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Ittelson

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(54) **CONNECTING A PHONE DEVICE TO A VIRTUAL MEETING USING MULTI-FACTOR AUTHENTICATION**

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(51) **Int. Cl.**

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H04L 9/40	(2022.01)
H04L 65/403	(2022.01)

(52) **U.S. Cl.**
CPC ***H04L 65/1093*** (2013.01); ***H04L 63/083*** (2013.01); ***H04L 63/0846*** (2013.01); ***H04L 63/0876*** (2013.01); ***H04L 65/403*** (2013.01); *H04L 2463/082* (2013.01)

(58) **Field of Classification Search**
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See application file for complete search history.

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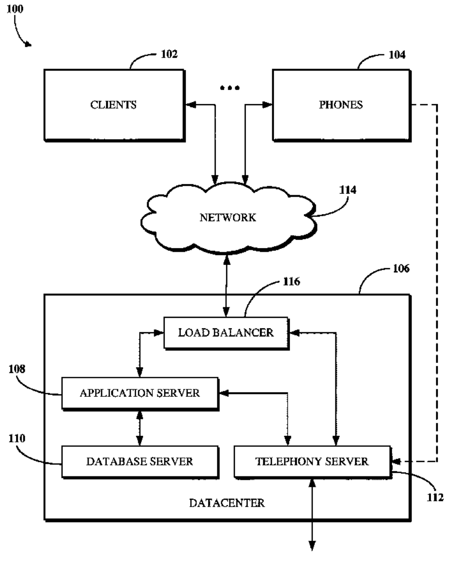
(57) **ABSTRACT**

Multi-factor authentication techniques are used to verify an identity of an audio-only caller requesting to join a video-enabled virtual meeting. A request for an audio-only caller to join a video-enabled virtual meeting is received from a phone device of the audio-only caller, in which the audio-only caller is using the phone device to call into the video-enabled virtual meeting. An authentication request is transmitted to the phone device to verify an identity of the audio-only caller. A response to the authentication request is received from the phone device and includes an authentication code generated based on the request for the audio-only caller to join the video-enabled virtual meeting. The identity of the audio-only caller is then verified using the authentication code and information associated with the phone device, and the request for the audio-only caller to join the video-enabled virtual meeting is allowed or denied based on the verification.

20 Claims, 8 Drawing Sheets



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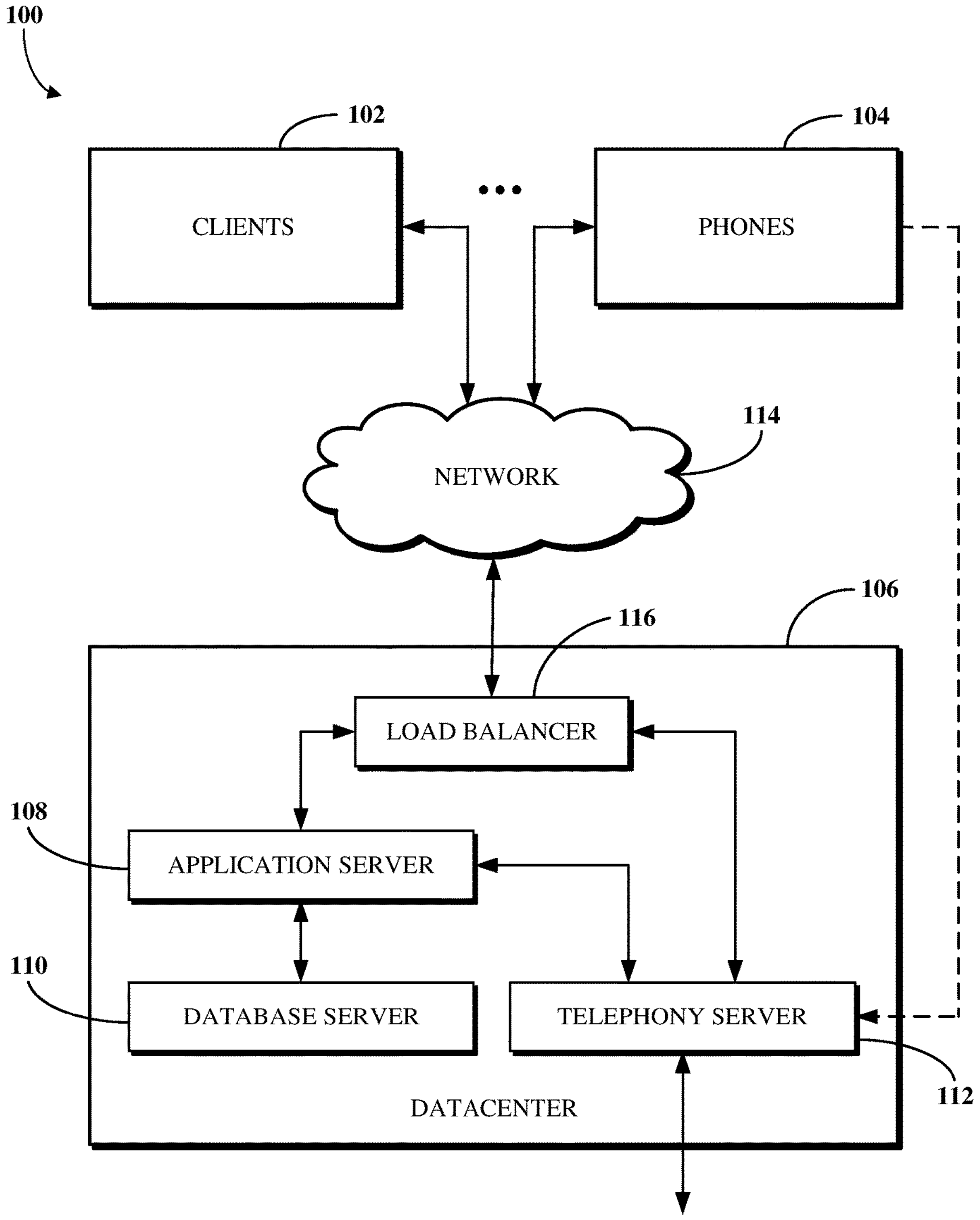
100
102
CLIENTS
...
104
PHONES
114
NETWORK
106
116
LOAD BALANCER
108
APPLICATION SERVER
110
DATABASE SERVER
TELEPHONY SERVER
112
DATACENTER

FIG. 1

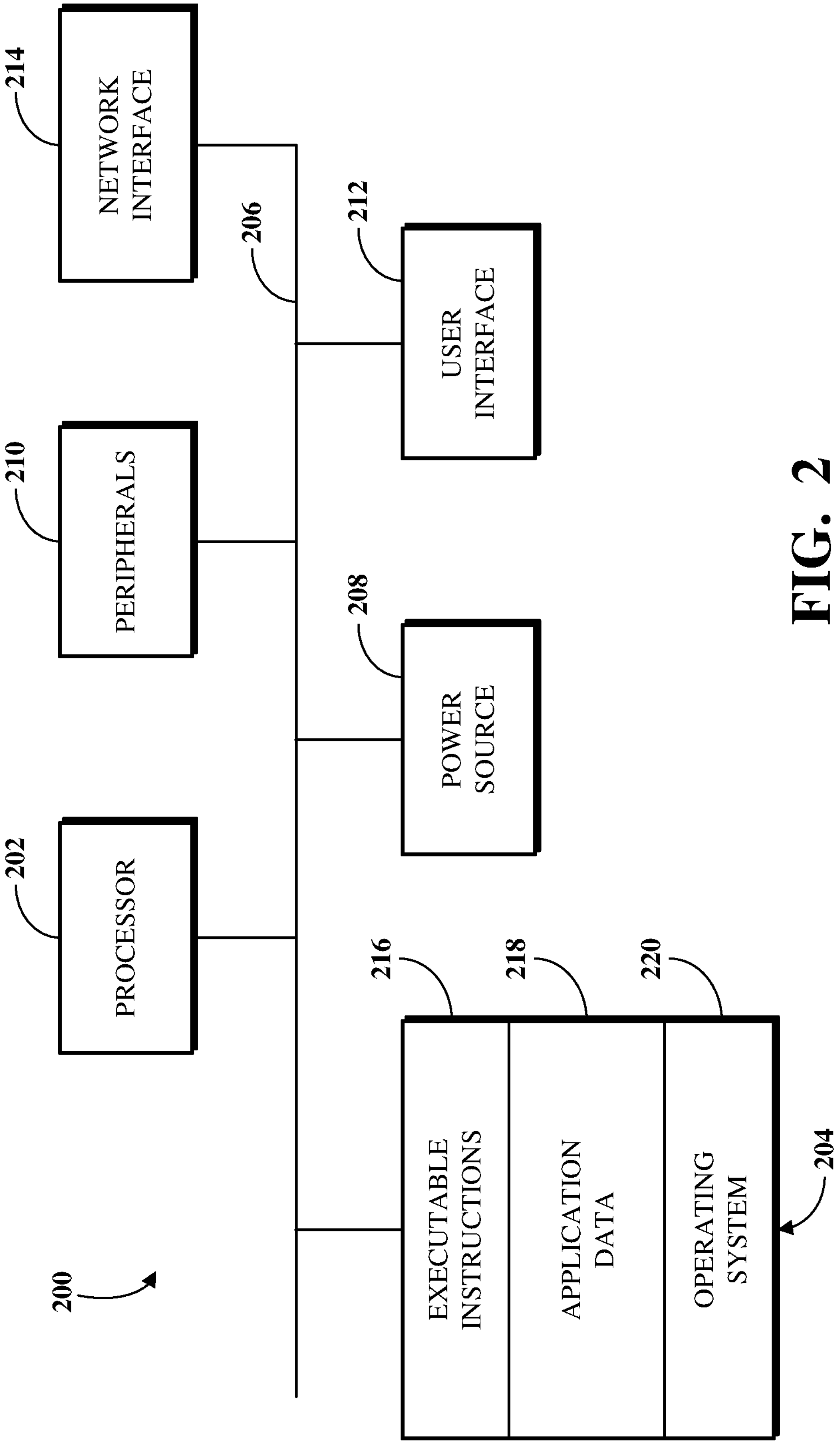
200
202
PROCESSOR
210
PERIPHERALS
214
NETWORK INTERFACE
206
208
POWER SOURCE
212
USER INTERFACE
216
218
220
EXECUTABLE INSTRUCTIONS
APPLICATION DATA
OPERATING SYSTEM
204

