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System and methods for UICC-based secure communication

US 9461993 B2

ABSTRACT

A system that incorporates the subject disclosure may include, for example, instructions which when executed cause a device processor to perform operations comprising sending a service request to a remote management server; receiving from the management server an authentication management function and an encryption key generator for execution by a secure element and an encryption engine for execution by a secure device processor, sending a request to establish a communication session with a remote device; and communicating with the remote device via a channel established using an application server. The secure element and the secure device processor authenticate each other using a mutual authentication keyset. The secure element, the secure device processor and the device processor each have a security level associated therewith; the security level associated with the secure device processor is intermediate between that of the secure element and that of the device processor. Other embodiments are disclosed.

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| Inventors | Walter Cooper Chastain , Stephen Emille Chin |
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DESCRIPTION

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a Continuation of and claims priority to U.S. patent application Ser. No. 14/023,932, filed Sep. 11, 2013, the disclosure of which is hereby incorporated by reference into this application as if set forth herein in full.

FIELD OF THE DISCLOSURE

The subject disclosure relates to a system and method for secure communications between devices, based on a universal integrated circuit card (UICC) included in those devices.

BACKGROUND

Wireless communication devices such as cellular phones typically use one or more software applications to provide security-related functions. A device may include a universal integrated circuit card (UICC), which typically can securely store encryption keys and authentication credentials and can execute small applets. The device processor, on the other hand, can store and execute large and processor intensive applications, but is relatively unsecure.

BRIEF DESCRIPTION OF THE DRAWINGS

CLAIMS (20)

What is claimed is:

1. A method comprising:

receiving, over a network by a system including a processor, a first request for service from a first end user device;

providing, by the system over the network to the first end user device, an authentication management function and an encryption key generator for execution by a secure element of the first end user device and an encryption engine for execution by a secure device processor of the first end user device, to cause the secure element and the secure device processor to authenticate each other using a mutual authentication keyset, wherein the secure element and the secure device processor are separate from each other;

receiving, by the system over the network from the first end user device, a second request for a secure signaling session, wherein the second request is initiated by the secure device processor of the first end user device;

providing, by the system over the network to the first end user device, a first authentication signal, wherein a secure application server associated with the system is authenticated by the authentication management

Reference will now be made to the accompanying drawings, which are not necessarily drawn to scale, and wherein:

FIG. 1 depicts an illustrative embodiment of a communication device incorporating a secure services platform;

FIG. 2 depicts an illustrative embodiment of a secure services platform of a communication device;

FIG. 3 schematically illustrates a network architecture for secure communication between user devices, according to an embodiment of the disclosure;

FIG. 4 depicts an illustrative embodiment of a method used in portions of the system described in FIG. 3, to establish a secure communication channel between user devices;

FIG. 5 depicts an illustrative embodiment of a method used in portions of the system described in FIG. 3, to establish an encrypted communication session between user devices;

FIG. 6 schematically illustrates a network architecture for secure communication between user devices, according to another embodiment of the disclosure;

FIG. 7 depicts an illustrative embodiment of a method used in portions of the system described in FIG. 6, to establish a secure communication channel between user devices;

FIG. 8 depicts an illustrative embodiment of a method used in portions of the system described in FIG. 6, to establish an encrypted communication session between user devices;

FIG. 9 depicts an illustrative embodiment of a communication system that provides media services to the user devices of FIG. 1;

FIG. 10 depicts an illustrative embodiment of a communication device; and

FIG. 11 is a diagrammatic representation of a machine in the form of a computer system within which a set of instructions, when executed, may cause the machine to perform any one or more of the methods described herein.

DETAILED DESCRIPTION

The subject disclosure describes, among other things, illustrative embodiments of a system and method for providing secure communication between devices. Other embodiments are included in the subject disclosure.

One embodiment of the subject disclosure includes a device comprising a secure element; a secure device processor separate from the secure element; a memory to store executable instructions; and a device processor separate from the secure device processor and coupled to the memory, the secure element and the secure device processor, wherein the device processor, responsive to executing the instructions, performs operations. The operations comprise sending a first request for service to a management server remote from the device; receiving from the management server an authentication management function and an encryption key generator for execution by the secure element and an encryption engine for execution by the secure device processor, to cause the secure element and the secure device processor to authenticate each other using a mutual authentication keyset; authenticating a user of the device using a user interface keyset, wherein user credentials are verified by the authentication management function; sending a second request for a secure signaling session to a secure application server remote from the device, wherein the second request is initiated by the secure device processor; receiving from the secure application server a first authentication signal, wherein the secure application server is authenticated by the authentication management function using a signaling authentication keyset; communicating

communicating by the system with the first end user device via a first encrypted channel using a first signaling encryption keyset, wherein encryption and decryption of communications over the first encrypted channel is performed by the encryption engine and the first signaling encryption keyset is generated by the encryption key generator;

receiving, by the system over the network from the first end user device, a third request to establish a communication session with a second end user device; and

communicating by the system with the second end user device via a second encrypted channel using a second signaling encryption keyset,

wherein the communicating by the system with the first and second end user devices enables establishing the communication session between the first and second end user devices, and

wherein the mutual authentication keyset, the signaling authentication keyset, and the first and second signaling encryption keysets are distinct keysets.

2. The method of claim 1, wherein the first end user device receives a second authentication signal from the second end user device, wherein the second end user device is authenticated by the authentication management function using a bearer path authentication keyset, and wherein the bearer path authentication keyset is a distinct keyset from the mutual authentication keyset, the signaling authentication keyset, and the first and second signaling encryption keysets.

3. The method of claim 1, wherein a user of the first end user device is authenticated using a user interface keyset, wherein user credentials are verified by the authentication management function.

4. The method of claim 1, wherein the secure element is a universal integrated circuit card, wherein the secure element and the secure device processor form a secure service platform separate from a device processor of the first end user device, wherein the mutual authentication keyset is provided to the secure service platform by a management server of the system, and wherein the management server transmits information to the secure service platform using a remote management keyset.

5. The method of claim 1, wherein the communication session between the first and second end user devices comprises an encrypted communication session with bi-directional encryption.

6. The method of claim 1, wherein the receiving of the first request and the providing of the authentication management function, the encryption key generator, and the encryption engine is from a management server of the system.

