United States Patent Application Publication	20250267441
Kind Code	A1
Publication Date	August 21, 2025
Inventor(s)	Eisner; Gerald Robert

DEVICE BASED ENHANCED EMERGENCY NETWORK OUTAGE AWARENESS

Abstract

A method, a device, and a non-transitory storage medium provide an enhanced emergency call outage reporting service. A network device receives an emergency call notice message. The emergency call notice message indicates that an emergency call was placed from a user equipment (UE) device using a visited network. The network device compares the emergency call notice message with outage data for a home network and reports, based on the comparing, a network outage associated with the emergency call notice message.

Inventors:	**Eisner; Gerald Robert (Pickerington, OH)**
Applicant:	**Verizon Patent and Licensing Inc.** (Basking Ridge, NJ)
Family ID:	**1000007700966**
Appl. No.:	**18/442553**
Filed:	**February 15, 2024**

Publication Classification

Int. Cl.: **H04W4/90** (20180101); **H04M3/51** (20060101); **H04W24/04** (20090101); **H04W64/00** (20090101)

U.S. Cl.:

CPC **H04W4/90** (20180201); **H04M3/5116** (20130101); **H04W24/04** (20130101); **H04W64/006** (20130101);

Background/Summary

BACKGROUND INFORMATION

[0001] Enhanced 911 (or E911) service is a feature of the 911 emergency-calling system that automatically associates a physical address with a calling party's Automatic Number Identification (ANI). The E911 service provides emergency responders with information identifying the location of the caller without the calling party/person having to provide it. Emergency calls are generally routed to a Public Safety Answering Point (PSAP) at a location remote from the caller. Based on the caller's situation, the PSAP may dispatch appropriate emergency response personnel. When a user places a 911 call from a mobile device, if the user's home network is not available, a competitor's network can be used to make and deliver the emergency call.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] FIG. **1** provides an example of an environment in which an emergency call outage reporting service may be implemented;

[0003] FIGS. **2**A-**2**B are diagrams illustrating the emergency call outage reporting service according to an exemplary scenario;

[0004] FIG. **3** is a diagram illustrating logical components of a User Equipment (UE) device, according to an implementation;

[0005] FIG. **4** is a diagram of exemplary functional components of the reporting system of the network depicted in FIG. **1**;

[0006] FIG. **5** is a flow chart of example operations by a user device for the emergency call outage reporting service, according to an implementation;

[0007] FIG. **6** is a flowchart of example operations by a network device for the emergency call outage reporting service, according to an implementation; and

[0008] FIG. **7** is a diagram illustrating exemplary components of a device that may correspond to one or more of the devices illustrated herein.

DETAILED DESCRIPTION

[0009] The following detailed description refers to the accompanying drawings. The same reference numbers in different drawings may identify the same or similar elements. Also, the following detailed description does not limit the invention.

[0010] Systems and methods described herein provide an emergency call outage reporting service to improve a wireless carrier's awareness of network outages that impact an emergency call (e.g., a 911 call) system. When a User Equipment (UE) device is within its home coverage area or in an area where its service provider has no roaming partners, and it is not able to connect to its home network to place an emergency call, the call may default to another reachable network that may be associated with an alternate carrier. For example, if the alternate carrier was not impacted by conditions that caused disruption to the home network, the alternate carrier may deliver the 911 call on the alternate carrier's network even if a user-specific roaming agreement is not in place.

[0011] Current regulations require that, under certain conditions, a carrier shall report network outages affecting emergency calls to appropriate Public Safety Answering Points (PSAPs) and/or other agencies. Carriers typically have a variety of network availability tools to detect and process when network elements or circuits fail. However, if an emergency call is successfully connected by an alternate carrier, the home network may not be aware that an emergency call from one of their subscribers was carried on an alternate carrier's network. As a result, the home network carrier may notify a PSAP or other agency unnecessarily when alternate carrier networks are available to accept and deliver emergency calls. This scenario may be especially relevant when there is no third-party emergency call location determination capability in place. Thus, the home network would benefit from additional information to accurately assess and report the impact of a network outage on

emergency calls.

[0012] Implementations described herein enable UE devices to detect and report network outages affecting emergency calls. Machine-readable code or a software package is installed or embedded in a UE device capable of initiating an emergency call using a wireless network (also referred to as a mobile network) connection. The UE device may evaluate the called party number to detect an emergency call; identify the wireless network used to complete the call; capture the date, time, and location of the UE device at the time the emergency call was initiated; and provides a notification if certain reporting criteria are met. The reporting criteria may include, for example, (a) that the called party number is 911, 999, 112 or any other supported emergency number in place based on the location of the UE device initiating the call; (b) that the call was successfully completed to a network; and (c) that the network used to complete the call is not the registered home network.

[0013] FIG. **1** provides an overview of a network environment **100** in which an emergency call outage reporting service may be implemented. As shown, network environment **100** may include UE device **110**, a home network **120**, a visited network **130**, a Public Safety Answering Point (PSAP) **140**, and a reporting system **150**.

