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(54) **METHOD AND SYSTEM FOR SECURED REMOTE PROVISIONING OF A UNIVERSAL INTEGRATED CIRCUIT CARD OF A USER EQUIPMENT**

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(57) **ABSTRACT**

The present invention provides a method and system for secured remote provisioning of a universal integrated circuit card of a user equipment. A system includes a user equipment for initiating a request for remote provisioning of an universal integrated circuit card (UICC) in the user equipment, where the request for remote provisioning includes a machine identifier (MID) associated with the user equipment and a public land mobile network (PLMN) identifier (ID) associated with an network operator. The system also includes at least one shared key management server for dynamically generating security keys and an operator shared key using the security keys, the MID. Moreover, the system includes an operator network for generating a subscription key using the operator shared key and an international mobile subscriber identity (IMSI), and provisioning the IMSI in a secured manner to the UICC of the user equipment using the security keys.

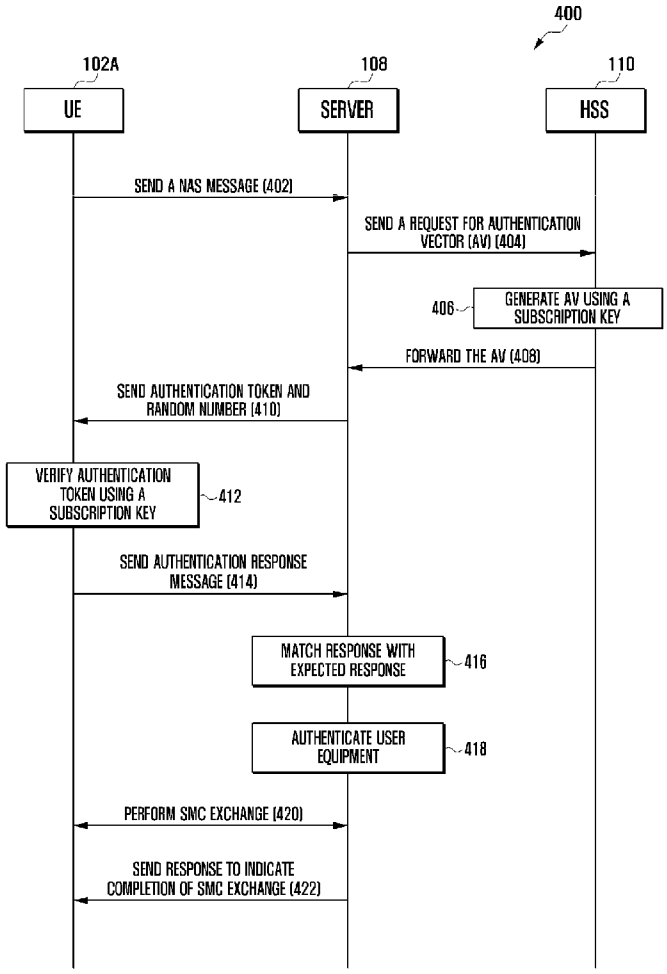


FIG. 1

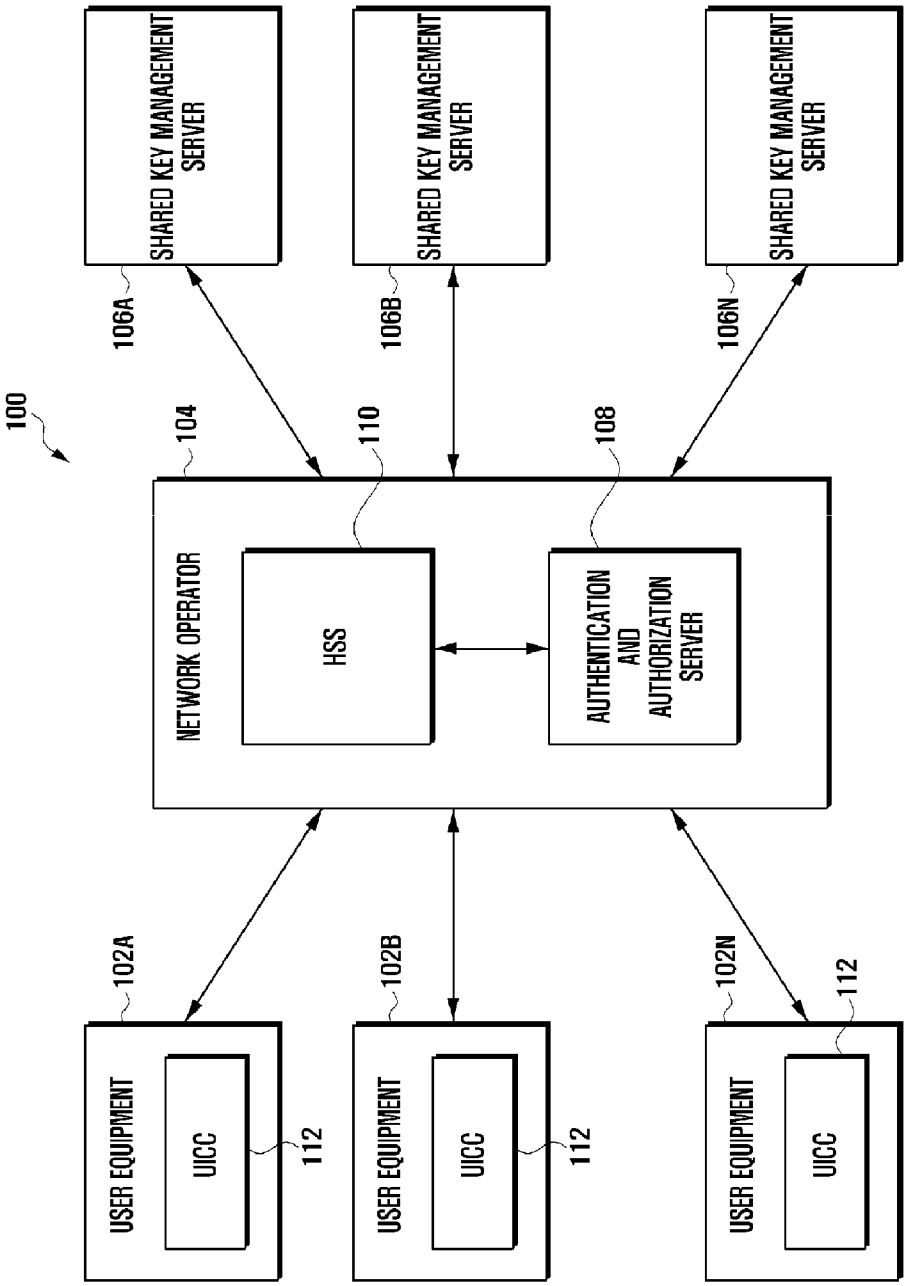

100
104
NETWORK OPERATOR
HSS
110
AUTHENTICATION AND AUTHORIZATION SERVER
108
SHARED KEY MANAGEMENT SERVER
106A
SHARED KEY MANAGEMENT SERVER
106B
SHARED KEY MANAGEMENT SERVER
106N
USER EQUIPMENT
UICC
102A
112
USER EQUIPMENT
UICC
102B
112
USER EQUIPMENT
UICC
102N
112

