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(54) Title: MOBILE DEVICE LOCATION DETERMINATION USING MICRONETWORKS

(57) Abstract: A facility for determining the location of a mobile device when a location determination of a desired accuracy is desired. If available, the facility determines the location of the mobile device using a device-based technique or using a location determination technique that is accessible over a macronetwork. Macronetworks are networks that are designed to cover relatively large areas. If a location determination technique of desired accuracy is not available on the device or over a macronetwork, the facility attempts to use a location determination technique that is accessible over a micronetwork to determine the location of the mobile device. Micronetworks are networks that are designed to cover smaller areas. By forcing a switch from a macronetwork-based location determination technique to a micronetwork-based location determination technique, the facility ensures that a location determination is made for the mobile device of a desired accuracy, time to fix (TTF), and/or yield.

MOBILE DEVICE LOCATION DETERMINATION USING MICRONETWORKS

BACKGROUND

[0001] The popularity of location-based services has substantially increased in recent years. For example, mobile device users now employ location-based services for navigation, to perform location-based searching, to receive location-based alerts or advertising, to search for or receive notification of nearby acquaintances, and/or the like. Likewise, other parties (e.g., network operators, third party location-based service providers, remote telemetry users, advertisers, etc.) may employ location-based services to enable E911 services, enable asset tracking or recovery services, provide location-based alerts or advertising, provide notification of nearby acquaintances, and/or the like.

[0002] The recent increase in the popularity of location-based services has led to the development of many different techniques to locate mobile devices. Each location determination technique may be available only with certain networks, in certain circumstances, or with certain equipment. Likewise, different location determination techniques may each provide differing levels of accuracy and/or precision. However, there are situations, such as during emergencies, where obtaining relatively accurate and precise location determinations is important.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] Figure 1 is a diagram of a suitable environment for practicing aspects of the invention.

[0004] Figure 2 is a block diagram of a suitable communications system for practicing aspects of the invention.

[0005] Figure 3 is a logical flow diagram of a process for determining the location of a mobile device.

[0006] Figure 4 is a logical flow diagram of a process for implementing a micronetwork-based location determination technique.

[0007] Figure 5 is a control flow diagram illustrating the transfer of information between system components when an emergency services communication is initiated from a mobile device.

DETAILED DESCRIPTION

[0008] A software and/or hardware facility for determining the location of a mobile device is disclosed. The facility is employed to determine the location of the mobile device when a location determination of a desired accuracy is desired. If available, the facility determines the location of the mobile device using a device-based technique or using a location determination technique that is accessible over a macronetwork. Macronetworks are networks that are designed to cover relatively large areas such as cities, metropolitan areas, regional areas, multi-state areas, and/or the like. Protocols and standards such as GSM, TDMA, UMTS, EVDO, LTE, CDMA, OFDM, GPRS, EDGE, AMPS, WiMAX, UMB, and/or the like are generally employed with macronetworks. If a location determination technique of desired accuracy is not available on the device or over a macronetwork, the facility attempts to use a location determination technique that is accessible over a micronetwork to determine the location of the mobile device. Micronetworks are networks that are designed to cover smaller areas such as neighborhoods, parks, cities, buildings, homes, and/or the like. Protocols and standards such as WiFi, GAN, UMA, Wireless Universal Serial Bus (WUSB), ZigBee, and/or the like are generally employed with micronetworks. By forcing a switch from a macronetwork-based location determination technique to a micronetwork-based location determination technique, the facility thereby ensures that a location determination of a desired accuracy is made for the mobile device.

[0009] The facility's use of a micronetwork-based location determination technique may include enabling a micronetwork interface of the mobile device, communicating with micronetworks near the mobile device, obtaining a micronetwork identifier, and determining the location of the mobile device according to the micronetwork identifier. Suitable examples of determining the location of a mobile

device according to micronetwork identifiers are described in International Patent Application PCT/US2007/066579, entitled "Mobile Computing Device Geographical Location Determination," which was filed on April 12, 2007; International Patent Application PCT/US2006/041226, entitled "System and Method for Determining Device Location in an IP-Based Wireless Telecommunications Network," which was filed on October 20, 2006; International Patent Application PCT/US2007/082136, entitled "System and Method for Utilizing IP-Based Wireless Telecommunications Client Location Data," which was filed on October 22, 2006; and International Patent Application PCT/US2007/082133, entitled "Two Stage Mobile Device Geographical Location Determination," which was filed on October 22, 2006; all of which are hereby incorporated by reference in their entirety.

[0010] The facility may be employed during emergency situations to locate a mobile device. As one example, a Public Safety Answering Point (PSAP) may utilize the facility in response to an emergency services communication (e.g., a 911 call, emergency text message, distress broadcast, etc.) that is received from a mobile device. The facility determines whether a Time Difference on Arrival (TDOA) procedure (including Uplink-TDOA (U-TDOA), Observed TDOA (OTDOA), Ideal Period Downlink-OTDOA (IPDL-OTDOA), or other TDOA procedure), a Global Positioning System (GPS) procedure, an Assisted GPS (AGPS) procedure, or a Round Trip Time (RTT) procedure is available to determine the location of the mobile device. If either of the TDOA, GPS, AGPS, or RTT procedure is available, the TDOA, GPS, AGPS, or RTT procedure is employed and the geographic location of the mobile device is reported to the PSAP. If, however, neither the TDOA, GPS, AGPS, nor the RTT procedure is available, the facility causes the mobile device to attempt to communicate with nearby micronetworks. If micronetworks are detected nearby, the mobile device or the detected micronetworks may provide a micronetwork identifier to a Mobile Switching Center (MSC), Unlicensed Network Controller (UNC), or Secure User Plane Location (SUPL) system to facilitate a look-up of a geographic location associated with the micronetwork. The MSC, UNC, or SUPL system then provides the geographic location of the micronetwork to the PSAP as an indication of the location of the mobile device. Optionally, the emergency services communication from the mobile device may be handed off from the macronetwork to the micronetwork.

[0011] The following description provides specific details for a thorough understanding of, and enabling description for, various examples of the technology. One skilled in the art will understand that the technology may be practiced without many of these details. In some instances, well-known structures and functions have not been shown or described in detail to avoid unnecessarily obscuring the description of the examples of the technology. It is intended that the terminology used in the description presented below be interpreted in its broadest reasonable manner, even though it is being used in conjunction with a detailed description of certain examples of the technology. Although certain terms may be emphasized below, any terminology intended to be interpreted in any restricted manner will be overtly and specifically defined as such in this Detailed Description section.

Illustrative Environments

[0012] Figure 1 illustrates an environment 100 in which the facility may be practiced. Environment 100 includes mobile devices 110, 112, and 114 and wireless networks 120, 122, 130, 132, and 134. Mobile devices 110, 112, and 114 are configured to wirelessly communicate with, or through, one or more of networks 120, 122, 130, 132, and 134.

[0013] Mobile devices 110, 112, and 114 may include virtually any devices for communicating over a wireless network. Such devices include cellular telephones, Global System for Mobile Communications (GSM) telephones, Time Division Multiple Access (TDMA) telephones, Universal Mobile Telecommunications System (UMTS) telephones, Evolution-Data Optimized (EVDO) telephones, Long Term Evolution (LTE) telephones, Secure User Plane Location (SUPL) Enabled Terminals (SETs), Generic Access Network (GAN) telephones, Unlicensed Mobile Access (UMA) telephones, Voice over Internet Protocol (VoIP) devices, other mobile telephones, Personal Digital Assistants (PDAs), radio frequency (RF) devices, infrared (IR) devices, handheld computers, laptop computers, wearable computers, tablet computers, pagers, integrated devices combining one or more of the preceding devices, and/or the like. As such, mobile devices 110, 112, and 114 may range widely in terms of capabilities and features. For example, a mobile telephone may have a numeric keypad and the capability to display only a few lines of text.

However, other mobile devices (e.g., smart phones) may have a touch-sensitive screen, a stylus, and a relatively high-resolution display.