[0014] UE device **110** may include a wireless communication device. Examples of UE device **110** include a cellular telephone device (e.g., a conventional cell phone with data processing capabilities), a smart phone, a personal digital assistant (PDA) that can include a radiotelephone, a wearable computer (e.g., a smart watch), a vehicle telematics system, etc. UE device **110** may store, for example, a home network ID or other indicator that identifies the home network of a subscriber. According to implementations described herein, UE device **110** may be configured to generate emergency call notice messages for an emergency call outage reporting service, as described further herein.

[0015] Home network **120** may include a network of a wireless carrier that is associated with UE device **110** via a subscription. Home network **120** may be a default/primary network for providing service, including emergency call service, to UE device **110**. Home network **120** may include, for example, a radio access network (RAN), a core network, and other networks. For example, home network **120** may include a local area network (LAN), a wireless LAN, a wide area network (WAN), a metropolitan area network (MAN), an optical network, a cable television network, a satellite network, a wireless network (e.g., a Code Division Multiple Access (CDMA) network, a general packet radio service (GPRS) network, a Long Term Evolution (LTE) network (e.g., 4G network), a 5G network, a 6G network, an ad hoc network, a telephone network (e.g., the Public Switched Telephone Network (PSTN) or a cellular network), an intranet, or a combination of networks. Network **120** may allow the delivery of Internet Protocol (IP) services to UE device **110** and may interface with and/or include other networks, such as a packet data network.

[0016] Depending on the implementation, home network **120** may include one or multiple types of network devices **122**. For example, a network device **122** may include a next generation Node B (gNB), an enhanced LTE (eLTE) evolved Node B (eNB), an eNB, a radio network controller (RNC), a radio intelligent controller (RIC), a base station controller (BSC), a remote radio head (RRH), a baseband unit (BBU), a radio unit (RU), a remote radio unit (RRU), a centralized unit (CU), a distributed unit (DU), a small cell node (e.g., a picocell device, a femtocell device, a microcell device, a home eNB, a home gNB, etc.), a 5G ultra-wide band (UWB) node, a future generation wireless access device (e.g., a 7G wireless station, a 7G wireless station, or another generation of wireless station). In other implementation, network device **122** may include core network devices, such as a user plane function (UPF), a Non-3GPP Interworking Function (N3IWF), an access and mobility management function (AMF), a session management function (SMF), a unified data management (UDM) device, an authentication server function (AUSF), a security anchor function (SEAF), a network slice selection function (NSSF), a network repository function (NRF), a policy control function (PCF), a network exposure function (NEF), a service capability exposure function (SCEF), a mobility management entity (MME), a packet data network

gateway (PGW), a serving gateway (SGW), a home subscriber server (HSS), an authentication, authorization, and accounting (AAA) server, a policy and charging rules function (PCRF), and/or a charging system (CS). According to other implementations, network devices **122** may include additional, different, and/or fewer network devices than those described. For example, a network device **122** may include a gateway, a router, a switch, a firewall, a bridge, a proxy server, a server, or some other type of device that processes and/or transfers data.

[0017] Emergency call processing system **124** may include a computing a network device (e.g., one of network devices **122**) that manages emergency calls received by home network **120**. In one implementation, emergency call processing system **124** may operate on data on behalf of a network (e.g., home network **120**) and may serve as an entrance to another network (e.g., an emergency services network of multiple PSAPs). Emergency call processing system **124** may route an emergency call from a calling device (e.g., UE device **110**) to PSAP **140**. In some implementations, emergency call processing system **124** also may identify certain location or source information of the calling device.

[0018] Visited network **130** may include a network of a wireless carrier that is not a home network for UE device (e.g., the network that is not registered as a primary network for the UE device **120**). For example, visited network **130** may be associated with a wireless carrier that supports a roaming agreement for UE device **120** or that otherwise may be able to support emergency calls when home network **120** is not available to UE device **110**. Visited network **130** may generally include features similar to those of home network **120** and have network devices **132** similar to those described above for home network **120** and network devices **122**. In some implementations, visited network **130** may include an emergency call processing system **134** to direct emergency calls to an appropriate PSAP **140**. However, as a visited network, some of the emergency call processing system capabilities of a home network are not typically available to a visiting UE device **110** in the handling of an emergency call.

[0019] PSAP **140** may include one or more entities that are responsible for answering emergency calls for emergency assistance from, e.g., police, fire, ambulance and/or other services. PSAP **140** may include one or more user devices, network devices, and/or other communication devices that service emergency calls, such as calls from UE device **110**. In one implementation, PSAP **140** may receive emergency calls routed through emergency call processing system **124** or **134**. In another implementation, PSAP **140** may communicate with emergency personnel (e.g., police, fire, and/or ambulance services) (not shown) to provide information associated with emergency calls.