FIG. 2a

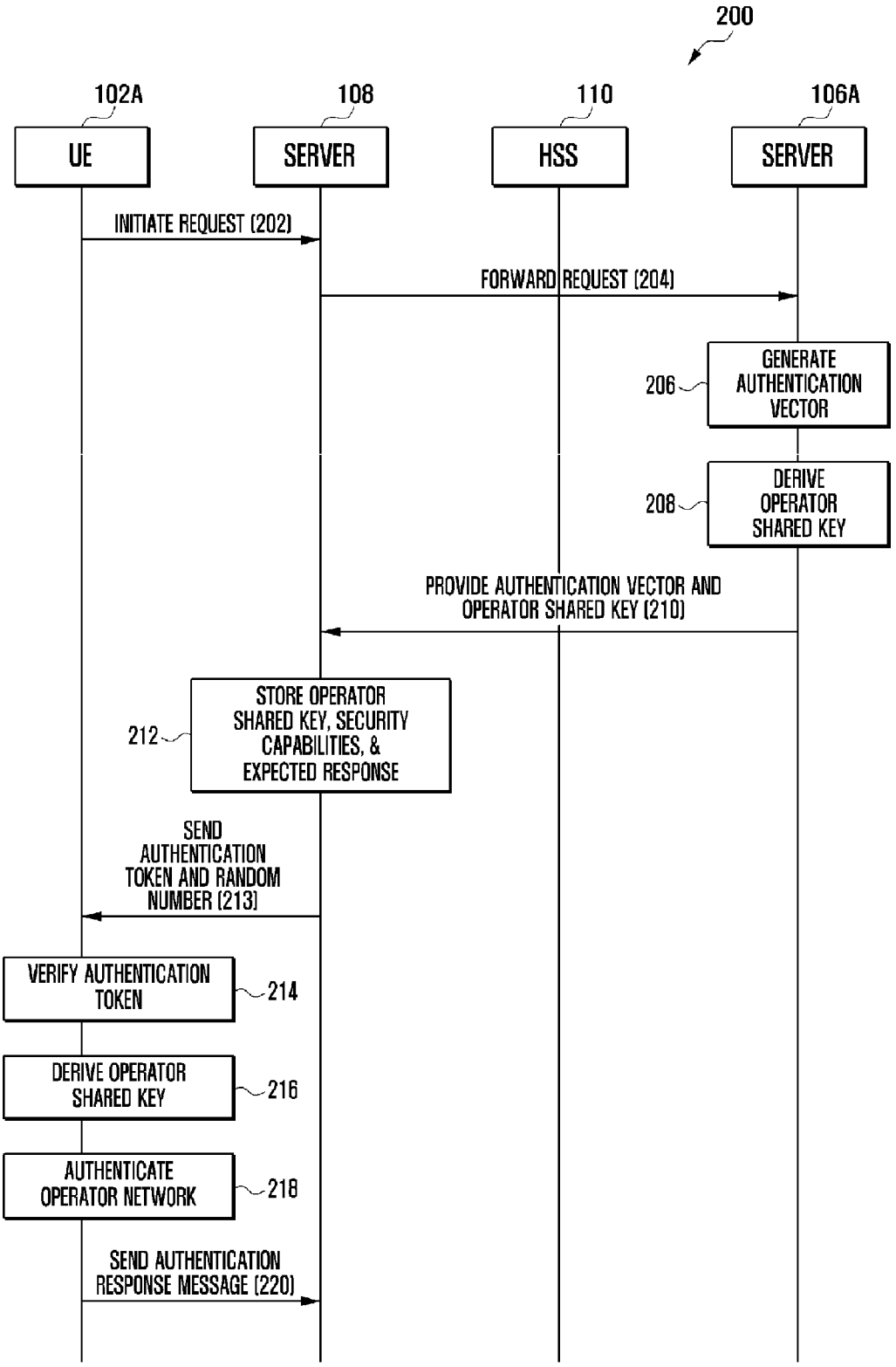

200
102A
UE
108
SERVER
110
HSS
106A
SERVER
INITIATE REQUEST (202)
FORWARD REQUEST (204)
206
GENERATE AUTHENTICATION VECTOR
208
DERIVE OPERATOR SHARED KEY
PROVIDE AUTHENTICATION VECTOR AND OPERATOR SHARED KEY (210)
212
STORE OPERATOR SHARED KEY, SECURITY CAPABILITIES, & EXPECTED RESPONSE
SEND AUTHENTICATION TOKEN AND RANDOM NUMBER (213)
VERIFY AUTHENTICATION TOKEN
214
DERIVE OPERATOR SHARED KEY
216
AUTHENTICATE OPERATOR NETWORK
218
SEND AUTHENTICATION RESPONSE MESSAGE (220)

FIG. 2b

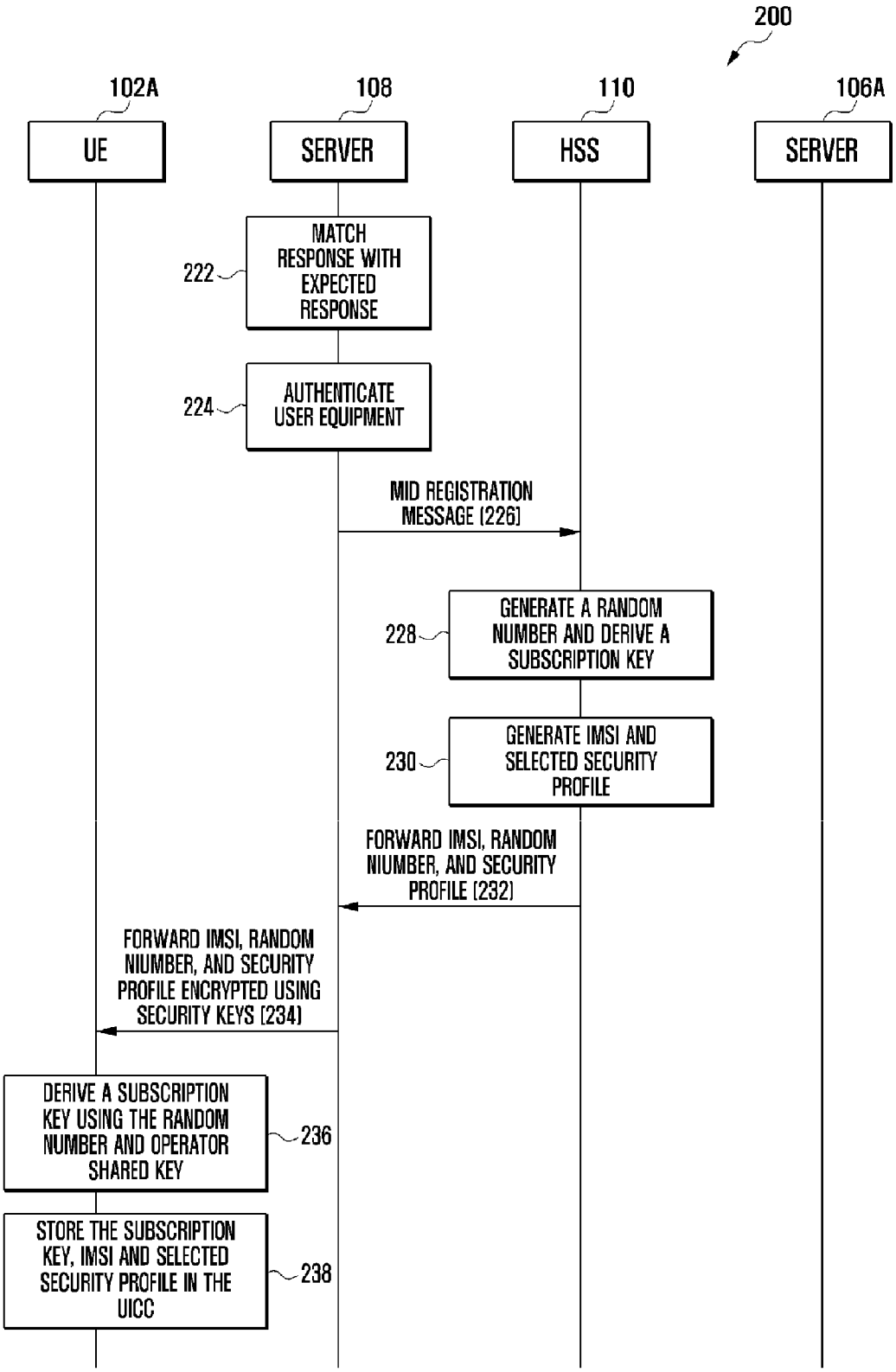

200
102A
UE
108
SERVER
110
HSS
106A
SERVER
222
MATCH RESPONSE WITH EXPECTED RESPONSE
224
AUTHENTICATE USER EQUIPMENT
MID REGISTRATION MESSAGE (226)
228
GENERATE A RANDOM NUMBER AND DERIVE A SUBSCRIPTION KEY
230
GENERATE IMSI AND SELECTED SECURITY PROFILE
FORWARD IMSI, RANDOM NIUMBER, AND SECURITY PROFILE (232)
FORWARD IMSI, RANDOM NIUMBER, AND SECURITY PROFILE ENCRYPTED USING SECURITY KEYS (234)
DERIVE A SUBSCRIPTION KEY USING THE RANDOM NUMBER AND OPERATOR SHARED KEY
236
STORE THE SUBSCRIPTION KEY, IMSI AND SELECTED SECURITY PROFILE IN THE UICC
238