7. The method of claim 6, wherein the management server is authenticated by the authentication management function using a remote management keyset, to provide mutual authentication of the secure element and the management server and to provide mutual authentication of the secure device processor and the management server.

8. The method of claim 1, wherein the receiving of the second request, the providing of the first authentication signal, the communicating via the first encrypted channel, and the communicating via the second encrypted channel is by the secure application server.

signaling encryption keyset, wherein encryption and decryption of communications over the first encrypted channel is performed by the encryption engine and the first signaling encryption keyset is generated by the encryption key generator; sending a third request to the secure application server to establish a communication session with a second device; and receiving from the second device a second authentication signal. The second device is authenticated by the authentication management function using a bearer path authentication keyset. The mutual authentication keyset, the user interface keyset, the signaling authentication keyset, the first signaling encryption keyset, and the bearer path authentication keyset are distinct keysets.

One embodiment of the subject disclosure includes a method comprising sending, by a device comprising a device processor, a secure element and a secure device processor separate from the device processor, a first request for service to a management server remote from the device; receiving, by the device, from the management server an authentication management function and an encryption key generator for execution by the secure element and an encryption engine for execution by the secure device processor, to cause the secure element and the secure device processor to authenticate each other using a mutual authentication keyset, wherein the secure element and the secure device processor are separate from each other; sending, by the device, a second request for a secure signaling session to a secure application server remote from the device, wherein the second request is initiated by the secure device processor; receiving, by the device, from the secure application server a first authentication signal, wherein the secure application server is authenticated by the authentication management function using a signaling authentication keyset; communicating, by the device, with the secure application server via a first encrypted channel using a first signaling encryption keyset, wherein encryption and decryption of communications over the first encrypted channel is performed by the encryption engine and the first signaling encryption keyset is generated by the encryption key generator; sending, by the device, a third request to the secure application server to establish a communication session with a second device; and receiving, by the device, from the second device a second authentication signal, wherein the second device is authenticated by the authentication management function using a bearer path authentication keyset. The mutual authentication keyset, the signaling authentication keyset, the first signaling encryption keyset, and the bearer path authentication keyset are distinct keysets.

One embodiment of the subject disclosure includes a tangible computer-readable storage device comprising instructions, which when executed by a device processor cause the device processor to perform operations. The operations comprise sending a first request for service to a management server remote from the device; receiving from the management server an authentication management function and an encryption key generator for execution by a secure element and an encryption engine for execution by a secure device processor, to cause the secure element and the secure device processor to authenticate each other using a mutual authentication keyset, wherein the secure element and the secure device processor are separate from each other and coupled to the device processor; authenticating a user using a user interface keyset, wherein user credentials are verified by the authentication management function; sending a second request to establish a communication session with a remote second device, wherein the second request is initiated by the secure device processor; and communicating with the second device via a communication channel established using an application server. The secure element, the secure device processor and the device processor each have a security level associated therewith, and the security level associated with the secure device processor is intermediate between that of the secure element and that of the device processor. The secure element is a universal integrated circuit card, the secure element and the secure device processor form a secure service platform separate from the device processor, the mutual authentication

each have a security level associated therewith, and wherein the security level associated with the secure device processor is intermediate between that of the secure element and that of the device processor.

10. An end user device comprising:

a secure element;

a secure device processor separate from the secure element;

a memory that store executable instructions; and

a device processor separate from the secure device processor and coupled to the memory, the secure element and the secure device processor, wherein the device processor, responsive to executing the instructions, performs operations comprising:

sending a first request for service over a network to a management server;

receiving, from the management server, an authentication management function and an encryption key generator for execution by the secure element and an encryption engine for execution by the secure device processor, to cause the secure element and the secure device processor to authenticate each other using a mutual authentication keyset;

authenticating a user of the device using a user interface keyset, wherein user credentials are verified by the authentication management function;

sending a second request for a secure signaling session to a secure application server remote from the device, wherein the second request is initiated by the secure device processor;

receiving from the secure application server a first authentication signal, wherein the secure application server is authenticated by the authentication management function using a signaling authentication keyset;

communicating with the secure application server via a first encrypted channel using a first signaling encryption keyset, wherein encryption and decryption of communications over the first encrypted channel is performed by the encryption engine and the first signaling encryption keyset is generated by the encryption key generator; and

sending a third request to the secure application server to establish an encrypted communication session with a second device, wherein the encrypted communication session provides bi-directional encryption,

wherein the mutual authentication keyset, the user interface keyset, the signaling authentication keyset, and the first signaling encryption keyset are distinct keysets.

11. The end user device of claim 10, wherein the operations further comprise:

receiving, from the second device, a second authentication signal, wherein the second device is authenticated by the authentication management function using a bearer path authentication keyset,

wherein the bearer path authentication keyset is a distinct keyset from the mutual authentication keyset, the user interface keyset, the signaling authentication keyset, and the first signaling encryption keyset.

and the management server transmits information to the secure service platform using a remote management keyset. The mutual authentication keyset, the user interface keyset and the remote management keyset are distinct keysets.

In accordance with an embodiment of the disclosure, FIG. 1 depicts an arrangement **100** of a communication device (CD) connected to a network and provided with a secure services platform enabling authentication of other communication devices and encrypted communication with those devices. It will be appreciated that the communication device may be any device, including a user device, that has a secure element and a secure device processor and thus has secure communication capability. The term "user," in this embodiment, refers to a human user of the communication device. In other embodiments, the user can be a machine that exchanges data with the communication device after being authenticated to the communication device. Communication device **102** includes device processor **104**, secure device processor **106** and a secure element **108**. In this embodiment, secure element **108** is a universal integrated circuit card (UICC). The UICC is a secure computing platform and offers a high level of security for storing encryption keys, authentication credentials, and the like. The UICC may be removable from the device. Alternatively, the UICC may be embedded in the device and not removable. In other embodiments, the secure element can be placed on a memory card or an embedded chip. The secure device processor (SDP) **106** is logically and/or physically separate from the device processor **104**, and is connected to both the device processor and the UICC. In this embodiment, the SDP offers a higher level of security than the device processor **104**, and stores and executes secure applications. The SDP can, for example, run applications in a trusted execution environment. The secure element and secure device processor together form a secure services platform **110** resident on device **102**. In this embodiment secure element **108**, secure device processor **106** and device processor **104** each have a security level associated therewith, and the security level associated with the secure device processor **106** is intermediate between that of the secure element **108** and that of the device processor **104**. The secure device processor and secure element use mutual authentication, as described in more detail below.