[0020] Reporting system **150** may include one or more computing devices or network devices (e.g., one or more network devices **122**) that receives incoming emergency call notice messages from UE devices **110**. Reporting system **150** may compare each incoming message against a record of known outages in home network **120**. Based on the comparison, reporting system **150** may assign a category code to the incoming message. For example, reporting system **150** may indicate that the incoming message is related to a known network outage, that the message is related to a UE device within a network service area but is not related to a known outage, or that the message is related to a UE device outside a network service area and is not related to a known outage. Based on the assigned category code, reporting system **150** may provide the emergency call notice message to an appropriate entity.

[0021] The number of devices, the number of networks, and the configuration in environment **100** are exemplary. According to other embodiments, environment **100** may include additional devices, fewer devices, and/or differently arranged devices, than those illustrated in FIG. **1**. For example, according to other embodiments, environment **100** may include additional wired and/or wireless networks.

[0022] FIG. **2**A and **2**B are diagrams illustrating an exemplary process of the emergency call outage reporting service in network environment **100**. Referring to FIG. **2**A, according to an exemplary scenario, a user (not shown) may use UE device **110** to initiate an emergency call. As

indicated at reference **202**, UE device **110** may detect that there is no network access available from home network **120**. For example, UE device may not detect signals from a RAN associated with home network **120**. Using known techniques, UE device **110** may attempt to access an alternate network to place the emergency call. Assuming visited network **130** is functional and accessible, UE device **110** may place the emergency call via visited network **130** and be connected to an appropriate PSAP **140** that can provide service to the location of UE device **110**, as indicated at reference **204**.

[0023] According to implementations described herein, UE device **110** may include software to support the emergency call outage reporting service. More particularly, UE device **110** may be configured to (a) detect when a notification for the emergency call outage reporting service is required and (b) generate an emergency call notice message for the home network.

[0024] To detect when a notification for the emergency call outage reporting service is required, UE device **110** may determine that the called number is a supported emergency number for the location of the device initiating the call. For example, the emergency number 911 may be a registered emergency number in one geographic region, and the number 999 may be a registered emergency number in a different geographic region. If UE device **110** detects that an emergency call has been successfully placed using a wireless network that is not the subscriber's home network (e.g., not home network **120**), UE device **110** may be triggered to generate an emergency call notice message. As shown at reference **206**, in response to connecting call **204**, UE device **110** may detect that an emergency call has been placed over a visited network **130** and log call data for an emergency call notice message. The logged call data may include, for example, the date, time, and information identifying a location of the call; a network ID of the network that failed (e.g., home network **120**); and a network ID of the network that was used to deliver the call (e.g., visited network **130**). If a network connection that supports a non-emergency message transfer is not available, UE device **110** may store (or enqueue) an emergency call notice message with the call data for delivery when a network connection is available.

[0025] Referring to FIG. **2**B, UE device **110** may send the emergency call notice message to reporting system **150**, as indicated at reference **208**. For example, UE device **110** may be configured with a predefined address (e.g., a fully qualified domain name (FQDN)) of the home network's reporting system (e.g., reporting system **150**). The emergency call notice message may be sent using any of multiple different networks including home network **120**, a roaming carrier (e.g., visited network **130**), a WPAN (e.g., Bluetooth), a WLAN (e.g., Wi-Fi), a mesh network (e.g., ZigBee), or any other public infrastructure capable of delivering a message without user subscription to a known server URL. In one implementation, UE device **110** may send the emergency call notice message in an encrypted format. In other implementations, hypertext transfer protocol-secure (HTTPS), short message service (SMS), radio transfer technology (RTT), or other communications mechanisms may be used, based on availability of network connections at the time of the failed call.

[0026] Reporting system **150** may receive the emergency call notice message from UE device **110**. Generally, reporting system **150** may parse and analyze the received data to determine whether or not a reportable emergency call system outage has occurred, as well as capturing data that could be used to represent the size and nature of the outage. Actions of reporting system **150** are described further below in connection with FIG. **4**.

[0027] Although FIGS. **2**A and **2**B illustrate an exemplary embodiment of a process of the emergency call outage reporting service, according to other exemplary scenarios, the emergency call outage reporting service may perform additional operations, fewer operations, and/or different operations than those illustrated and described.

[0028] FIG. **3** is a diagram illustrating logical components of UE device **110** for use with the emergency call outage reporting service, according to implementations described herein. As shown in FIG. **3**, UE device **110** may include an operating system (OS) **305**, an emergency call outage

notification application (app) **310**, location determining logic **340**, one or more dialer apps **350**, and modem(s) **360**.

[0029] OS **305** may perform various support functions for components of UE device **110**. For example, OS **305** may provide interfaces between applications (e.g., dialer apps **350**, emergency call outage notification application **310**, etc.) and other components (e.g., communication interfaces, etc.). In another example, OS **305** may provide a TCP/IP stack to support communication applications. In addition, OS **305** may provide other functions, such as thread management, memory management, storage management, etc.