FIG. 2

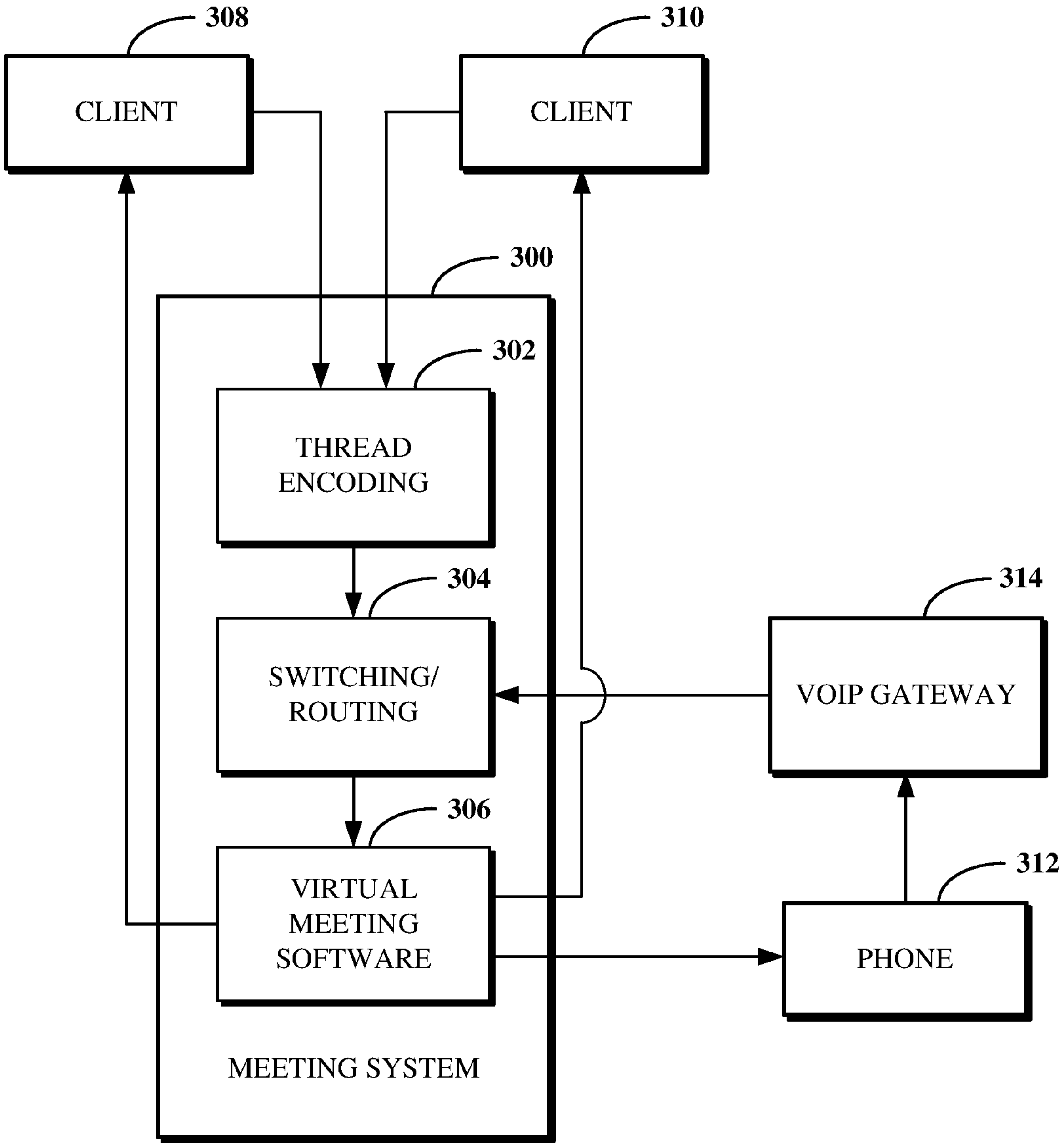
308
CLIENT
310
CLIENT
300
302
THREAD ENCODING
304
SWITCHING/ ROUTING
314
VOIP GATEWAY
306
VIRTUAL MEETING SOFTWARE
312
PHONE
MEETING SYSTEM

FIG. 3

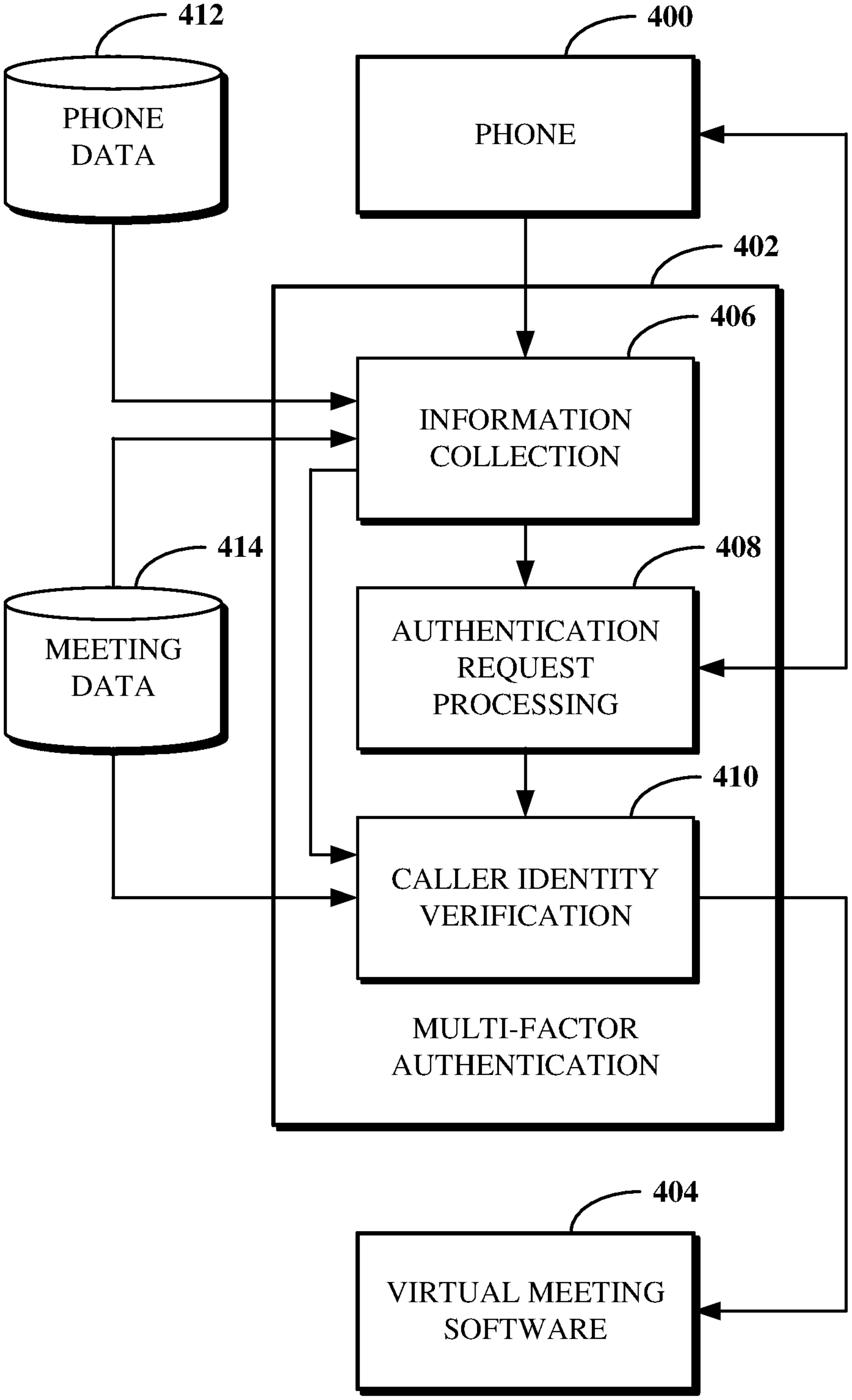
412
PHONE DATA
400
PHONE
402
406
INFORMATION COLLECTION
414
MEETING DATA
408
AUTHENTICATION REQUEST PROCESSING
410
CALLER IDENTITY VERIFICATION
MULTI-FACTOR AUTHENTICATION
404
VIRTUAL MEETING SOFTWARE

FIG. 4

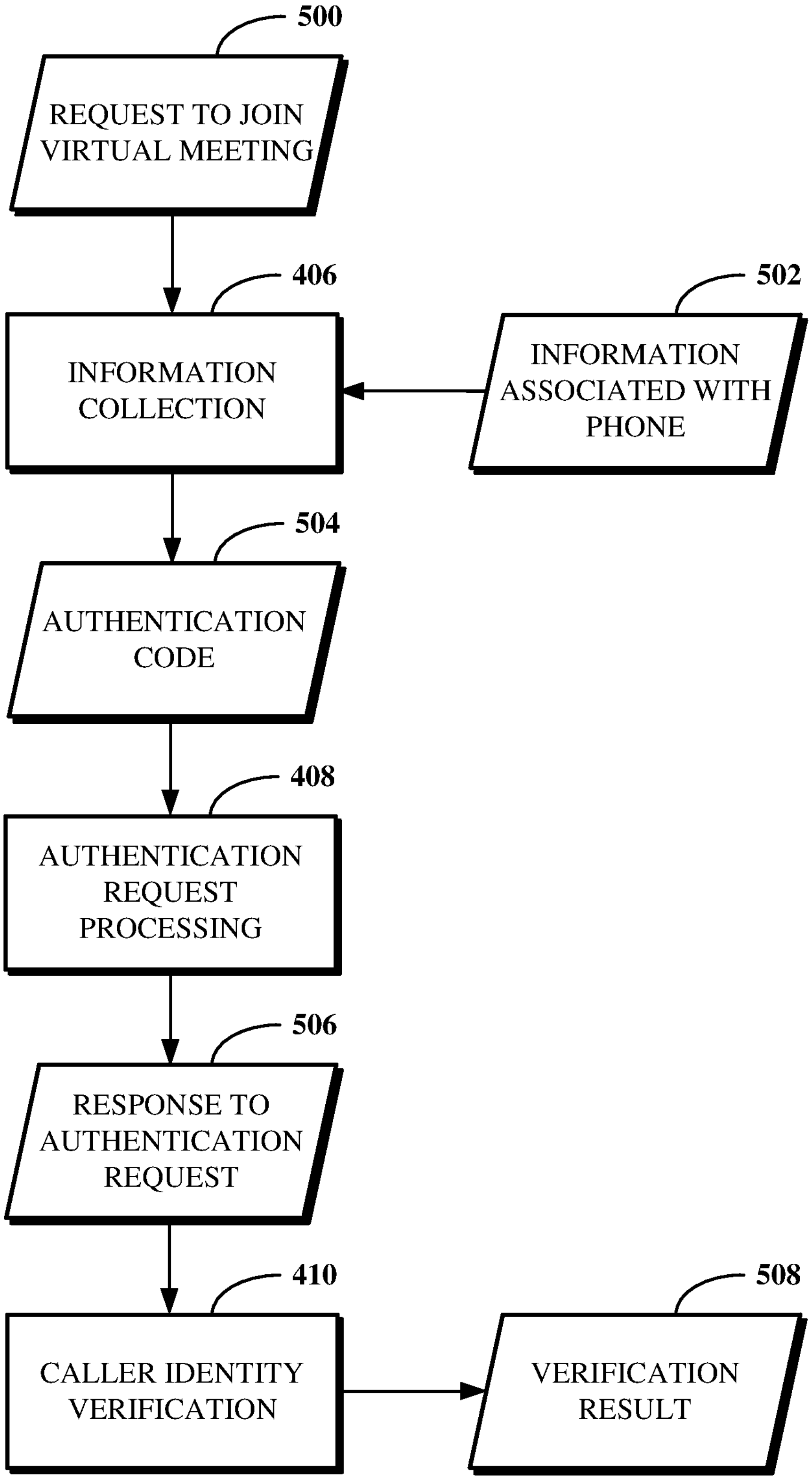
500
REQUEST TO JOIN VIRTUAL MEETING
406
INFORMATION COLLECTION
502
INFORMATION ASSOCIATED WITH PHONE
504
AUTHENTICATION CODE
408
AUTHENTICATION REQUEST PROCESSING
506
RESPONSE TO AUTHENTICATION REQUEST
410
CALLER IDENTITY VERIFICATION
508
VERIFICATION RESULT