The secure element and secure device processor communicate with a management server **120**, located remotely from device **102**. The remote management server is a platform for provisioning and managing applications in the secure element and secure device processor. The remote management server also manages data (such as keys, credentials, etc.) that are used by the applications.

In this embodiment, user device **102** is a wireless communication device connected to a cellular network **122**. Network **122** can also be a WiFi network. In other embodiments, device **102** can be connected to other devices via a wired connection through a computer. In still other embodiments, user devices may communicate with each other using Bluetooth, infrared communications (IRDa) or near field communications (NFC). A communication session between user devices, wherein information is transferred between the users, can be effected by a wide variety of arrangements. As explained in detail below, a secure application server (SAS) is used in some embodiments to establish a secure communication session between devices. However, a secure application server is not used in embodiments where the communication session is established in a peer-to-peer manner, such as in Bluetooth, IRDa or NFC.

FIG. 2 is a schematic illustration **200** showing details of a secure services platform **110**, according to an embodiment of the disclosure. The secure element **108** (in this embodiment, a UICC) contains an authentication management function **202** and a real-time encryption key generator **204**. The authentication management function **202** provides all authentication services for the device. Specifically, the authentication management function supports the

12. The end user device of claim 10, wherein the operations further comprise:

sending a notification message indicating that the encrypted communication session with bi-directional encryption has been established.

13. The end user device of claim 10, wherein the secure element is a universal integrated circuit card, wherein the secure element and the secure device processor form a secure service platform separate from the device processor, wherein the mutual authentication keyset is provided to the secure service platform by the management server, and wherein the management server transmits information to the secure service platform using a remote management keyset.

14. The end user device of claim 13, wherein the secure element and the management server authenticate each other using the remote management keyset, and wherein the authentication management function performs authentication of the management server by the secure element.

15. The end user device of claim 13, wherein the secure device processor and the management server authenticate each other using the remote management keyset, and wherein the authentication management function performs authentication of the management server by the secure device processor.

16. The end user device of claim 10, wherein the authentication management function comprises a network authentication service for mutual authentication between the device and equipment of the network, and wherein the device processor comprises a plurality of processors operating in a distributed processing environment.

17. The end user device of claim 16, wherein the network is a cellular communications network, and wherein the second device and the secure application server are coupled to the network.

18. The end user device of claim 10, wherein the secure application server communicates with the second device via a second encrypted channel using a second signaling encryption keyset, wherein the second encrypted channel is separate from the first encrypted channel and wherein the second signaling encryption keyset is distinct from the first signaling encryption keyset.

19. A computer-readable storage device comprising instructions, which when executed by a device processor of an end user device cause the device processor to perform operations comprising:

sending a first request for service over a network to a management server;

receiving, over the network from the management server, an authentication management function and an encryption key generator for execution by a secure element of the end user device and an encryption engine for execution by a secure device processor of the end user device, to cause the secure element and the secure device processor to authenticate each other using a mutual authentication keyset, wherein the secure element and the secure device processor are separate from each other and coupled to the device processor;

sending, over the network to a secure application server, a second request to establish an encrypted communication session with a second end user device; and

receiving, over the network from the second end user device, a second

the remote management server. As shown in FIG. 2, the authentication management function includes a user authentication service **212** for authenticating the user to the device and a network authentication service **214** for authenticating the device to network equipment. The real-time encryption key generator **204** supplies encryption keys to the real-time encryption engine **206** which is located in the SDP **106**. The real-time encryption engine **206** encrypts and decrypts user information transmitted to or from a bearer path **216** that terminates at another user device, and may encrypt and decrypt information transmitted on a signaling path **218** to the network. In another embodiment, the encryption engine can be loaded on a second secure element, separate from the secure element **108**.

The remote management server **120** performs a remote provisioning and management function **210** to load applications and content into the UICC and SDP. In this embodiment, the remote management server provisions the authentication management function **202** and real-time encryption key generator **204** on the UICC **108**, and provisions the real-time encryption engine **206** on the SDP **106**. This is done securely by the use of one or more remote management keysets. Before the secure services platform **110** can be used for communication, the SDP must be authenticated by the UICC. This is done using a UICC-SDP keyset. The UICC-SDP keyset may be provisioned remotely by the remote management server or locally by an authorized user. In this embodiment, after the UICC and SDP are mutually authenticated using the UICC-SDP keyset, they communicate via a signaling path **208** within the secure services platform **110**. Alternatively, the path between the UICC **108** and the SDP **106** may go through the device processor **104** rather than directly between the UICC and the SDP.

FIG. 3 schematically illustrates a network architecture **300** for facilitating secure communication between two user devices, according to an embodiment of the disclosure. In this embodiment, end-to-end security can be provided to end users by using the UICC and the SDP as a security platform in conjunction with a secure application server (SAS). A first user device **301** and a second user device **302** are each managed and provisioned by remote management server **320**. Remote management keyset **321** is used to securely transmit information from the remote management server to the user devices. (In other embodiments, devices **301**, **302** can be provisioned by separate remote management servers, generally using different keysets.) Each user device has a UICC and a SDP mutually authenticated by a UICC-SDP keyset, shown schematically at **311** and **312** respectively.

Each device must also have a user (or, in other embodiments, a machine that interacts with the device) authenticated to that device. User authentication is performed by the authentication management function of the UICC of each device, using a user interface keyset **313**, **314** respectively. User authentication may involve many types of credentials: pin numbers, fingerprints, retinal scans, voice recognition, etc. The user interface keysets **313**, **314** may be provisioned by the remote management server or locally by an authorized user.

In this embodiment, a secure application server **330** is used to establish a communication session between user devices **301**, **302**. The remote management server **320** provisions the secure application server **330** with user information related to the secure communication service. The secure application server and the UICC of user device **301** mutually authenticate each other using a signaling authentication keyset **331**; the secure application server and the UICC of user device **302** mutually authenticate each other using a signaling authentication keyset **333**. The secure application server can then establish secure signaling sessions with the user devices **301**, **302**, using signaling encryption keysets **332**, **334** respectively. The authentication and encryption keysets are provisioned to the secure application server by the remote management server.

