase is a market order may be an item of the transaction information. The name of the stock account (e.g. Ameritrade, Charles Schwab, etc.) or broker may also be an item of the transaction information.

[0167] In step **356**, the transaction information S_D may be encrypted with a key K, as $M_D=E(S_D, K)$, and optionally stored in secure memory system **104**. In step **358**, secure processor system **106** applies a hash function Φ to the first passcode generator G_D stored in secure memory **104** (step **306**) and the transaction information received S_D in step **354** to generate a first one-time transaction-passcode P_D. In other words, $P_D=\Phi(G_D,S_D)$. The first transaction-passcode may be used once for the transaction S_D, and the transaction passcode may be unique to every transaction and every use. The one-time transaction passcode P_D, may be a sequence of symbols. In this specification passcode, transaction passcode, and one-time transaction passcode may be substituted one for another to obtain different embodiments. The one-time transaction passcode P_D, may dependent on the transaction information S_D. An example of a numeric passcode is "925438710". An example of a transaction passcode may be a sequence of hexadecimal numbers "3A 21 5B DE 0F 99". An example of an alphanumeric passcode with 8 symbols may be "4zc8vNXA" and an example with 16 symbols including punctuation and other symbols is "&xL#WBq61!j$uS_m". In an embodiment, each time a user submits a valid biometric print to the passcode generator, a new one-time transaction passcode is created from the current passcode generator G. The service provider checks that the passcode is derived from one of the passcode generator in the database and the particular transaction information. In other embodiments, a new passcode is generated more frequently than every time a user submits a valid user authentication. For example, a new passcode may be generated every other time or on a random schedule that the user is unaware.

[0168] In step **360**, the current passcode generator G_D is altered to generate a new passcode generator, the next passcode generator, for creating the next transaction passcode in the next use of the transaction system. In other words, new $G_D'=f(G_D)$, where there are an infinite number of functions that f could be. In at least one embodiment, the new value of G_D (the second passcode generator) can be updated to $f(G_D, S_D)$ where the new passcode generator (the second passcode generator) is dependent on the transaction information S_D. The function f will be referred to as the perturbing function. One possible perturbing function f could update the new transaction passcode generator to $\Phi(G_D, S_D)$. An alternative perturbing function f could add $\Phi(G_D, S_D)$ to G_D. Another possible perturbing function f could xor G_D and $\Phi(G_D, S_D)$. Another possible perturbing function f could add 1 to G and permute the order of the symbols in G_D using some randomly chosen permutation. Even another possible perturbing function f could add 1 to G_D, and then permute the bits in G_D. G_D could be used as a seed for a deterministic "pseudo-random" number generator, which is used as f to generate a new G_D. In step **362**, the one-time transaction passcode P_D and transaction information $E(S_D, K)$ may be transmitted to a display or submitted directly to service provider **126**. In at least one embodiment, the one-time transaction passcode P_D may be encrypted before transmitting to the service provider **126** for additional security.

[0169] In an embodiment, the one-time transaction-passcode P_D (e.g., the first one time passcode) and transaction information M_D may be displayed to service provider system **126**, when the user is in the same physical location as service provider system **126**. In another embodiment, the user may transmit the one-time transaction-passcode P_D over a telephone. In another embodiment, the user may submit the one-time transaction-passcode P_D and transaction information M_D to the web browser and use the Internet for transmission to service provider system **126**. In another embodiment, the user may submit the one-time transaction-passcode P_D and transaction information M_D by some other electronic means such as a fax machine or an ATM machine.

[0170] In an embodiment, each of the steps of method **300**C may be a distinct step. In other embodiments, method **300**C may not have all of the above steps and/or may have other steps in addition to or instead of those listed above. The steps of method **300**C may be performed in another order. Subsets of the steps listed above as part of method **300**C may be used to form their own method. In an embodiment, there could be multiple instances of method **300**C.