[0014] Users may employ mobile devices 110, 112, and 114 to communicate with other users or devices. In addition, users may employ mobile devices 110, 112, and 114 to receive, provide, or otherwise interact with location-based services such as E911 services, asset tracking or recovery services, location-based alerts or advertising services, social networking services such as identification of nearby friends and family, and/or the like. Location-based services may be initiated via network devices or via the mobile device.

[0015] Mobile devices 110, 112, and 114 typically include a processing unit, volatile memory and/or nonvolatile memory, a power supply, one or more network interfaces, an audio interface, a display, a keypad or keyboard, a GPS receiver and/or other location determination component, and other input and/or output interfaces (not shown). The various components of mobile devices 110, 112, and 114 may be interconnected via a bus. The volatile and nonvolatile memories generally include storage media for storing information such as processor-readable instructions, data structures, program modules, or other data. Some examples of information that may be stored include basic input/output systems (BIOS), operating systems, and applications. In addition, the memories may be employed to store operational data, content, contexts, and/or the like. The memories may also store one or more applications configured to receive and/or provide messages from and/or to another device or component. These messages may also be displayed and/or stored on mobile device 110, 112, or 114. Such messages may include short message service (SMS) messages, multi-media message service (MMS) messages, instant messaging (IM) messages, enhanced message service (EMS) messages, and/or any other content directed towards a user of mobile device 110, 112, or 114. Likewise, the memories may also store one or more applications configured to receive and/or provide information to location-based services or to facilitate performance of location determination techniques. These memories may also store applications for performing location determination techniques.

[0016] Networks 120, 122, 130, 132, and 134 may include virtually any networks for facilitating communications to or from mobile devices 110, 112, and 114

using any wireless protocol or standard. These protocols or standards include GSM, TDMA, UMTS, EVDO, LTE, GAN, UMA, Code Division Multiple Access (CDMA), Orthogonal Frequency Division Multiple Access (OFDM), General Packet Radio Service (GPRS), Enhanced Data GSM Environment (EDGE), Advanced Mobile Phone System (AMPS), Worldwide Interoperability for Microwave Access (WiMAX), Wireless Fidelity (WiFi), Ultra Mobile Broadband (UMB), VoIP, SUPL, IP Multimedia Subsystem (IMS), and/or the like. Networks 120, 122, 130, 132, and 134 may be operated by a mobile telephony service provider, an Internet service provider, businesses, individuals, or other network operators.

[0017] In Figure 1, networks 120 and 122 are illustrated as macronetworks, which are networks designed to cover relatively large areas such as cities, metropolitan areas, regional areas, multi-state areas, and/or the like. Protocols and standards such as GSM, TDMA, UMTS, EVDO, LTE, CDMA, OFDM, GPRS, EDGE, AMPS, WiMAX, UMB, and/or the like are generally employed with macronetworks. Further, networks 130, 132, and 134 are illustrated as micronetworks, which are networks designed to cover smaller areas such as neighborhoods, parks, cities, buildings, homes, and/or the like. To provide an example, protocols and standards such as WiFi, GAN, UMA, Wireless Universal Serial Bus (WUSB), ZigBee, and/or the like are generally employed with micronetworks.

[0018] At any given location, one or more of networks 120, 122, 130, 132, and 134 may provide overlapping coverage areas. For example, at a particular geographical location, a mobile device may be within range of a UMA network, a GSM network, a UMTS network, and an EVDO network. At another geographical location, the mobile device may be within range of the same or a different set of networks.

[0019] At times, a user of a mobile device or a party providing services to a mobile device may want to determine the location of the mobile device with relatively high accuracy. Traditionally, relatively high accuracy location determinations are performed according to a standalone GPS procedure, or macronetwork-based TDOA, GPS, AGPS, or RTT procedures. In situations where none of these procedures are readily available, however, the facility described herein attempts to

determine the location of the mobile device based on micronetworks within communications range of the mobile device.

Illustrative Communications System

[0020] Figure 2 illustrates a communications system 200, in which the facility may operate. Communications system 200 includes a base station (BTS) 240, a Node-B 241, a Base Station Controller (BSC) 242, a Radio Network Controller (RNC) 243, eNode-Bs 244, an access point 230, an Unlicensed Network Controller (UNC) 245, Serving Mobile Location Centers (SMLC)/Standalone Assisted GPS SMLCs (SAS) 250, a Mobility Management Entity (MME) 260, an IP Multimedia Subsystem (IMS) 261, a Secure User Plane Location (SUPL) system 264, a switch 270, a Gateway Mobile Location Center (GMLC) 272, an Automatic Location Identification Database (ALI DB) server 274, and a Location-Based Service (LBS) application server 276. While communications system 200 is illustrated and described in terms of GSM/GPRS/UMTS/LTE/UMA network components and architecture, the facility is not limited to such technologies. Any suitable communications system may employ all or part of the facility described herein.

[0021] In an example of a GSM/GPRS/EDGE/UMTS communications system, BTS 240 and Node-B 241 are configured to provide a low-level radio interface to mobile devices under the control of BSC 242 and RNC 243. For example, BTS 240 may provide low-level GSM radio interfacing while Node-B 241 provides low-level GPRS and/or UMTS radio interfacing. In such an example, BTS 240 and Node-B 241 include limited command and control functionality or no command and control functionality. Instead, BSC 242 and/or RNC 243 provide such functionality while BTS 240 and Node-B 241 provide physical layer interfaces to associated mobile devices. BTSs and Node-Bs may be positioned at distributed locations to provide network coverage throughout a geographical area.

[0022] BSC 242 is coupled between switch 270 and BTS 240 to provide a voice interface to, and control certain operational aspects of, BTS 240. For example, BSC 242 may be configured to control handoffs, network registration for mobile devices, channel allocation, radio transmitter output power, and/or the like. BSC 242 may be employed to control any number of BTSs.

[0023] Similarly, RNC 243 is coupled between switch 270 and Node-B 241 to provide a data interface to, and control certain operational aspects of, Node-B 241. Also, RNC 243 may be employed to control any number of Node-Bs. As one example, RNC 243 is employed in a UMTS system.

[0024] One instance of eNode-B 244 is coupled to switch 270 to interface mobile devices directly to switch 270. As one example, this instance of eNode-B 244 is employed as a consolidated LTE counterpart of BTS 240, Node-B 241, BSC 242, and RNC 243. A second instance of eNode-B 244 may be employed in an IMS/SUPL communications system and be configured to provide radio access network (RAN) functionality in order to interface mobile devices to MME 260, as discussed below.

[0025] BTS 240, Node-B 241, eNode-Bs 244, or virtually any other components or devices positioned at distributed locations to provide wireless network coverage throughout a geographical area may be referred to as a cell site. In certain instances, cell sites may also include other components such as BSCs, RNCs, SMLC/SASs, switches, MMEs, and/or the like.

[0026] An access point 230 may also serve to route communications between mobile devices and other network components (e.g., UNC 245) over an IP-based network. An access point typically provides coverage for a relatively small area, such as for a femtocell within a building (e.g., home, office, shopping mall, train station, or the like) or within an aircraft, ship, train, or other vehicle. Access point 230 may take the form of a WiFi access point, a HotSpot component, a wireless router, a wireless access point, and/or the like. One or more access points may be coupled to UNC 245 or another network component.

[0027] Access point 230 is included, for example, in IP-based network implementations of communications system 200. Such IP-based network implementations may take the form of a VoIP broadcast architecture, UMA or GAN broadcast architecture, femtocell broadcast architecture, and/or the like. As used herein, VoIP is a telecommunication system for the transmission of voice over the Internet or other packet-switched networks, and UMA is a commercial name of the 3rd Generation Partnership Project (3GPP) GAN standard. Somewhat like VoIP,

UMA/GAN is a telecommunication system that extends services, voice, data, and IP Multimedia Subsystem/Session Initiation Protocol (IMS/SIP) applications over IP-based networks. For example, a common application of UMA/GAN is in a dual-mode handset service in which mobile device users can roam and handoff between local area networks and wide area networks using a GSM/WiFi dual-mode mobile phone. UMA/GAN enables the convergence of mobile, fixed, and Internet telephony, which is sometimes called Fixed Mobile Convergence.