FIG. 3

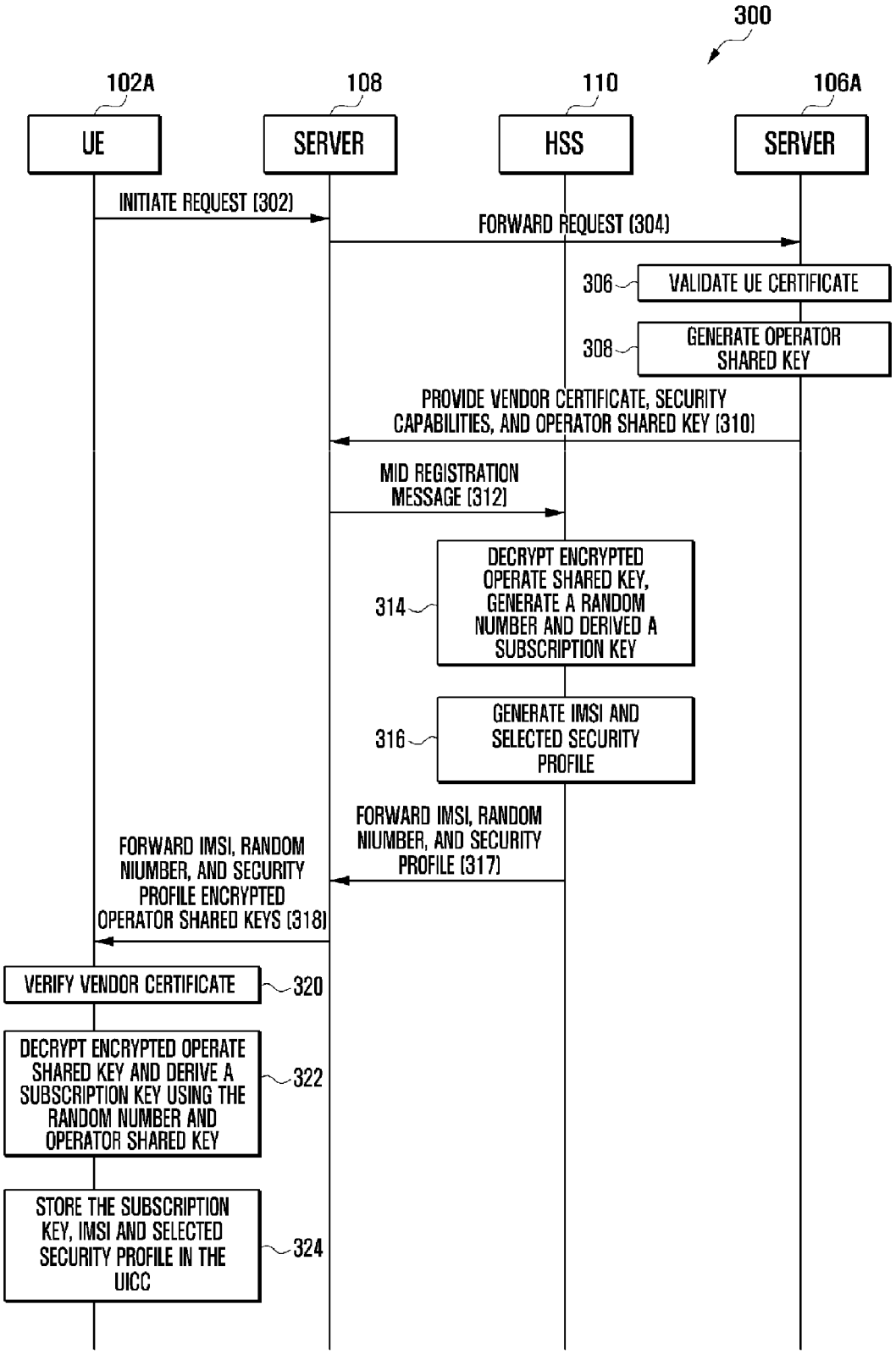

300
102A
108
110
106A
UE
SERVER
HSS
SERVER
INITIATE REQUEST (302)
FORWARD REQUEST (304)
306
VALIDATE UE CERTIFICATE
308
GENERATE OPERATOR SHARED KEY
PROVIDE VENDOR CERTIFICATE, SECURITY CAPABILITIES, AND OPERATOR SHARED KEY (310)
MID REGISTRATION MESSAGE (312)
314
DECRYPT ENCRYPTED OPERATE SHARED KEY, GENERATE A RANDOM NUMBER AND DERIVED A SUBSCRIPTION KEY
316
GENERATE IMSI AND SELECTED SECURITY PROFILE
FORWARD IMSI, RANDOM NIUMBER, AND SECURITY PROFILE (317)
FORWARD IMSI, RANDOM NIUMBER, AND SECURITY PROFILE ENCRYPTED OPERATOR SHARED KEYS (318)
VERIFY VENDOR CERTIFICATE
320
DECRYPT ENCRYPTED OPERATE SHARED KEY AND DERIVE A SUBSCRIPTION KEY USING THE RANDOM NUMBER AND OPERATOR SHARED KEY
322
STORE THE SUBSCRIPTION KEY, IMSI AND SELECTED SECURITY PROFILE IN THE UICC
324