Service Provider Method of Authenticating the User and Requesting Authentication

[0171] FIG. **4** shows a flowchart of an embodiment of method **400** in a system **100** for securing transactions against cyber attacks, authenticating the user, and requesting authentication of the user to authenticate the service provider **126**. Method **400** may be performed by service provider **126** upon a request to perform a secure transaction. Service provider **126** stores registration code R and encrypted key K during setup performed by method **300**A. Method **400** may be an embodiment of a combination of authentication of user **224** and request for authentication routine **226** (FIG. **2**B).

[0172] In step **402**, service provider system **126** receives one-time transaction passcode P_D and transaction information M_D, (sent in step **362**). In step **404**, service provider system **126** decrypts the transaction information using the stored encryption key K and applies the decryption function to M_D to get S_S according to S_S=decrypt M_D with K. In step **405**, service provider system **126** computes transaction passcode P_D based on the passcode generator and received transaction information S_S, and computes the next passcode generator based on the prior transaction passcode generator G_{S-1}, as $G_S=\Phi(G_{S-1})$; and transaction passcode $P_S=\Phi(G_S, S_S)$. In step **406**, method **400** compares the received one-time passcode P_D and computes one-time passcode P. If the received one-time passcode and computed one-time passcode do not match, then method **400** proceeds to step **408**. In step **408**, service provider system **126** aborts the transaction. Returning to step **406**, if the received one-time passcode and computed one-time passcode match, then method **400** proceeds to step **410**. In step **410**, service provider system **126** updates the transaction passcode generator G_S to the next transaction passcode generator G_S' by applying a hash function, $G_S'=f(G_S)$, where f may be the same as, or different from, Φ. In step **412**, service provider system **126** computes a new one-time transaction-passcode P_S' using the updated transaction passcode generator G_S', the system computes $P_S'=\Phi(G_S', S_S)$. The new one-time transaction-passcode P_S' is transmitted to user system **101**. In step **414**, the encryption key K may be updated using methods similar to updating transaction passcode generator. In other words, updated encryption key K'=h(K). Step **414** is optional. In step **416**, the transaction information is computed as $M_S=E(S_S, h(K))$ and sent to user system **101**. Steps **402-410** may be an embodiment of a combination of authentication of user **224**, and steps **412-416** may be an embodiment of request for authentication routine **226** (FIG. **2**B). The generation of the new passcodes and new passcode generator sent to the user may be performed as part of authentication of user **224** or request for authentication routine **226** (FIG. **2**B).

[0173] In an embodiment, each of the steps of method **400** may be a distinct step. In other embodiments, method **400** may not have all of the above steps and/or may have other steps in addition to or instead of those listed above. The steps of method **400** may be performed in another order. Subsets of the steps listed above as part of method **400** may be used to form their own method. In an embodiment, there could be multiple instances of method **400**.

User System Method of Authenticating the Service Provider and Requesting Completion of the Transaction

[0174] FIG. **5** shows a flowchart of an embodiment of method **500** in a system for authenticating the service provider and requesting completion of the transaction, for securing transactions against cyber attacks. Method **500** may be performed by user system **101** after receiving transaction passcode P_S' and transaction information M_S from service provider system **126** after method **300**C. Method **500** may be an embodiment of authentication of service provider routine **162**.

[0175] Method **500** verifies that user system **101** is communicating to the correct service provider system by checking the next passcode and further verifies that the transaction information has not changed by decrypting the received transaction information S_D'=Decrypt E(S, h(K)) and checks that the service provider system knows that the transaction information is still S_D. If the verification or check is invalid, then the transaction is aborted. In an embodiment, although transaction information may initially be sent as part of method **300**C, the transaction is not committed as a result of method **300**C, but instead is committed on the basis of the transaction information sent in method **500**. Method **500** is an embodiment of authentication of service provider **162**.

