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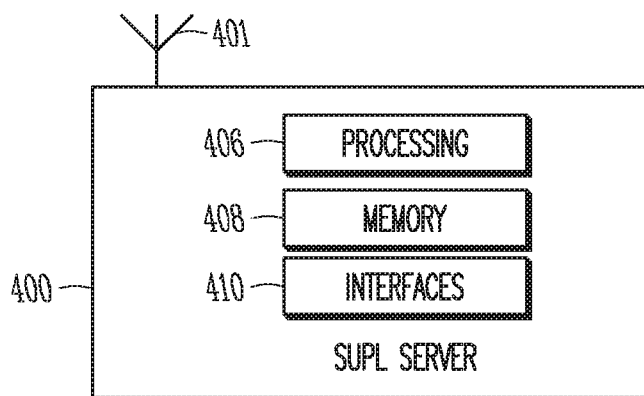


FIG. 4

(57) Abstract: Embodiments of a User Equipment (UE), a Secure User Plane Location (SUPL) server, and methods for communication of UE position information are generally described herein. The UE may determine UE position information as part of an emergency location session between the UE and a SUPL server. The UE may determine data connectivity between the UE and the SUPL server, and may transmit the UE position information on a data connection when the data connectivity is available. When the data connectivity is unavailable, the UE may transmit, to the SUPL server, a short messaging service (SMS) message that includes the UE position information.



USER EQUIPMENT (UE), SECURE USER PLANE LOCATION (SUPL)
SERVER AND METHODS FOR COMMUNICATION OF POSITION
INFORMATION

TECHNICAL FIELD

[0001] Embodiments pertain to wireless communications. Some embodiments relate to wireless networks including 3GPP (Third Generation Partnership Project) networks, 3GPP LTE (Long Term Evolution) networks, and 3GPP LTE-A (LTE Advanced) networks, although the scope of the embodiments is not limited in this respect. Some embodiments relate to location aware wireless communication. Some embodiments relate to Secure User Plane Location (SUPL) protocols. Some embodiments relate to emergency communication systems, including systems that use position information.

BACKGROUND

[0002] A mobile network may support communication with mobile devices. In some cases, a location of the mobile device may be used by the network for various purposes. As an example, location information of a mobile device may be communicated to emergency personnel responding to an emergency situation. Accordingly, there is a general need for methods and systems for enabling determination and/or communication of such location information in mobile networks in these and other scenarios.

BRIEF DESCRIPTION OF THE DRAWINGS

- [0003] FIG. 1 is a functional diagram of a 3GPP network in accordance with some embodiments;
- [0004] FIG. 2 is a block diagram of a User Equipment (UE) in accordance with some embodiments;
- [0005] FIG. 3 is a block diagram of an Evolved Node-B (eNB) in accordance with some embodiments;
- [0006] FIG. 4 is a block diagram of a Secure User Plane Location (SUPL) server in accordance with some embodiments;
- [0007] FIG. 5 illustrates an example of a scenario in which a UE may be in communication with an eNB and with a SUPL server in accordance with some embodiments;
- [0008] FIG. 6 illustrates the operation of a method of communication of UE position information in accordance with some embodiments;
- [0009] FIG. 7 illustrates example scenarios for communication of UE position information in accordance with some embodiments;
- [0010] FIG. 8 illustrates another example scenario for communication of UE position information in accordance with some embodiments;
- [0011] FIG. 9 illustrates an example of a short messaging service (SMS) message in accordance with some embodiments;
- [0012] FIG. 10 illustrates the operation of another method of communication of UE position information in accordance with some embodiments;
- [0013] FIG. 11 illustrates the operation of another method of communication of UE position information in accordance with some embodiments;
- [0014] FIGs. 12A-B illustrate examples of communication of UE position information in accordance with some embodiments; and
- [0015] FIG. 13 illustrates a block diagram of an example machine in accordance with some embodiments.

DETAILED DESCRIPTION

[0016] The following description and the drawings sufficiently illustrate specific embodiments to enable those skilled in the art to practice them. Other embodiments may incorporate structural, logical, electrical, process, and other changes. Portions and features of some embodiments may be included in, or substituted for, those of other embodiments. Embodiments set forth in the claims encompass all available equivalents of those claims.

[0017] FIG. 1 is a functional diagram of a 3GPP network in accordance with some embodiments. The network comprises a radio access network (RAN) (e.g., as depicted, the E-UTRAN or evolved universal terrestrial radio access network) 100 and the core network 120 (e.g., shown as an evolved packet core (EPC)) coupled together through an S1 interface 115. For convenience and brevity sake, only a portion of the core network 120, as well as the RAN 100, is shown.

[0018] The core network 120 includes a mobility management entity (MME) 122, a serving gateway (serving GW) 124, and packet data network gateway (PDN GW) 126. The RAN 100 includes Evolved Node-B's (eNBs) 104 (which may operate as base stations) for communicating with User Equipment (UE) 102. The eNBs 104 may include macro eNBs and low power (LP) eNBs.