The secure application server **330** creates an unsecure communication session between user devices **301**, **302** over a bearer path **340**. The bearer path can include, but is not limited to, UMTS, LTE, and WiFi. Mutual authentication between the user devices is performed using a bearer path authentication keyset **341**. If increased security is desired, the communication between devices can be encrypted using a bearer path encryption keyset **342**.

FIG. 4 is a flowchart **400** showing a procedure for establishing a communication session between two user devices using a secure application server, in accordance with an embodiment of the disclosure. Upon receiving a request for service (step **402**), the remote management server **320** downloads programs and content to user devices **301**, **302** to allow the user devices to support a secure communication service that includes real-time encryption and authentication services (step **404**). For each of the user devices, the remote management server loads the real-time encryption engine into the secure device processor (SDP) of the device (e.g. smartphone, M2M device), the authentication management function to the secure element (e.g. a UICC), and the real-time encryption key generator to the secure element.

In step **406**, the remote management server provisions the secure application server (SAS) **330** with information regarding the user devices **301**, **302**. Remote management keyset(s) **321** are used to securely transmit information from the remote management server to the user devices and to the secure application server **330**. This process involves mutual

20. The computer-readable storage device of claim 19, wherein the secure element is a universal integrated circuit card, wherein the secure element and the secure device processor form a secure service platform separate from the device processor, wherein the mutual authentication keyset is provided to the secure service platform by the management server, wherein the management server transmits information to the secure service platform using a remote management keyset, and wherein the device processor comprises a plurality of processors operating in a distributed processing environment.

After the user devices are provisioned, the UICC and SDP within each device mutually authenticate each other (step **408**). In this embodiment, this is done using UICC-SDP keysets **311**, **312**. In general, the UICC-SDP keysets used in the two user devices will be distinct keysets. The user of device **301** then authenticates with the device using user interface keyset **313** (step **410**). User authentication may be performed using a variety of credentials, including pin number, fingerprint, retinal scan, etc. The user's credentials are verified by the authentication management function within the UICC of device **301**. In this embodiment, wherein signaling to a secure application server is performed, the each of the users must authenticate with their device before establishment of a secure signaling channel to the SAS.

Secure application server **330** is used to set up a secure communication path between the two users through their respective devices (user device **301** and user device **302**). The SDP of user device **301** initiates a request for a secure signaling session to the secure application server **330** (step **412**). The secure application server **330** and the UICC of user device **301** mutually authenticate each other using a signaling authentication keyset **331**. The secure application server **330** is authenticated by the authentication management function within the UICC of user device **301**.

Once the user device **301** and the secure application server **330** are mutually authenticated, an encrypted channel is established between them using the signaling encryption keyset **332** (step **414**). The encryption and decryption is performed by the real-time encryption engine in the SDP of user device **301**. The signaling encryption keyset **332** is provided to the SDP by the real-time encryption key generator within the UICC of user device **301**. The request for the session (originating from device **301** in step **412**) is passed to the secure application server **330**.

The user of device **302** must authenticate with the device before a signaling session can take place between device **302** and the secure application server **330**. This is done (step **416**) using user interface keyset **314**, which may be different from user interface keyset **313**. The user authentication process is performed by the authentication management function within the UICC of user device **302**. The secure application server **330** then instructs user device **302** to establish a secure signaling session with the SAS (step **418**). The secure application server **330** and the UICC of user device **302** mutually authenticate each other using signaling authentication keyset **333** (which may be different from signaling authentication keyset **331**). The secure application server **330** is authenticated by the authentication management function within the UICC of user device **302**.

Once mutually authenticated, an encrypted channel is established between user device **302** and the secure application server **330** (step **420**), using signaling encryption keyset **334** (which may be different from signaling encryption keyset **332**). The encryption and decryption is performed within the by the real-time encryption engine in the SDP of user device **302**. The signaling encryption keyset **334** is provided to the SDP by the real-time encryption key generator within the UICC of user device **302**. The request for the session (originating from device **301** in step **412**) is passed from the secure application server **330** to user device **302**.

In step **422**, user device **302** is notified by the secure application server **330** that a session request has been made.

Mutual authentication is then performed directly between user device **301** and user device **302** using the bearer path authentication keyset **341** (step **424**). This authentication process is performed by the authentication management functions within the UICC of user device **301** and user device **302**.

FIG. 5 is a flowchart **500** showing a process, in accordance with an embodiment, to establish an encrypted communication session between user devices **301** and **302**. This process is performed after the devices have mutually authenticated in accordance with a secure signaling session using SAS **330** and a bearer path **340** has been established, as described above with reference to FIG. 4.

User devices **301** and **302** communicate via bearer path **340** (step **502**). If either user wishes to increase the security of the communication (step **504**), that user's device sends a notice to the other device that a bi-directional encrypted session is desired (step **506**). The SDP of each user device requests a bearer path encryption keyset from the real-time encryption key generator within the UICC of that device (step **508**). The encryption and decryption is performed by the real-time encryption engine in each SDP (step **510**). The devices **301**, **302** then send notices to the respective users that each user is authenticated and that the communication session is encrypted (step **512**).

FIG. 6 schematically illustrates a network architecture **600** for facilitating secure communication between two user devices, according to another embodiment of the disclosure. In this embodiment, an application server is used to establish an unsecure communication channel; secure signaling between the devices and the application server is not performed. Authentication of the user devices to each other and encryption of the communication channel (bearer path) can be performed directly between the user devices.

The first user device **601** and the second user device **602** are each managed and provisioned by remote management server **620**. Remote management keyset **621** is used to securely transmit information from the remote management server to the user devices. Each user device has a UICC and a SDP authenticated by a UICC-SDP keyset, shown schematically at **611** and **612** respectively.

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Each device must also have a user authenticated to that device. (In other embodiments, the device can interact with a machine instead of a user.) User authentication is performed by the authentication management function of the UICC of each device, using a user interface keyset **613**, **614** respectively. User authentication may involve many types of credentials: pin numbers, fingerprints, retinal scans, voice recognition, etc. The user interface keysets **613**, **614** may be provisioned by the remote management server or locally by an authorized user.