[0176] In step **502**, the transaction information M_S (sent from service provider **126** in step **416**) is decrypted, S_D'=decrypt M_S In step **504**, the decrypted transaction information S_D' is compared with the stored transaction information S_D (stored in step **354**) to further verify whether the service provider system **126** received the correct transaction information. If the received (and optionally decrypted) transaction information does not match the stored (and optionally decrypted) transaction information, method **500** proceeds to step **518**. If the received and generated second transaction passcode match and/or the received and stored transation information match, method **500** proceeds to step **506**. In step **506**, user system **101** computes the next transaction passcode $P_D'=\Phi(G_D', S_D)$ (the second transaction passcode) using the next transaction passcode generator G_D'(computed in step **360**) unless the next transaction passcode was already computed in method **300**C. In an embodiment, the next transaction passcode (the second transaction passcode) is only generated just before the next transaction passcode is needed (e.g., milliseconds before the next transaction passcode is needed) and then deleted immediately after use so that the transaction passcode never exists for more than a few millisecond or for more than a few seconds. In step **508**, the received transaction passcode P_S' (computed in step **412** and sent from service provider system **126**) is compared with the computed (or generated) transaction passcode P_D' to verify that user system **101** is communicating with service provider **126**. If the passcodes do not match, then method **500** proceeds to step **518**. In step **510**, the passcode generator is updated by user system **101** for the third time, $G_D''=f(G_D')$ or $G_D''=f(S_D, G_D')$. In step **512**, the next (or third) one time transaction passcode P_D'' is computed by applying a hash function on the transaction passcode G_D'' and transaction information S_D, $P_D''=\Phi(G_D'', S_D)$. In step **514**, transaction information $M_D'=E(S_D, h(K)))$ is computed (optionally, if the transaction information was stored in encrypted form, encrypted with the first encryption key, the transaction information is first decrypted with the first encryption key prior to being encrypted with the third encryption key, if necessary). In step **516**, the transaction information M_D' (now encrypted with the third encryption key) and the transaction passcode P_D'' (the third transaction passcode) are transmitted to service provider system **126**. As mentioned above, in step **508**, if the decrypted transaction information does not match the stored transaction information, method **500** proceeds to step **518**. In step **518**, method **500** aborts the transaction which may be due to a mismatch in transaction passcode or a mismatch of transaction information.

[0177] In an embodiment, each of the steps of method **500** may be a distinct step. In other embodiments, method **500**

may not have all of the above steps and/or may have other steps in addition to or instead of those listed above. The steps of method **500** may be performed in another order. Subsets of the steps listed above as part of method **500** may be used to form their own method. In an embodiment, there could be multiple instances of method **500**.

Service Provider Method of Completing the Transaction

[0178] FIG. **6** shows a flowchart of an embodiment of method **600** in a system for completing secure transactions against cyber attacks. Method **600** may be performed by service provider system **126** after receiving one-time transaction passcode P_D'' and transaction information M_D' (after step **516**). Method **600** may be an embodiment of completion of transaction routine **228**.

[0179] In step **601**, method **600** receives the transaction passcode and transaction information for the second time (which were sent in step **516** of method **500**, FIG. **5**). In step **602**, passcode generator is updated by applying a function on the previous passcode generator, $G_S''=f(G_S')$. In step **604**, method **600** decrypts the received transaction information (sent from user system **101** in step **516**), $S_S'=\text{Decrypt}(M_D')$. In step **606**, the next transaction passcode is computed by applying a hash function to a combination of the updated passcode generator of step **602** and transaction information S_S', to create transaction passcode $P_S''=\Phi(G_S'', S_S')$. In step **608**, the received transaction passcode P_D'' (sent from user system **101** in step **516**) is compared with the computed transaction passcode P_S'' to verify that service provider **126** is communicating with the correct user system **101**. If the passcodes do not match, method **600** proceeds to step **614** where the method **600** terminates. In step **610**, method **600** compares the decrypted transaction information S_S' with the stored transaction information S_S (stored in step **354**) to further verify whether the service provider system **126** received the correct transaction information. If the decrypted transaction information does not match the stored transaction information, method **600** proceeds to step **614** where the method terminates. In step **612**, service provider **126** completes the transaction requested by user system **101**. Method **600** transfers control to step **614** from either step **608** or step **610**. In step **614**, method **600** aborts the transaction which may be due to an invalid transaction passcode or a mismatch in transaction information.