[0030] Emergency call outage notification application **310** may perform one or more functions of UE device **110** for the emergency call outage reporting service described above. For example, emergency call outage notification application **310** may detect when a notification for the emergency call outage reporting service is required and generate an emergency call notice message for home network **120**. Emergency call outage notification application **310** may detect when an emergency call is placed over a visited network **130** and, in response, generate an emergency call notice message (e.g., corresponding to reference **208** of FIG. **2**B). As described further below, the emergency call notice message may include, among other data, information that identifies the location of UE device **110** at the time of the emergency call. Emergency call outage notification application **310** may be configured with an address (e.g., a network address, IP address, etc.) for proving emergency call notice messages to reporting system **150**. In one implementation, emergency call outage notification application **310** may be a carrier-specific application that may be preloaded by an original equipment manufacturer (OEM).

[0031] Location determining logic **340** may identify location coordinates for UE device **110**. According to one implementation, location determining logic **340** may use known technologies and techniques to provide location services, such as, for example, satellite-based positioning (e.g., GPS, differential GPS (DGPS), GLONASS, etc.) or cellular-based positioning (e.g., triangulation, Enhanced Observed Time Difference (E-OTD), Uplink Time Difference of Arrival (U-TDOA), assisted GPS, etc.). Location information from location determining logic **340** may be used to identify the location of UE device **110** at the time an emergency call is placed. Information from location determining logic **340** may be provided to emergency call outage notification application **310** directly or via OS **305**, for example.

[0032] Dialer apps **350** may include a native dialer application or another dialer application that provides a user interface to initiate and receive phone calls, including emergency calls. In one implementation, a dialer app **350** may be integrated with a list of contacts to automatically initiate an outbound call of a selected contact, such as an emergency contact associated with the number 911.

[0033] Modem **360** may perform communication-related functions, including establishing connections and/or sessions between UE device **110** and networks **120**/**130**, delivering messages from/to UE device **110** and to/from networks **120**/**130**, perform modulation/demodulation, perform signal processing, etc. Modem **360** may establish a connection to a subscriber's home network **120**, when available, or to a visited network **130** for an emergency call.

[0034] Although FIG. **3** shows exemplary logical components of UE device **110**, in other implementations, UE device **110** may include fewer components, different components, differently arranged components, or additional components than depicted in FIG. **3**. In addition, functions described as being performed by one of the logical components in FIG. **3** may alternatively be performed by another one or more of the components of UE device **110**. For example, in another implementation, functions of emergency call outage notification application **310** may be integrated into operating system **305**.

[0035] FIG. **4** is a block diagram illustrating communications among components of reporting system **150**. Reporting system **150** may be a standalone system or distributed within one or multiple devices of network environment **100**. The components of reporting system **150** may be

implemented, for example, via processor **710** executing instructions from memory **715**, as described in connection with FIG. **7**. Alternatively, some or all of the components included in reporting system **150** may be implemented via hard-wired circuitry. As shown in FIG. **4**, reporting system **150** may include an emergency call notice message manager **410** and emergency call notification logic **415**.

[0036] Emergency call notice message manager **410** may receive emergency call notice messages from UE devices **110**. For example, emergency call notice message manager **410** may be assigned the predefined address (e.g., FQDN) of reporting system **150**, such that emergency call notice messages **420** (e.g., corresponding to reference **208** of FIG. **2**B) from UE device **110** are delivered to emergency call notice message manager **410**. According to an implementation, emergency call notice message manager **410** may include a database, via which emergency call notice message manager **410** may accept and aggregate emergency call notice messages **420** from multiple different UE devices **110**.

[0037] Emergency call notice message manager **410** may also include a PSAP mapping feature to associate impacted areas (e.g., UE device locations associated with a network outage) with PSAP **140** facilities. Thus, in one implementation, emergency call notice message manager **410** may initiate an investigation that triggers an outage notification by another system (e.g., an existing outage notification tool). According to another implementation, when outage reporting is required, emergency call notice message manager **410** may provide outage reports to an appropriate PSAP **140** affected by an outage (e.g., as a backup to existing outage notification tools).

[0038] Emergency call notice message **420** may include but is not limited to, for example, the emergency call date/time, the calling party number, the called party number, information that identifies the device-based location, and the network ID used to complete the emergency call. The emergency call date/time may include, for example, a Coordinated Universal Time (UTC) in seconds. In some implementations, the emergency call date/time may include a start connection time. In other implementations, the emergency call date/time may also include an end time. The calling party number may include a unique identifier for the calling device (UE device **110**), such as Subscription Permanent Identifier (SUPI), a Subscription Concealed Identifier (SUCI), an International Mobile Subscriber Identity (IMSI), and a Mobile Station International Subscriber Directory Number (MSISDN). The called party number may include the emergency number UE device **110** used to place the emergency call (e.g., 911, 999, etc.). The device-based location information may include location coordinates (e.g., non-third-party determined coordinates) known by UE device **110** at the time the emergency call was placed. In another implementation, location information may be in the form of cellular tower triangulation information collected from the mobile communications device. In still other implementations, location information may be in the form of a single tower or base station location collected from the mobile communications device. The network ID used to complete the emergency call may include a network ID of the visited network, such as a network ID that uniquely identifies visited network **130**. For example, the network ID may include a Public Land Mobile Network (PLMN) ID that uniquely identifies a cellular network. In other implementations, emergency call notice message **420** may include different or additional information to enable comparison with network outage information.