An application server is used to establish an unsecure communication session over a bearer path **640** between the user devices **601**, **602**. (Alternatively, the unsecure communication session can be established directly between the devices, for example in a peer-to-peer arrangement.) The bearer path can include, but is not limited to, UMTS, LTE, and WiFi. If increased security is desired, mutual authentication between the user devices can be performed using a bearer path authentication keyset **641**. The communication between devices **601**, **602** can also be encrypted using a bearer path encryption keyset **642**.

FIG. 7 is a flowchart **700** showing a procedure for establishing a communication session between two user devices, in accordance with the embodiment shown in FIG. 6. Upon receiving a request for service (step **702**), the remote management server **620** downloads programs and content to user devices **601**, **602** to allow the user devices to support a secure communication service that includes real-time encryption and authentication services (step **704**). For each of the user devices, the remote management server loads the real-time encryption engine into the secure device processor (SDP) of the device (e.g. smartphone, M2M device), the authentication management function to the secure element (e.g. a UICC), and the real-time encryption key generator to the secure element. Remote management keyset(s) **621** are used to securely transmit information from the remote management server to the user devices. This process involves mutual authentication and encryption.

After the user devices are provisioned, the UICC and SDP within each device mutually authenticate each other (step **706**). In this embodiment, this is done using UICC-SDP keysets **611**, **612**. In general, the UICC-SDP keysets used in the two user devices will be distinct keysets.

In this embodiment, an application server is used to set up an unsecure communication path between the two users through their respective devices (user device **601** and user device **602**). The SDP of user device **601** begins the process of establishing communication with device **602** by directing a request for a communication session secure signaling session to the application server (step **708**). It will be appreciated that in other embodiments, use of an application server is optional in setting up an unsecure communication path. For example, to establish a peer-to-peer communication session using Bluetooth or NFC, an application server would not be used.

In step **710**, user device **602** is notified by the application server that a session request has been made.

An unsecure communication channel (bearer path **640**) is established between user devices **601**, **602** (step **712**). The devices are not required to be authenticated to each other to establish the unsecure bearer path. Both users are notified that the communication channel has been established and is unsecure (step **716**). In this embodiment, since the communication channel is unsecure, the users are not required to authenticate with their respective devices prior to the establishment of the bearer path.

FIG. 8 is a flowchart **800** showing a process, in accordance with an embodiment, to establish communication with increased security between user devices **601** and **602** after an unsecure bearer path has been established.

User devices **601** and **602** communicate via unsecure bearer path **640** (step **802**). During the communication session, either user can determine (step **804**) that the other user should be authenticated. Alternatively, this determination can be made by an automated process. If increased security is desired, the users authenticate with their respective devices (steps **806**, **808**), and the devices perform mutual authentication using bearer path authentication keyset **641** (step **810**). The users must be authenticated with their respective devices prior to the mutual authentication of the devices to each other. This authentication process is performed by the authentication management functions within the secure element of the respective user devices. If the users were previously authenticated, they may be prompted to re-authenticate.

If encryption of the communication session is also desired (step **812**), one user device (device **601** in this example) notifies the other that bi-directional encryption is to be performed (step **814**). The SDP of each user device requests a bearer path encryption keyset from the real-time encryption key generator within the secure element of that device (step **816**). The encryption and decryption is performed by the real-time encryption engine in each SDP (step **818**). The devices **601**, **602** then send notices to the respective users that each user is authenticated and that the communication session is encrypted (step **820**).

FIG. 9 depicts an illustrative embodiment of a communication system **900** employing an IP Multimedia Subsystem (IMS) network architecture to facilitate the combined services of circuit-switched and packet-switched systems. Communication system **900** can be overlaid or operably coupled with the architecture of FIG. 3 or FIG. 6 as another representative embodiment of the disclosure. For example, any or all of the remote management server **620**, the secure application

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device **905** can comprise a secure element such as a UICC; a secure device processor (SDP) separate from the secure element; a memory to store executable instructions; and a device processor separate from the secure device processor (see FIG. 1), wherein in response to executing the instructions the device processor sends a first request for service to a management server and receives from the management server an authentication management function and an encryption key generator for execution by the secure element and an encryption engine for execution by the secure device processor, to cause the secure element and the secure device processor to mutually authenticate each other using a UICC-SDP keyset (see FIG. 2), and wherein the device authenticates a user of the device using a user interface keyset to verify user credentials by the authentication management function; sends a second request for a secure signaling session to a secure application server remote from the device, receives from the secure application server a first authentication signal, wherein the secure application server is authenticated by the authentication management function using a signaling authentication keyset; communicates with the secure application server via a first encrypted channel using a first signaling encryption keyset, wherein encryption and decryption of communications over the first encrypted channel is performed by the encryption engine and the first signaling encryption keyset is generated by the encryption key generator; and sends a third request to the secure application server to establish a communication session with a second device (see FIG. 3).

Communication system **900** can comprise a remote management server **930**, located remotely from user communication device **905**. In an embodiment, server **930** performs remote provisioning and management functions (shown schematically at **931**) for user communication devices. User communication device **905** can perform an authentication management and real-time encryption key generation functions (shown schematically at **933**). Communication system **900** can also comprise a Home Subscriber Server (HSS) **940**, a tElephone NUmber Mapping (ENUM) server **935** and other network elements of an IMS network **950**. The IMS network **950** can establish communications between IMS-compliant communication devices (CDs) **901**, **902**, Public Switched Telephone Network (PSTN) CD **903**, and combinations thereof by way of a Media Gateway Control Function (MGCF) **920** coupled to a PSTN network **960**. The MGCF **920** need not be used when a communication session involves IMS CD to IMS CD communications. A communication session involving at least one PSTN CD may utilize the MGCF **920**.