[0180] In an embodiment, each of the steps of method **600** may be a distinct step. In other embodiments, method **600** may not have all of the above steps and/or may have other steps in addition to or instead of those listed above. The steps of method **600** may be performed in another order. Subsets of the steps listed above as part of method **600** may be used to form their own method. In an embodiment, there could be multiple instances of method **600**.

[0181] Methods **300**B, **400**, **500** and **600** may be repeated every time the user would like perform a transaction, and the passcode, passcode generator, and optionally the encryption key are further updated to new values as a result of the repetition.

[0182] In methods **300**B, **400**, **500**, and **600**, although the transaction information sent always pertains to the same transaction (until that transaction is committed) different the transaction information may be sent each time the user sends transaction information to the service provider, so long as the service provider receives all the transaction information the second time the passcode and transaction information are sent (prior to the completing the transaction).

[0183] FIG. **7** shows a diagram of a browser showing the recipient information being entered into the web browser.

[0184] In at least one embodiment, it may be more convenient for part of the transaction information T to be entered into the web browser and part of the transaction information S will come from the secure area. In at least one embodiment, transaction information T for the recipient may be entered directly into the web browser. Transaction information may contain the recipient's name on the account; the name of the bank or financial institution; the recipient's account number and other important items such as the routing number. In at least one embodiment, the user's transaction information S may be entered into the secure area of the device during setup (enrollment). This may occur when the bank or financial account is opened. The user's transaction information S may be entered after the account is opened at the financial institution or remotely on the device.

Securing Executables and Their Functionality

[0185] In at least one embodiment, there is computer program E that performs an important functionality. In at least one embodiment, computer program is executable code that has been compiled from source code such as C or C++ or FORTRAN. In other embodiments, computer program may refer to virtual machine code. As an example, a computer program written in the source code language JAVA compiles to java virtual machine code, which is then executed on the JAVA virtual machine. It is important that the functionality of computer program E is not be disabled by malware. In embodiments that use vehicles such as autos and truck, E may unlock the brakes. In another vehicle embodiment, some computer program E may turn off an engine. In another embodiment, computer program E may start the turbines in a dam. In another embodiments, computer program E may carry out a financial transaction between two financial institutions. In another embodiment, computer program E may execute inside a router and help transmit data packets over the internet. In another embodiment, computer program E may regulate the water flow in a nuclear power plant. In another embodiment, computer program E may run the infrastructure in an oil refinery plant.

[0186] In at least one embodiment, there are methods used to prevent malware from changing or corrupting the functionality of some computer program E, which may be in the form of executable code. The methods that protect against malware may be combined in various ways in different embodiments. One method is to authenticate the computer code. This means that the method assures that the purpose or functionality of the computer code is not altered. This method is helpful in cyber security as some kinds of malware change or sabotage the purpose of the computer program. As an example, malware may lock the brakes in an automobile when the driver did not press on the brake pedal. Sometimes, the malware may reach the network of the automobile via wireless access. One method is for the authentication to occur by creating a signature S for correct computer program E and making all other programs that call or request the functionality from computer program E to communicate to computer program E that they know this signature. Consider program F which would like to call computer program E, and then it could take a private key V and sign signature S without revealing S so that malware cannot fake knowledge of the signature. In this embodiment, D(V, S) may be transmitted to computer program E along with a request to execute computer program E. Computer program E validates the signature by decrypting with public key P and then checking that S is a valid signature for computer program E. In at least one embodiment, the signature S may be created at the time of programming the chip that contains computer program E. In other embodiments, signature S may be created later after the vehicle is registered with one or more owners. This might occur after the automobile has been purchased by an owner.