FIG. 5

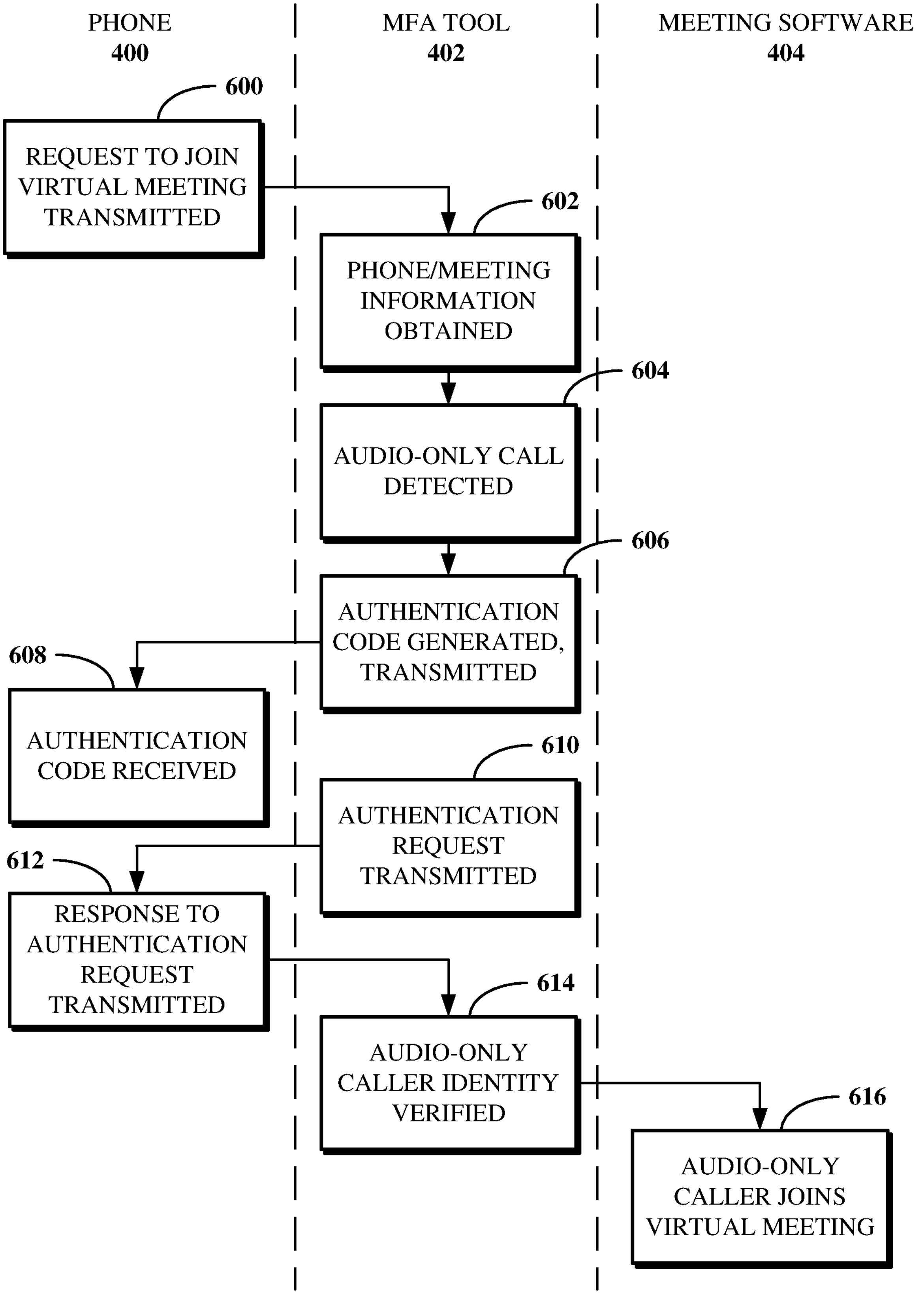
PHONE
400
MFA TOOL
402
MEETING SOFTWARE
404
600
REQUEST TO JOIN VIRTUAL MEETING TRANSMITTED
602
PHONE/MEETING INFORMATION OBTAINED
604
AUDIO-ONLY CALL DETECTED
606
AUTHENTICATION CODE GENERATED, TRANSMITTED
608
AUTHENTICATION CODE RECEIVED
610
AUTHENTICATION REQUEST TRANSMITTED
612
RESPONSE TO AUTHENTICATION REQUEST TRANSMITTED
614
AUDIO-ONLY CALLER IDENTITY VERIFIED
616
AUDIO-ONLY CALLER JOINS VIRTUAL MEETING

FIG. 6

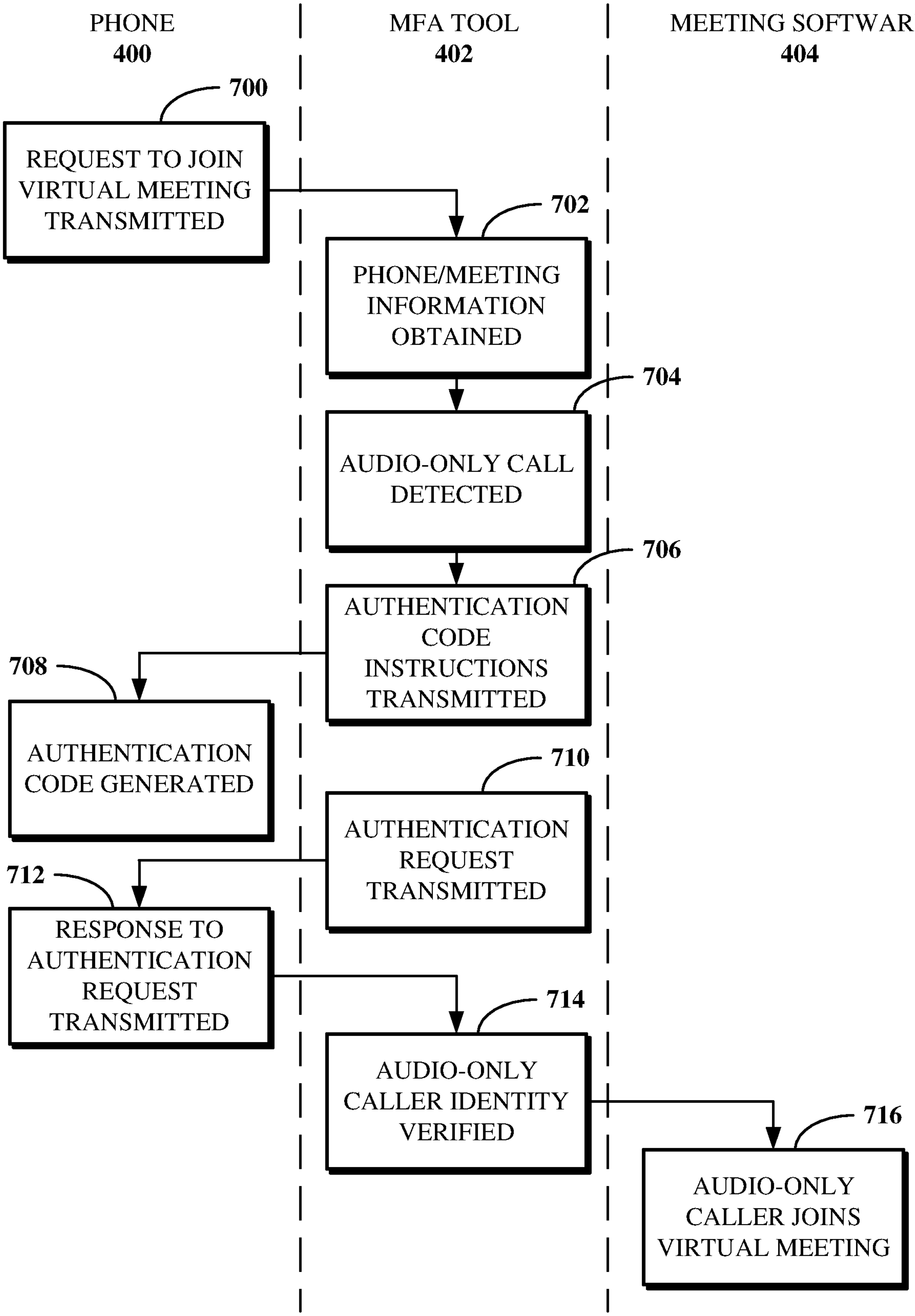
PHONE
400
MFA TOOL
402
MEETING SOFTWARE
404
700
REQUEST TO JOIN VIRTUAL MEETING TRANSMITTED
702
PHONE/MEETING INFORMATION OBTAINED
704
AUDIO-ONLY CALL DETECTED
706
AUTHENTICATION CODE INSTRUCTIONS TRANSMITTED
708
AUTHENTICATION CODE GENERATED
710
AUTHENTICATION REQUEST TRANSMITTED
712
RESPONSE TO AUTHENTICATION REQUEST TRANSMITTED
714
AUDIO-ONLY CALLER IDENTITY VERIFIED
716
AUDIO-ONLY CALLER JOINS VIRTUAL MEETING