IMS CDs **901**, **902** can register with the IMS network **950** by contacting a Proxy Call Session Control Function (P-CSCF) which communicates with an interrogating CSCF (I-CSCF), which in turn, communicates with a Serving CSCF (S-CSCF) to register the CDs with the HSS **940**. To initiate a communication session between CDs, an originating IMS CD **901** can submit a Session Initiation Protocol (SIP INVITE) message to an originating P-CSCF **904** which communicates with a corresponding originating S-CSCF **906**. The originating S-CSCF **906** can submit the SIP INVITE message to one or more application servers (ASs) **917** that can provide a variety of services to IMS subscribers. An application server **917** can provide encryption and authentication functions (shown schematically at **932**) for signaling messages between user devices and the application server. The IMS can support a secure application server as well as an application server.

For example, the application servers **917** can be used to perform originating call feature treatment functions on the calling party number received by the originating S-CSCF **906** in the SIP INVITE message. Originating treatment functions can include determining whether the calling party number has international calling services, call ID blocking, calling name blocking, 7-digit dialing, and/or is requesting special telephony features (e.g., *72 forward calls, *73 cancel call forwarding, *67 for caller ID blocking, and so on). Based on initial filter criteria (iFCs) in a subscriber profile associated with a CD, one or more application servers may be invoked to provide various call originating feature services.

Additionally, the originating S-CSCF **906** can submit queries to the ENUM system **935** to translate an E.164 telephone number in the SIP INVITE message to a SIP Uniform Resource Identifier (URI) if the terminating communication device is IMS-compliant. The SIP URI can be used by an Interrogating CSCF (I-CSCF) **907** to submit a query to the HSS **940** to identify a terminating S-CSCF **914** associated with a terminating IMS CD such as reference **902**. Once identified, the I-CSCF **907** can submit the SIP INVITE message to the terminating S-CSCF **914**. The terminating S-CSCF **914** can then identify a terminating P-CSCF **916** associated with the terminating CD **902**. The P-CSCF **916** may then signal the CD **902** to establish Voice over Internet Protocol (VoIP) communication services, thereby enabling the calling and called parties to engage in voice and/or data communications. Based on the iFCs in the subscriber profile, one or more application servers may be invoked to provide various call terminating feature services, such as call forwarding, do not disturb, music tones, simultaneous ringing, sequential ringing, etc.

In some instances the aforementioned communication process is symmetrical. Accordingly, the terms "originating" and "terminating" in FIG. 9 may be interchangeable. It is further noted that communication system **900** can be adapted to support video conferencing. In addition, communication system **900** can be adapted to provide the IMS CDs **901**, **902** with the multimedia and Internet services of communication system **400** of FIG. 4.

If the terminating communication device is instead a PSTN CD such as CD **903**, the ENUM system **935** can respond with an unsuccessful address resolution which can cause the originating S-CSCF **906** to forward the call to the MGCF **920** via a Breakout Gateway Control Function (BGCF) **919**. The MGCF **920** can then initiate the call to the terminating PSTN CD over the PSTN network **960** to enable the calling and called parties to engage in voice and/or data communications.

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However, a PSTN endpoint that does not have a secure element (such as a UICC) will not be able to establish a secure communication path as described herein.

It is further appreciated that the CDs of FIG. 9 can operate as wireline or wireless devices. For example, the CDs of FIG. 9 can be communicatively coupled to cellular base station **122**, a femtocell, a WiFi router, a Digital Enhanced Cordless Telecommunications (DECT) base unit, or another suitable wireless access unit to establish communications with the IMS network **950** of FIG. 9. The cellular access base station **122** can operate according to common wireless access protocols such as GSM, CDMA, TDMA, UMTS, WiMax, SDR, LTE, and so on. Other present and next generation wireless network technologies can be used by one or more embodiments of the subject disclosure. Accordingly, multiple wireline and wireless communication technologies can be used by the CDs of FIG. 9.

Cellular phones supporting LTE can support packet-switched voice and packet-switched data communications and thus may operate as IMS-compliant mobile devices. In this embodiment, the cellular base station **122** may communicate directly with the IMS network **950** as shown by the arrow connecting the cellular base station **122** and the P-CSCF **916**.

Alternative forms of a CSCF can operate in a device, system, component, or other form of centralized or distributed hardware and/or software. Indeed, a respective CSCF may be embodied as a respective CSCF system having one or more computers or servers, either centralized or distributed, where each computer or server may be configured to perform or provide, in whole or in part, any method, step, or functionality described herein in accordance with a respective CSCF. Likewise, other functions, servers and computers described herein, including but not limited to, the HSS, the ENUM server, the BGCF, and the MGCF, can be embodied in a respective system having one or more computers or servers, either centralized or distributed, where each computer or server may be configured to perform or provide, in whole or in part, any method, step, or functionality described herein in accordance with a respective function, server, or computer.

For illustration purposes only, the terms S-CSCF, P-CSCF, I-CSCF, and so on, can be server devices, but may be referred to in the subject disclosure without the word "server." It is also understood that any form of a CSCF server can operate in a device, system, component, or other form of centralized or distributed hardware and software. It is further noted that these terms and other terms such as DIAMETER commands are terms can include features, methodologies, and/or fields that may be described in whole or in part by standards bodies such as 3rd Generation Partnership Project (3GPP). It is further noted that some or all embodiments of the subject disclosure may in whole or in part modify, supplement, or otherwise supersede final or proposed standards published and promulgated by 3GPP.

FIG. 10 depicts an illustrative embodiment of a communication device **1000**. Communication device **1000** can serve in whole or in part as an illustrative embodiment of the devices depicted in FIGS. 1 and 2. In particular, as shown in FIG. 10, the communication device can include a secure services platform that comprises a secure element such as a UICC; and a secure device processor (SDP) separate from the secure element (see FIG. 1), wherein the device can receive from a management server an authentication management function and an encryption key generator for execution by the secure element and an encryption engine for execution by the secure device processor, to cause the secure element and the secure device processor to mutually authenticate each other using a UICC-SDP keyset (see FIG. 2).

To enable these features, communication device **1000** can comprise a wireline and/or wireless transceiver **1002** (herein transceiver **1002**), a user interface (UI) **1004**, a power supply **1014**, a location receiver **1016**, a motion sensor **1018**, an orientation sensor **1020**, and a controller **1006** for managing operations thereof. The transceiver **1002** can support short-range or long-range wireless access technologies such as Bluetooth, NFC, ZigBee, WiFi, DECT, or cellular communication technologies, just to mention a few. Cellular technologies can include, for example, CDMA-1X, UMTS/HSDPA, GSM/GPRS, TDMA/EDGE, EV/DO, WiMAX, SDR, LTE, as well as other next generation wireless communication technologies as they arise. The transceiver **1002** can also be adapted to support circuit-switched wireline access technologies (such as PSTN), packet-switched wireline access technologies (such as TCP/IP, VoIP, etc.), and combinations thereof.