[0019] In some embodiments, the eNB 104 may be communicatively coupled to a Secure User Plane Location (SUPL) server 106, which may perform various operations related to device location. These embodiments are not limiting, however, as other components may be used to perform some or all of those operations related to device location. In some embodiments, the SUPL server 106 may be communicatively coupled to the UE 102 over one or more wireless links. In some embodiments, a SUPL protocol may be used in location aware wireless communication devices, such as the UE 102. The SUPL protocol may be used for various operations, such as communication of assistance data from the SUPL server 106 to the UE 102 to enable the UE 102 to determine UE

position or location information. The assistance data may enable the UE 102 to determine the information more quickly and/or more efficiently, in some cases.

[0020] In some embodiments, the UE 102 may transmit a short message service (SMS) message to the SUPL server 106. The SMS may include location information, in some cases. The SUPL server 106 may transmit positioning assistance information to the eNB 104 for forwarding to the UE 102, in some cases. Accordingly, the eNB 104 may operate as a relay to enable communication between the UE 102 and the SUPL server 106 in some cases. These embodiments will be described in more detail below.

[0021] The MME 122 is similar in function to the control plane of legacy Serving GPRS Support Nodes (SGSN). The MME 122 manages mobility aspects in access such as gateway selection and tracking area list management. The serving GW 124 terminates the interface toward the RAN 100, and routes data packets between the RAN 100 and the core network 120. In addition, it may be a local mobility anchor point for inter-eNB handovers and also may provide an anchor for inter-3GPP mobility. Other responsibilities may include lawful intercept, charging, and some policy enforcement. The serving GW 124 and the MME 122 may be implemented in one physical node or separate physical nodes. The PDN GW 126 terminates an SGi interface toward the packet data network (PDN). The PDN GW 126 routes data packets between the EPC 120 and the external PDN, and may be a key node for policy enforcement and charging data collection. It may also provide an anchor point for mobility with non-LTE accesses. The external PDN can be any kind of IP network, as well as an IP Multimedia Subsystem (IMS) domain. The PDN GW 126 and the serving GW 124 may be implemented in one physical node or separated physical nodes.

[0022] The eNBs 104 (macro and micro) terminate the air interface protocol and may be the first point of contact for a UE 102. In some embodiments, an eNB 104 may fulfill various logical functions for the RAN 100 including but not limited to RNC (radio network controller functions) such as radio bearer management, uplink and downlink dynamic radio resource management and data packet scheduling, and mobility management. In accordance with embodiments, UEs 102 may be configured to communicate

Orthogonal Frequency Division Multiplexing (OFDM) communication signals with an eNB 104 over a multicarrier communication channel in accordance with an Orthogonal Frequency Division Multiple Access (OFDMA) communication technique. The OFDM signals may comprise a plurality of orthogonal subcarriers.

[0023] The S1 interface 115 is the interface that separates the RAN 100 and the EPC 120. It is split into two parts: the S1-U, which carries traffic data between the eNBs 104 and the serving GW 124, and the S1-MME, which is a signaling interface between the eNBs 104 and the MME 122. The X2 interface is the interface between eNBs 104. The X2 interface comprises two parts, the X2-C and X2-U. The X2-C is the control plane interface between the eNBs 104, while the X2-U is the user plane interface between the eNBs 104.

[0024] With cellular networks, LP cells are typically used to extend coverage to indoor areas where outdoor signals do not reach well, or to add network capacity in areas with very dense phone usage, such as train stations. As used herein, the term low power (LP) eNB refers to any suitable relatively low power eNB for implementing a narrower cell (narrower than a macro cell) such as a femtocell, a picocell, or a micro cell. Femtocell eNBs are typically provided by a mobile network operator to its residential or enterprise customers. A femtocell is typically the size of a residential gateway or smaller and generally connects to the user's broadband line. Once plugged in, the femtocell connects to the mobile operator's mobile network and provides extra coverage in a range of typically 30 to 50 meters for residential femtocells. Thus, a LP eNB might be a femtocell eNB since it is coupled through the PDN GW 126. Similarly, a picocell is a wireless communication system typically covering a small area, such as in-building (offices, shopping malls, train stations, etc.), or more recently in-aircraft. A picocell eNB can generally connect through the X2 link to another eNB such as a macro eNB through its base station controller (BSC) functionality. Thus, LP eNB may be implemented with a picocell eNB since it is coupled to a macro eNB via an X2 interface. Picocell eNBs or other LP eNBs may incorporate some or all functionality of a macro eNB. In some cases, this may be referred to as an access point base station or enterprise femtocell.