[0028] Picocell access points may also be referred to as cell sites. Picocell access points typically cover a relatively small area, such as an area within a building (e.g., home, office, shopping mall, train station, or the like), a vehicle (e.g., within an aircraft, ship, train, or the like), or other location. A picocell access point is analogous to a WiFi access point, except that the picocell access point communicates with mobile devices over the licensed spectrum of an associated wireless carrier. A picocell access point serves as an access point for routing communication between mobile devices and other network components, e.g., BSC 242 or UNC 245, over IP-based networks, dedicated connections (e.g., T1 connections, OC3 connections, etc.), frame relay connections, microwave connections, and/or the like.

[0029] UNC 245 is coupled between switch 270 and one or more access points to interface the access points to switch 270. As one example, UNC 245 may be a UMA/GAN counterpart of RNC 243. In addition, a Generic Access Network Controller (GANC) may be suitably employed as UNC 245.

[0030] As shown, each of BTS 240, Node-B 241, BSC 242, RNC 243, and an instance of eNode-B 244 are coupled to instances of Serving Mobile Location Centers (SMLC) and/or Standalone Assisted GPS SMLCs (SAS) 250. Suitable SMLCs are configured to provide and/or coordinate location determination or estimation. In addition, suitable SASs may additionally include AGPS equipment and be configured to provide AGPS location determination or estimation. As one example, SMLC/SAS 250 may also be configured to select and/or employ location determination techniques.

[0031] In addition, MME 260 is coupled between an IMS/SUPL instance of eNode-B 244 and SUPL system 264. MME 260 functions as a node in an LTE/IMS/SUPL communications system to provide core network control and/or other functionality. MME 260 may be a MME as described by the System Architecture Evolution (SAE) standards available from the 3rd Generation Partnership Project (3GPP), such as by TS 23.401.

[0032] An IMS 261 is coupled between MME 260 and SUPL system 264 and interacts with other network components to provide IP services to a mobile device. As illustrated, IMS 261 includes Call Session Control Function (CSCF) 262 and Home Subscriber Server (HSS) 263. IMS 261, CSCF 262, and HSS 263 may respectively be an IMS, CSCF, and HSS as described by the IMS specifications of the 3GPP, 3rd Generation Partnership Project 2 (3GPP2), Telecoms and Internet Converged Services and Protocols for Advanced Networks (TISPAN), or other standards organizations.

[0033] SUPL system 264 is coupled between IMS 261 and LBS application server 276 and is configured to select, employ, and/or facilitate location determination techniques and/or location-based services. As illustrated, SUPL system 264 includes SUPL Location Center (SLC) 265 and SUPL Positioning Center (SPC) 266. Each of SUPL system 264, SLC 265, and SPC 266 may be as described by the SUPL standards available from the Open Mobile Alliance (OMA).

[0034] Switch 270 is configured to provide voice and data interfaces, as appropriate, to BSC 242, RNC 243, eNode-B 244, and UNC 245. Switch 270 may be configured to switch voice traffic from one or more base station controllers to a Public Switched Telephone Network (PTSN) or to a telephone switch such as a 5ESS switch, a PBX switch, and/or the like. Likewise, switch 270 may be further configured to switch data from one or more RNCs to a data network, to a router, to another switch, and/or the like. Also, switch 270 may include a Mobile Switching Center (MSC), a media gateway, a call gateway, and/or the like.

[0035] Switch 270 is also coupled to GMLC 272, which is coupled to ALI DB server 274 and LBS application server 276. Switch 270 and or GMLC 272 may be configured to select, employ, and/or facilitate location determination techniques

and/or location-based services. LBS application server 276 may communicate with ALI DB server 274 and/or GMLC 272 to receive location determination information or to perform a location determination.

[0036] In one example, LBS application server 276 is configured as, or to provide location information to, a PSAP, e.g., as part of an E911 service. However, LBS application server 276 may also be configured to provide location information to any other entity or for any other purpose. For example, LBS application server 276 may be configured to provide location information to mobile device users, network operators, third party location-based service providers, remote telemetry users, advertisers, and/or the like. Likewise, LBS application server 276 may instead be an LBS client such as a PSAP, LBS application, user device, and/or the like.

[0037] While Figures 1 and 2 illustrate specific examples of suitable environments and communications systems in which the facility may operate, various modifications such as the inclusion of additional components, consolidation and/or deletion of various components, and shifting of functionality from one component to another may be made without deviating from the invention.

Illustrative Logical Flow Diagrams

[0038] Figure 3 is a logical flow diagram of process 300 that is implemented by the facility for determining the location of a mobile device. Figure 4 is a logical flow diagram of process 400 that is used by the facility to implement a micronetwork-based location determination technique. For clarity, processes 300 and 400 are described below as being performed by SUPL system 264 of Figure 2. For example, processes 300 and 400 may be performed wholly or partially by SLC 265 and/or SPC 266 of SUPL system 264. However, processes 300 and 400 may also be, for example, performed on mobile devices 110, 112, or 114, SMLC/SAS 250, Node-B 241, switch 270, LBS application server 276, and/or on or by other processors, other components, or other systems, whether or not such processors, components, or systems are described herein. Further, instructions causing processes 300 and 400 to be executed may be stored in nonvolatile memory.

[0039] Flowing from a start block, processing starts at step 310 where SUPL system 264 detects a location determination request. For example, a location

determination request may be detected by SUPL system 264 in response to a message from eNode-B 244 or MME 260 representing initiation of an emergency services communication from mobile device 110. From step 310, processing flows to decision block 320.

[0040] At decision block 320, SUPL system 264 determines whether a device or macronetwork-based location determination technique having a desired accuracy is available. In general, the SUPL system makes this determination by assessing whether the mobile device and at least one macronetwork with which mobile device 110 is currently associated are capable of employing or facilitating a location determination technique expected to provide the desired accuracy. As one example, a device or macronetwork-based location determination technique is available if mobile device 110 is capable of performing a GPS location determination having a desired accuracy. As another example, a device or macronetwork-based location determination technique is available if mobile device 110 and a macronetwork with which it is associated are capable of performing a TDOA, GPS, AGPS, or RTT location determination having the desired accuracy, time to fix (TTF), and/or yield (e.g., expected or actual percentage of successful and/or valid location determinations). The desired accuracy, TTF, and/or yield may depend on the particular application that requires the location determination. In certain emergency applications, for example, the desired accuracy is achieved when an implemented location determination technique is expected to determine the location of the mobile device within no more than 20 meters of the actual location of the mobile device. Also, the desired accuracy, TTF, and/or yield may be configured by a network operator, by the PSAP, or by other parties. Also, the desired accuracy, TTF, and/or yield may be inferentially defined by manually selecting or configuring device and/or macronetwork based location determination techniques expected to provide the desired levels.

[0041] If a device or macronetwork-based location determination technique having the desired accuracy, TTF, and/or yield is determined to be available by the SUPL system, processing flows to step 330 where the device or macronetwork-based location determination technique is implemented and/or employed to determine the location of mobile device 110. For example, the location of mobile device 110 may be determined by implementing a TDOA, GPS, AGPS, RTT, or

other device or macronetwork-based location determination technique. From step 330, processing flows to step 350.

[0042] At step 350, the location of mobile device 110 is provided to the requesting party, such as to a PSAP (e.g., to enable the dispatch of emergency response) or to a user of mobile device 110. The location of mobile device 110 may alternatively, or additionally, be provided to another party, device, entity, or component. For example, the location of mobile device 110 may be provided to another location-based service, to a remote party, to a network operator, and/or the like. From step 350, processing ends or returns to other actions.

[0043] Returning to decision block 320, if the SUPL system determines that a device or macronetwork-based location determination technique having a desired accuracy, TTF, and/or yield is not available, processing flows to step 340 where the SUPL system causes a micronetwork-based location determination technique to be implemented. A representative micronetwork-based location determination technique is described in process 400 of Figure 4.