[0039] Emergency call notification logic **415** may obtain network outage records **422**. For example, home network **120** may include an outage reporting system (not shown) from which outage records may be derived. Outage records may include time/location/coverage outage information for home network **120**. Thus, emergency call notification logic **415** may retrieve outage records for known outages within home network **120**. Emergency call notification logic **415** may also retrieve **424** emergency call notice messages **420** from emergency call notice message manager **410**. Each incoming emergency call notice messages **420** may be compared against known outages from network outage records **422**.

[0040] Based on the comparison, emergency call notification logic **415** may assign the incoming

emergency call notice messages **420** to a category. Examples of categories include (1) known outages, (2) unreported outage-inside, and (3) unreported outage-outside. The known outage category may indicate that the message (e.g., emergency call notice message **420**) is related to a known outage based on date, time, and location correlation between emergency call notice message **420** and network outage records **422**. The unreported outage-inside category may indicate that the message is not related to a known outage and the reported location is within a coverage area of home network **120**. The unreported outage-outside category may indicate that the message is not related to a known outage and the reported location is not within a coverage area of home network **120**.

[0041] The categories of incoming emergency call notice messages **420** described above are exemplary. In other implementations, additional or different categories may be used. For example, in another implementation, criteria for UE device **110** to generate an emergency call notice message may include successfully placed emergency calls that fail to include device location information. Thus, an additional category may be used to reflect that emergency call delivery was not impacted, but third-party location determination is offline. As indicated at references **426**, emergency call notification logic **415** may append a code to the emergency call notice message **420** based on the assigned category.

[0042] As shown at reference **428**, emergency call notification logic **415** may return the emergency call notice message **420** with the appended code back to emergency call notice message manager **410**, reflecting the result of the analysis. Emergency call notice message manager **410** may use the code to manage routing/forwarding **430** of outage notifications. For example, if the code indicates a known outage category, emergency call notice message manager **410** may not report the message to avoid redundancy. If the code indicates the unreported outage—inside category, the message may be reported to a service team for investigations. If the code indicates the unreported outage—outside, the message may be reported to a network improvement group for investigation. In some implementations, emergency call notice message manager **410** may store the emergency call notice message **420** with the appended code in the database for future retrieval and analysis.

[0043] Although FIG. **4** shows exemplary components of reporting system **150**, in other implementations, reporting system **150** may contain fewer components, different components, differently arranged components, or additional components than depicted in FIG. **4**. Alternatively, or additionally, one or more components of reporting system **150** may perform one or more other tasks described as being performed by one or more other components of reporting system **150**.

[0044] FIG. **5** is a process flow **500** illustrating exemplary operations by a UE device for the emergency call outage reporting service. In one implementation, the operations of process flow **500** may be performed by UE device **110**. For example, operations of process flow **500** may be performed by a modem, an operating system, and/or a client application of UE device **110**. In another implementation, some or all of the operations of process flow **500** may be performed by UE device **100** in conjunction with one or more of network devices of network environment **100**.

[0045] Process **500** may include detecting initiation of an emergency call (block **510**), identifying a lack of service for a home network (block **520**), and connect the emergency call via a visited network (block **530**). For example, a user may initiate an emergency call using UE device **110**. UE device **110** may determine that no network connection is available through home network **120** and, thus, UE device **110** may attach to visited network **130** to place the emergency call.

[0046] Process **500** may further include determining the carrying network for the emergency call is the same as the home network (block **540**). For example, the operating system of UE device **110** may identify the network identifier of the visited network **130** used for the emergency call against the network identifier of home network **120**. Based on the comparison of the network identifiers, UE device **110** may determine if the emergency call was conducted over the subscriber's home network or a visited network.

[0047] If the carrying network for the emergency call is not the same as the home network (block

540—No), process **500** may include collecting data for an emergency call notice message (block **550**), generating and/or storing the emergency call notice message (block **560**) and sending the emergency call notice message when network access is detected (block **570**). For example, by querying OS **305** or other systems within UE device **110**, emergency call outage notification application **310** may collect emergency call data from dialer app **350**, location determining logic **340**, OS **305**, and/or other applications available on UE device **110**. The emergency call data may include the emergency call date/time, the calling party number, the called party number, information identifying the device-based location, and the network ID used to complete the emergency call. UE device **110** may generate emergency call notice message **420** that includes the collected emergency call data. When UE device **110** is able to connect to a network that permits non-emergency access, UE device **110** may send emergency call notice message **420** to a designated network address for reporting system **150**.

[0048] If the carrying network for the emergency call is the same as the home network (block **540** —Yes) or after sending the emergency call notice message, process **500** may end.