FIG. 7

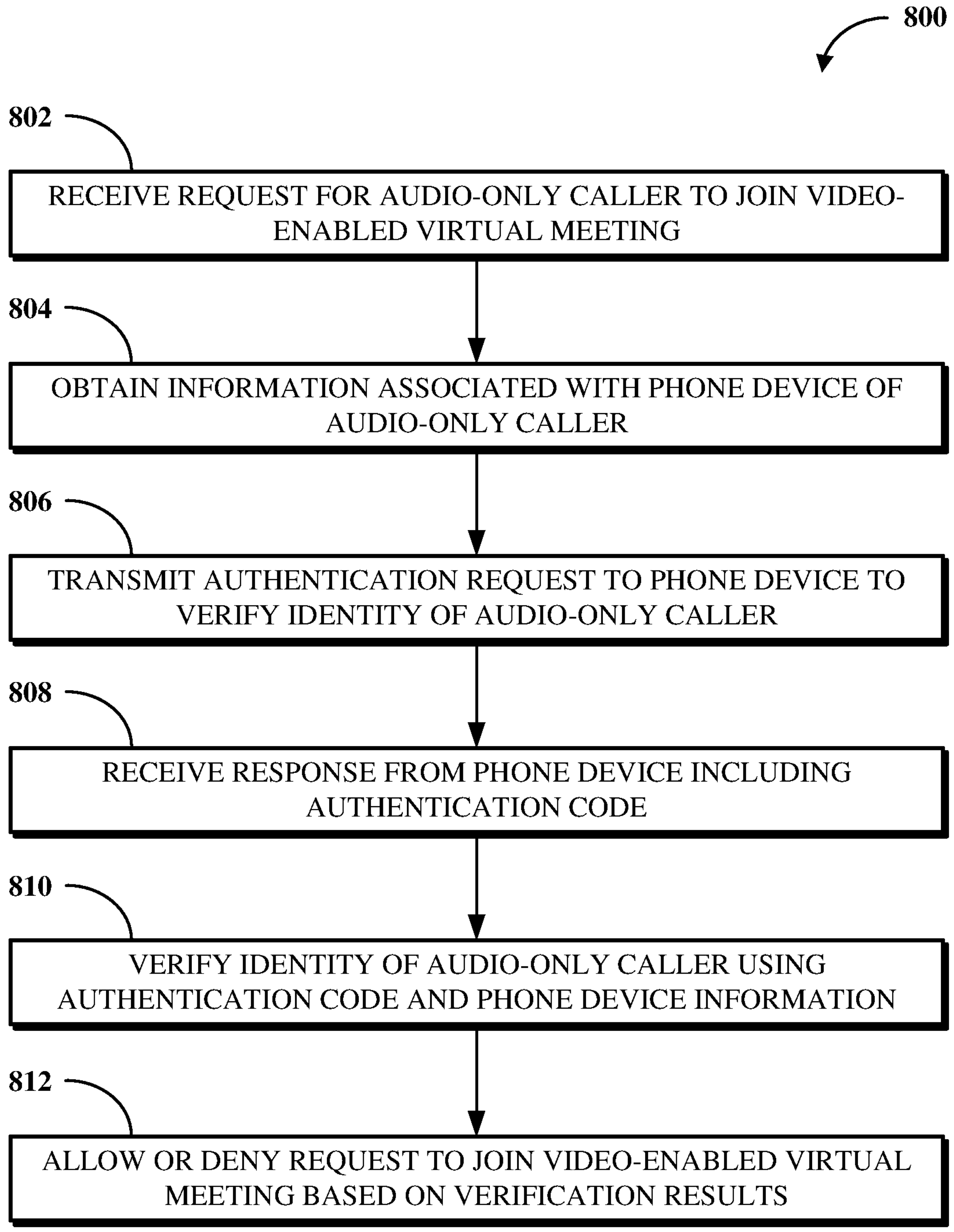
800
802
RECEIVE REQUEST FOR AUDIO-ONLY CALLER TO JOIN VIDEO-ENABLED VIRTUAL MEETING
804
OBTAIN INFORMATION ASSOCIATED WITH PHONE DEVICE OF AUDIO-ONLY CALLER
806
TRANSMIT AUTHENTICATION REQUEST TO PHONE DEVICE TO VERIFY IDENTITY OF AUDIO-ONLY CALLER
808
RECEIVE RESPONSE FROM PHONE DEVICE INCLUDING AUTHENTICATION CODE
810
VERIFY IDENTITY OF AUDIO-ONLY CALLER USING AUTHENTICATION CODE AND PHONE DEVICE INFORMATION
812
ALLOW OR DENY REQUEST TO JOIN VIDEO-ENABLED VIRTUAL MEETING BASED ON VERIFICATION RESULTS

FIG. 8

CONNECTING A PHONE DEVICE TO A VIRTUAL MEETING USING MULTI-FACTOR AUTHENTICATION

CROSS-REFERENCE TO RELATED APPLICATION(S)

This application is a continuation of U.S. application Ser. No. 17/160,208, filed Jan. 27, 2021, the entire disclosure of which is herein incorporated by reference.

BACKGROUND

Virtual meetings help people all around the world to connect with one another every day in a variety of business and personal settings. A virtual meeting may be video-enabled to allow participants to see each other in real-time and may also accommodate participants interacting with others through audio alone. Virtual meeting platforms use network connections with participant devices to facilitate audio and/or video communications between participants. The growing ubiquity of network-connected devices enables more and more people to communicate over virtual meetings every day.

SUMMARY

Disclosed herein are, inter alia, implementations of systems and techniques for multi-factor authentication for audio meeting participants.

One aspect of this disclosure is a method, which includes receiving, from a phone device of an audio-only caller, a request for the audio-only caller to join a video-enabled virtual meeting. An authentication request is transmitted to the phone device to verify an identity of the audio-only caller. A response to the authentication request including an authentication code generated based on the request for the audio-only caller to join the video-enabled virtual meeting is received from the phone device. Responsive to verifying the identity of the audio-only caller using the authentication code and information associated with the phone device, the request for the audio-only caller to join the video-enabled virtual meeting is allowed.

Another aspect of this disclosure is a method, which includes detecting that an audio-only caller requesting to join a video-enabled virtual meeting is using a phone device to call into the video-enabled virtual meeting. Responsive to the detecting, an authentication request is transmitted to the phone device to verify an identity of the audio-only caller. A response to the authentication request including an authentication code generated for the audio-only caller is received from the phone device. Responsive to verifying the identity of the audio-only caller using the authentication code, the audio-only caller is allowed to join the video-enabled virtual meeting.

Yet another aspect of this disclosure is a method, which includes receiving an authentication code generated based on a request for an audio-only caller to join a video-enabled virtual meeting, in which the request for the audio-only caller to join the video-enabled virtual meeting is received from a phone device of the audio-only caller and includes a meeting identifier for the video-enabled virtual meeting. Information associated with the phone device is obtained responsive to verifying the meeting identifier. The request for the audio-only caller to join the video-enabled virtual meeting is then allowed responsive to verifying an identity of the audio-only caller using the authentication code and the information associated with the phone device.

BRIEF DESCRIPTION OF THE DRAWINGS

This disclosure is best understood from the following detailed description when read in conjunction with the accompanying drawings. It is emphasized that, according to common practice, the various features of the drawings are not to-scale. On the contrary, the dimensions of the various features are arbitrarily expanded or reduced for clarity.

FIG. **1** is a block diagram of an example of an electronic computing and communications system.

FIG. **2** is a block diagram of an example internal configuration of a computing device of an electronic computing and communications system.

FIG. **3** is a block diagram of an example of a meeting system for delivering virtual meeting software services in an electronic computing and communications system.

FIG. **4** is a block diagram of an example of multi-factor authentication for authenticating an audio-only caller requesting to join a virtual meeting.

FIG. **5** is a block diagram of example inputs and outputs of a multi-factor authentication tool.

FIG. **6** is an illustration of swim lanes showing a first example sequence of operations performed for multi-factor authentication.

FIG. **7** is an illustration of swim lanes showing a second example sequence of operations performed for multi-factor authentication.

FIG. **8** is a flowchart of an example of a technique for multi-factor authentication for audio meeting participants.

DETAILED DESCRIPTION

Online security is an increasingly complex but important field, as malicious actors continue to seek new ways to intercept credentials and gain access to locked or private data and communications. In the context of a virtual meeting, participants accessing the virtual meeting through a client may log into the virtual meeting using authenticated credentials, such as a username and/or password, or a participant may use an encrypted link processed via the client to authenticate the participant.

Although useful to users of clients, these conventional authentication techniques are generally not available to meeting participants calling into a virtual meeting from via a telephony connection. For example, it may be difficult or impossible for an audio-only caller to enter a username and/or password. Furthermore, these conventional authentication techniques to do not themselves provide a mechanism to verify an identity of the audio-only caller. For example, a malicious actor who gains access to an email account of an audio-only caller may use credentials within an email thereof to access the virtual meeting without ever sharing his or her true identity.

One solution for verifying a user identity is two-factor authentication, in which a user registers a secondary device with a system. When the user attempts to access a system service from a primary device, the system sends a verification code to the secondary device, typically a SMS message sent to a cell phone. Because it is unlikely that a malicious actor will have access to the secondary device itself, the timely entry of the verification code within the system verifies the identity of the user to allow user access to the service. Another solution involves using a tokenization system to verify device access based on a valid token issued by a system service.

However, these solutions are not suitable for verifying an identity of an audio-only caller requesting to join a virtual meeting from a phone. For example, two-factor authentication is likely not useful for audio-only callers because they typically do not have access to a secondary device. Furthermore, because many phones are used without access to client-side features for receiving tokens, audio-only callers may not be able to benefit from a token system in every case. Thus, these solutions do not accommodate the verification of an identity of an audio-only caller joining a virtual meeting over a telephony line and using a single device.

Implementations of this disclosure address problems such as these using multi-factor authentication techniques for verifying an identity of an audio-only caller requesting to join a video-enabled virtual meeting. A request for an audio-only caller to join a video-enabled virtual meeting is received from a phone device of the audio-only caller, in which the audio-only caller is using the phone device to call into the video-enabled virtual meeting. An authentication request is transmitted to the phone device to verify an identity of the audio-only caller. A response to the authentication request is received from the phone device and includes an authentication code generated based on the request for the audio-only caller to join the video-enabled virtual meeting. The identity of the audio-only caller is then verified using the authentication code and information associated with the phone device, and the request for the audio-only caller to join the video-enabled virtual meeting is allowed or denied based on the verification. Thus, the identity of the audio-only caller is verified using the information associated with the phone device and the authentication code, and without requiring a secondary device or the use of a token.

To describe some implementations in greater detail, reference is first made to examples of hardware and software structures used to implement multi-factor authentication for audio meeting participants. FIG. **1** is a block diagram of an example of an electronic computing and communications system **100**, which can be or include a distributed computing system (e.g., a client-server computing system), a cloud computing system, a clustered computing system, or the like. The system **100** connects various clients **102** and/or phones **104** to services implemented within or otherwise using a datacenter **106**. The system **100** can connect a number of clients **102** and/or phones **104** or can have a configuration of clients or phones different from that generally illustrated in FIG. **1**. For example, and without limitation, the system **100** can connect hundreds or thousands of clients and/or phones.

A client **102** may be or otherwise refer to one or both of a client device or a client application. Where a client is or refers to a client device, the client can comprise a computing system, which can include one or more computing devices, such as a mobile phone, a tablet computer, a laptop computer, a notebook computer, a desktop computer, or another suitable computing device or combination of computing devices. Where a client instead is or refers to a client application, the client can be an instance of software running on a device. In some implementations, a client can be implemented as a single physical unit or as a combination of physical units. In some implementations, a single physical unit can include multiple clients.