[0187] In other embodiments, computer program E may have functionality that executes a bitcoin transaction or another cryptocurrency transaction or transaction at a tradition bank or investment fund or even a government institution such as the post office, the IRS or Freddie Mac.

User Interface in the Secure Area

[0188] In at least one embodiment, the user interface may be connected to the secure area of the device may have a display screen and navigation buttons or character entry of letters, numbers or symbols using a touch sensitive screen. In at least one embodiment, the device may have a USB connection. In at least one embodiment, the device containing the secure area **102** may contain a wireless chip and a battery. In at least one embodiment, the device may be a mobile phone.

[0189] FIG. **8** shows a display screen. In at least one embodiment, the display screen may be an OLED. In other embodiments, the display screen may use an LCD. In at least one embodiment, some or all of the financial institution members of the worldwide banking system may be stored into the secure area of the chip inside the device when the user registers with the bank or opens an account. In at least one embodiment, the user may use the navigation buttons, and/or character entry of letters, numbers or symbols using a touch sensitive screen and a display screen to scroll and select one of the banks to make a transaction with. In at least one embodiment, the user may use navigations buttons or a touch sensitive screen and display screen to scroll and select other transaction information stored in the secure area of the chip. In at least one embodiment, the user may use the navigation buttons and display screen to scroll and select letters or words that help enter transaction information.

[0190] In at least one embodiment, the user may be using a cryptocurrency wallet such as bitcoin or ripple. In at least one embodiment, the user wallet may be used to securely execute wire transfers between two banks. In at least one embodiment, the user wallet may be used to purchase a retail item such as a cup of coffee or a sandwich. In at least one embodiment, the device containing the secure area may contain a microphone. In at least one embodiment, the secure area of the chip may contain speech recognition code to receive transaction instructions or information from the user. In at least one embodiment, the device may have one or more biometric sensors. In at least one embodiment, the display screen may act as a keyboard for entering passwords and transaction information. In at least one embodiment, the display screen may enable the user to verify that the transaction information is correct or has not been tampered with by malware before executing the transaction.

[0191] In an embodiment, each passcode generator or private key is not stored in a database but stored in a separate chip which is indexed by the user's address (public key) and/or user id. In an embodiment, the function call trx**1**_passcode(user_address, trx_amount, other_trx_info); is passed in the user's address, user_address, the transaction amount, trx_amount, and optionally transaction info The function trx**1**_passcode returns a transaction passcode or signing of the that the blockchain network **124** expects to be the correct passcode.

[0192] The returned transaction passcode is compared to the transaction code received from the user's device or wallet. This embodiment protects the passcode generator or private key, because the passcode generator or private key never leaves the separate chip.

[0193] In an alternative embodiment, trx**2** _passcode(recipient_address, trx_amount, trx_info); passes the address of the recipient recipient_address, and the transaction amount, trx_amount, and trx**2** _passcode returns a transaction passcode Q that the blockchain network checks and validates to be the correct transaction passcode, which is dependent on the recipient's address, the transaction amount and optionally other transaction information (trx_info) to be sent from the user to the recipient. The transaction passcode Q is compared to the transaction passcode received from the user's device, which may be a token, mobile phone or other device.

[0194] In an embodiment, an interface retrieves a passcode generator, passcode_generator, from a database. In an embodiment, the interface is implemented with the diameter protocol <http://en.wikipedia.org/wiki/Diameter_(protocol)>. In an alternative embodiment, the interface is implemented with the RADIUS protocol <http://en.wikipedia.org/wiki/RADIUS>. In an embodiment, each passcode_generator is stored in an embedded database. In an embodiment, the passcode generator, passcode_generator, is a string of the form "23 102 215 211 55 125 14 25 36 48 152 201 106 11 77 20 21 76 53 89 29 104 114 188 209 45 135 94 15 35 47 254 219 125 35 14 19 25 27 244 236" or the string might be longer. In an embodiment, the passcode generator, passcode_generator, is a sequence of bytes of the form:

"2AB02CE4E1BA93DBC9E844E6551E3CC3FF83A7877
B1A4A3205885E724159AB72918A
FCD15FE817A87B305F43C10500CE2290C49AC032F7B
674230A84FEA2DD1E".