[0049] FIG. **6** is a process flow **600** illustrating exemplary operations by a network device for the emergency call outage reporting service. In one implementation, the operations of process flow **600** may be performed by reporting device **150**. In another implementation, some or all of the operations of process flow **600** may be performed by reporting device **150** in conjunction with one or more of network devices of network environment **100**.

[0050] Process **600** may include receiving an emergency call notice message (block **610**) and comparing the emergency call notice with a network outage log (block **620**). For example, reporting device **150** (e.g., emergency call notice message manager **410**) may receive an emergency call notice message **420** from UE device **110**. Reporting device **150** (e.g., emergency call notification logic **415**) may compare incoming emergency call notice message **420** against known outages from network outage records. Based on the comparison, reporting device **150** may assign the incoming emergency call notice messages **420** to a category, such as the known outage category, the unreported outage—inside category, or the unreported outage—outside category described above.

[0051] Process **600** may further include assigning a category code to the emergency call notice message (block **630**) and forwarding the emergency call notice message with the appended message code (block **640**). For example, reporting system **150** (e.g., emergency call notification logic **415**) may append a code to the emergency call notice message **420** based on the assigned category. Based on the code, reporting system **150** (e.g., emergency call notice message manager **410**) may report an outage to a contact point within home network **120**.

[0052] FIG. **6** illustrate an exemplary process **600** of the emergency call outage reporting service, however, according to other embodiments, process **600** may include additional operations, fewer operations, and/or different operations than those illustrated in FIG. **6** and described herein.

[0053] FIG. **7** is a diagram illustrating exemplary components of a device **700** that may correspond to one or more of the devices described herein. For example, device **700** may correspond to components included in UE devices **110**, home network **120**, visited network **130**, and/or other elements illustrated in FIGS. **1-3**. As illustrated in FIG. **7**, according to an exemplary embodiment, device **700** includes a bus **705**, one or more processors **710**, memory/storage **715** that stores software **720**, a communication interface **725**, an input **730**, and an output **735**. According to other embodiments, device **700** may include fewer components, additional components, different components, and/or a different arrangement of components than those illustrated in FIG. **7** and described herein.

[0054] Bus **705** includes a path that permits communication among the components of device **700**. For example, bus **705** may include a system bus, an address bus, a data bus, and/or a control bus. Bus **705** may also include bus drivers, bus arbiters, bus interfaces, and/or clocks.

[0055] Processor **710** includes one or multiple processors, microprocessors, data processors, co-

processors, application specific integrated circuits (ASICs), controllers, programmable logic devices, chipsets, field-programmable gate arrays (FPGAs), application specific instruction-set processors (ASIPs), system-on-chips (SoCs), central processing units (CPUs) (e.g., one or multiple cores), microcontrollers, and/or some other type of component that interprets and/or executes instructions and/or data. Processor **710** may be implemented as hardware (e.g., a microprocessor, etc.), a combination of hardware and software (e.g., a SoC, an ASIC, etc.), may include one or multiple memories (e.g., cache, etc.), etc. Processor **710** may be a dedicated component or a non-dedicated component (e.g., a shared resource).

[0056] Processor **710** may control the overall operation or a portion of operation(s) performed by device **700**. Processor **710** may perform one or multiple operations based on an operating system and/or various applications or computer programs (e.g., software **720**). Processor **710** may access instructions from memory/storage **715**, from other components of device **700**, and/or from a source external to device **700** (e.g., a network, another device, etc.). Processor **710** may perform an operation and/or a process based on various techniques including, for example, multithreading, parallel processing, pipelining, interleaving, etc.

[0057] Memory/storage **715** includes one or multiple memories and/or one or multiple other types of storage mediums. For example, memory/storage **715** may include one or multiple types of memories, such as, random access memory (RAM), dynamic random-access memory (DRAM), cache, read only memory (ROM), a programmable read only memory (PROM), a static random-access memory (SRAM), a single in-line memory module (SIMM), a dual in-line memory module (DIMM), a flash memory (e.g., a NAND flash, a NOR flash, etc.), and/or some other type of memory. Memory/storage **715** may include a hard disk (e.g., a magnetic disk, an optical disk, a magneto-optic disk, a solid-state disk, etc.), a Micro-Electromechanical System (MEMS)-based storage medium, and/or a nanotechnology-based storage medium. Memory/storage **715** may include a drive for reading from and writing to the storage medium.

[0058] Memory/storage **715** may be external to and/or removable from device **700**, such as, for example, a Universal Serial Bus (USB) memory stick, a dongle, a hard disk, mass storage, off-line storage, network attached storage, or some other type of storing medium. Memory/storage **715** may store data, software, and/or instructions related to the operation of device **700**.

[0059] Software **720** includes an application or a program that provides a function and/or a process. Software **720** may include an operating system. Software **720** is also intended to include firmware, middleware, microcode, hardware description language (HDL), and/or other forms of instruction. For example, according to an implementation, software **720** may be used by UE device **110** and/or reporting system **150** to implement portions of the emergency call outage reporting service.