The UI **1004** can include a depressible or touch-sensitive keypad **1008** with a navigation mechanism such as a roller ball, a joystick, a mouse, or a navigation disk for manipulating operations of the communication device **1000**. The keypad **1008** can be an integral part of a housing assembly of the communication device **1000** or an independent device operably coupled thereto by a tethered wireline interface (such as a USB cable) or a wireless interface supporting for example Bluetooth or NFC. The keypad **1008** can represent a numeric keypad commonly used by phones, and/or a QWERTY keypad with alphanumeric keys. The UI **1004** can further include a display **1010** such as monochrome or color LCD (Liquid Crystal Display), OLED (Organic Light Emitting Diode) or other suitable display technology for conveying images to an end user of the communication device **1000**. In an embodiment where the display **1010** is touch-sensitive, a portion or all of the keypad **1008** can be presented by way of the display **1010** with navigation features.

The display **1010** can use touch screen technology to also serve as a user interface for detecting user input. As a touch screen display, the communication device **1000** can be adapted to present a user interface with graphical user interface (GUI) elements that can be selected by a user with a touch of a finger. The touch screen display **1010** can be equipped

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placed on a portion of the touch screen display. This sensing information can be used to control the manipulation of the GUI elements or other functions of the user interface. The display **1010** can be an integral part of the housing assembly of the communication device **1000** or an independent device communicatively coupled thereto by a tethered wireline interface (such as a cable) or a wireless interface.

The UI **1004** can also include an audio system **1012** that utilizes audio technology for conveying low volume audio (such as audio heard in proximity of a human ear) and high volume audio (such as speakerphone for hands free operation). The audio system **1012** can further include a microphone for receiving audible signals of an end user. The audio system **1012** can also be used for voice recognition applications. The UI **1004** can further include an image sensor **1013** such as a charged coupled device (CCD) camera for capturing still or moving images, or sensors for fingerprints or other biometrics.

The power supply **1014** can utilize common power management technologies such as replaceable and rechargeable batteries, supply regulation technologies, and/or charging system technologies for supplying energy to the components of the communication device **1000** to facilitate long-range or short-range portable applications. Alternatively, or in combination, the charging system can utilize external power sources such as DC power supplied over a physical interface such as a USB port or other suitable tethering technologies.

The location receiver **1016** can utilize location technology such as a global positioning system (GPS) receiver capable of assisted GPS for identifying a location of the communication device **1000** based on signals generated by a constellation of GPS satellites, which can be used for facilitating location services such as navigation. The motion sensor **1018** can utilize motion sensing technology such as an accelerometer, a gyroscope, or other suitable motion sensing technology to detect motion of the communication device **1000** in three-dimensional space. The orientation sensor **1020** can utilize orientation sensing technology such as a magnetometer to detect the orientation of the communication device **1000** (north, south, west, and east, as well as combined orientations in degrees, minutes, or other suitable orientation metrics).

The communication device **1000** can use the transceiver **1002** to also determine a proximity to a cellular, WiFi, Bluetooth, or other wireless access points by sensing techniques such as utilizing a received signal strength indicator (RSSI) and/or signal time of arrival (TOA) or time of flight (TOF) measurements. The controller **1006** can utilize computing technologies such as a microprocessor, a digital signal processor (DSP), programmable gate arrays, application specific integrated circuits, and/or a video processor with associated storage memory such as Flash, ROM, RAM, SRAM, DRAM or other storage technologies for executing computer instructions, controlling, and processing data supplied by the aforementioned components of the communication device **400**.

Other components not shown in FIG. 10 can be used in one or more embodiments of the subject disclosure. For instance, the communication device **1000** can include a reset button (not shown). The reset button can be used to reset the controller **1006** of the communication device **1000**. In yet another embodiment, the communication device **1000** can also include a factory default setting button positioned, for example, below a small hole in a housing assembly of the communication device **1000** to force the communication device **1000** to re-establish factory settings. In this embodiment, a user can use a protruding object such as a pen or paper clip tip to reach into the hole and depress the default setting button. The communication device **400** can also include a slot for adding or removing a memory card or an identity module such as a Subscriber Identity Module (SIM) card. SIM cards can be used for identifying subscriber services, executing programs, storing subscriber data, and so forth.

The communication device **1000** as described herein can operate with more or less of the circuit components shown in FIG. 10. These variant embodiments can be used in one or more embodiments of the subject disclosure.

The communication device **1000** can be adapted to perform the functions of the media processor **406**, the media devices **408**, or the portable communication devices **416** of FIG. 4, as well as the IMS CDs **901-902** and PSTN CD **903** of FIG. 9. It will be appreciated that the communication device **1000** can also represent other devices that can operate in communication systems **400-500** of FIGS. 4-5 such as a gaming console and a media player.

The communication device **1000** shown in FIG. 10 or portions thereof can serve as a representation of one or more of the devices of FIGS. 1 and/or 2, the user communication devices of FIGS. 3 and 6, and communication system **900**. In addition, the controller **1006** can be adapted in various embodiments to perform the functions of device processor **104**, coupled to secure services platform **110**.

Upon reviewing the aforementioned embodiments, it would be evident to an artisan with ordinary skill in the art that said embodiments can be modified, reduced, or enhanced without departing from the scope of the claims described below.

It should be understood that devices described in the exemplary embodiments can be in communication with each other via various wireless and/or wired methodologies. The methodologies can be links that are described as coupled, connected and so forth, which can include unidirectional and/or bidirectional communication over wireless paths and/or wired paths that utilize one or more of various protocols or methodologies, where the coupling and/or connection can be direct (e.g., no intervening processing device) and/or indirect (e.g., an intermediary processing device such as a router).