FIG. 4

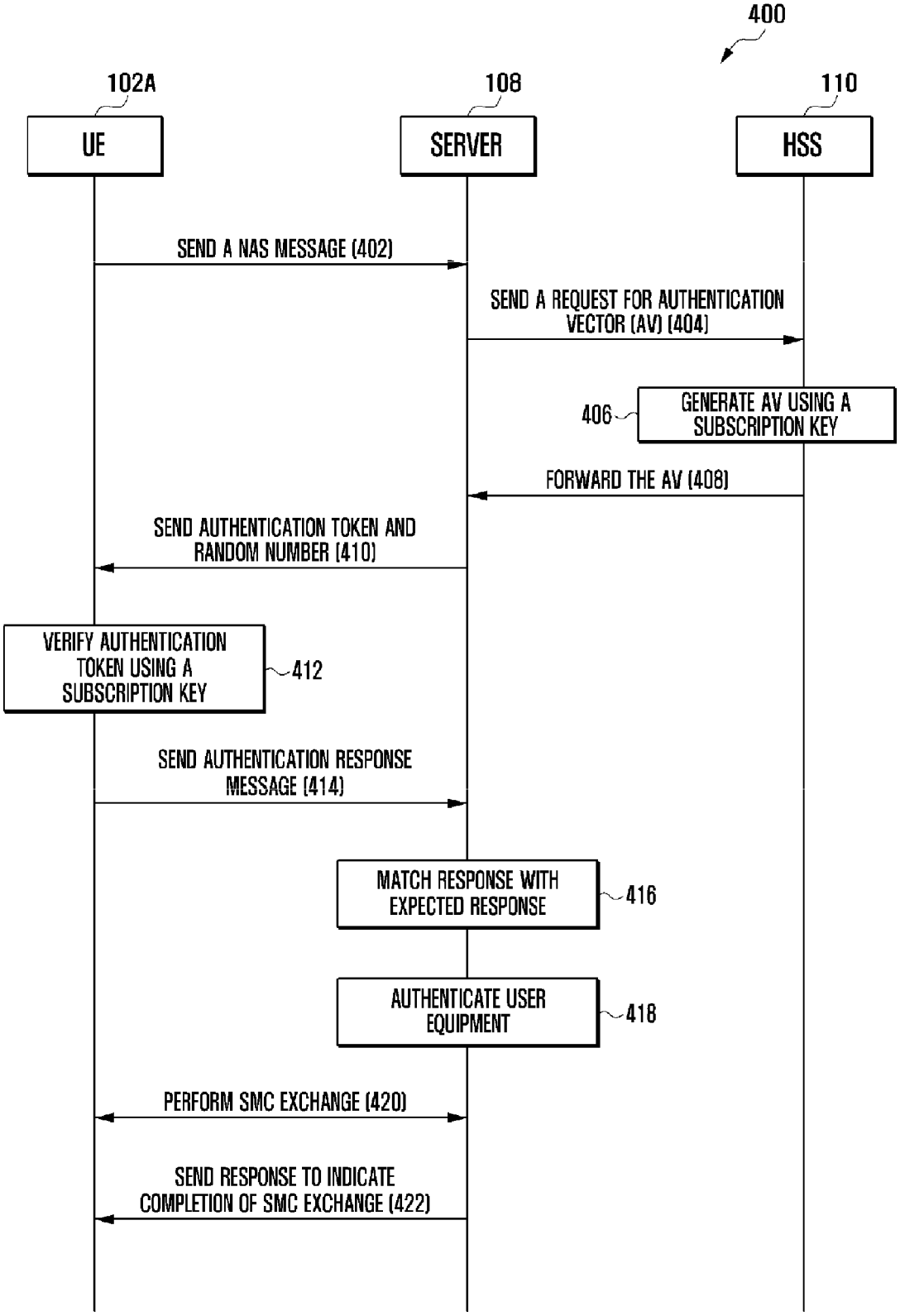

400
102A
UE
108
SERVER
110
HSS
SEND A NAS MESSAGE (402)
SEND A REQUEST FOR AUTHENTICATION VECTOR (AV) (404)
406
GENERATE AV USING A SUBSCRIPTION KEY
FORWARD THE AV (408)
SEND AUTHENTICATION TOKEN AND RANDOM NUMBER (410)
VERIFY AUTHENTICATION TOKEN USING A SUBSCRIPTION KEY
412
SEND AUTHENTICATION RESPONSE MESSAGE (414)
MATCH RESPONSE WITH EXPECTED RESPONSE
416
AUTHENTICATE USER EQUIPMENT
418
PERFORM SMC EXCHANGE (420)
SEND RESPONSE TO INDICATE COMPLETION OF SMC EXCHANGE (422)

FIG. 5

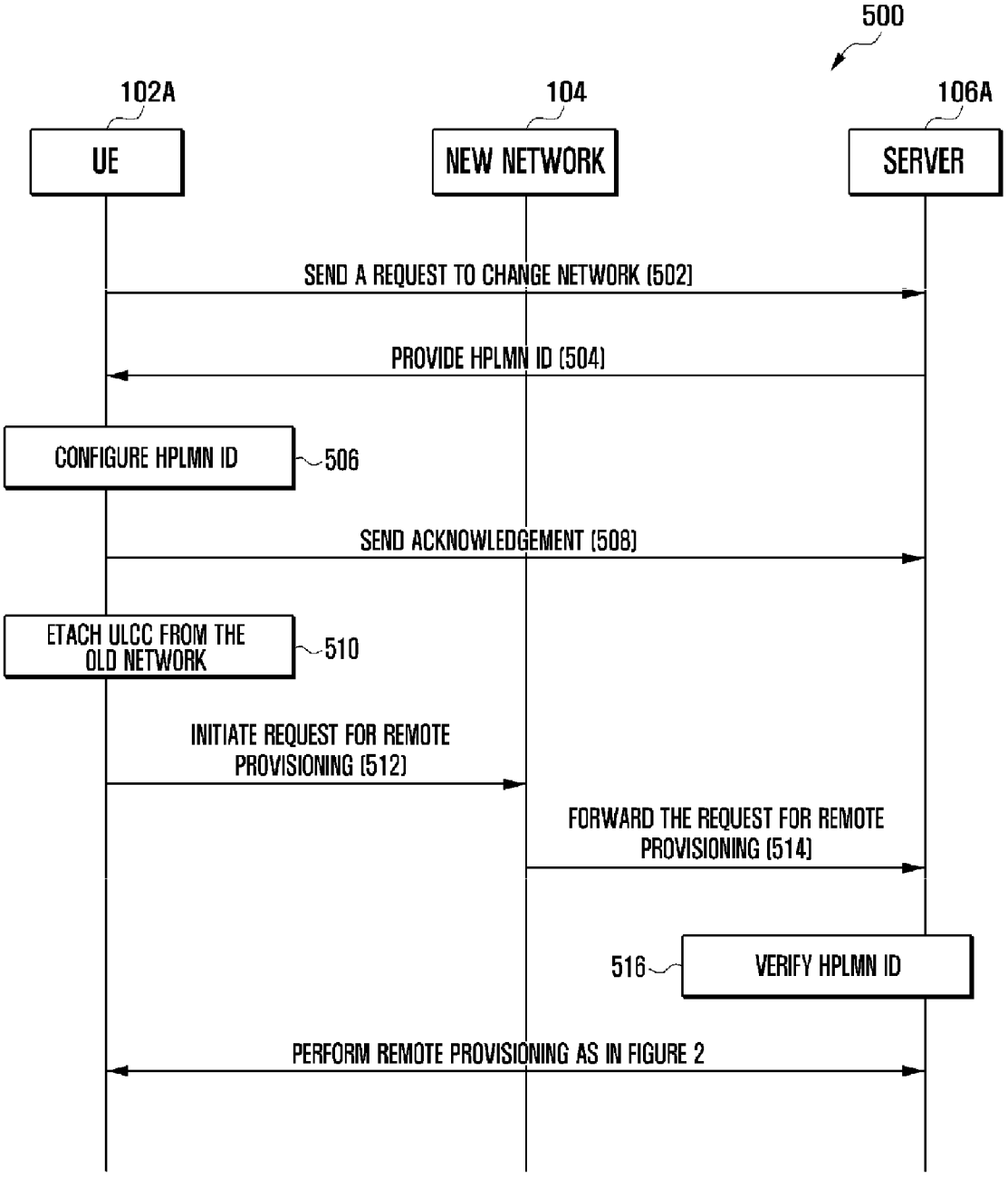
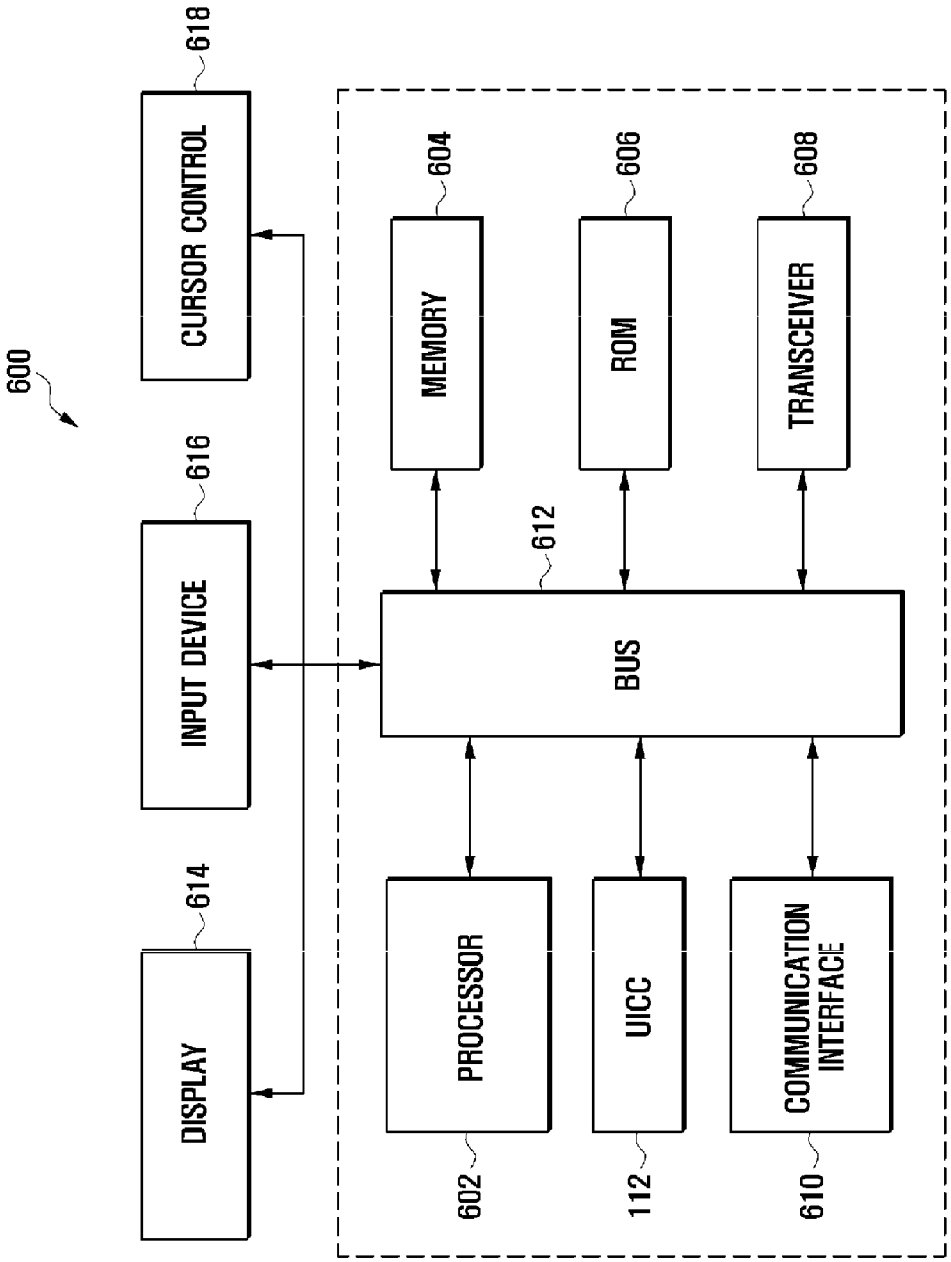