[0044] At step 410 of Figure 4, SUPL system 264, via IMS 261, MME 260, and eNode-B 244, may instruct mobile device 110 to enable a micronetwork interface. Alternatively, e.g., if the processing reflected by decision block 320 is performed on mobile device 110, the mobile device may independently enable the micronetwork interface. Also, the enabling of the mobile device's micronetwork interface may be forced from a network component, may occur automatically without prompting or receiving input from a user of the mobile device, or may require prompting and receiving confirmation from a user of mobile device before proceeding. Such selective enabling of the mobile device's micronetwork interface may reduce power consumption during non-emergency situations, while still providing the flexibility and/or benefits of micronetworks during emergency situations. From step 410, processing flows to step 420.

[0045] At step 420, mobile device 110 communicates with, or attempts to communicate with, in-range micronetworks. For example, mobile device 110 may scan and/or search for micronetworks that are geographically near the mobile device and/or for micronetworks that are within range of the current location of the mobile

device. Step 420 may be initiated by the mobile device in response to a command from SUPL system 264, switch 270, BTS 240, and/or other network component.

[0046] Step 420 may also or alternatively include broadcasting and/or otherwise transmitting a distress message from mobile device 110 to one or more micronetwork access points, attempting a handoff and/or registration with a micronetwork access point, and/or the like. For example, by broadcasting a distress message, mobile device 110 may enable its location to be determined even if it is unable to establish two-way communications with a micronetwork (e.g., if the micronetwork signal is weak, interference is present, the micronetwork employs access control or encryption, etc.).

[0047] Processing then flows to step 430 where SUPL system 264 and/or another network component (e.g., UNC 245 and/or switch 270) obtains a micronetwork identifier of a micronetwork near mobile device 110. The micronetwork identifier may include an Internet Protocol (IP) address, a Media Access Control (MAC) address, a Service Set Identifier (SSID), an International Mobile Subscriber Identity (IMSI), an International Mobile Equipment Identity (IMEI), a serial number, a machine name (e.g., fully qualified domain name, hostname, domain name, etc.), and/or the like. As one example, the micronetwork identifier is provided to SUPL system 264 and/or the other network component from mobile device 110 via the micronetwork and via the Internet. As another example, the micronetwork identifier may be communicated to SUPL system 264 and/or the other network component from the micronetwork access point with which mobile device 110 communicated, from UNC 245, or from the other micronetwork or macronetwork component. The micronetwork identifier may be communicated to SUPL system 264 and/or the other network component through any suitable communications channel including through the macronetwork, the micronetwork, the Internet, and/or the like.

[0048] From step 430, processing flows to step 440 where SUPL system 264 and/or the other network component looks up a geographical location associated with the received micronetwork identifier. For example, the geographical location associated with the micronetwork identifier may be looked up as described in International Patent Application PCT/US2007/066579, entitled "Mobile Computing Device Geographical Location Determination," which was filed on April 12, 2007; International Patent Application PCT/US2006/041226, entitled "System and Method

for Determining Device Location in an IP-Based Wireless Telecommunications Network," which was filed on October 20, 2006; International Patent Application PCT/US2007/082136, entitled "System and Method for Utilizing IP-Based Wireless Telecommunications Client Location Data," which was filed on October 22, 2006; and International Patent Application PCT/US2007/082133, entitled "Two Stage Mobile Device Geographical Location Determination," which was filed on October 22, 2006. The geographical location may be defined by a latitude, longitude, altitude, address, and/or the like. As one example, the geographical location is an address at which a micronetwork access point is installed.

[0049] Returning to Figure 3, following the implementation of a location determination technique by either a micronetwork-based location determination technique, processing continues to step 350 where the location of mobile device 110 is indicated to the requesting party, such as to a PSAP (e.g., to enable the dispatch of emergency response), to a user of mobile device 110, or to another party, device, entity, or component.

[0050] By employing process 300, the facility may enable accurate and/or reliable location determination in situations in which less accurate location determinations would otherwise have been employed. For example, during emergencies, process 300 may enable faster dispatch of emergency service personnel, less time before emergency service personnel are on-site, and/or the like.

Illustrative Control Flow Diagrams

[0051] Figure 5 is a control flow diagram illustrating the transfer of information between system components when an emergency services communication is initiated from mobile device 110 and no device or macronetwork-based location determination technique is available to determine the location of the mobile device. Although Figure 5 is described with reference to a mobile-device-initiated emergency services communication, aspects of the described technology may also be employed with other mobile device communications. For clarity, Figure 5 is described as involving specific communications between specific mobile devices and network components, and Figure 5 is illustrated and described in terms of GSM/UMTS/UMA network components and architecture. However, the technology is not limited to the

described example. The control flow is described below with reference to processing steps 505-585.

[0052] Step 505: An emergency services communication and/or location determination request is initiated from mobile device 110 to switch 270. The emergency services communication and/or location request may be routed to switch 270 via, for example, BTS 240, BSC 242, eNode-B 244, and/or the like.

[0053] Step 510: Switch 270 sends a Mobile Application Protocol (MAP) Subscriber Location Response (SLR) message to GMLC 272. The MAP SLR message may include a request for an Emergency Services Return Key (ESRK).

[0054] Step 515: GMLC 272 sends a MAP SLR response to switch 270. The MAP SLR response may include an ESRK, e.g., if an ESRK was requested in step 510.

[0055] Step 520: Switch 270 routes the emergency services communication to PSAP 276 such that mobile device 110 and PSAP 276 can initiate the emergency services communication. In this example, LBS application server 276 of Figure 2 is a PSAP.

[0056] Step 525: PSAP 276 may send a re-bid or Auto Location Identification (ALI) request to an Emergency Services Messaging Entity (ESME) 590, e.g., to indicate that PSAP 276 is awaiting the location of mobile device 110 and/or a more accurate location of mobile device 110.

[0057] Step 530: GMLC 272 sends a MAP Provide Subscriber Location (PSL) message to switch 270. For example, the MAP PSL message may be sent to indicate that GMLC 272 is requesting a more accurate determination of mobile device 110's location.

[0058] Step 535: Switch 270 sends a Platform Location Request (PLRQ) message to BTS 240. For example, the PLRQ message may represent a request to determine whether a device or macronetwork-based location determination technique is available that meets a desired level of accuracy to determine the location of mobile device 110.

[0059] Step 540: BTS 240 (or alternately Node-B eNode-B, etc.) sends a Platform Location Response (PLRS) message to switch 270. In this example, the

PLRS message is a failure message indicating that no device or macronetwork-based location determination technique is available to determine the location of the mobile device. Such a failure message may be generated if the available device or macronetwork techniques do not meet a desired level of accuracy, TTF, and/or yield, if the location of mobile device 110 is not available, or if the location is not accurate for other reasons such as a lack of network or mobile device resources, an error or startup condition, insufficient data, and/or the like.

[0060] Step 545: Switch 270 transmits a Handoff (HO) or other command to mobile device 110 to cause the device to initiate a micronetwork-based location determination technique. For example, switch 270 may transmit a command for mobile device 110 to enable a micronetwork interface and/or to search for nearby micronetworks.

[0061] Step 550: After locating an available micronetwork, mobile device 110 transmits a HO access message to UNC 245.

[0062] Step 555: UNC 245 (such as a GANC) sends a Traffic Channel Assignment (TCA) message to mobile device 110 to indicate a traffic channel assignment for continuing the emergency services communications via the micronetwork.

[0063] Step 560: Mobile device 110 sends a HO complete message to UNC 245.

[0064] Step 565: Mobile device 110 transmits a registration message to UNC 245. At this point, the emergency services communications have been handed off from the macronetwork to the micronetwork. While steps 545, 550, 555, 560, and 565 represent a process whereby an emergency services communication is automatically handed off from a macronetwork to a micronetwork as a forced handoff, in other examples the emergency services communications may continue over the macronetwork after mobile device 110 has communicated with a micronetwork access point. For example, mobile device 110 may transmit or broadcast a distress message to one or more micronetwork access points in order to allow the location of the mobile device to be determined based on the access point identifier. During and after transmission of the distress message, however, the

mobile device may continue with the primary communication session established with emergency services over the macronetwork.