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FIG. 11 depicts an exemplary diagrammatic representation of a machine in the form of a computer system **1100** within which a set of instructions, when executed, may cause the machine to perform any one or more of the methods described above. One or more instances of the machine can operate, for example, as the remote management server **320** or the secure application server **330**, and other devices of FIGS. 1-3. In some embodiments, the machine may be connected (e.g., using a network **1126**) to other machines. In a networked deployment, the machine may operate in the capacity of a server or a client user machine in server-client user network environment, or as a peer machine in a peer-to-peer (or distributed) network environment.

The machine may comprise a server computer, a client user computer, a personal computer (PC), a tablet PC, a smart phone, a laptop computer, a desktop computer, a control system, a network router, switch or bridge, or any machine capable of executing a set of instructions (sequential or otherwise) that specify actions to be taken by that machine. It will be understood that a communication device of the subject disclosure includes broadly any electronic device that provides voice, video or data communication. Further, while a single machine is illustrated, the term "machine" shall also be taken to include any collection of machines that individually or jointly execute a set (or multiple sets) of instructions to perform any one or more of the methods discussed herein.

The computer system **1100** may include a processor (or controller) **1102** (e.g., a central processing unit (CPU), a graphics processing unit (GPU), or both), a main memory **1104** and a static memory **1106**, which communicate with each other via a bus **11011**. The computer system **1100** may further include a display unit **1110** (e.g., a liquid crystal display (LCD), a flat panel, or a solid state display). The computer system **1100** may include an input device **1112** (e.g., a keyboard), a cursor control device **1114** (e.g., a mouse), a disk drive unit **1116**, a signal generation device **1118** (e.g., a speaker or remote control) and a network interface device **1120**. In distributed environments, the embodiments described in the subject disclosure can be adapted to utilize multiple display units **1110** controlled by two or more computer systems **1100**. In this configuration, presentations described by the subject disclosure may in part be shown in a first of the display units **1110**, while the remaining portion is presented in a second of the display units **1110**.

The disk drive unit **1116** may include a tangible computer-readable storage medium **1122** on which is stored one or more sets of instructions (e.g., software **1124**) embodying any one or more of the methods or functions described herein, including those methods illustrated above. The instructions **1124** may also reside, completely or at least partially, within the main memory **1104**, the static memory **1106**, and/or within the processor **1102** during execution thereof by the computer system **1100**. The main memory **1104** and the processor **1102** also may constitute tangible computer-readable storage media.

Dedicated hardware implementations including, but not limited to, application specific integrated circuits, programmable logic arrays and other hardware devices that can likewise be constructed to implement the methods described herein. Application specific integrated circuits and programmable logic array can use downloadable instructions for executing state machines and/or circuit configurations to implement embodiments of the subject disclosure. Applications that may include the apparatus and systems of various embodiments broadly include a variety of electronic and computer systems. Some embodiments implement functions in two or more specific interconnected hardware modules or devices with related control and data signals communicated between and through the modules, or as portions of an application-specific integrated circuit. Thus, the example system is applicable to software, firmware, and hardware implementations.

In accordance with various embodiments of the subject disclosure, the operations or methods described herein are intended for operation as software programs or instructions running on or executed by a computer processor or other computing device, and which may include other forms of instructions manifested as a state machine implemented with logic components in an application specific integrated circuit or field programmable gate array. Furthermore, software implementations (e.g., software programs, instructions, etc.) including, but not limited to, distributed processing or component/object distributed processing, parallel processing, or virtual machine processing can also be constructed to implement the methods described herein. It is further noted that a computing device such as a processor, a controller, a state machine or other suitable device for executing instructions to perform operations or methods may perform such operations directly or indirectly by way of one or more intermediate devices directed by the computing device.

While the tangible computer-readable storage medium **1122** is shown in an example embodiment to be a single medium, the term "tangible computer-readable storage medium" should be taken to include a single medium or multiple media (e.g., a centralized or distributed database, and/or associated caches and servers) that store the one or more sets of instructions. The term "tangible computer-readable storage medium" shall also be taken to include any non-transitory medium that is capable of storing or encoding a set of instructions for execution by the machine and that cause the machine to perform any one or more of the methods of the subject disclosure.

The term "tangible computer-readable storage medium" shall accordingly be taken to include, but not be limited to: solid-state memories such as a memory card or other package that houses one or more read-only (non-volatile) memories, random access memories, or other re-writable (volatile) memories, a magneto-optical or optical memory such as a disk or tape, or other tangible media which can be used to store information. Accordingly, the disclosure is considered to include

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any one or more of a tangible computer-readable storage medium, as listed herein and including art-recognized equivalents and successor media, in which the software implementations herein are stored.

Although the present specification describes components and functions implemented in the embodiments with reference to particular standards and protocols, the disclosure is not limited to such standards and protocols. Each of the standards for Internet and other packet switched network transmission (e.g., TCP/IP, UDP/IP, HTML, HTTP) represent examples of the state of the art. Such standards are from time-to-time superseded by faster or more efficient equivalents having essentially the same functions. Wireless standards for device detection (e.g., RFID), short-range communications (e.g., Bluetooth, NFC, WiFi, Zigbee), and long-range communications (e.g., WiMAX, GSM, CDMA, LTE) can be used by computer system **1100**.

The illustrations of embodiments described herein are intended to provide a general understanding of the structure of various embodiments, and they are not intended to serve as a complete description of all the elements and features of apparatus and systems that might make use of the structures described herein. Many other embodiments will be apparent to those of skill in the art upon reviewing the above description. The exemplary embodiments can include combinations of features and/or steps from multiple embodiments. Other embodiments may be utilized and derived therefrom, such that structural and logical substitutions and changes may be made without departing from the scope of this disclosure. Figures are also merely representational and may not be drawn to scale. Certain proportions thereof may be exaggerated, while others may be minimized. Accordingly, the specification and drawings are to be regarded in an illustrative rather than a restrictive sense.

Although specific embodiments have been illustrated and described herein, it should be appreciated that any arrangement calculated to achieve the same purpose may be substituted for the specific embodiments shown. This disclosure is intended to cover any and all adaptations or variations of various embodiments. Combinations of the above embodiments, and other embodiments not specifically described herein, can be used in the subject disclosure.

The Abstract of the Disclosure is provided with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, in the foregoing Detailed Description, it can be seen that various features are grouped together in a single embodiment for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed embodiments require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed embodiment. Thus the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separately claimed subject matter.

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