[0195] In an embodiment, the passcode generator, passcode_generator may be substantially longer. For example, passcode generator may have a length of 2048 bytes or 65,536 bytes.

[0196] In the C programming language the length of the passcode generator could be declared as follows

[0197] unsigned char passcode_generator[64]; or

[0198] char passcode_generator[2048]; or unsigned char passcode_generator[65536];

An example of a user_name is Haley Arielle. In the C programming language the user name could be declared as follows. unsigned char user_name[200]={'a', '1', 'e', 'y ', ' ', 'A', 'r', 'e', '1', '1', 'e', '\0'};

[0199] An example of a routing_number is string "124000379". An example of trx_amount is "$5000".

[0200] Cryptor is the name of function that encrypts or decrypts transaction data. In an embodiment, the function decrypts and encrypts transactions may execute a symmetric cryptography algorithm such as AES-256. In another embodiment, function that encrypts or decrypts transaction data, cryptor, may execute an asymmetric cryptography algorithm such as RSA or ECC (Elliptic curve cryptography).

[0201] Consider the C function call cryptor("d", ciper_text, key_bytes).

The option "d" tells the function to decrypt ciper text. In an embodiment ciper_text is an encypted string of the form "A1092BFF . . . 55." In an alternative embodiment "127 134 147 189 209 . . . 234". This represents the text that has been encrypted. key_bytes is the variable storing the key that is used by cryptor to decrypt ciper_text. In an embodiment, key_bytes is a string of the form "7BCAF22D . . . 0E38". In an alternative embodiment, "123 202 242 45 . . . 14 156". In an embodiment, key_bytes may have length of 32 bytes. In another embodiment, key_bytes may have length of 2048 bytes. In an embodiment, the decrypted ciphertext may be returned in the string ciper_text.

[0202] Consider the C function call cryptor("e", plain text, key bytes); The option "e" tells the function to encrypt plain_text. In an embodiment plain_text is a string of the form "User: Haley Arielle. Account Number: 121456789--3456789956. Bank: Wells Fargo. Amount: $5000. Recipient: Michael Fiske. Account Number: 101345729--2411779888 Bank: Citibank" This represents the text that has been encrypted. key_bytes is the variable storing the key that is used by cryptor to encrypt plain_text.

[0203] In an embodiment, key_bytes is a string of the form "7BCAF22D . . . 0E38". In an alternative embodiment, key_bytes may have the string "123 202 242 45 . . . 14 156". In an embodiment, key_bytes may have length of 32 bytes. In another embodiment, key_bytes may have length of 2048 bytes. In an embodiment, the encrypted ciphertext may be returned in the string plain_text.

[0204] Transaction Demo Steps

Some of the details of these steps are for pedagogical purposes in order to teach or demonstrate to a potential licensee how the underlying security works.

[0205] Step 1. Enter transaction information into the secure area. For example the transaction information may be

[0206] Name: Haley Arielle

[0207] Recipient Address: 3J98t1WpEZ73CNmQviecrnyiWrnqRhWNLy

[0208] Transaction Amount: 5 bitcoins

[0209] Step 2. The secure area displays in encrypted form the transaction information on the display screen (e.g., an organic light emitting diode OLED). In some production versions the transaction information is not displayed, but is wirelessly sent to the web browser or to another application which forwards it to the block chain network.

[0210] Step 3. A user with privileged access to the secure area reads information read off the display or listens to voice data along with a one-time passcode and enters them into a browser that is displaying a special webpage. Similarly, in at least some production versions the transaction information with the one-time transaction passcode is sent automatically to the system that would form the secure area of the user system to the service provider system such as blockchain network **124**.