A phone **104** may be or otherwise refer to one or both of a phone device or a phone application such as a softphone. For example, a phone **104** may be a smart phone or other cell phone which may or may not be configured to run mobile applications, such as a client **102**. In another example, a phone **104** may be a desk phone, such as a desktop unit configured to at least send and receive calls and includes an input device for receiving a telephone number or extension to dial to and an output device for outputting audio and/or video for a call in progress. In yet another example, the phone **104** may be a softphone representing telephony functionality of a client **102**. A phone **104** may or may not be voice over IP (VOID)-enabled.

The datacenter **106** includes one or more servers. The datacenter **106** can represent a geographic location, which can include a facility, where the one or more servers are located. The system **100** can include a number of datacenters and servers or can include a configuration of datacenters and servers different from that generally illustrated in FIG. **1**. For example, and without limitation, the system **100** can include tens of datacenters, and at least some of the datacenters can include hundreds or another suitable number of servers.

The datacenter **106** includes servers used for implementing software services. The datacenter **106** as generally illustrated includes an application server **108**, a database server **110**, and a telephony server **112**. The servers **108** through **112** can each be a computing system, which can include one or more computing devices, such as a desktop computer, a server computer, or another computer capable of operating as a server, or a combination thereof. A suitable number of each of the servers **108** through **112** can be implemented at the datacenter **106**.

In some implementations, one or more of the servers **108** through **112** can be a non-hardware aspect implemented on a physical device, such as a hardware server. In some implementations, a combination of two or more of the application server **108**, the database server **110**, and the telephony server **112** can be implemented as a single hardware server or as a single non-hardware server implemented on a single hardware server. In some implementations, the datacenter **106** can include servers other than or in addition to the servers **108** through **112**, for example, a media server, a proxy server, or a web server.

The application server **108** runs web-based software services deliverable to the clients **102** and at least partially to the phones **104**. The software services may be or include virtual meeting software which enables audio, video, and/or other forms of virtual meetings between multiple devices (e.g., between ones of the clients **102**, between ones of the phones **104**, or between ones of the clients **102** and ones of the phones **104**), such as to facilitate a conference between the users of those devices. The virtual meeting software can include functionality for hosting, presenting scheduling, joining, or otherwise participating in a virtual meeting. The virtual meeting software may further include functionality for recording some or all of a virtual meeting and/or documenting a transcript for the virtual meeting. The application server **108** may, for example, be or include a unitary Java Virtual Machine (JVM).

In some implementations, the application server **108** can include an application node, which can be a process executed on the application server **108**. For example, and without limitation, the application node can be executed in order to deliver software services to a client **102** as part of a software application. The application node can be implemented using processing threads, virtual machine instantiations, or other computing features of the application server **108**. In some such implementations, the application server **108** can include a suitable number of application nodes, depending upon a system load or other characteristics associated with the application server **108**. For example, and without limitation, the application server **108** can include two or more nodes forming a node cluster. In some such implementations, the application nodes implemented on a single application server **108** can run on different hardware servers.

The database server **110** stores, manages, or otherwise provides data for delivering software services of the application server **108** to a client **102**. In particular, the database server **110** may implement one or more databases, tables, or other information sources suitable for use with a software application implemented using the application server **108**. The database server **110** may include a data storage unit accessible by software executed on the application server **108**. A database implemented by the database server **110** may be a relational database management system (RDBMS), an object database, an XML database, a configuration management database (CMDB), a management information base (MIB), one or more flat files, other suitable non-transient storage mechanisms, or a combination thereof. The system **100** can include one or more database servers, in which each database server can include one, two, three, or another suitable number of databases configured as or comprising a suitable database type or combination thereof.

In some implementations, one or more databases, tables, other suitable information sources, or portions or combinations thereof may be stored, managed, or otherwise provided by one or more of the elements of the system **100** other than the database server **110**, for example, one of the clients **102** or the application server **108**.

The telephony server **112** enables network-based telephony and web communications from and to ones of the clients **102** and ones of the phones **104** which are VOIP-enabled devices configured to send and receive calls over a network, for example, a network **114**. In particular, the telephony server **112** includes a session initiation protocol (SIP) zone and a web zone. The SIP zone enables a client **102** or a phone **104** (e.g., a VOIP-enabled phone), to send and receive calls over the network **114** using SIP requests and responses. The web zone integrates telephony data with the application server **108** to enable telephony-based traffic access to software services run by the application server **108**. Given the combined functionality of the SIP zone and the web zone, the telephony server **112** may be or include a cloud-based private branch exchange (PBX) system.

The SIP zone receives telephony traffic from a client **102** or a phone **104** (e.g., a VOIP-enabled phone) and directs same to a destination device. The SIP zone may include one or more call switches for routing the telephony traffic. For example, to route a VOIP call from a first VOIP-enabled client to a second VOIP-enabled client within the same domain or network, the telephony server **112** may initiate a SIP transaction between a first client and the second client using a PBX. However, in another example, to route a VOIP call from a VOIP-enabled client to a client or phone which is not VOIP-enabled, the telephony server **112** may initiate a SIP transaction via a VOIP gateway that transmits the SIP signal to a public switched telephone network (PSTN) system for outbound communication to the non-VOIP-enabled client or non-client phone. Hence, the telephony server **112** may include a PSTN system and may in some cases access an external PSTN system.

The telephony server **112** includes one or more session border controllers (SBCs) for interfacing the SIP zone with one or more aspects external to the telephony server **112**. In particular, an SBC can act as an intermediary to transmit and receive SIP requests and responses between ones of the clients **102** and/or between ones of the phones **104**. When incoming telephony traffic for delivery to a client **102** or a phone **104** originating from outside the telephony server **112** is received, a SBC receives the traffic and forwards it to a call switch for routing to the client **102** or the phone **104**.

The web zone receives telephony traffic from a client **102** or a phone **104**, via the SIP zone, and directs same to the application server **108** via one or more Domain Name System (DNS) resolutions. For example, a first DNS within the web zone may process a request received via the SIP zone and then deliver the processed request to a web service which connects to a second DNS at or otherwise associated with the application server **108**. Once the second DNS resolves the request, it is delivered to the destination service at the application server **108**. The web zone may also include a database for authenticating access to a software application for telephony traffic processed within the SIP zone, for example, a softphone.

The clients **102** and the phones **104** communicate with aspects of the datacenter **106** via the network **114**. The network **114** can be or include, for example, the Internet, a local area network (LAN), a wide area network (WAN), a virtual private network (VPN), or another public or private means of electronic computer communication capable of transferring data between a client and one or more servers. In some implementations, a client can connect to the network **114** via a communal connection point, link, or path, or using a distinct connection point, link, or path. For example, a connection point, link, or path can be wired, wireless, use other communications technologies, or a combination thereof. In some implementations in which one or more of the phones **104** is not a VOIP-enabled device, those one or more of the phones **104** may communicate other than via the network **114**.

The network **114**, the datacenter **106**, or another element, or combination of elements, of the system **100** can include network hardware such as routers, switches, other network devices, or combinations thereof. For example, the datacenter **106** can include a load balancer **116** for routing traffic from the network **114** to various servers associated with the datacenter **106**. The load balancer **116** can route, or direct, computing communications traffic, such as signals or messages, to respective elements of the datacenter **106**.

For example, the load balancer **116** can operate as a proxy, or reverse proxy, for a service, such as a service provided to one or more remote clients, such as one or more of the clients **102**, by the application server **108**, and/or another server. Routing functions of the load balancer **116** can be configured directly or via a DNS. The load balancer **116** can coordinate requests from remote clients and can simplify client access by masking the internal configuration of the datacenter **106** from the remote clients.

In some implementations, the load balancer **116** can operate as a firewall, allowing or preventing communications based on configuration settings. Although the load balancer **116** is depicted in FIG. **1** as being within the datacenter **106**, in some implementations, the load balancer **116** can instead be located outside of the datacenter **106**, for example, when providing global routing for multiple datacenters. In some implementations, load balancers can be included both within and outside of the datacenter **106**. In some implementations, the load balancer **116** can be omitted.

FIG. **2** is a block diagram of an example internal configuration of a computing device **200** of an electronic computing and communications system, for example, a computing device which implements one or more of one of the clients **102**, the application server **108**, the database server **110**, or the telephony server **112** of the system **100** shown in FIG. **1**.

The computing device **200** includes components or units, such as a processor **202**, a memory **204**, a bus **206**, a power source **208**, peripherals **210**, a user interface **212**, a network interface **214**, other suitable components, or a combination thereof. One or more of the memory **204**, the power source **208**, the peripherals **210**, the user interface **212**, or the network interface **214** can communicate with the processor **202** via the bus **206**.

The processor **202** is a central processing unit, such as a microprocessor, and can include single or multiple processors having single or multiple processing cores. Alternatively, the processor **202** can include another type of device, or multiple devices, now existing or hereafter developed, configured for manipulating or processing information. For example, the processor **202** can include multiple processors interconnected in one or more manners, including hardwired or networked, including wirelessly networked. For example, the operations of the processor **202** can be distributed across multiple devices or units that can be coupled directly or across a local area or other suitable type of network. The processor **202** can include a cache, or cache memory, for local storage of operating data or instructions.

The memory **204** includes one or more memory components, which may each be volatile memory or non-volatile memory. For example, the volatile memory of the memory **204** can be random access memory (RAM) (e.g., a DRAM module, such as DDR SDRAM) or another form of volatile memory. In another example, the non-volatile memory of the memory **204** can be a disk drive, a solid state drive, flash memory, phase-change memory, or another form of non-volatile memory configured for persistent electronic information storage. The memory **204** may also include other types of devices, now existing or hereafter developed, configured for storing data or instructions for processing by the processor **202**. In some implementations, the memory **204** can be distributed across multiple devices. For example, the memory **204** can include network-based memory or memory in multiple clients or servers performing the operations of those multiple devices.

The memory **204** can include data for immediate access by the processor **202**. For example, the memory **204** can include executable instructions **216**, application data **218**, and an operating system **220**. The executable instructions **216** can include one or more application programs, which can be loaded or copied, in whole or in part, from non-volatile memory to volatile memory to be executed by the processor **202**. For example, the executable instructions **216** can include instructions for performing some or all of the techniques of this disclosure. The application data **218** can include user data, database data (e.g., database catalogs or dictionaries), or the like. In some implementations, the application data **218** can include functional programs, such as a web browser, a web server, a database server, another program, or a combination thereof. The operating system **220** can be, for example, Microsoft Windows®, Mac OS X®, or Linux®; an operating system for a mobile device, such as a smartphone or tablet device; or an operating system for a non-mobile device, such as a mainframe computer.

The power source **208** includes a source for providing power to the computing device **200**. For example, the power source **208** can be an interface to an external power distribution system. In another example, the power source **208** can be a battery, such as where the computing device **200** is a mobile device or is otherwise configured to operate independently of an external power distribution system. In some implementations, the computing device **200** may include or otherwise use multiple power sources. In some such implementations, the power source **208** can be a backup battery.