[0065] Step 570: UNC 245 determines the location of mobile device 110 utilizing information associated with the micronetwork. For example, step 570 may include steps 430 and 440 of Figure 4 and may be based on information included in the registration message of step 565. However, step 570 may also include other techniques for determining the location of a mobile device according to a micronetwork; e.g., using any of the techniques in the references that are incorporated by reference herein.

[0066] Step 575: UNC 245 sends a PLRS message to switch 270. In this instance, the PLRS message includes the geographical location of mobile device 110 as determined by UNC 245 at step 570.

[0067] Step 580: Switch 270 transmits a MAP PSL response to GMLC 272.

[0068] Step 585: GMLC 272 sends a response message including the geographical location to PSAP 276. PSAP 276 may then forward the geographical location to another component or entity and/or employ the geographical location to dispatch emergency services or provide other location-based services.

Conclusion

[0069] Unless the context clearly requires otherwise, throughout the description and the claims, the words "comprise," "having," "include," and the like, and conjugates thereof, are to be construed in an inclusive sense, as opposed to an exclusive or exhaustive sense; that is to say, in the sense of "including, but not limited to." As used herein, the term "connected," "coupled," or any variant thereof means any connection or coupling, either direct or indirect, between two or more elements; the coupling or connection between the elements can be physical, logical, or a combination thereof. Additionally, the words "herein," "above," "below," and words of similar import, when used in this application, shall refer to this application as a whole and not to any particular portions of this application. Where the context permits, words in the above Detailed Description that are singular or plural may also be deemed to include plural or singular forms, respectively. The word "or," in reference to a list of two or more items, covers all of the following interpretations of the word: any of the items in the list, all of the items in the list, and any combination

of the items in the list. The terms "based on," "according to," and the like are not exclusive and are equivalent to the term "based, at least in part, on," "at least according to," or the like and include being based on, or in accordance with, additional factors, whether or not the additional factors are described herein.

[0070] The above Detailed Description of embodiments of the system is not intended to be exhaustive or to limit the system to the precise form disclosed above. While specific embodiments of, and examples for, the system are described above for illustrative purposes, various equivalent modifications are possible within the scope of the system, as those skilled in the relevant art will recognize. For example, while processes or steps are presented in a given order, alternative embodiments may perform routines having steps, or employ systems having steps, in a different order, and some processes or steps may be deleted, moved, added, subdivided, combined, and/or modified to provide alternative or subcombinations. Each of these processes or steps may be implemented in a variety of different ways. Also, while processes or steps are at times shown as being performed in series, these processes or steps may instead be performed in parallel, or may be performed at different times.

[0071] Any patents and applications and other references noted above, including any that may be listed in accompanying filing papers, are incorporated herein by reference. While certain aspects of the invention are presented below in certain claim forms, the applicant contemplates the various aspects of the invention in any number of claim forms. For example, while only one aspect of the invention is recited as a means-plus-function claim under 35 U.S.C. § 112, ¶ 6, other aspects may likewise be embodied as a means-plus-function claim, or in other forms, such as being embodied in a processor-readable medium. (Any claims intended to be treated under 35 U.S.C. § 112, ¶ 6 will begin with the words "means for." Use of the term "for" in any other context is not intended to invoke treatment under 35 U.S.C. § 112, ¶ 6.) Accordingly, the applicant reserves the right to add additional claims after filing the application to pursue such additional claim forms for other aspects of the invention.

CLAIMS

I claim:

1. A method, coordinated from a switch, for determining a location of a mobile device and providing the location to a Public Safety Answering Point (PSAP), the method comprising:

while engaging in an emergency services communication over a macronetwork, and while the mobile device is in range of one or more micronetworks, determining whether at least one macronetwork-based location determination technique from a set of macronetwork-based location determination techniques is available; and

if at least one macronetwork-based location determination technique of the set of macronetwork-based location determination technique is available,

determining the geographic location of the mobile device according to at least one of the available macronetwork-based location determination techniques; and

providing the determined geographic location as an indication of the location of the mobile device to a Public Safety Answering Point (PSAP),

otherwise, while continuing the emergency services communication over the macronetwork,

determining the location of the mobile device according to a micronetwork by:

receiving an identifier from at least one micronetwork; and

retrieving a geographic location based on the received identifier; and

providing the retrieved geographic location as an indication of the location of the mobile device to the Public Safety Answering Point (PSAP).

2. The method of claim 1, wherein the location determination techniques of the set include a Time Delay On Arrival (TDOA) technique, an Assisted Global Positioning System (AGPS) technique, and a Round Trip Time (RTT) technique.

3. The method of claim 1, wherein the micronetwork includes a Wireless Fidelity (WiFi) access point, and wherein the identifier includes at least one of an Internet Protocol (IP) address, a Media Access Control (MAC) address, a Service Set Identifier (SSID), an International Mobile Subscriber Identity (IMSI), an International Mobile Equipment Identity (IMEI), a serial number, or a machine name.

4. The method of claim 1, wherein retrieving the geographic location includes:

looking up a previously stored address that is correlated to the identifier.

5. The method of claim 1, wherein receiving the identifier includes:

receiving the identifier of the at least one micronetwork from the mobile device via the macronetwork or from a micronetwork component via the Internet.

6. A method for determining a location of a mobile device, comprising:

while the mobile device is associated with a macronetwork and is within communications range of at least one micronetwork, receiving a request to determine the location of the mobile device;

determining an availability of one or more location determination techniques associated with the macronetwork or with the mobile device, each of the location determination techniques having an expected accuracy associated therewith of at least a desired level; and

if at least one of the one or more location determination techniques is available, determining the location of the mobile device according to one of the one or more location determination techniques; and

otherwise, determining the location of the mobile device according to a micronetwork.

7. The method of claim 6, wherein determining the location of the mobile device according to the micronetwork includes:

enabling a micronetwork interface of the mobile device;

searching for micronetworks identifiable by the mobile device; and

determining the location of the mobile device according to a micronetwork identified by the mobile device.

8. The method of claim 6, wherein determining the location of the mobile device according to the micronetwork includes:

scanning for micronetworks identifiable from the mobile device;

finding a micronetwork identifiable from the mobile device, the micronetwork being a femtocell network having an access point with an identifier;

receiving the identifier at the mobile device;

providing the identifier from the mobile device to a network component to enable a lookup of a correlated geographical location; and

providing the geographical location as an indication of the location of the mobile device.

9. The method of claim 6, wherein determining the location of the mobile device according to the micronetwork includes:

receiving, at a femtocell access point, an emergency indication from a mobile device;

transmitting an identifier of the femtocell access point fr om the femtocell access point to a network component in response to the emergency indication; and

looking up a previously stored location that is associated with the identifier.

10. The method of claim 9, wherein the femtocell access point is a Wireless Fidelity (WiFi) access point, and wherein the identifier includes at least one of an Internet Protocol (IP) address, a Media Access Control (MAC) address, a Service Set Identifier (SSID), an International Mobile Subscriber Identity (IMSI), an International Mobile Equipment Identity (IMEI), a serial number, or a machine name.

11. The method of claim 9, wherein determining the location of the mobile device according to the micronetwork includes:

continuing a voice communication, over the macronetwork, between the mobile device and another party.

12. The method of claim 9, wherein determining the location of the mobile device according to the micronetwork further includes:

handing off a voice communication between the mobile device and another party from the macronetwork to the micronetwork.

13. The method of claim 6, wherein the request is received from a Public Safety Answering Point (PSAP) in response to an emergency communication from the mobile device, and wherein the method is coordinated from a Mobile Switching Center (MSC), or an Unlicensed Network Controller (UNC).

14. The method of claim 6, wherein the one or more location determination techniques include only a Time Delay On Arrival (TDOA) technique.