[0060] Communication interface **725** permits device **700** to communicate with other devices, networks, systems, devices, and/or the like. Communication interface **725** includes one or multiple wireless interfaces and/or wired interfaces. For example, communication interface **725** may include one or multiple transmitters and receivers, or transceivers (e.g., radio frequency transceivers). Communication interface **725** may include one or more antennas. For example, communication interface **725** may include an array of antennas. Communication interface **725** may operate according to a protocol stack and a communication standard. Communication interface **725** may include various processing logic or circuitry (e.g., multiplexing/de-multiplexing, filtering, amplifying, converting, error correction, etc.).

[0061] Input **730** permits an input into device **700**. For example, input **730** may include a keyboard, a mouse, a display, a button, a switch, an input port, speech recognition logic, a biometric mechanism, a microphone, a visual and/or audio capturing device (e.g., a camera, etc.), and/or some other type of visual, auditory, tactile, etc., input component. Output **735** permits an output from device **700**. For example, output **735** may include a speaker, a display, a light, an output port, and/or some other type of visual, auditory, tactile, etc., output component. According to some embodiments, input **730** and/or output **735** may be a device that is attachable to and removable

from device **700**.

[0062] Device **700** may perform a process and/or a function, as described herein, in response to processor **710** executing software **720** stored by memory/storage **715**. By way of example, instructions may be read into memory/storage **715** from another memory/storage **715** (not shown) or read from another device (not shown) via communication interface **725**. The instructions stored by memory/storage **715** cause processor **710** to perform a process described herein. Alternatively, for example, according to other implementations, device **700** performs a process described herein based on the execution of hardware (processor **710**, etc.).

[0063] As described herein, a method, a device, and a non-transitory storage medium provide an emergency call outage reporting service. In one implementation, a network device receives an emergency call notice message. The emergency call notice message indicates an emergency call was placed from a UE device using a visited network. The network device compares the emergency call notice message with outage data for a home network and reports, based on the comparing, a network outage associated with the emergency call notice message. In another implementation, a UE device detects that an emergency call was placed from the UE device over a visited network, collects information identifying a device-based location at the time of the emergency call, generates an emergency call notice message that includes the information identifying the device-based location, and sends the emergency call notice message to a network device in the home network.

[0064] The foregoing description of embodiments provides illustrations but is not intended to be exhaustive or to limit the embodiments to the precise form disclosed. In the preceding description, various embodiments have been described with reference to the accompanying drawings. However, various modifications and changes may be made thereto, and additional embodiments may be implemented, without departing from the broader scope of the invention as set forth in the claims that follow. The description and drawings are accordingly to be regarded as illustrative rather than restrictive. For example, while reporting system **150** is described herein in the context of residing in a home network, in other implementations, reporting system **150** may be included within another network, such as a third-party network.

[0065] In addition, while series of blocks have been described with regard to the processes illustrated in FIGS. **5** and **6**, and series of signals with respect to FIGS. **2**A-**2**B the order of the blocks and/or signals may be modified according to other embodiments. Further, non-dependent blocks may be performed in parallel. Additionally, other processes described in this description may be modified and/or non-dependent operations may be performed in parallel.

[0066] The embodiments described herein may be implemented in many different forms of software executed by hardware. For example, a process or a function may be implemented as "logic" or as a "component." The logic or the component may include, for example, hardware (e.g., processor **710**, etc.), or a combination of hardware and software. The embodiments have been described without reference to the specific software code since the software code can be designed to implement the embodiments based on the description herein and commercially available software design environments/languages.

[0067] As set forth in this description and illustrated by the drawings, reference is made to "an exemplary embodiment," "an embodiment," "embodiments," etc., which may include a particular feature, structure or characteristic in connection with an embodiment(s). However, the use of the phrase or term "an embodiment," "embodiments," etc., in various places in the specification does not necessarily refer to all embodiments described, nor does it necessarily refer to the same embodiment, nor are separate or alternative embodiments necessarily mutually exclusive of other embodiment(s). The same applies to the term "implementation," "implementations," etc.

[0068] The terms "a," "an," and "the" are intended to be interpreted to include one or more items. Further, the phrase "based on" is intended to be interpreted as "based, at least in part, on," unless explicitly stated otherwise. The term "and/or" is intended to be interpreted to include any and all combinations of one or more of the associated items. The word "exemplary" is used herein to mean

"serving as an example." Any embodiment or implementation described as "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments or implementations.

[0069] Use of ordinal terms such as "first," "second," "third," etc., in the claims to modify a claim element does not by itself connote any priority, precedence, or order of one claim element over another, the temporal order in which acts of a method are performed, the temporal order in which instructions executed by a device are performed, etc., but are used merely as labels to distinguish one claim element having a certain name from another element having a same name (but for use of the ordinal term) to distinguish the claim elements.