[0211] Each embodiment disclosed herein may be used or otherwise combined with any of the other embodiments disclosed. Any element of any embodiment may be used in any embodiment. At least one embodiment of this specification includes all of the embodiments being used together except for those that are mutually exclusive. Although the invention has been described with reference to specific embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the true spirit and scope of the invention. In addition, modifications may be made without departing from the essential teachings of the invention.

1. A method of securing a transaction comprising:

generating a passcode at a user system, whose value depends upon the transaction information and a private key, the user system having a processor system having at least one processor, a communications interface, and a memory system;

sending the transaction information and the passcode generated by the user system, to a blockchain network, for validation in conjunction with a request to perform the transaction.

2. The method of claim **1**, wherein the user system includes a secure area and a remaining portion that includes all of the user system but the secure area, the remaining portion of the user system not having access to the secure area; the method further comprising computing and/or storing a private key in the secure area of the user system.

3. The method of claim **1**, wherein the user system includes a secure area and a remaining portion that includes all of the user system but the secure area, the remaining portion of the user system not having access to the secure area; the method further comprising computing and/or storing a transaction passcode generator in a secure area of the user system.

4. The method of claim **2**, wherein user information is entered into an interface with the user system that is part of the secure area wherein said private key is derived at least partly from some of the user information.

5. The method of claim **4**, where user information entered into the interface is a PIN or password.

6. The method of claim **4**, where user information entered into the interface is biometric data of the user such as a fingerprint, voice data, face data, finger vein or hand geometry.

7. The method of claim **4**, where user information entered into the interface is the selection of one or more visual images.

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

the blockchain network validates the transaction information and passcode received from the user system with a user system public key.

9. The method of claim **4**, applying a one-way function on the user information and a seed to compute said private key.

10. The method of claim **9** wherein the one-way function is a one-way hash function.

11. A system of securing a transaction comprising:

generating a passcode at a user system, whose value depends upon the transaction information and a private key, the user system having a processor system having at least one processor, a communications interface, and a memory system;

sending the transaction information and the passcode generated by the user system, to a blockchain network, for validation in conjunction with a request to perform the transaction.

12. A system of claim **11**, wherein the user system includes a secure area and a remaining portion that includes all of the user system but the secure area, the remaining portion of the user system not having access to the secure area; the method further comprising computing and/or storing a private key in the secure area of the user system.

13. The system of claim **11**, wherein the user system includes a secure area and a remaining portion that includes all of the user system but the secure area, the remaining portion of the user system not having access to the secure area; the method further comprising computing and/or storing a transaction passcode generator in a secure area of the user system.

14. The method of claim **12**, wherein user information is entered into an interface with the user system that is part of the secure area wherein said private key is derived at least partly from some of the user information.

15. A system comprising;

a first processor system having at least one processor,

a first memory system with which the processor system communicates,

a user interface for the user to enter and view information that is processed by the processor system, and

a network communications system for receiving and sending messages over a network that are processed by the processor system;

a secure area including at least

a second processor system for processing secure transactions, and

a second memory system storing a private key, which is a value from which a passcode or a signature is generated;

the second memory and second processor system being communicatively coupled to one another;

the first processor system having no access to the second processor system and the second memory system.

16. The system of claim **15**, wherein said system executes on a mobile phone.

17. The system of claim **15**, further comprising:

a display screen, the secure area being communicatively coupled to the display screen;

the secure area being communicatively coupled to at least a portion of the display screen for displaying information about the transaction on the display screen.

18. The system of claim **15** the first processor not having access to the display screen controlled by the second processor system in the secure area at least while the portion of the display screen is being controlled by the second processor system.

19. The system of claim **15** further comprising buttons or character entry of letters, numbers or other symbols into a user interface that is only connected to the secure area so as to not be accessible to the first processor system.

20. The system of claim **15** where the second memory system, which is in the secure area storing one or more algorithms that cryptographically bind the passcode to the transaction information, so that the passcode will not be valid if the passcode is based on incorrect transaction information.

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