The peripherals **210** includes one or more sensors, detectors, or other devices configured for monitoring the computing device **200** or the environment around the computing device **200**. For example, the peripherals **210** can include a geolocation component, such as a global positioning system location unit. In another example, the peripherals can include a temperature sensor for measuring temperatures of components of the computing device **200**, such as the processor **202**. In some implementations, the computing device **200** can omit the peripherals **210**.

The user interface **212** includes one or more input interfaces and/or output interfaces. An input interface may, for example, be a positional input device, such as a mouse, touchpad, touchscreen, or the like; a keyboard; or another suitable human or machine interface device. An output interface may, for example, be a display, such as a liquid crystal display, a cathode-ray tube, a light emitting diode display, or other suitable display.

The network interface **214** provides a connection or link to a network (e.g., the network **114** shown in FIG. **1**). The network interface **214** can be a wired network interface or a wireless network interface. The computing device **200** can communicate with other devices via the network interface **214** using one or more network protocols, such as using Ethernet, transmission control protocol (TCP), internet protocol (IP), power line communication, an IEEE 802.X protocol (e.g., Wi-Fi, Bluetooth, ZigBee, etc.), infrared, visible light, general packet radio service (GPRS), global system for mobile communications (GSM), code-division multiple access (CDMA), Z-Wave, another protocol, or a combination thereof.

FIG. **3** is a block diagram of an example of a meeting system **300** for delivering virtual meeting software services in an electronic computing and communications system, for example, the system **100** shown in FIG. **1**. The meeting system **300** includes a thread encoding tool **302**, a switching/routing tool **304**, and virtual meeting software **306**. The meeting system **300** enables use of the virtual meeting software **306** by clients and phones, such as clients **308** and **310** and phone **312**. For example, one or both of the clients **308** or **310** may be a client **102** shown in FIG. **1**. In another example, the phone **312** may be a phone **104** shown in FIG. **1**. The meeting system **300** may in at least some cases be implemented using one or more servers of the system **100**. Although two clients and a phone are shown in FIG. **3**, other numbers of clients and/or other numbers of phones can connect to the meeting system **300**.

A virtual meeting includes transmitting and receiving video, audio, and/or other data between clients and/or phones of virtual meeting participants. Each of the client **308**, the client **310**, and the phone **312** may connect through the meeting system **300** using separate input streams to enable users thereof to participate in a virtual meeting together using the virtual meeting software. The virtual meeting software **306** is software for implementing virtual meetings between users of two or more clients and/or phones. For example, the virtual meting software **306** can be the virtual meeting software described above with respect to the application server **108** of FIG. **1**.

The virtual meeting software **306** includes a dedicated meeting view for each input stream received and processed at the meeting system **300**. For example, a meeting view may be represented within a graphical user interface (GUI) of the virtual meeting software **306** by a dedicated box for a given participant. The content of the meeting view for a given participant may be dependent upon the source of the input stream for that participant. For example, where a participant accesses the virtual meeting software **306** from a client, such as the client **308** or **310**, the meeting view for the participant may include a video output stream transmitted from the meeting system for viewing by all participants based on a video input stream received from the client, although the participant may optionally disable video features to suspend the video output stream from being presented in the meeting view. In another example, where a participant access the virtual meeting software **306** from a phone, such as the phone **312**, the meeting view for the participant may be limited to a static image or other default background aspect since there is no video output stream produced for that participant.

The thread encoding tool **302** receives video input streams separately from the clients **308** and **310** and encodes those video input streams using one or more transcoding tools, such as to produce variant streams at different resolutions. The video input streams may be received over a network, for example, the network **114** shown in FIG. **1**, or by a direct wired connection, such as using a universal serial bus (USB) connection or like coupling aspect. After the video input streams are encoded, the switching/routing tool **304** direct the encoded streams through applicable network infrastructure and/or other hardware to deliver the encoded streams to the virtual meeting software **306**. The virtual meeting software **306** delivers output video streams representative of the respective encoded streams to each connected client, such as the clients **308** and **310**, which receive and decode the output video streams to output them for display by video output components of the clients, such as within respective meeting views of the virtual meeting software **306**.

A user of the phone **312** participates in the virtual meeting using an audio-only connection and may thus be referred to an audio-only caller. To participate in the virtual meeting from the phone **312**, an audio signal from the phone **312** is received and processed at a VOIP gateway **314** to prepare a digital telephony signal for processing at the meeting system **300**. The VOIP gateway **314** may be part of the system **100**, for example, implemented at or in connection with a server of the datacenter **106**. Alternatively, the VOIP gateway **314** may be located on the user-side, such as in a same location as the phone **312**. The digital telephony signal is a packet switched signal transmitted to the switching/routing tool **304** for delivery to the virtual meeting software **306**. The virtual meeting software **306** outputs an audio signal representing a combined audio capture for each participant of the virtual meeting for output by an audio output component of the phone **312**. In some implementations, the VOIP gateway **314** may be omitted, for example, where the phone **312** is a VOIP-enabled phone.

A virtual meeting may be referred to as a video-enabled virtual meeting in which video streaming is enabled for one or more participants. The enabling of video streaming for a participant of a virtual meeting does not require that the participant activate or otherwise use video functionality for participating in the virtual meeting. For example, a virtual meeting may still be a video-enabled virtual meeting where none of the participants joining using clients turns on their video feed for any portion of the virtual meeting. In some cases, however, the virtual meeting may have video disabled, such as where each participant connects to the virtual meeting using a phone rather than a client, or where a host of the virtual meeting selectively configures the virtual meeting to exclude video functionality.

In some implementations, other software services may be accessible in connection with a virtual meeting implemented using the meeting system **300**. For example, a virtual meeting may include or otherwise integrate functionality for instant messaging, unified messaging, and other types of messaging communications between participants of the virtual meeting, such as to facilitate a chat or like virtual conversation between users of those participants. Those other software services may be implemented at the meeting system **300** and/or a different aspect of the system **100**.

FIG. **4** is a block diagram of an example of multi-factor authentication for authenticating an audio-only caller requesting to join a virtual meeting. A phone **400**, which may, for example, be the phone **312** shown in FIG. **3**, transmits a request received by a multi-factor authentication tool **402** for an operator of the phone **400** to join a virtual meeting (e.g., a video-enabled virtual meeting) implemented by virtual meeting software **404**, which may, for example, be the virtual meeting software **306** shown in FIG. **3**. The multi-factor authentication tool **402** is software which processes the request for the operator of the phone **400**, who is an audio-only caller given that the operator seeks to join the virtual meeting over a telephony connection, to verify the identity of the audio-only caller before the audio-only caller is allowed to join the virtual meeting at the virtual meeting software **404**.

The multi-factor authentication tool **402** and the virtual meeting software **404** may be implemented by different servers or by the same server, for example, the application server **108** shown in FIG. **1**. As shown, the multi-factor authentication tool **402** is separate from the virtual meeting software **404**. However, in some implementations, the multi-factor authentication tool **402** may be included in the virtual meeting software **404**. For example, the multi-factor authentication tool **402** may represent a threshold check process performed at the virtual meeting software **404** itself for verifying an identity of an audio-only caller before allowing the audio-only caller to join a virtual meeting.

As shown, the multi-factor authentication tool **402** includes an information collection tool **406**, an authentication request processing tool **408**, and a caller identity verification tool **410**. However, in some implementations, the multi-factor authentication tool **402** may include other tools in addition to or instead of the tools **406** through **410**.

The information collection tool **406** obtains information associated with the phone **400** and a meeting identifier associated with the virtual meeting the audio-only caller is requesting to join. The meeting identifier is some information for uniquely identifying a particular virtual meeting implemented at the virtual meeting software **404**. The information associated with the phone **400** includes one or more of caller ID information, contact record information, proximity information, and device owner information.

In some cases, the information associated with the phone **400** and the meeting identifier are both obtained within the request for the audio-only caller to join the virtual meeting received from the phone **400**. For example, the request for the audio-only caller to join the virtual meeting can include the meeting identifier, and the information collection tool **406**, responsive to the request for the audio-only caller to join the virtual meeting, can transmit a request to obtain the information associated with the phone **400** from the phone

400. In other cases, the meeting identifier is received from the phone **400** and at least some of the information associated with the phone **400** is received from a phone data database **412**. For example, the phone data database **412** can store information associated with phones which have previously been used to join a virtual meeting at the virtual meeting software **404**. The phone data database **412** may, for example, be implemented by the database server **110** shown in FIG. **1**.

In another example, a meeting data database **414** which includes information associated with guests who are authorized to join virtual meetings can include information associated with phones of those guests, who may be audio-only callers. The meeting identifier received from the phone **400** can be used to search through the meeting data of the meeting data database for information associated with the virtual meeting corresponding to the meeting identifier received from the phone **400**. That information associated with the virtual meeting may, for example, include at least some information associated with the phone **400**. In some cases, the information associated with the phone **400** obtained from within the meeting data database **414** may be used to search the phone data database **412** for other aspects of the information associated with the phone **400**.

The authentication request processing tool **408** transmits an authentication request to verify an identity of the audio-only caller to the phone **400** and receives a response to the authentication request from the phone **400**. The authentication request may be a request for an authentication code generated based on the request for the audio-only caller to join the virtual meeting received from the phone **400**. In some cases, the authentication code is generated at the multi-factor authentication tool **402** and then transmitted to the phone **400** so that the operator of the phone **400** can transmit the authentication code within the response to the authentication request from the phone **400**. In other cases, the authentication code is generated at the phone **400** using instructions for generating the authentication code transmitted to the phone **400** from the multi-factor authentication tool **402**. The authentication code is generated particular to the phone **400**, the audio-only caller, and the virtual meeting the audio-only caller is requesting to join.

The caller identity verification tool **410** verifies the identity of the audio-only caller to determine whether to allow or deny the request for the audio-only caller to join the virtual meeting at the virtual meeting software **404**. The caller identity verification tool **410** verifies the identity of the audio-only caller based on the response to the authentication request received from the phone **400**, and, optionally based also on the information associated with the phone **400** and/or the meeting identifier received from the phone **400**.

Verifying the identity of the audio-only caller based on the response to the authentication request includes determining whether the response to the authentication request includes the authentication code. For example, the response to the authentication request may be parsed to search for data matching the authentication code. The verification is successful where the response to the authentication request includes the authentication code. The verification fails where the response to the authentication request omits the authentication code, for example, by entirely omitting the authentication code or including a misrepresentation (e.g., a misspelling) of the authentication code.

Verifying the identity of the audio-only caller based on the response to the authentication request and based on the information associated with the phone **400** and/or the meeting identifier received from the phone **400** includes the above related to the verification of the response to the authentication request, as well as verifying the meeting identifier and at least some of the information associated with the phone **400**. For example, the meeting data database **414** can be searched for the meeting identifier. The meeting identifier may be successfully verified where the search of the meeting data database **414** identifies an upcoming or in-progress virtual meeting associated with the meeting identifier. The verification of the meeting identifier fails where the search of the meeting data database **414** does not identify such an upcoming or in-progress virtual meeting. In another example, the meeting data database **414** can be searched for the virtual meeting associated with the meeting identifier, but to identify information associated with authorized guests of the virtual meeting. The information associated with the phone **400** may be successfully verified where at least some of that information is represented within the meeting data database **414** record for the virtual meeting; otherwise, the verification of the information associated with the phone **400** fails.