500
102A
104
106A
UE
NEW NETWORK
SERVER
SEND A REQUEST TO CHANGE NETWORK (502)
PROVIDE HPLMN ID (504)
CONFIGURE HPLMN ID
506
SEND ACKNOWLEDGEMENT (508)
ETACH ULCC FROM THE OLD NETWORK
510
INITIATE REQUEST FOR REMOTE PROVISIONING (512)
FORWARD THE REQUEST FOR REMOTE PROVISIONING (514)
516
VERIFY HPLMN ID
PERFORM REMOTE PROVISIONING AS IN FIGURE 2

FIG. 6


600
618
CURSOR CONTROL
616
INPUT DEVICE
614
DISPLAY
604
MEMORY
606
ROM
608
TRANSCEIVER
612
BUS
602
PROCESSOR
112
UICC
610
COMMUNICATION INTERFACE

METHOD AND SYSTEM FOR SECURED REMOTE PROVISIONING OF A UNIVERSAL INTEGRATED CIRCUIT CARD OF A USER EQUIPMENT

TECHNICAL FIELD

[0001] The present invention relates to the field of wireless communication, and more particularly relates to provisioning of an universal integrated circuit card of a user equipment.

BACKGROUND ART

[0002] Recent developments in Machine-to-Machine (M2M) applications has given rise to the possibility of having a universal integrated circuit card (UICC) that is embedded in a communication device in such a way that the UICC is not easily accessible or replaceable. The ability to change network subscriptions on such devices becomes problematic, thus necessitating mechanisms for securely and remotely provisioning access credentials on these embedded UICCs (eUICC) and managing subscription changes from one network operator to another. These mechanisms shall take into account that the change of subscription may involve provisioning of a new eUICC network access application as well as operator specific applications. Any changes must preserve the industry and end-user benefits that the non-embedded UICC provides today for GSM, 3GPP, 3GPP2 and other systems employing it, particularly in terms of security, flexibility in business relationships, logistics, and end-user experience.

DISCLOSURE OF INVENTION

Solution to Problem

[0003] The present invention provides a method and system for secured remote provisioning of a universal integrated circuit card of a user equipment. In one aspect, a method of secured remote provisioning of a universal integrated circuit card (UICC) of a user equipment includes generating a request for remote provisioning of an UICC of a user equipment remotely located from an operator network, where the request for remote provisioning includes a machine identifier (MID) associated with the user equipment and a public land mobile network (PLMN) identifier (ID) associated with an network operator.

[0004] The method further includes providing the request for remote provisioning to an associated one of shared key management servers by the operator network based on the MID. Also, the method includes dynamically generating security keys and an operator shared key using the security keys by the associated one of the shared key management servers based on the MID. Furthermore, the method includes generating a subscription key using the operator shared key and an international mobile subscriber identity (IMSI). Moreover, the method includes provisioning the IMSI in a secured manner to the UICC of the user equipment using the security keys by the operator network.

[0005] In another aspect, a non-transitory computer-readable storage medium having instructions stored therein, that when executed by a remote provisioning system, result in performing a method described above.

[0006] In yet another aspect, a system includes a user equipment for initiating a request for remote provisioning of an universal integrated circuit card (UICC) in the user equipment, where the request for remote provisioning includes a machine identifier (MID) associated with the user equipment and a public land mobile network (PLMN) identifier (ID) associated with an network operator. The system also includes at least one shared key management server for dynamically generating security keys and an operator shared key using the security keys, the MID. Moreover, the system includes an operator network for generating a subscription key using the operator shared key and an international mobile subscriber identity (IMSI) and provisioning the IMSI in a secured manner to the UICC of the user equipment using the security keys.

[0007] Other features of the embodiments will be apparent from the accompanying drawings and from the detailed description that follows.

BRIEF DESCRIPTION OF DRAWINGS

[0008] FIG. **1** illustrates a block diagram of a remote provisioning system for secured remote provisioning of an universal integrated circuit card (UICC) in a user equipment, according to one embodiment.

[0009] FIGS. **2***a* and **2***b* are flow diagrams illustrating an exemplary method of secured remote provisioning of the UICC in the user equipment, according to one embodiment.

[0010] FIG. **3** is a flow diagram illustrating an exemplary method of secured remote provisioning of the UICC in the user equipment, according to another embodiment.

[0011] FIG. **4** is a flow diagram illustrating an exemplary method of establishing a communication session with the operator network using an international mobile subscriber identifier (IMSI) assigned to the user equipment, according to one embodiment.

[0012] FIG. **5** is a flow diagram illustrating an exemplary method of changing a network operator and initiating secured remote provisioning of the UICC upon change of network operator, according to one embodiment.

[0013] FIG. **6** is a block diagram of a user equipment showing various components for implementing embodiments of the present subject matter.

[0014] The drawings described herein are for illustration purposes only and are not intended to limit the scope of the present disclosure in any way.

MODE FOR THE INVENTION

[0015] The present invention provides a method and system for secured remote provisioning of a universal integrated circuit card of a user equipment. In the following detailed description of the embodiments of the invention, reference is made to the accompanying drawings that form a part hereof, and in which are shown by way of illustration specific embodiments in which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention, and it is to be understood that other embodiments may be utilized and that changes may be made without departing from the scope of the present invention. The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of the present invention is defined only by the appended claims.

[0016] FIG. **1** illustrates a block diagram of a remote provisioning system **100** for secured remote provisioning of an universal integrated circuit card (UICC) in a user equipment, according to one embodiment. In FIG. **1**, the remote provisioning system **100** includes a plurality of user equipments **102**A-N, a network operator **104**, and a plurality of shared key

management servers **106**A-N. The operator network **104** includes an authentication and authorization server **108**, and a home subscriber server **110**.

[0017] The user equipments **102**A-N may include machine to machine communication devices or consumer equipments integrated with a universal integrated circuit card (UICC) **112** for communication with the network operator **104**. The shared key management servers **106**A-N may be vendors of the UICC **112** or manufactures of the user equipments **102**A-N embedded with the UICC **112**.