15. The method of claim 6, wherein the macronetwork is least one of a Global System for Mobile Communications (GSM) network, a Time Division Multiple Access (TDMA) network, a Code Division Multiple Access (CDMA) network, an Orthogonal Frequency Division Multiple Access (OFDM) network, a General Packet Radio Service (GPRS) network, an Enhanced Data GSM Environment (EDGE) network, an Advanced Mobile Phone System (AMPS) network, a Worldwide Interoperability for Microwave Access (WiMAX) network, a Universal Mobile Telecommunications System (UMTS) network, an Evolution-Data Optimized (EVDO) network, a Long Term Evolution (LTE) network, or an Ultra Mobile Broadband (UMB) network.

16. A system for locating a first mobile device and a second mobile device that are each connectable to a communications network, comprising:

a communications network component configured to (a) determine that one or more location determination techniques are available to locate the first

mobile device, (b) determine that the one or more location determination techniques are not available to locate the second mobile device, wherein each of the one or more location determination techniques has at least a desired level of expected accuracy associated therewith and is capable of being employed without communicating with any network with which a mobile device to be located is not already associated, (c) determine the location of the first mobile device according to one of the one or more location determination techniques, and (d) determine the location of the second mobile device according to a micronetwork that is within communications range of the second mobile device by forcing the second mobile device to communicate with the micronetwork.

17. The system of claim 16, wherein the communications network component is further configured to coordinate a handoff of a voice communication from a macronetwork to the micronetwork.

18. The system of claim 16, wherein each of the one or more location determination techniques is operable to determine the location of the first mobile device within approximately 20 meters of an actual location of the first mobile device.

19. The system of claim 16, wherein the one or more location determination techniques include a Time Delay On Arrival (TDOA) technique, an Assisted Global Positioning System (AGPS) technique, or a Round Trip Time (RTT) technique.

20. The system of claim 16, further comprising:
the first mobile device.

21. The system of claim 16, wherein the communications network component is an Unlicensed Network Controller (UNC) configured to locate the first

mobile device in response to an emergency services communication between the first device and a Public Safety Answering Point (PSAP).

22. The system of claim 16, wherein the communications network component is configured to determine the location of the second mobile device according to an identifier provided by an access point of the micronetwork.

23. The system of claim 16, wherein the communications network component is further configured to determine the location of the second mobile device according to at least one of an Internet Protocol (IP) address, a Media Access Control (MAC) address, a Service Set Identifier (SSID), an Int ernational Mobile Subscriber Identity (IMSI), an International Mobile Equipment Identity (IMEI), a serial number of an access point of the micronetwork, or a machine name.

24. The system of claim 16, wherein the communications network component is further configured to instruct the second mobile device to scan for micronetworks identifiable from the second mobile device and to provide an identifier of a micronetwork identified by the second mobile device to the communications network component.

25. The system of claim 16, wherein the micronetwork employs at least one of a Wireless Fidelity (WiFi) standard, a Generic Access Network (GAN) standard, an Unlicensed Mobile Access (UMA) standard, a Wireless Universal Serial Bus (WUSB) standard, a ZigBee standard, or a Bluetooth standard.

26. A processor-readable storage medium storing processor-readable instructions, which, when executed, cause a first device to perform a plurality of operations for determining the location of a mobile device that is associated with a macronetwork and that is within communications range of at least one micronetwork, including:

determining an availability of one or more location determination techniques having at least a desired level of expected accuracy associated therewith and that are capable of being employed without

communicating with any network with which the mobile device is not already associated; and

if at least one of the one or more location determination techniques is available, coordinating a location determination of the mobile device according to one of the one or more location determination techniques; and

otherwise, coordinating a location determination of the mobile device according to a micronetwork.

27. The processor-readable storage medium of claim 26, wherein coordinating the location determination of the mobile device according to the micronetwork includes:

instructing the mobile device to search for micronetworks identifiable from the mobile device;

receiving an identifier of a micronetwork identified by the mobile device; and

looking up a previously correlated geographical location of an access point of the identifiable micronetwork.

28. The processor-readable storage medium of claim 27, wherein the plurality of operations further includes:

providing a geographical location that was previously associated with the identifier as an indication of the location of the mobile device.

29. The processor-readable storage medium of claim 26, wherein the plurality of operations further includes:

handing off an emergency services communication from the macronetwork to the micronetwork.

30. The processor-readable storage medium of claim 26, wherein the one or more location determination techniques include a Time Delay On Arrival (TDOA) technique, an Assisted Global Positioning System (AGPS) technique, or a Round Trip Time (RTT) technique.

31. A processor-readable storage medium storing processor-readable instructions, which, when executed, cause a mobile device to perform a plurality of operations for determining the location of the mobile device, including:

determining an availability of one or more location determination techniques having at least a desired level of expected accuracy associated therewith and that are capable of being employed independent of any micronetwork; and

if none of the one or more location determination techniques are available:

scanning for micronetworks identifiable from the mobile device;

finding a micronetwork identifiable from the mobile device, the micronetwork having an access point with an identifier;

receiving the identifier at the mobile device; and

providing the identifier from the mobile device to a network component to enable a lookup of a correlated geographical location of the access point.

32. The processor-readable storage medium of claim 31, wherein the plurality of operations further include:

enabling a micronetwork interface of the mobile device.

33. The processor-readable storage medium of claim 31, wherein the processor-readable instructions are executed in association with an emergency services communication, and wherein the plurality of operations further include:

forcing a handoff of an emergency services voice communication to the micronetwork.

34. The processor-readable storage medium of claim 31, wherein the identifier includes at least one of an Internet Protocol (IP) address, a Media Access Control (MAC) address, a Service Set Identifier (SSID), an Int ernational Mobile Subscriber Identity (IMSI), an International Mobile Equipment Identity (IMEI), a serial number of a Wireless Fidelity (WiFi) access point, or a machine name.

35. A system for locating a mobile device that is involved in an emergency services communication with a Public Safety Answering Point (PSAP), comprising:

means for determining an availability of one or more location determination techniques having at least a desired level of expected accuracy associated therewith and that are capable of being employed without communicating with any network with which the mobile device is not already associated;

means for coordinating a location determination of the mobile device according to one of the one or more location determination techniques if at least one of the one or more location determination techniques is available; and

means for coordinating a location determination of the mobile device according to a micronetwork if none of the one or more location determination techniques are available.