Where each verification performed by the caller identity verification tool **410** is successful, the identity of the audio-only caller is deemed to have been successfully verified. In such a case, the request for the audio-only caller to join the virtual meeting is allowed, and the phone **400** is connected into the virtual meeting software **404** accordingly. However, where at least one verification performed by the caller identity verification tool **410** fails, the identity of the audio-only caller is deemed to have failed. In such a case, the request for the audio-only caller to join the virtual meeting is denied, and the phone **400** is prohibited from connecting into the virtual meeting software **404**.

In some implementations, a failed verification by the caller identity verification tool **410** may prompt one or more subsequent caller identity verification checks. For example, upon the verification of the identity of the audio-only caller failing, a new authentication code can be generated, and the operations performed by the authentication request processing tool **408** and the caller identity verification tool **410** can be repeated until a successful verification of the identity of the audio-only caller or until a maximum number of unsuccessful attempts have been made, whichever occurs first.

FIG. **5** is a block diagram of example inputs and outputs of a multi-factor authentication tool, such as the multi-factor authentication tool **402** shown in FIG. **4**. In particular, FIG. **5** visually represents the data flows between the tools **406** through **410** shown in FIG. **4**. A request **500** for an audio-only caller to join a virtual meeting is received by the information collection tool **406**, which obtains information **502** associated with the phone. The processing of the request **500** and the information **502** may ultimately result in the generation of an authentication code **504**, which serves as the basis for the processing performed by the authentication request processing tool **408**. The authentication request processing tool **408** receives a response **506** to an authentication request, which response **506** is processed by the caller identity verification tool **410** to result in a verification result **508**.

FIGS. **6** and **7** are illustrations of swim lanes showing example sequences of operations performed for multi-factor authentication between the phone **400**, the multi-factor authentication tool **402**, and the virtual meeting software **404** shown in FIG. **4**. Referring first to FIG. **6**, a first example sequence of operations performed for multi-factor authentication is shown. At **600**, a request to join a virtual meeting, for example, the request **500** shown in FIG. **5**, is transmitted from the phone **400** to the multi-factor authentication tool **402**. At **602**, information associated with the phone **400**, for example, the information **502** shown in FIG. **5**, and meeting information such as a meeting identifier are obtained at the multi-factor authentication tool **402**. At **604**, the multi-factor authentication tool **402** detects, based on the information associated with the phone **400**, that the request to join the virtual meeting is received over a telephony connection and thus that the operator of the phone **400** is an audio-only caller. At **606**, the multi-factor authentication tool generates an authentication code, for example, the authentication code **504** shown in FIG. **5**, and transmits the authentication code to the phone **400**, which the phone **400** receives at **608**. At **610**, an authentication request is transmitted from the multi-factor authentication tool **402** to the phone **400**. At **612**, a response to the authentication request, for example, the response **506** shown in FIG. **5**, is transmitted from the phone **400** to the multi-factor authentication tool **402**. At **614**, the multi-factor authentication tool verifies the identity of the audio-only caller, for example, to determine the verification result **508** shown in FIG. **5**. At **616**, based on the verification result, the audio-only caller joins the virtual meeting at the virtual meeting software **404**.

Referring next to FIG. **7**, a second example sequence of operations performed for multi-factor authentication is shown. The example sequence shown in FIG. **7** is largely the same as the example sequence shown in FIG. **6**, except that the authentication code is generated at the phone **400** instead of at the multi-factor authentication tool **402**. At **700**, a request to join a virtual meeting, for example, the request **500** shown in FIG. **5**, is transmitted from the phone **400** to the multi-factor authentication tool **402**. At **702**, information associated with the phone **400**, for example, the information **502** shown in FIG. **5**, and meeting information such as a meeting identifier are obtained at the multi-factor authentication tool **402**. At **704**, the multi-factor authentication tool **402** detects, based on the information associated with the phone **400**, that the request to join the virtual meeting is received over a telephony connection and thus that the operator of the phone **400** is an audio-only caller. At **706**, the multi-factor authentication tool transmits to the phone **400** instructions usable at the phone **400** to generate an authentication code, for example, the authentication code **504** shown in FIG. **5**. At **708**, the authentication code is generated at the phone **400**. At **710**, an authentication request is transmitted from the multi-factor authentication tool **402** to the phone **400**. At **712**, a response to the authentication request, for example, the response **506** shown in FIG. **5**, is transmitted from the phone **400** to the multi-factor authentication tool **402**. At **714**, the multi-factor authentication tool verifies the identity of the audio-only caller, for example, to determine the verification result **508** shown in FIG. **5**. At **716**, based on the verification result, the audio-only caller joins the virtual meeting at the virtual meeting software **404**.

To further describe some implementations in greater detail, reference is next made to examples of techniques which may be performed using multi-factor authentication for audio meeting participants. FIG. **8** is a flowchart of an example of a technique **800** for multi-factor authentication for audio meeting participants. The technique **800** can be executed using computing devices, such as the systems, hardware, and software described with respect to FIGS. **1-7**. The technique **800** can be performed, for example, by executing a machine-readable program or other computer-executable instructions, such as routines, instructions, programs, or other code. The steps, or operations, of the technique **800** or another technique, method, process, or algorithm described in connection with the implementations disclosed herein can be implemented directly in hardware, firmware, software executed by hardware, circuitry, or a combination thereof.

For simplicity of explanation, the technique **800** is depicted and described herein as a series of steps or operations. However, the steps or operations in accordance with this disclosure can occur in various orders and/or concurrently. Additionally, other steps or operations not presented and described herein may be used. Furthermore, not all illustrated steps or operations may be required to implement a technique in accordance with the disclosed subject matter.

At **802**, a request for an audio-only caller to join a video-enabled virtual meeting is received from a phone device of an audio-only caller. The request for the audio-only caller to join the video-enabled virtual meeting is received at a server device which runs software for implementing all or a portion of the virtual meeting. The request for the audio-only caller to join the video-enabled virtual meeting includes a telephony signal indicating a telephone number associated with a virtual meeting software service used for the video-enabled virtual meeting. In some implementations, the request for the audio-only caller to join the video-enabled virtual meeting may also or instead include a meeting identifier for the video-enabled virtual meeting.

At **804**, information associated with the phone device of the audio-only caller is obtained. The information associated with the phone device includes one or more of caller ID information, contact record information, location information, and device owner information. In some implementations, the information associated with the phone device may include other information in addition to or instead of some or all of the information described above. The information associated with the phone device is obtained responsive to the request for the audio-only caller to join the video-enabled virtual meeting. The information may be obtained from a database of the system used for the multi-factor authentication, from the phone device itself, or from another source.

The caller ID information refers to an emergency location identification number (ELIN) of the phone device. The contact record information includes information of one or more phonebook contacts stored at or for the phone device. The proximity information includes information related to a location of the phone device at the time the request for the audio-only caller to join the video-enabled virtual meeting is received from it and/or locations of the phone device at one or more previous times. The device owner information identifies an owner of the device, which may, for example, be the audio-only caller, a relative of the audio-only caller, an employer of the audio-only caller, or another person or entity.

At **806**, an authentication request to verify an identity of the audio-only caller is transmitted to the phone device of the audio-only caller. The authentication request includes a request for the audio-only caller to verify his or her identity using an authentication code generated based on the request for the audio-only caller to join the video-enabled virtual meeting. The authentication code is generated based on the request for the audio-only caller to join the video-enabled virtual meeting. The authentication code may be generated before the authentication request is transmitted, but after the request for the audio-only caller to join the video-enabled virtual meeting is received. Alternatively, authentication code may be generated after the authentication request is transmitted. As a further alternative, the authentication code may be generated concurrently or substantially concurrently with the transmission of the authentication request.

The authentication code may be generated at the server device or at the phone device of the audio-only caller. For example, where the server device generates the authentication code, the server device may transmit the authentication code to the phone device based on the request for the audio-only caller to join the video-enabled virtual meeting. In another example, where the phone device generates the authentication code, the server device may transmit instructions for generating the authentication code to the phone device based on the request for the audio-only caller to join the video-enabled virtual meeting. In some implementations, the instructions to generate the authentication code include information usable to generate the authentication code, for example, a hashing function and an input thereto. In some implementations, the instructions to generate the authentication code include instructions for software running on the phone device to run an algorithm synchronized with the server device. Whether the authentication code is generated at the server device or at the phone device, the server device knows the authentication code (e.g., by temporarily storing the authentication code or the instructions therefor in an encrypted format) and will use that knowledge of the authentication code later to verify the identity of the audio-only caller.

In some implementations, the authentication code may be generated at the phone device without the server device transmitting instructions for generating the authentication code to the phone device. For example, software running at the phone device may be synchronized with the server device when the phone device is registered with the meeting software of the server device. In such a case, the server device may not transmit data to the phone device, but rather merely signal a response when queried by the phone device.

When the authentication code is generated other than at the phone device, the authentication may be transmitted in one of several ways. For example, the authentication code may be transmitted to the phone device by text message or instant message, to a registered email address of the audio-only caller, or in another manner. In some implementations, where the phone device is a smart phone, the authentication code may be transmitted to a connected application which may, for example, use some form of encrypted communication with the server device to securely receive the authentication code.

The authentication request is transmitted to the phone device responsive to the request for the audio-only caller to join the video-enabled virtual meeting. In some implementations, the server device uses the information associated with the phone device to detect that the audio-only caller is using the phone device to call into the video-enabled virtual meeting. For example, a caller ID number of the phone device can be used to verify that the phone device is in communication with the server device based on a telephony signal (e.g., a phone call) from the phone device. The authentication request may thus in such an implementation be transmitted to the phone device responsive to the detecting.

In some implementations where the request for the audio-only caller to join the video-enabled virtual meeting includes a meeting identifier for the video-enabled virtual meeting, the meeting identifier may be verified before the authentication request is transmitted to the phone device. For example, the server device may search through records of virtual meetings based on the meeting identifier to verify that the meeting identifier is valid (e.g., that it pertains to an upcoming or in-progress virtual meeting) and to identify a guest list for the virtual meeting associated therewith. The information associated with the phone device is used to determine whether the audio-only caller is on the guest list.

At **808**, a response to the authentication request is received from the phone device of the audio-only caller. The response to the authentication request includes information which will be used to verify the identity of the audio-only caller, for example, the authentication code. The response to the authentication request is received in at least one of a text format or an audio format. For example, the authentication code may be a text code or an audio code. Thus, the particular form of the authentication response may be based on the form of the authentication code. For example, where the authentication code is a text code, the response to the authentication request may be received via a messaging service or a website associated with the video-enabled virtual meeting. The messaging service may be or include a software service which runs one or more of text messaging software, email software, chat software, or the like. In another example, where the authentication code is an audio code, the response to the authentication request may be verbally received from the phone device via a call connection between the phone device and the server device, such as during a same call connection used to receive the request for the audio-only caller to join the video-enabled virtual meeting. The response to the authentication request may be processed using natural language processing.