[0018] When installed for a first time, the UICC **112** installed in each of the user equipments **102**A-N includes a private key infrastructure (PKI) (including an UE certificate, and a root certificate) or a vendor shared key, a machine identifier, security capabilities, and storage space for storing provisioning data. It can be noted that, each of the user equipments **102**A-N includes the UICC **112** without the provisioning data of the network operator. The provisioning data may include international mobile subscriber identifier (IMSI), a security profile selected by the network operator, and a subscription key. The security profile contains a security algorithm (e.g., AES, SNOW 3G, MILENAGE, the like), supported modes of the security algorithm, and a key length.

[0019] In one embodiment, each of the user equipments **102**A-N is remotely provisioned with provisioning data when the user equipments **102**A-N are powered on for the first time. In an alternate embodiment, the UICC **112** in the user equipments **102**A-N is remotely provisioned in a secure manner when there is a change in a network operator.

[0020] For the purpose of illustration, consider that the user equipment **102**A is manufactured by a manufacturer 'A' and the manufacturer 'A' employs the shared key management server **106**A to enable remote provisioning of the UICC **112** in the user equipment **102**A via the operator network **104**. When the user equipment **102**A is powered on for the first time and the user equipment **102**A wants to access services provided by the operator network **104**, then the user equipment **102**A initiates a request for remote provisioning of the UICC **112** to the operator network **104**. The request for remote provisioning includes the MID and a public land mobile network (PLMN) identifier (ID) of the operator network **104**. The authentication and authorization server **108** identifies a shared key management server associated with the user equipment **102**A based on the MID. Accordingly, the server **108** provides the request for remote provisioning to the shared key management server **106**A.

[0021] The shared key management server **106**A generates authentication vectors, security keys (e.g., ciphering key (CK), and integrity protection key (IK)), an operator shared key using the security keys (CK and IK) and other parameters for mutual authentication based on the MID. The shared key management server **106**A provides the operator shared key to the HSS **110** via the server **108**. Alternatively, the operator shared key may be generated at the authentication and authorization server **108** using the security keys. The HSS **110** then generates an international mobile subscriber identity, a random number (Nonce), and a subscription key using the operator shared key and selects a security profile upon authenticating the user equipment **102**A by the authentication and authorization server **108**.

[0022] Accordingly, the authentication and authorization server **108** securely provisions the UICC **112** in the user equipment **102**A with the IMSI, the selected security profile, and the random number using the security keys. Then, the user equipment **102**A generates a subscription key using the operator shared key and the random number and stores the IMSI assigned by the network operator along with security profile and subscription key and uses the IMSI for establishing communication sessions with the operator network **104**. One skilled in the art will realize that the subscription key is derived in the UICC **112** and the HSS **110** using the operator shared key, thereby avoiding the key assignment over the air. The detailed process of secured remote provisioning of the UICC **112** is explained in greater detail in description that follows.

[0023] FIGS. **2***a* and **2***b* are flow diagrams **200** illustrating an exemplary method of secured remote provisioning of the UICC **112** in the user equipment **102**A, according to one embodiment. At step **202**, the user equipment **102**A initiates a request for remote provisioning of the UICC **112**. At step **204**, the authentication and authorization server **104** forwards the request for remote provisioning along with a network type to the shared key management server **106**A based on the MID. At step **206**, the shared key management server **106**A generates an authentication vector based on the request for remote provisioning received from the user equipment **102**A. The authentication vector includes an authentication token, a random number, response expected from the user equipment **102**A. At step **208**, the shared key management server **106**A derives an operator shared key using the security keys (ciphering key (CK), and integrity protection key (IK)) based on the MID.

[0024] At step **210**, the shared key management server **106**A provides the authentication token, the random number, the operator shared key, security capabilities, the expected response, and the security keys to the authentication and authorization server **108**. At step **212**, the authentication and authorization server **108** stores the operator shared key, the security capabilities, the expected response, and the security keys. At step **213**, the authentication and authorization server **108** forwards the MID, the authentication token and the random number to the user equipment **102**A. At step **214**, the user equipment **102**A verifies the authentication token using a vendor shared key. At step **216**, the user equipment **102**A derives security keys and an operator shared key using the security keys upon successful verification of the authentication token.

[0025] The shared key management server **106**A may prestore a list of operator shared keys and associated index values in the UICC **112** (during manufacturing phase). This enables the shared key management server **106**A to select different keys for different network operator. In such case, the shared key management server **106**A selects an operator shared key along with the associated index value from the list of operator shared keys (at step **208**). Then, the shared key management server **106**A shares the selected operator shared key and associated index value with the authentication and authorization server **108**. Accordingly, the authentication and authorization server **108** provides the index value associated with the selected operator shared key to the user equipment **102**A such that the user equipment **102**A selects a corresponding operator shared key from the list of operator shared keys based on the index value during authentication phase.

[0026] At step **218**, the user equipment **102**A authenticates the network operator based on the authentication token and the random number. At step **220**, the user equipment **102**A generates and forwards an authentication response message including a response and the MID to the authentication and

authorization server **108**. At step **222**, the authentication and authorization server **108** matches the response with the response expected from the user equipment **102**A. At step **224**, the authentication and authorization server **108** authenticates the user equipment **102**A if the response matches with the expected response. At step **226**, the authentication and authorization server **108** sends a MID registration message including the operator shared key, the security capabilities, and the MID to the HSS **110**.

[0027] At step **228**, the HSS **110** derives a subscription key associated with the registration of the user equipment **102**A using the operator shared key, and a random number. At step **230**, the HSS **110** generates IMSI for the user equipment **102**A using the subscription key and selects a security profile from the security capabilities. At step **232**, the authentication and authorization server **108** may encrypt the IMSI, the random number, and security profile associated with the user equipment **102**A using the security keys.

[0028] At step **234**, the authentication and authorization server **108** provides the IMSI, the random number and the security profile to the user equipment **102**A. At step **236**, the user equipment **102**A derives the subscription key using the operator shared key and the random number. At step **238**, the user equipment **102**A stores the subscription key and the IMSI along with the security profile in the storage space of the UICC **112**.

[0029] FIG. **3** is a flow diagram **300** illustrating an exemplary method of secured remote provisioning of the UICC **112** of the user equipment **102**A, according to another embodiment. At step **302**, the user equipment **102**A initiates a request for remote provisioning of the UICC **112**. The request includes MID, PLMN ID, and UE certificate. At step **304**, the authentication and authorization server **104** forwards the request for remote provisioning along with a network type to the shared key management server **106**A based on the MID. At step **306**, the shared key management server **106**A verifies and validates the UE certificate in the request for remote provisioning received from the user equipment **102**A. At step **308**, the shared key management server **106**A generates an operator shared key. At step **310**, the shared key management server **106**A provides the operator shared key, security capabilities, a shared key management server certificate to the authentication and authorization server **108**. In one embodiment, the shared key management server **106**A encrypts the operator shared key using a public key associated with the user equipment **106**A and a public key associated with the HSS **110** respectively.

[0030] The shared key management server **106**A may prestore a list of operator shared keys and associated index values in the UICC **112** (during manufacturing phase). This enables the shared key management server **106**A to select different keys for different network operator. In such case, the shared key management server **106**A selects an operator shared key along with the associated index value from the list of operator shared keys (at step **308**). Then, the shared key management server **106**A shares the selected operator shared key and associated index value with the authentication and authorization server **108**. Accordingly, the authentication and authorization server **108** provides the index value associated with the selected operator shared key to the user equipment **102**A such that the user equipment **102**A selects a corresponding operator shared key from the list of operator shared keys based on the index value during IMSI assignment.

[0031] At step **312**, the authentication and authorization server **108** sends a MID registration message including the encrypted operator shared key, the security capabilities, and the MID to the HSS **110**. At step **314**, the HSS **110** decrypts the encrypted operator shared key, generates a random number, and derives a subscription key using the operator shared key. At step **316**, the HSS **110** generates an IMSI for the user equipment **102**A using the subscription key and selects a security profile from the security capabilities and provides the same to the authentication and authorization server **108** (step **317**).