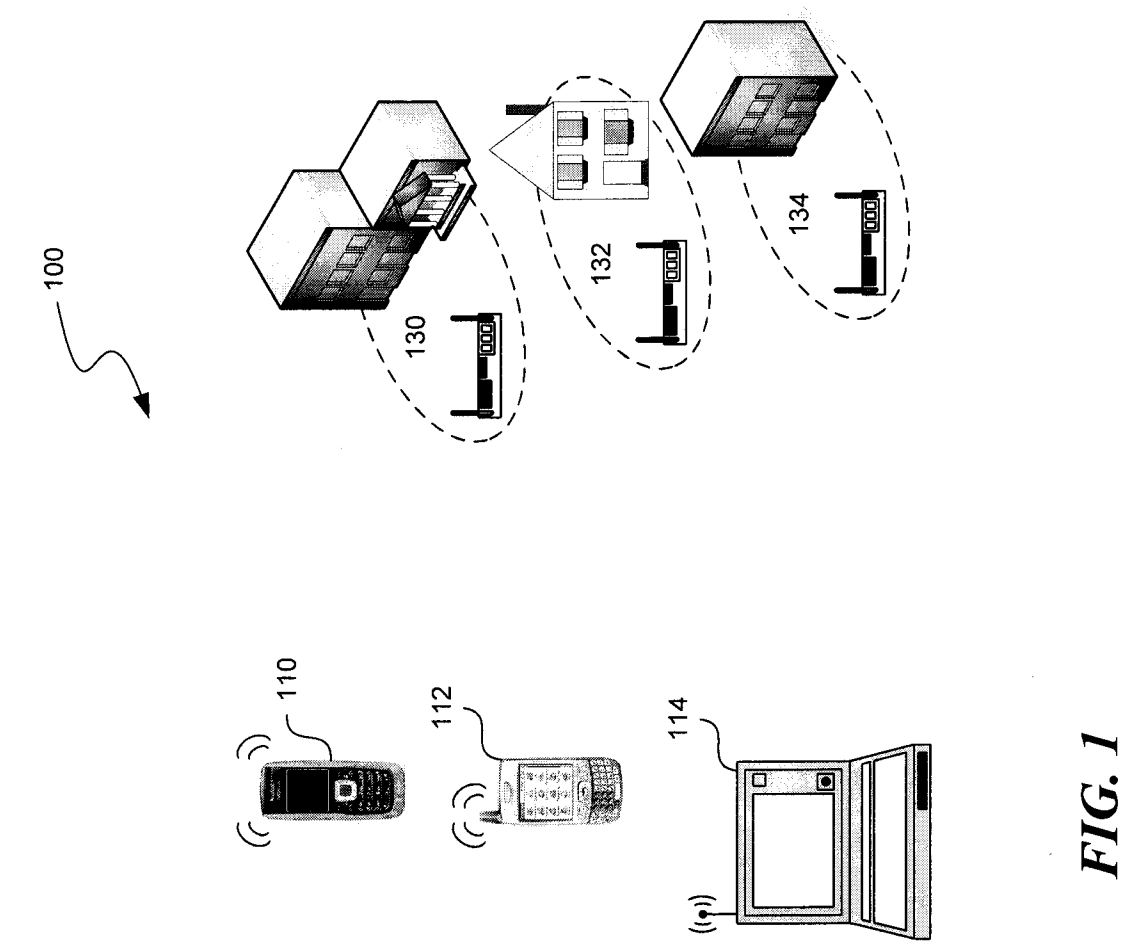


FIG. 1

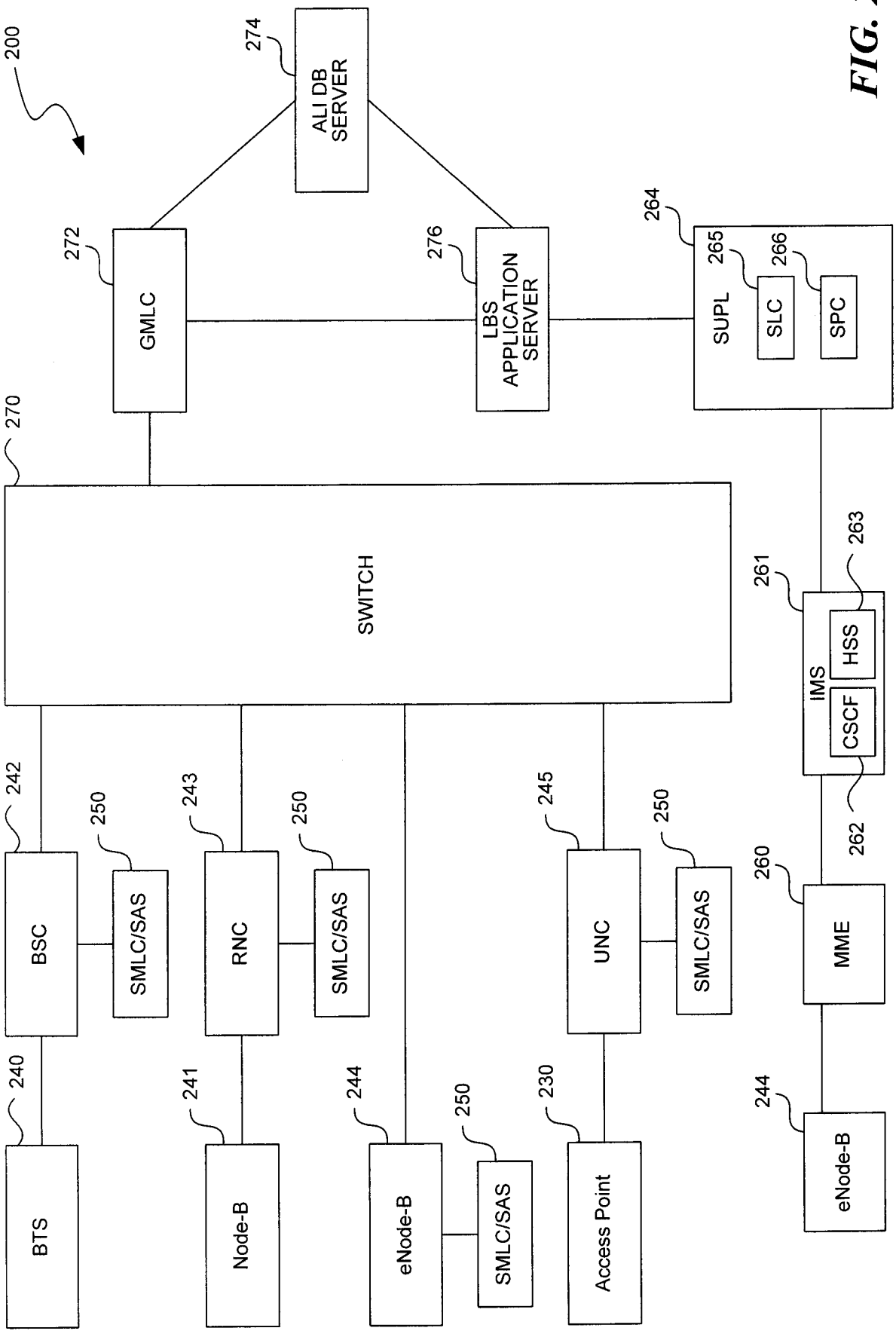

200
274
ALI DB SERVER
272
GMLC
276
LBS APPLICATION SERVER
264
SUPL
265
SLC
266
SPC
270
SWITCH
261
263
IMS
HSS
CSCF
262
260
MME
242
250
BSC
SMLC/SAS
243
250
RNC
SMLC/SAS
245
250
UNC
SMLC/SAS
240
BTS
241
Node-B
244
250
eNode-B
SMLC/SAS
230
Access Point
244
eNode-B