[0025] In some embodiments, a downlink resource grid may be used for downlink transmissions from an eNB 104 to a UE 102, while uplink transmission from the UE 102 to the eNB 104 may utilize similar techniques. The grid may be a time-frequency grid, called a resource grid or time-frequency resource grid, which is the physical resource in the downlink in each slot. Such a time-frequency plane representation is a common practice for OFDM systems, which makes it intuitive for radio resource allocation. Each column and each row of the resource grid correspond to one OFDM symbol and one OFDM subcarrier, respectively. The duration of the resource grid in the time domain corresponds to one slot in a radio frame. The smallest time-frequency unit in a resource grid is denoted as a resource element (RE). Each resource grid comprises a number of resource blocks (RBs), which describe the mapping of certain physical channels to resource elements. Each resource block comprises a collection of resource elements in the frequency domain and may represent the smallest quanta of resources that currently can be allocated. There are several different physical downlink channels that are conveyed using such resource blocks. With particular relevance to this disclosure, two of these physical downlink channels are the physical downlink shared channel and the physical down link control channel.

[0026] The physical downlink shared channel (PDSCH) carries user data and higher-layer signaling to a UE 102 (FIG. 1). The physical downlink control channel (PDCCH) carries information about the transport format and resource allocations related to the PDSCH channel, among other things. It also informs the UE 102 about the transport format, resource allocation, and hybrid automatic repeat request (HARQ) information related to the uplink shared channel. Typically, downlink scheduling (e.g., assigning control and shared channel resource blocks to UEs 102 within a cell) may be performed at the eNB 104 based on channel quality information fed back from the UEs 102 to the eNB 104, and then the downlink resource assignment information may be sent to a UE 102 on the control channel (PDCCH) used for (assigned to) the UE 102.

[0027] The PDCCH uses CCEs (control channel elements) to convey the control information. Before being mapped to resource elements, the PDCCH

complex-valued symbols are first organized into quadruplets, which are then permuted using a sub-block inter-leaver for rate matching. Each PDCCH is transmitted using one or more of these control channel elements (CCEs), where each CCE corresponds to nine sets of four physical resource elements known as resource element groups (REGs). Four QPSK symbols are mapped to each REG. The PDCCH can be transmitted using one or more CCEs, depending on the size of DCI and the channel condition. There may be four or more different PDCCH formats defined in LTE with different numbers of CCEs (e.g., aggregation level, $L=1, 2, 4$, or 8).

[0028] As used herein, the term "circuitry" may refer to, be part of, or include an Application Specific Integrated Circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group), and/or memory (shared, dedicated, or group) that execute one or more software or firmware programs, a combinational logic circuit, and/or other suitable hardware components that provide the described functionality. In some embodiments, the circuitry may be implemented in, or functions associated with the circuitry may be implemented by, one or more software or firmware modules. In some embodiments, circuitry may include logic, at least partially operable in hardware. Embodiments described herein may be implemented into a system using any suitably configured hardware and/or software.

[0029] FIG. 2 is a block diagram of a User Equipment (UE) in accordance with some embodiments. The UE 200 may be suitable for use as a UE 102 as depicted in FIG. 1. In some embodiments, the UE 200 may include application circuitry 202, baseband circuitry 204, Radio Frequency (RF) circuitry 206, front-end module (FEM) circuitry 208 and one or more antennas 210, coupled together at least as shown. In some embodiments, other circuitry or arrangements may include one or more elements and/or components of the application circuitry 202, the baseband circuitry 204, the RF circuitry 206 and/or the FEM circuitry 208, and may also include other elements and/or components in some cases. As an example, "processing circuitry" may include one or more elements and/or components, some or all of which may be included in the application circuitry 202 and/or the baseband circuitry 204. As another example,

“transceiver circuitry” may include one or more elements and/or components, some or all of which may be included in the RF circuitry 206 and/or the FEM circuitry 208. These examples are not limiting, however, as the processing circuitry and/or the transceiver circuitry may also include other elements and/or components in some cases.

[0030] The application circuitry 202 may include one or more application processors. For example, the application circuitry 202 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The processor(s) may include any combination of general-purpose processors and dedicated processors (e.g., graphics processors, application processors, etc.). The processors may be coupled with and/or may include memory/storage and may be configured to execute instructions stored in the memory/storage to enable various applications and/or operating systems to run on the system.

[0031] The baseband circuitry 204 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The baseband circuitry 204 may include one or more baseband processors and/or control logic to process baseband signals received from a receive signal path of the RF circuitry 206 and to generate baseband signals for a transmit signal path of the RF circuitry 206. Baseband processing circuitry 204 may interface with the application circuitry 202 for generation and processing of the baseband signals and for controlling operations of the RF circuitry 206. For example, in some embodiments, the baseband circuitry 204 may include a second generation (2G) baseband processor 204a, third generation (3G) baseband processor 204b, fourth generation (4G) baseband processor 204c, and/or other baseband processor(s) 204d for other existing generations, generations in development or to be developed in the future (e.g., fifth generation (5G), 6G, etc.). The baseband circuitry 204 (e.g., one or more of baseband processors 204a-d) may handle various radio control functions that enable communication with one or more radio networks via the RF circuitry 206. The radio control functions may include, but are not limited to, signal modulation/demodulation, encoding/decoding, radio frequency shifting, etc. In some embodiments,