[0032] At step **318**, the authentication and authorization server **108** provides the IMSI, the random number, the security profile, the encrypted operator shared key, and the shared key management server certificate to the user equipment **102**A via a secured channel. At step **320**, the user equipment **102**A verifies the shared key management server certificate using the root certificate in the UICC **112**. Upon successful verification, at step **322**, the user equipment **102**A decrypts the encrypted operator shared key and derives the subscription key using the decrypted operator shared key and the random number. At step **324**, the user equipment **102**A stores the subscription key and the IMSI along with the security profile in the storage space of the UICC **112**.

[0033] FIG. **4** is a flow diagram **400** illustrating an exemplary method of establishing a communication session with the operator network using the IMSI assigned to the user equipment **102**A, according to one embodiment. At step **402**, the user equipment **102**A sends a non-access stratum message including the assigned IMSI to the operator network **104**. At step **404**, the authentication and authorization server **108** requests the HSS **110** for an authentication vector to authenticate the user equipment **102**A. At step **406**, the HSS **110** generates the authentication vector using the subscription key. At step **408**, the HSS **110** provides the authentication vector to the authentication and authorization server **108**.

[0034] At step **410**, the authentication and authorization server **108** sends a random number and authentication token in the authentication vector to the user equipment **102**A for authentication. At step **412**, the user equipment **102**A verifies the authentication token using a subscription key. At step **414**, the user equipment **102**A generates and forwards an authentication response message including a response and associated MID to the authentication and authorization server **108**. At step **416**, the authentication and authorization server **108** matches the response with a response expected from the user equipment **102**A. At step **418**, the authentication and authorization server **108** authenticates the user equipment **102**A if the response matches with the expected response.

[0035] At step **420**, a security mode command (SMC) exchange is performed between the user equipment **102**A and the operator network **104**. At step **422**, the operator network **104** sends a response to the user equipment **102**A upon successful SMC exchange.

[0036] FIG. **5** is a flow diagram **500** illustrating an exemplary method of changing a network operator and initiating secured remote provisioning of the UICC upon change of network operator, according to one embodiment. At step **502**, the user equipment **102**A request for a change in network operator to the shared key management server **106**A. At step **504**, the shared key management server **106**A sends a home PLMN ID associated with a new operator to the user equipment **102**A. At step **506**, the user equipment **102**A configures the HPLMN ID in the UICC **112** of the user equipment **102**A.

At step **508**, the user equipment **102**A sends an acknowledgement to the shared key management server **106**A that the HPLMN ID is configured.

[0037] At step **510**, the user equipment **102**A detaches the UICC **112** from the current operator network **104**. At step **512**, the user equipment **102**A initiates a request for remote provisioning of the UICC **112** to the new operator network. At step **514**, the new operator network **104** forwards the request for remote provisioning including the MID and HPLMN ID to the shared key management server **106**A. At step **516**, the shared key management server **106**A verifies the HPLMN ID in the request for remote provisioning matches with the HPLMN ID of the new operator network **104**. if match is found, the remote provisioning of the UICC **112** is performed via the new operator network **104** as described in FIGS. **2***a*, **2***b* and **3**.

[0038] Moreover, in one embodiment, a non-transitory computer-readable storage medium having instructions stored therein, that when executed by the remote provisioning system **100**, result in performing the method described in FIGS. **2***a* through **5**.

[0039] FIG. **6** is a block diagram of a user equipment **102**A showing various components for implementing embodiments of the present subject matter. In FIG. **6**, the user equipment **102**A includes the UICC **112**, a processor **602**, memory **604**, a read only memory (ROM) **606**, a transceiver **608**, a bus **610**, a communication interface **612**, a display **614**, an input device **616**, and a cursor control **618**.

[0040] The UICC **112** is a smart card capable of storing provisioning data and SIM application. The UICC **112** primarily includes a private key infrastructure (PKI) (including a UE certificate, and a root certificate) or a vendor shared key, a machine identifier, security capabilities, and storage space for storing provisioning data. The processor **602**, as used herein, means any type of computational circuit, such as, but not limited to, a microprocessor, a microcontroller, a complex instruction set computing microprocessor, a reduced instruction set computing microprocessor, a very long instruction word microprocessor, an explicitly parallel instruction computing microprocessor, a graphics processor, a digital signal processor, or any other type of processing circuit. The processor **602** may also include embedded controllers, such as generic or programmable logic devices or arrays, application specific integrated circuits, single-chip computers, smart cards, and the like.

[0041] The memory **604** and the ROM **606** may be volatile memory and non-volatile memory. The memory **604** includes instructions temporarily stored therein to initiate a request for remote provisioning of the UICC **112** and receive provisioning data from the operator network **104**, according to the embodiments of the present subject matter. A variety of computer-readable storage media may be stored in and accessed from the memory elements. Memory elements may include any suitable memory device(s) for storing data and machine-readable instructions, such as read only memory, random access memory, erasable programmable read only memory, electrically erasable programmable read only memory, hard drive, removable media drive for handling memory cards, Memory Sticks™, and the like.

[0042] Embodiments of the present subject matter may be implemented in conjunction with modules, including functions, procedures, data structures, and application programs, for performing tasks, or defining abstract data types or low-level hardware contexts. Machine-readable instructions stored on any of the above-mentioned storage media may be executable by the processor **602**. For example, a computer program may include machine-readable instructions capable of initiating a request for remote provisioning of the UICC **112** and receiving provisioning data from the operator network **104** according to the teachings and herein described embodiments of the present subject matter. In one embodiment, the program may be included on a storage medium and loaded from the storage medium to a hard drive in the non-volatile memory. The machine-readable instructions may cause the user equipment **102**A to encode according to the various embodiments of the present subject matter.

[0043] The transceiver **608** may be capable of sending the request for remote provisioning and securely receiving provisioning data including IMSI from the operator network **104**. The bus **610** acts as interconnect between various components of the user equipment **102**A. The components such as communication interfaces **612**, the display **614**, the input device **616**, and the cursor control **618** are well known to the person skilled in the art and hence the explanation is thereof omitted.

INDUSTRIAL APPLICABILITY

[0044] The present embodiments have been described with reference to specific example embodiments, it will be evident that various modifications and changes may be made to these embodiments without departing from the broader spirit and scope of the various embodiments. Furthermore, the various devices, modules, selectors, estimators, and the like described herein may be enabled and operated using hardware circuitry, for example, complementary metal oxide semiconductor based logic circuitry, firmware, software and/or any combination of hardware, firmware, and/or software embodied in a machine readable medium. For example, the various electrical structure and methods may be embodied using transistors, logic gates, and electrical circuits, such as application specific integrated circuit.

1. A method of secured remote provisioning of a universal integrated circuit card (UICC) of a user equipment, the method comprising:

generating a request for remote provisioning of a UICC of a user equipment remotely located from an operator network, wherein the request for remote provisioning includes a machine identifier (MID) associated with the user equipment and a public land mobile network (PLMN) identifier (ID) associated with an network operator;

providing the request for remote provisioning to an associated one of shared key management servers by the operator network based on the MID;

dynamically generating security keys and an operator shared key using the security keys by the associated one of the shared key management servers based on the MID;

generating a subscription key using the operator shared key and an international mobile subscriber identity (IMSI) by the operator network; and

provisioning the IMSI in a secured manner to the UICC of the user equipment using the security keys by the operator network.

2. The method of claim **1**, wherein the request for remote provisioning is generated upon powering on the user equipment.

3. The method of claim **1**, wherein dynamically generating the security keys and the operator shared key using the security keys by the associated one of the shared key management servers based on the MID comprises:

generating an authentication vector based on the request for remote provisioning received from the user equipment, wherein the authentication vector comprises an authentication token, a random number, expected response, and security keys;

deriving an operator shared key based on the security keys, and the MID; and

providing the authentication token, the random number, the operator shared key, security capabilities, response expected from the user equipment, the security keys during authentication to the authentication and authorization server.

4. The method of claim **1**, wherein the UICC in the user equipment comprises a pre-shared list of operator shared keys and associated index value.