FIG. 2

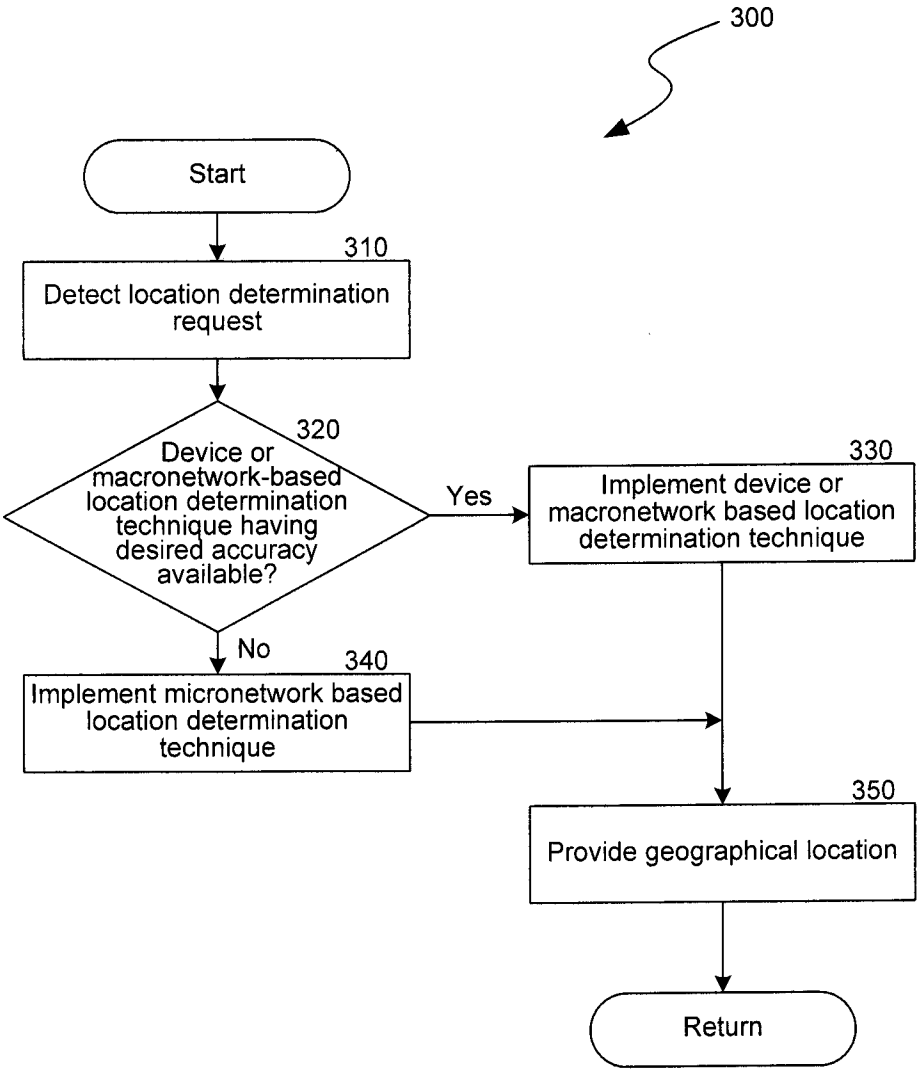

300
Start
310
Detect location determination request
320
Device or macronetwork-based location determination technique having desired accuracy available?
Yes
330
Implement device or macronetwork based location determination technique
No
340
Implement micronetwork based location determination technique
350
Provide geographical location
Return

FIG. 3

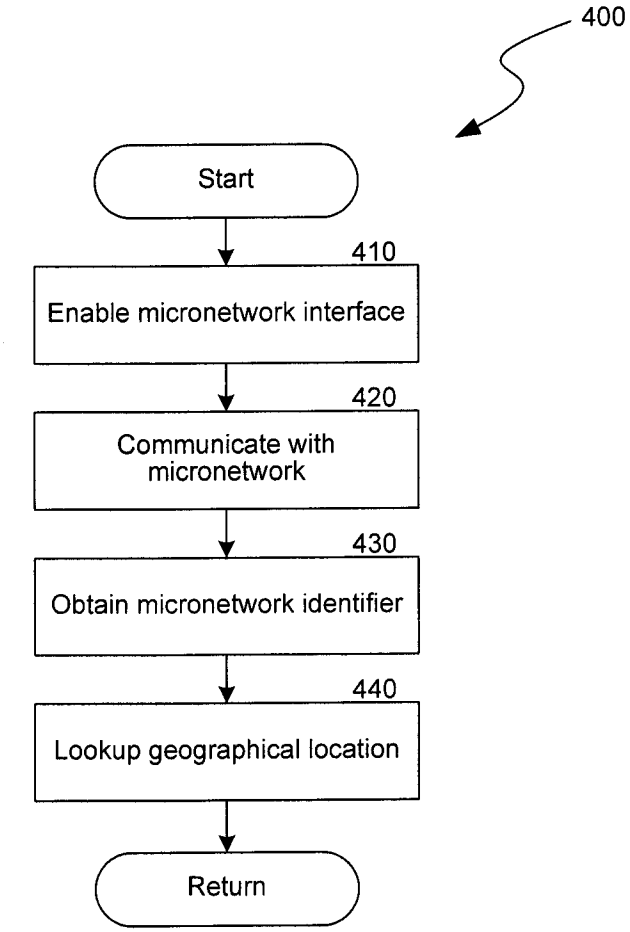

400
Start
410
Enable micronetwork interface
420
Communicate with micronetwork
430
Obtain micronetwork identifier
440
Lookup geographical location
Return

FIG. 4

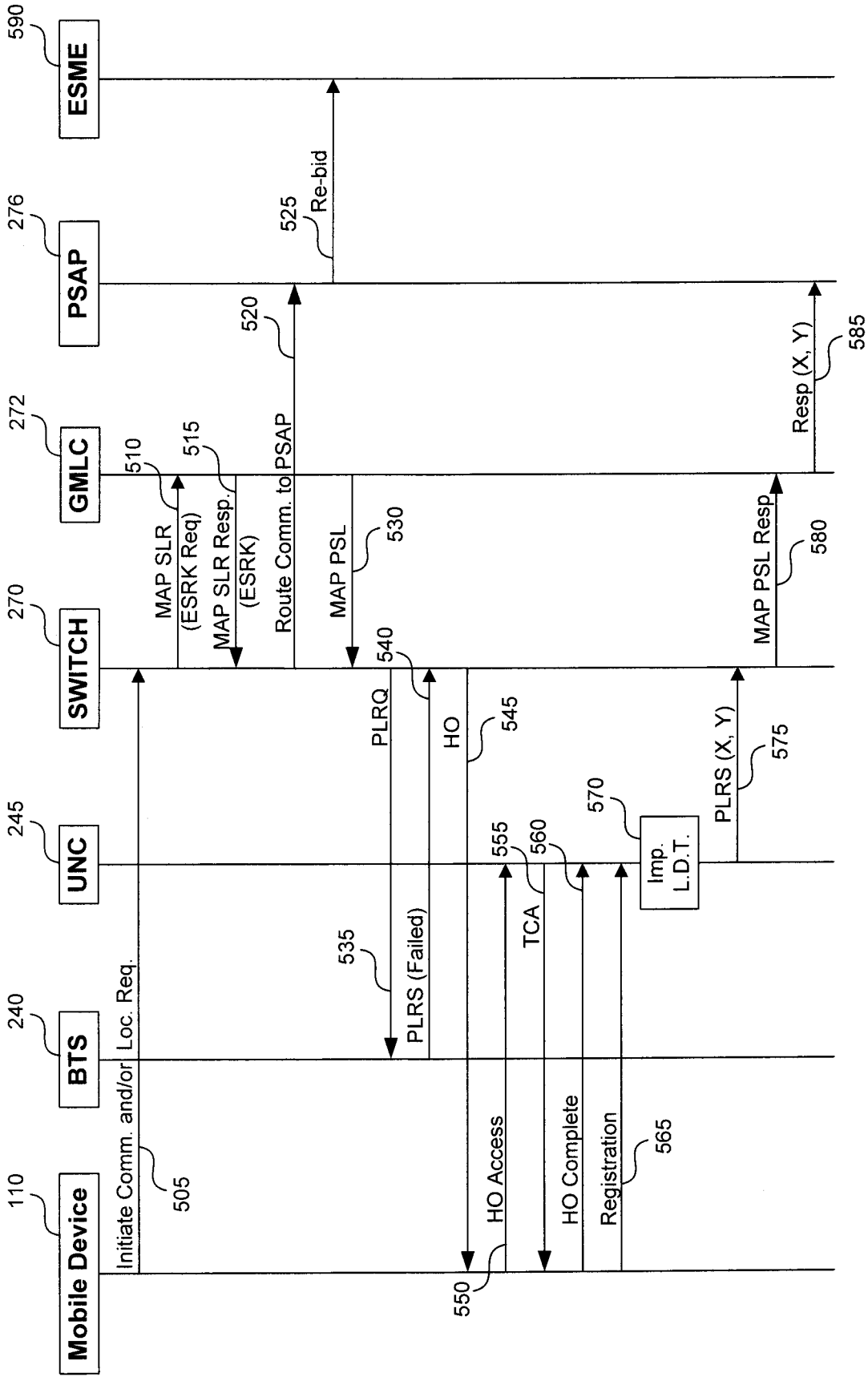

Mobile Device
110
BTS
240
UNC
245
SWITCH
270
GMLC
272
PSAP
276
ESME
590
Initiate Comm. and/or Loc. Req.
505
MAP SLR (ESRK Req)
510
MAP SLR Resp. (ESRK)
515
Route Comm. to PSAP
520
Re-bid
525
MAP PSL
530
PLRQ
540
HO
545
PLRS (Failed)
535
HO Access
550
TCA
555
HO Complete
560
Registration
565
Imp. L.D.T.
570
PLRS (X, Y)
575
MAP PSL Resp
580
Resp (X, Y)
585

FIG. 5