At **810**, an identity of the audio-only caller is verified. The identity of the audio-only caller is verified using the authentication code and optionally also using the information associated with the phone device. In particular, verifying the identity of the audio-only caller includes determining whether the response to the authentication request includes the authentication code. This may be performed my parsing the response to the authentication request and comparing portions of the parsed response to the authentication code as it is known to the server device. Verification using the authentication code requires a complete match of the authentication code as known to the server device with at least a portion of the parsed response.

Verification using the information associated with the phone device includes using a meeting identifier received from the phone device to determine whether the audio-only caller is named on a guest list for the video-enabled virtual meeting. The server device searches through records of virtual meetings based on the meeting identifier to verify that the meeting identifier is valid (e.g., that it pertains to an upcoming or in-progress virtual meeting) and to identify a guest list for the virtual meeting associated therewith. The information associated with the phone device is used to determine whether the audio-only caller is on the guest list. For example, the guest list may include a list of phone numbers of authorized participants, a list of domains associated with one or more phone device owners, and/or other information.

As described above, in some implementations, the meeting identifier may be received as the request for the audio-only caller to join the video-enabled virtual meeting or as part of that request. In some implementations, the meeting identifier may be received from the phone device separate from the request for the audio-only caller to join the video-enabled virtual meeting. For example, the authentication request may include a request for the user to provide the meeting identifier. In another example, a separate request for the meeting identifier may be transmitted to the phone device.

In some implementations, the authentication code may be a time-limited single-use code. In such a case, verifying the identity of the audio-only caller can include determining whether a time-limit associated with the authentication code has elapsed. The time-limit associated with the authentication code is determined to be elapsed if an amount of time equal to or greater than the time-limit has passed since a start time of the authentication code, which may, for example, be a time at which the authentication code is generated at the server device or a time at which the instructions for generating the authentication code are transmitted to the phone device, as applicable. The value of the time-limit may be set in one or more ways. For example, the time-limit may have a default value, for example, five minutes. In another example, the time-limit may be variable such as based on one or more factors related to the video-enabled virtual meeting the audio-only caller seeks to join, for example, configurable settings of the video-enabled virtual meeting indicative of a security level for the virtual meeting. In some implementations, the time-limit may be adjusted after the start time for the authentication code.

At **812**, the request for the audio-only caller to join the video-enabled virtual meeting is allowed or denied based on the results of the verification. In particular, the request for the audio-only caller to join the video enabled virtual meeting is allowed responsive to a successful verification of the identity of the audio-only caller, for example, using the authentication code and optionally the information associated with the phone device. Upon the request for the audio-only caller to join the video enabled virtual meeting being allowed, the audio-only caller is entered into the video-enabled virtual meeting as a participant.

However, the request for the audio-only caller to join the video enabled virtual meeting is denied responsive to a failed verification of the identity of the audio-only caller. For example, the verification may fail where the response to the authentication request does not include the authentication code (e.g., where the authentication code is omitted, misspelled, misspoken, etc., as applicable) In another example, where the authentication code is a time-limited single-use code, the verification may fail where a time-limit for the authentication code has elapsed. Upon the request for the audio-only caller to join the video enabled virtual meeting being denied, the audio-only caller is prevented from accessing or otherwise participating in the video-enabled virtual meeting.

In some implementations, responsive to a failed verification, the server device may optionally transmit a new authentication code or instructions for generating a new authentication code, as applicable, to the phone device to repeat the authentication request and response process. This repetition may be limited to a single additional attempt or to more than one additional attempt. A second or subsequent verification of the identity of the audio-only caller may thus be performed based on the new authentication code.

In some implementations, the technique **800** may omit obtaining the information associated with the phone device. In such an implementation, the authentication code is transmitted to the phone device without reference to or otherwise using such phone device information, and the identity of the audio-only caller is verified without reference to or otherwise using such phone device information.

The implementations of this disclosure can be described in terms of functional block components and various processing operations. Such functional block components can be realized by a number of hardware or software components that perform the specified functions. For example, the disclosed implementations can employ various integrated circuit components (e.g., memory elements, processing elements, logic elements, look-up tables, and the like), which can carry out a variety of functions under the control of one or more microprocessors or other control devices. Similarly, where the elements of the disclosed implementations are implemented using software programming or software elements, the systems and techniques can be implemented with a programming or scripting language, such as C, C++, Java, JavaScript, assembler, or the like, with the various algorithms being implemented with a combination of data structures, objects, processes, routines, or other programming elements.

Functional aspects can be implemented in algorithms that execute on one or more processors. Furthermore, the implementations of the systems and techniques disclosed herein could employ a number of conventional techniques for electronics configuration, signal processing or control, data processing, and the like. The words "mechanism" and "component" are used broadly and are not limited to mechanical or physical implementations, but can include software routines in conjunction with processors, etc. Likewise, the terms "system" or "tool" as used herein and in the figures, but in any event based on their context, may be understood as corresponding to a functional unit implemented using software, hardware (e.g., an integrated circuit, such as an ASIC), or a combination of software and hardware. In certain contexts, such systems or mechanisms may be understood to be a processor-implemented software system or processor-implemented software mechanism that is part of or callable by an executable program, which may itself be wholly or partly composed of such linked systems or mechanisms.

Implementations or portions of implementations of the above disclosure can take the form of a computer program product accessible from, for example, a computer-usable or computer-readable medium. A computer-usable or computer-readable medium can be a device that can, for example, tangibly contain, store, communicate, or transport a program or data structure for use by or in connection with a processor. The medium can be, for example, an electronic, magnetic, optical, electromagnetic, or semiconductor device.

Other suitable mediums are also available. Such computer-usable or computer-readable media can be referred to as non-transitory memory or media (e.g., as a non-transitory computer readable medium storing instructions operable to cause one or more processors to perform operations), and can include volatile memory or non-volatile memory that can change over time. A memory of an apparatus described herein, unless otherwise specified, does not have to be physically contained by the apparatus, but is one that can be accessed remotely by the apparatus, and does not have to be contiguous with other memory that might be physically contained by the apparatus.

While the disclosure has been described in connection with certain implementations, it is to be understood that the disclosure is not to be limited to the disclosed implementations but, on the contrary, is intended to cover various modifications and equivalent arrangements included within the scope of the appended claims, which scope is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures as is permitted under the law.

What is claimed is:

1. A method, comprising:

transmitting, based on a phone device requesting to join a video-enabled virtual meeting, a multi-factor authentication request to the phone device to verify an identity of a user of the phone device; and

connecting the phone device to the video-enabled virtual meeting based on a verification of the identity using a multi-factor authentication code that is obtained from the phone device in response to the multi-factor authentication request without use of a secondary user device and is generated based on the phone device requesting to join the video-enabled virtual meeting.

2. The method of claim **1**, comprising:

receiving, from the phone device, the multi-factor authentication code within a response to the multi-factor authentication request; and

verifying the identity of the user of the phone device using the multi-factor authentication code.

3. The method of claim **1**, comprising:

generating the multi-factor authentication code in response to a request from the phone device to join the video-enabled virtual meeting.

4. The method of claim **1**, comprising:

transmitting instructions for generating the multi-factor authentication code to the phone device.

5. The method of claim **1**, comprising:

verifying the identity of the user of the phone device using the multi-factor authentication code and information associated with the phone device, wherein the information associated with the phone device includes one or more of caller ID information, contact record information, proximity information, and device owner information.

6. The method of claim **1**, comprising:

obtaining a meeting identifier for the video-enabled virtual meeting based on a request from the phone device to join the video-enabled virtual meeting; and

verifying the meeting identifier.

7. The method of claim **1**, comprising:

determining, using information associated with the phone device, that the user of the phone device is using the phone device to call into the video-enabled virtual meeting.

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

generating the multi-factor authentication code before or substantially concurrent with the transmitting of the multi-factor authentication request to the phone device.

9. The method of claim **1**, comprising:

generating the multi-factor authentication code after or substantially concurrent with the transmitting of the multi-factor authentication request to the phone device.

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

receiving, from the phone device, a response to the multi-factor authentication request in at least one of a text format or an audio format.

11. A non-transitory computer readable medium storing instructions operable to cause one or more processors to perform operations comprising:

transmitting, based on a phone device requesting to join a video-enabled virtual meeting, a multi-factor authentication request to the phone device to verify an identity of a user of the phone device; and

connecting the phone device to the video-enabled virtual meeting based on a verification of the identity using a multi-factor authentication code that is obtained from the phone device in response to the multi-factor authentication request without use of a secondary user device and is generated based on the phone device requesting to join the video-enabled virtual meeting.

12. The non-transitory computer readable medium of claim **11**, the operations comprising:

obtaining, from the phone device, a meeting identifier for the video-enabled virtual meeting, wherein the multi-factor authentication request is transmitted to the phone device based on a verification of the meeting identifier.

13. The non-transitory computer readable medium of claim **11**, the operations comprising one of:

transmitting the multi-factor authentication code to the phone device; or

transmitting instructions for generating the multi-factor authentication code to the phone device.

14. The non-transitory computer readable medium of claim **11**, wherein the multi-factor authentication code is transmitted to the phone device via a messaging service.

15. The non-transitory computer readable medium of claim **11**, wherein the multi-factor authentication code is a text code or an audio code.

16. A system, comprising:

one or more memories; and

one or more processors configured to execute instructions stored in the one or more memories to:

transmit, based on a phone device requesting to join a video-enabled virtual meeting, a multi-factor authentication request to the phone device to verify an identity of a user of the phone device; and

connect the phone device to the video-enabled virtual meeting based on a verification of the identity using a multi-factor authentication code that is obtained from the phone device in response to the multi-factor authentication request without use of a secondary user device and is generated based on the phone device requesting to join the video-enabled virtual meeting.

17. The system of claim **16**, wherein the one or more processors are configured to execute the instructions to:

determine whether a time-limit associated with the multi-factor authentication code has elapsed;

responsive to a determination that the time-limit has not elapsed, perform the verification of the identity of the user of the phone device using the multi-factor authentication code; and

responsive to a determination that the time-limit has elapsed, deny the verification without connecting the phone device to the video-enabled virtual meeting.

18. The system of claim **16**, wherein the one or more processors are configured to execute the instructions to:

obtain information associated with the phone device in response to a request from the phone device to join the video-enabled virtual meeting; and

verify the identity of the user of the phone device using the multi-factor authentication code and the information associated with the phone device.

19. The system of claim **16**, wherein the one or more processors are configured to execute the instructions to:

determine whether the user of the phone device is named on a guest list for the video-enabled virtual meeting.

20. The system of claim **16**, wherein the multi-factor authentication code is transmitted to the phone device using an intermediary application.

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