modulation/demodulation circuitry of the baseband circuitry 204 may include Fast-Fourier Transform (FFT), precoding, and/or constellation mapping/demapping functionality. In some embodiments, encoding/decoding circuitry of the baseband circuitry 204 may include convolution, tail-biting convolution, turbo, Viterbi, and/or Low Density Parity Check (LDPC) encoder/decoder functionality. Embodiments of modulation/demodulation and encoder/decoder functionality are not limited to these examples and may include other suitable functionality in other embodiments.

[0032] In some embodiments, the baseband circuitry 204 may include elements of a protocol stack such as, for example, elements of an evolved universal terrestrial radio access network (EUTRAN) protocol including, for example, physical (PHY), media access control (MAC), radio link control (RLC), packet data convergence protocol (PDCP), and/or radio resource control (RRC) elements. A central processing unit (CPU) 204e of the baseband circuitry 204 may be configured to run elements of the protocol stack for signaling of the PHY, MAC, RLC, PDCP and/or RRC layers. In some embodiments, the baseband circuitry may include one or more audio digital signal processor(s) (DSP) 204f. The audio DSP(s) 204f may include elements for compression/decompression and echo cancellation and may include other suitable processing elements in other embodiments. Components of the baseband circuitry may be suitably combined in a single chip, a single chipset, or disposed on a same circuit board in some embodiments. In some embodiments, some or all of the constituent components of the baseband circuitry 204 and the application circuitry 202 may be implemented together such as, for example, on a system on a chip (SOC).

[0033] In some embodiments, the baseband circuitry 204 may provide for communication compatible with one or more radio technologies. For example, in some embodiments, the baseband circuitry 204 may support communication with an evolved universal terrestrial radio access network (EUTRAN) and/or other wireless metropolitan area networks (WMAN), a wireless local area network (WLAN), a wireless personal area network (WPAN). Embodiments in which the baseband circuitry 204 is configured to

support radio communications of more than one wireless protocol may be referred to as multi-mode baseband circuitry.

[0034] RF circuitry 206 may enable communication with wireless networks using modulated electromagnetic radiation through a non-solid medium. In various embodiments, the RF circuitry 206 may include switches, filters, amplifiers, etc. to facilitate the communication with the wireless network. RF circuitry 206 may include a receive signal path which may include circuitry to down-convert RF signals received from the FEM circuitry 208 and provide baseband signals to the baseband circuitry 204. RF circuitry 206 may also include a transmit signal path which may include circuitry to up-convert baseband signals provided by the baseband circuitry 204 and provide RF output signals to the FEM circuitry 208 for transmission.

[0035] In some embodiments, the RF circuitry 206 may include a receive signal path and a transmit signal path. The receive signal path of the RF circuitry 206 may include mixer circuitry 206a, amplifier circuitry 206b and filter circuitry 206c. The transmit signal path of the RF circuitry 206 may include filter circuitry 206c and mixer circuitry 206a. RF circuitry 206 may also include synthesizer circuitry 206d for synthesizing a frequency for use by the mixer circuitry 206a of the receive signal path and the transmit signal path. In some embodiments, the mixer circuitry 206a of the receive signal path may be configured to down-convert RF signals received from the FEM circuitry 208 based on the synthesized frequency provided by synthesizer circuitry 206d. The amplifier circuitry 206b may be configured to amplify the down-converted signals and the filter circuitry 206c may be a low-pass filter (LPF) or band-pass filter (BPF) configured to remove unwanted signals from the down-converted signals to generate output baseband signals. Output baseband signals may be provided to the baseband circuitry 204 for further processing. In some embodiments, the output baseband signals may be zero-frequency baseband signals, although this is not a requirement. In some embodiments, mixer circuitry 206a of the receive signal path may comprise passive mixers, although the scope of the embodiments is not limited in this respect. In some embodiments, the mixer circuitry 206a of the transmit signal path may be configured to up-convert

input baseband signals based on the synthesized frequency provided by the synthesizer circuitry 206d to generate RF output signals for the FEM circuitry 208. The baseband signals may be provided by the baseband circuitry 204 and may be filtered by filter circuitry 206c. The filter circuitry 206c may include a low-pass filter (LPF), although the scope of the embodiments is not limited in this respect.

[0036] In some embodiments, the mixer circuitry 206a of the receive signal path and the mixer circuitry 206a of the transmit signal path may include two or more mixers and may be arranged for quadrature downconversion and/or upconversion respectively. In some embodiments, the mixer circuitry 206a of the receive signal path and the mixer circuitry 206a of the transmit signal path may include two or more mixers and may be arranged for image rejection (e.g., Hartley image rejection). In some embodiments, the mixer circuitry 206a of the receive signal path and the mixer circuitry 206a may be arranged for direct downconversion and/or direct upconversion, respectively. In some embodiments, the mixer circuitry 206a of the receive signal path and the mixer circuitry 206a of the transmit signal path may be configured for super-heterodyne operation.