[0070] Additionally, embodiments described herein may be implemented as a non-transitory storage medium that stores data and/or information, such as instructions, program code, data structures, program modules, an application, etc. The program code, instructions, application, etc., is readable and executable by a processor (e.g., processor **710**) of a computational device. A non-transitory storage medium includes one or more of the storage mediums described in relation to memory **715**.

[0071] To the extent the aforementioned embodiments collect, store or employ personal information provided by individuals, or any other user data or subscription data, it should be understood that such information shall be used in accordance with all applicable laws concerning protection of personal information. Additionally, the collection, storage and use of such information may be subject to consent of the individual to such activity, for example, through well known "opt-in" or "opt-out" processes as may be appropriate for the situation and type of information. Storage and use of personal information may be in an appropriately secure manner reflective of the type of information, for example, through various encryption and anonymization techniques for particularly sensitive information.

Claims

1. A method, comprising: receiving, by a network device, an emergency call notice message, wherein the emergency call notice message indicates that an emergency call was placed from a user equipment (UE) device using a visited network; comparing, by a network device, the emergency call notice message with outage data for a home network; and reporting, by a network device and based on the comparing, a network outage associated with the emergency call notice message.

2. The method of claim 1, wherein the emergency call notice message includes: a time of the emergency call, a calling party identifier of the emergency call, a called number of the emergency call, information that identifies a device-based location at the time of the emergency call, and a network identifier of the visited network used for the emergency call.

3. The method of claim 1, wherein the reporting comprises: assigning a category code to the emergency call notice message based on the comparing.

4. The method of claim 3, wherein the assigning further comprises identifying a category for the emergency call notice message as one of: a first category indicating the emergency call notice message is consistent with a known outage in the home network, a second category indicating that the emergency call notice message is not related to a known outage and the device-based location is within a coverage area of the home network, or a third category indicating that the emergency call notice message is not related to a known outage and the device-based location is not within a coverage area of the home network.

5. The method of claim 1, wherein receiving the emergency call notice message comprises: receiving the emergency call notice message via the home network.

6. The method of claim 1, wherein receiving the emergency call notice message comprises: receiving the emergency call notice message from the UE device after the emergency call is connected to a public safety answering point (PSAP).

7. The method of claim 1, wherein the home network includes a mobile network and wherein the network device is associated with the home network of the UE device.

8. The method of claim 1, wherein the comparing comprises: obtaining reported network outage data for the home network, and comparing the network outage data with a time and device-based location information provided in the emergency call notice message.

9. A network device, comprising: a processor configured execute instructions to: receive an emergency call notice message, wherein the emergency call notice message indicates that an emergency call was placed from a user equipment (UE) device using a visited network; compare the emergency call notice message with outage data for a home network; and report, based on the comparing, a network outage associated with the emergency call notice message.

10. The network device of claim 9, wherein the emergency call notice message includes: a time of the emergency call, a calling party identifier of the emergency call, a called number of the emergency call, information identifying a device-based location at the time of the emergency call, and a network identifier of the visited network used for the emergency call.

11. The network device of claim 9, wherein, when reporting the network outage, the processor is further to execute instructions to: assign a category code to the emergency call notice message based on the comparing.

12. The network device of claim 11, wherein, when assigning the category code, the processor is further to execute instructions to: identify a category for the emergency call notice message as one of: a first category indicating the emergency call notice message is consistent with a known outage in the home network, a second category indicating that the emergency call notice message is not related to a known outage and the device-based location is within a coverage area of the home network, or a third category indicating that the emergency call notice message is not related to a known outage and the device-based location is not within a coverage area of the home network.

13. The network device of claim 9, wherein, when receiving the emergency call notice message, the processor is further to execute instructions to: receive the emergency call notice message via the home network.

14. The network device of claim 9, wherein, when receiving the emergency call notice message, the processor is further to execute instructions to: receive the emergency call notice message from the UE device after the emergency call is connected to a public safety answering point (PSAP).

15. The network device of claim 9, wherein the network device is associated with the home network of the UE device.

16. The network device of claim 9, wherein, when reporting the network outage, the processor is further to execute instructions to: identify a public safety answering point (PSAP) associated with device-based location information provided in the emergency call notice message.

17. A method comprising: detecting, by a user equipment (UE) device, that an emergency call was placed from the UE device over a visited network; collecting, by the UE device, information identifying a device-based location at the time of the emergency call; generating, by the UE device, an emergency call notice message that includes the information identifying the device-based location; and sending, by the UE device, the emergency call notice message.

18. The method of claim 17, wherein the emergency call notice message further includes: a time of the emergency call, a calling party identifier of the emergency call, a called number of the emergency call, and a network identifier of the visited network used for the emergency call.

19. The method of claim 17, wherein sending the emergency call notice message includes: sending the emergency call notice message to a network device associated with a home network of the UE device.

20. The method of claim 17. further comprising: storing, after the generating, the emergency call notice message until the UE device connects to a network that permits non-emergency access.