5. The method of claim **4**, wherein dynamically generating the security keys and the operator shared key using the security keys by the associated one of the shared key management servers based on the MID comprises:

generating an authentication vector based on the request for remote provisioning received from the user equipment, wherein the authentication vector comprises an authentication token, a random number, expected response, and security keys;

selecting an operator shared key and an associated index value from the list of operator shared keys; and

providing the authentication token, the random number, the operator shared key, the associated index value, security capabilities, response expected from the user equipment, the security keys during authentication to the authentication and authorization server.

6. The method of claim **3**, wherein generating the subscription key using the operator shared key and the IMSI by the operator network comprises:

providing the random number, the MID and the authentication token to the user equipment by an authentication and authorization server of the operator network;

verifying the authentication token received from the authentication and authorization server by the user equipment based on a vendor shared key, wherein the vendor shared key is pre-stored in the UICC;

generating the operator shared key upon successful verification of the authentication token;

authenticating the network operator based on the authentication token and the random number;

generating and forwarding a user authentication response message including a response and the machine identifier in response to the random number and the authentication token to the authentication and authorization server;

determining whether the response in the user authentication response message matches the response expected from the user equipment received from the associated one of the shared key management servers; and

authenticating the user equipment if the response matches the response expected from the user equipment.

7. The method of claim **6**, wherein generating the subscription key using the operator shared key and the IMSI by the operator network further comprises:

generating and sending a MID registration message to a home subscriber server (HSS) of the operator network, wherein the MID registration message includes the operator shared key, the security capabilities, and the MID;

generating a random number, and a subscription key associated with registration of the user equipment with the network operator using the operator shared key, random number, and the MID;

generating the IMSI for the user equipment and selecting a security profile from the security capabilities by the HSS;

providing the IMSI, the random number, and the security profile associated with the user equipment upon successful registration of the UICC to the authentication and authorization server; and

encrypting the IMSI, the random number and the security profile associated with the user equipment using the security keys.

8. The method of claim **7**, wherein provisioning the IMSI in a secured manner to the UICC of the user equipment using the security keys comprises:

providing the encrypted IMSI, random number and security profile to the user equipment by the authentication and authorization server via a secured channel;

generating the subscription key using the operator shared key and the random number; and

storing the subscription key and the IMSI along with the security profile in the UICC by the user equipment.

9. The method of claim **1**, wherein the security keys comprises a ciphering key and an integrity protection key.

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

establishing one or more communication sessions with the network operator by the user equipment using the IMSI assigned to the UICC.

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

requesting a change of network operator by the user equipment to the associated one of shared key management servers;

receiving a home PLMN ID from the associated one of the shared key management servers;

configuring the home PLMN ID in the UICC of the user equipment;

detaching the UICC from the current operator network upon successful configuration of the home PLMN ID by the user equipment;

requesting remote provisioning of the UICC by the user equipment to another operator network associated with the home PLMN ID; and

generating a subscription key and provisioning an IMSI in a secured manner to the UICC of the user equipment upon successful verification of the home PLMN ID by the associated one of the shared key management server.

12. A system for secured remote provisioning of a universal integrated circuit card (UICC) of a user equipment, the system comprising:

a user equipment with an UICC for initiating a request for remote provisioning of the UICC in the user equipment, wherein the request for remote provisioning includes a machine identifier (MID) associated with the user equipment and a public land mobile network (PLMN) identifier (ID) associated with an network operator;

at least one shared key management server for dynamically generating security keys and an operator shared key using the security keys based on the MID; and

an operator network for generating a subscription key using the operator shared key and an international mobile subscriber identity (IMSI), and provisioning the IMSI in a secured manner to the UICC of the user equipment using the security keys.

13. The system of claim **12**, wherein the user equipment initiates the request for remote provisioning of the UICC upon power on.

14. The system of claim **12**, wherein in dynamically generating the security keys and the operator shared key using the security keys based on the MID, the at least one shared key management server:

generates an authentication vector based on the request for remote provisioning received from the user equipment, wherein the authentication vector comprises an authentication token, a random number, expected response, and security keys;

derives an operator shared key based on the security keys, and the MID; and

provides the authentication token, the random number, the operator shared key, security capabilities, response expected from the user equipment, security keys during authentication to the operator network.

15. The system of claim **13**, wherein in generating the subscription key using the operator shared key and the IMSI, the operator network comprises:

an authentication and authorization server for generating and sending a MID registration message to a home subscriber server (HSS) of the operator network, wherein the MID registration message includes the operator shared key, the security capabilities, and the MID; and

a home subscriber server for:

generating a random number and a subscription key associated with registration of the user equipment with the network operator using the operator shared key, the random number, and the MID;

generating an IMSI for the user equipment using the subscription key and selecting a security profile from the security capabilities; and

providing the IMSI, the Nonce, and the security profile associated with the user equipment upon successful registration of the UICC to the authentication and authorization server.

16. The system of claim **13**, wherein in provisioning the IMSI in a secured manner to the UICC of the user equipment using the security keys, the user equipment receives the IMSI, the random number, and the security profile from the authentication and authorization server via a secured channel, derives the subscription key using the operator shared key and the random number, and stores the subscription key and the IMSI along with the security profile in the UICC.

17. The system of claim **12**, wherein the security keys comprises a ciphering key and an integrity protection key.

18. The system of claim **12**, wherein the user equipment establishes one or more communication sessions with the network operator using the IMSI assigned to the UICC.

19. The system of claim **12**, wherein the user equipment requests a change of network operator to the at least one shared key management server, receives a home PLMN ID from the at least one the shared key management server, configures the home PLMN ID in the UICC, detaches the UICC from the current operator network upon successful configuration of the home PLMN ID, and initiates a request for remote provisioning of the UICC by another operator network associated with the home PLMN ID.

20. A non-transitory computer-readable storage medium having instructions stored therein that when executed by a remote provisioning system, result in performing the method comprising:

generating a request for remote provisioning of a UICC of a user equipment remotely located from an operator network, wherein the request for remote provisioning includes a machine identifier (MID) associated with the user equipment and a public land mobile network (PLMN) identifier (ID) associated with an network operator;

providing the request for remote provisioning to an associated one of shared key management servers by the operator network based on the MID;

dynamically generating security keys and an operator shared key using the security keys by the associated one of the shared key management servers based on the MID;

generating a subscription key using the operator shared key and an international mobile subscriber identity (IMSI) by the operator network; and

provisioning the IMSI in a secured manner to the UICC of the user equipment using the security keys by the operator network.

21. A method of a user equipment for secured remote provisioning of a universal integrated circuit card (UICC) of the user equipment, the method comprising:

initiating a request for remote provisioning of the UICC of the user equipment remotely located from an operator network to a shared key management server via the operator network, wherein the request for remote provisioning includes a machine identifier (MID) associated with the user equipment and a public land mobile network (PLMN) identifier (ID) associated with an network operator;

receiving authentication parameters from the operator network in response to the request for remote provisioning;

sending an authentication response message to the operator network upon successful verification of authentication parameters;

securely receiving security credentials from the operator network in response to the authentication response message; and

generating a subscription key at the UICC based on the security credentials received from the operator network.

22. The method of claim **21**, wherein the authentication parameters comprises an authentication token and random number.

23. The method of claim **22**, wherein the security credentials comprises an international mobile subscriber identity (IMSI) assigned to the UICC, a security profile, and a random number.

24. The method of claim **23**, wherein sending the authentication response message upon successful verification of authentication parameters, comprises:

verifying the authentication parameters using a vendor shared key stored in the UICC by the shared key management server for authenticating the operator network;

deriving security keys based on the authentication parameters and generating an operator shared key using the security keys;

generating a response upon successful verification of the authentication parameters; and

sending an authentication response message including the response to the operator network upon successful verification of the authentication parameters.

25. The method of claim **24**, wherein the subscription key is generated based on the operator shared key, and the random number.

26. The method of claim **25**, further comprising:

storing the IMSI, the security profile, and the subscription key in the UICC.

27. The method of claim **21**, wherein the request for remote provisioning is initiated upon powering on the user equipment.

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