[0037] In some embodiments, the output baseband signals and the input baseband signals may be analog baseband signals, although the scope of the embodiments is not limited in this respect. In some alternate embodiments, the output baseband signals and the input baseband signals may be digital baseband signals. In these alternate embodiments, the RF circuitry 206 may include analog-to-digital converter (ADC) and digital-to-analog converter (DAC) circuitry and the baseband circuitry 204 may include a digital baseband interface to communicate with the RF circuitry 206. In some dual-mode embodiments, a separate radio IC circuitry may be provided for processing signals for each spectrum, although the scope of the embodiments is not limited in this respect.

[0038] In some embodiments, the synthesizer circuitry 206d may be a fractional-N synthesizer or a fractional N/N+1 synthesizer, although the scope of the embodiments is not limited in this respect as other types of frequency synthesizers may be suitable. For example, synthesizer circuitry 206d may be a delta-sigma synthesizer, a frequency multiplier, or a synthesizer comprising a

phase-locked loop with a frequency divider. The synthesizer circuitry 206d may be configured to synthesize an output frequency for use by the mixer circuitry 206a of the RF circuitry 206 based on a frequency input and a divider control input. In some embodiments, the synthesizer circuitry 206d may be a fractional $N/N+1$ synthesizer. In some embodiments, frequency input may be provided by a voltage controlled oscillator (VCO), although that is not a requirement. Divider control input may be provided by either the baseband circuitry 204 or the applications processor 202 depending on the desired output frequency. In some embodiments, a divider control input (e.g., N) may be determined from a look-up table based on a channel indicated by the applications processor 202.

[0039] Synthesizer circuitry 206d of the RF circuitry 206 may include a divider, a delay-locked loop (DLL), a multiplexer and a phase accumulator. In some embodiments, the divider may be a dual modulus divider (DMD) and the phase accumulator may be a digital phase accumulator (DPA). In some embodiments, the DMD may be configured to divide the input signal by either N or $N+1$ (e.g., based on a carry out) to provide a fractional division ratio. In some example embodiments, the DLL may include a set of cascaded, tunable, delay elements, a phase detector, a charge pump and a D-type flip-flop. In these embodiments, the delay elements may be configured to break a VCO period up into N_d equal packets of phase, where N_d is the number of delay elements in the delay line. In this way, the DLL provides negative feedback to help ensure that the total delay through the delay line is one VCO cycle.

[0040] In some embodiments, synthesizer circuitry 206d may be configured to generate a carrier frequency as the output frequency, while in other embodiments, the output frequency may be a multiple of the carrier frequency (e.g., twice the carrier frequency, four times the carrier frequency) and used in conjunction with quadrature generator and divider circuitry to generate multiple signals at the carrier frequency with multiple different phases with respect to each other. In some embodiments, the output frequency may be a LO frequency (f_{LO}). In some embodiments, the RF circuitry 206 may include an IQ/polar converter.

[0041] FEM circuitry 208 may include a receive signal path which may include circuitry configured to operate on RF signals received from one or more antennas 210, amplify the received signals and provide the amplified versions of the received signals to the RF circuitry 206 for further processing. FEM circuitry 208 may also include a transmit signal path which may include circuitry configured to amplify signals for transmission provided by the RF circuitry 206 for transmission by one or more of the one or more antennas 210.

[0042] In some embodiments, the FEM circuitry 208 may include a TX/RX switch to switch between transmit mode and receive mode operation. The FEM circuitry may include a receive signal path and a transmit signal path. The receive signal path of the FEM circuitry may include a low-noise amplifier (LNA) to amplify received RF signals and provide the amplified received RF signals as an output (e.g., to the RF circuitry 206). The transmit signal path of the FEM circuitry 208 may include a power amplifier (PA) to amplify input RF signals (e.g., provided by RF circuitry 206), and one or more filters to generate RF signals for subsequent transmission (e.g., by one or more of the one or more antennas 210). In some embodiments, the UE 200 may include additional elements such as, for example, memory/storage, display, camera, sensor, and/or input/output (I/O) interface.

[0043] FIG. 3 is a block diagram of an Evolved Node-B (eNB) in accordance with some embodiments. It should be noted that in some embodiments, the eNB 300 may be a stationary non-mobile device. The eNB 300 may be suitable for use as an eNB 104 as depicted in FIG. 1. The eNB 300 may include physical layer circuitry 302 and a transceiver 305, one or both of which may enable transmission and reception of signals to and from the UE 200, other eNBs, other UEs or other devices using one or more antennas 301. As an example, the physical layer circuitry 302 may perform various encoding and decoding functions that may include formation of baseband signals for transmission and decoding of received signals. As another example, the transceiver 305 may perform various transmission and reception functions such as conversion of signals between a baseband range and a Radio Frequency (RF) range. Accordingly, the physical layer circuitry 302 and the transceiver 305 may

be separate components or may be part of a combined component. In addition, some of the described functionality related to transmission and reception of signals may be performed by a combination that may include one, any or all of the physical layer circuitry 302, the transceiver 305, and other components or layers. The eNB 300 may also include medium access control layer (MAC) circuitry 304 for controlling access to the wireless medium. The eNB 300 may also include processing circuitry 306 and memory 308 arranged to perform the operations described herein. The eNB 300 may also include one or more interfaces 310, which may enable communication with other components, including other eNBs 104 (FIG. 1), the SUPL server 106, components in the EPC 120 (FIG. 1) or other network components. In addition, the interfaces 310 may enable communication with other components that may not be shown in FIG. 1, including components external to the network. The interfaces 310 may be wired or wireless or a combination thereof.

[0044] In some embodiments, the UE 200 or the eNB 300 may be a mobile device and may be a portable wireless communication device, such as a personal digital assistant (PDA), a laptop or portable computer with wireless communication capability, a web tablet, a wireless telephone, a smartphone, a wireless headset, a pager, an instant messaging device, a digital camera, an access point, a television, a wearable device such as a medical device (e.g., a heart rate monitor, a blood pressure monitor, etc.), or other device that may receive and/or transmit information wirelessly. In some embodiments, the UE 200 or eNB 300 may be configured to operate in accordance with 3GPP standards, although the scope of the embodiments is not limited in this respect. Mobile devices or other devices in some embodiments may be configured to operate according to other protocols or standards, including IEEE 802.11 or other IEEE standards. In some embodiments, the UE 200, eNB 300 or other device may include one or more of a keyboard, a display, a non-volatile memory port, multiple antennas, a graphics processor, an application processor, speakers, and other mobile device elements. The display may be an LCD screen including a touch screen.

[0045] FIG. 4 is a block diagram of a Secure User Plane Location (SUPL) server in accordance with some embodiments. It should be noted that in some embodiments, the SUPL server 400 may be a stationary non-mobile device. The SUPL server 400 may be suitable for use as a SUPL server 106 as depicted in FIG. 1. The SUPL server 400 may include processing circuitry 406 and memory 408 arranged to perform the operations described herein. The SUPL server 400 may also include one or more interfaces 410, which may enable communication with other components, including eNBs 104 (FIG. 1), components in the EPC 120 (FIG. 1) or other network components. In addition, the interfaces 410 may enable communication with other components that may not be shown in FIG. 1, including components external to the network. The interfaces 410 may be wired or wireless or a combination thereof. In some embodiments, the SUPL server 400 may include one or more antennas 401. As an example, the antennas 401 may enable communication over a wireless link with the UE 200, in some cases. As another example, the SUPL server 400 may communicate indirectly with the UE 200 by forwarding packets, messages and/or other information to the eNB 300 for forwarding to the UE 200.

[0046] The antennas 210, 301, 401 may comprise one or more directional or omnidirectional antennas, including, for example, dipole antennas, monopole antennas, patch antennas, loop antennas, microstrip antennas or other types of antennas suitable for transmission of RF signals. In some multiple-input multiple-output (MIMO) embodiments, the antennas 210, 301 may be effectively separated to take advantage of spatial diversity and the different channel characteristics that may result.

[0047] Although the UE 200, the eNB 300, and the SUPL server 400 are each illustrated as having several separate functional elements, one or more of the functional elements may be combined and may be implemented by combinations of software-configured elements, such as processing elements including digital signal processors (DSPs), and/or other hardware elements. For example, some elements may comprise one or more microprocessors, DSPs, field-programmable gate arrays (FPGAs), application specific integrated circuits (ASICs), radio-frequency integrated circuits (RFICs) and combinations of

various hardware and logic circuitry for performing at least the functions described herein. In some embodiments, the functional elements may refer to one or more processes operating on one or more processing elements.

[0048] Embodiments may be implemented in one or a combination of hardware, firmware and software. Embodiments may also be implemented as instructions stored on a computer-readable storage device, which may be read and executed by at least one processor to perform the operations described herein. A computer-readable storage device may include any non-transitory mechanism for storing information in a form readable by a machine (e.g., a computer). For example, a computer-readable storage device may include read-only memory (ROM), random-access memory (RAM), magnetic disk storage media, optical storage media, flash-memory devices, and other storage devices and media. Some embodiments may include one or more processors and may be configured with instructions stored on a computer-readable storage device.

[0049] It should be noted that in some embodiments, an apparatus used by the UE 200 and/or eNB 300 and/or SUPL server 400 may include various components of the UE 200 and/or the eNB 300 and/or the SUPL server 400 as shown in FIGs. 2-4. Accordingly, techniques and operations described herein that refer to the UE 200 (or 102) may be applicable to an apparatus for a UE. In addition, techniques and operations described herein that refer to the eNB 300 (or 104) may be applicable to an apparatus for an eNB. In addition, techniques and operations described herein that refer to the SUPL server 400 (or 106) may be applicable to an apparatus for a SUPL server.

[0050] In accordance with embodiments, the UE 102 may determine UE position information as part of an emergency location session between the UE 102 and the SUPL server 106. The UE 102 may determine data connectivity between the UE 102 and the SUPL server 106, and may transmit the UE position information on a data connection when the data connectivity is available. When the data connectivity is unavailable, the UE 102 may transmit, to the SUPL server 106, a short messaging service (SMS) message that includes the UE position information. These embodiments are described in more detail below.

[0051] FIG. 5 illustrates an example of a scenario in which a UE may be in communication with an eNB and with a SUPL server in accordance with some embodiments. Although the example scenario 500 shown in FIG. 5 may illustrate some or all aspects of techniques disclosed herein, it is understood that embodiments are not limited by this example scenario 500. It should also be noted that embodiments are not limited to the components shown in the example scenario 500. As an example, embodiments are not limited to usage of the UE 102, as other mobile devices may be used in some cases. For instance, a station (STA) arranged to communicate using a wireless local area network (WLAN) protocol (or other protocol) may be used. As another example, embodiments are not limited to usage of the eNB 104, as other base station devices may be used in some cases. For instance, an access point (AP) arranged to communicate using a WLAN protocol (or other protocol) may be used. As another example, embodiments are not limited to usage of the SUPL server 106, as other components arranged to support operations for device location may be used in some cases.

[0052] In the example scenario 500, the UE 102 may exchange packets, signals and/or messages with the eNB 104 over the wireless link 510 using any suitable communication protocol, which may or may not be included as part of one or more standards. As a non-limiting example, the UE 102 may be arranged to communicate with the eNB 104 using a Third Generation Partnership Protocol (3GPP) Long Term Evolution (LTE) protocol in some cases.

[0053] In addition, in the example scenario 500, the UE 102 may exchange data packets and/or messages with the SUPL server 106 over the data connection 520. In some embodiments, the data connection 520 may include and/or utilize a wireless link 522 between the UE 102 and the eNB 104. The data connection 520 may further include and/or utilize a link 524 (which may be wired or wireless or a combination thereof) between the eNB 104 and the SUPL server 106. Accordingly, the eNB 104 may operate as a relay for forwarding packets, messages and/or signals between the UE 102 and the SUPL server 106 in some cases. As an example, the UE 102 may transmit a packet to the eNB 104 over the wireless link 522 for forwarding to the SUPL server 106 over the

link 524. As another example, the SUPL server 106 may transmit a packet to the eNB 104 over the link 524 for forwarding to the UE 102 over the wireless link 522. As another example, the UE 102 may transmit a packet to the SUPL server 106 directly over a wireless link 530 between the UE 102 and the SUPL server 106.

[0054] In some embodiments, the data connection 520 between the UE 102 and the SUPL server 106 may be or may include a Transport Control Protocol / Internet Protocol (TCP/IP) connection. These embodiments are not limiting, however, as the data connection 520 may be arranged to operate according to one or more other data protocols in some embodiments.

[0055] It should be noted that some embodiments may not necessarily include separate wireless links 510, 522 between the UE 102 and the eNB 104. In some cases, a same wireless link may be used for first communication between the UE 102 and the eNB 104 and for second communication (with the eNB 104 operating as a relay) between the UE 102 and the SUPL server 106. It should also be noted that embodiments are not limited to the first and second communication as shown in FIG. 5. For instance, the eNB 104 may also be configured to operate as a relay between the UE 102 and other components in some cases.

[0056] As a non-limiting example, the data connection 520 may be used for and/or established for an emergency location session between the SUPL server 106 and the UE 102. The emergency location session may be initiated by the eNB 104 (or other network component) in order to determine UE position information (such as a position or location of the UE 102) for usage in an emergency communication session for the UE 102. Although embodiments are not limited as such, the emergency communication session may be initiated by the UE 102 in some cases. For instance, a user of the UE 102 may dial an emergency phone number such as 9-1-1 or other to initiate the emergency communication session. In some embodiments, the emergency communication session may include communication between the UE 102 and a Public Safety Answering Point (PSAP) or other component. As an example, data messages and/or packets may be exchanged between the UE 102 and the PSAP. As

another example, a user of the UE 102 may speak to an operator of the PSAP. In addition, in some cases, the UE position information that is determined as part of the emergency location session may be made available at the PSAP for usage by the operator or other person (such as responding emergency personnel).

[0057] In some embodiments, the eNB 104 or other component may trigger a SUPL Location Platform (SLP) (or SUPL server 106), which may be deployed in the network, to request for a location of the UE 102. Accordingly, the emergency location session (such as an emergency SUPL session) may be initiated, and may preempt and/or take precedence over established SUPL sessions for the UE 102. The SUPL server 106 may receive UE position information from the UE 102, and may forward such information (either directly or indirectly) to the PSAP or other component. In some cases, the SUPL server 106 may use the received UE position information to determine other related information, such as a position of the UE 102 and/or coordinates of the UE 102, and may forward the related information to the PSAP or other component.

[0058] FIG. 6 illustrates the operation of a method of communication of UE position information in accordance with some embodiments. It is important to note that embodiments of the method 600 may include additional or even fewer operations or processes in comparison to what is illustrated in FIG. 6. In addition, embodiments of the method 600 are not necessarily limited to the chronological order that is shown in FIG. 6. In describing the method 600, reference may be made to FIGs. 1-5 and 7-12, although it is understood that the method 600 may be practiced with any other suitable systems, interfaces and components.

[0059] In addition, while the method 600 and other methods described herein may refer to eNBs 104 or UEs 102 operating in accordance with 3GPP or other standards, embodiments of those methods are not limited to just those eNBs 104 or UEs 102 and may also be practiced on other devices, such as a Wi-Fi access point (AP) or user station (STA). The method 600 and other methods described herein may also refer to SUPL servers 106 operating in accordance with Open Mobile Alliance (OMA) standards or other standards, but embodiments of those methods are not limited to just those SUPL servers 106

and may also be practiced on other devices. In addition, the method 600 and other methods described herein may be practiced by wireless devices configured to operate in other suitable types of wireless communication systems, including systems configured to operate according to various IEEE standards such as IEEE 802.11. The method 600 may also refer to an apparatus for a UE 102 and/or eNB 104 and/or SUPL server 106 and/or other device described above.

[0060] At operation 605 of the method 600, the UE 102 may transmit, to the eNB 104, one or more emergency communication initiation messages for an initiation of an emergency communication session. In some embodiments, the emergency communication session may include communication between the UE 102 and a Public Safety Answering Point (PSAP). These embodiments are not limiting, however, as the emergency communication session may include communication between the UE 102 and other components in some cases.

[0061] As a non-limiting example, the emergency communication initiation messages may be transmitted at least partly in response to a reception, at the UE 102, of user input that indicates a request for the emergency communication session. For instance, the user may dial an emergency phone number, such as 9-1-1 or other number to initiate the emergency communication session. As another non-limiting example, the emergency communication initiation messages may be transmitted in response to another trigger at the UE 102, such as sensor input or other input.

[0062] It should be noted that messages and/or data exchanged between the SUPL server 106 and the UE 102 in the operations included in the method 600 (and other methods disclosed herein) may be exchanged using the eNB 104 as a relay, although embodiments are not limited as such. Accordingly, as part of such operation as a relay, the eNB 104 may receive messages and/or data from one of the components and may forward the messages and/or data to another component. Embodiments are not limited to forwarding of the exact messages and/or data, however. In some cases, the contents of the messages (or at least a portion of the contents) may be transmitted using different messages. For instance, the eNB 104 may extract information from a message and may

transmit the information to the other component as part of a different message in a different format.

[0063] At operation 610, the UE 102 may receive a SUPL initiation message for an emergency location session between the UE and a SUPL server 106. As a non-limiting example, the SUPL initiation message may be a SUPL INIT message included in OMA standards or other standards. However, it is understood that other messages may be received at the UE 102 for the initiation of the emergency location session.

[0064] In some embodiments, the emergency location session may be for determination and/or communication of UE position information for usage in the emergency communication session. It should be noted that embodiments are not limited to emergency scenarios. As an example, the SUPL initiation message may be for an establishment of a location session in a non-emergency scenario, in some cases. In addition, other techniques and/or operations described herein may be applicable, in some cases, to non-emergency scenarios. Accordingly, although reference may be made to an “emergency location session” and/or “emergency communication session,” it is understood that some or all of the techniques and/or operations described may be applicable, in some cases, to location sessions and/or communication sessions for non-emergency scenarios.

[0065] In some embodiments, the SUPL initiation message may be received from the eNB 104 operating as a relay for the SUPL server 106, although embodiments are not limited as such. As a non-limiting example, the SUPL initiation message received at the UE 102 may be included in an SMS message that is forwarded to the UE 102 by the eNB 104 operating as a relay for the SUPL server 106. This example is not limiting, however, as WAP Push, UDP and/or other techniques may also be used for sending the SUPL initiation message to the UE 102.

[0066] In some embodiments, the SUPL initiation message may include information related to how the UE 102 is to determine UE position information for the emergency location session. As an example, the SUPL initiation message may indicate that the UE 102 is to determine a UE position for inclusion in the UE position information based on one or more signal measurements at the UE

102. As another example, the SUPL initiation message may indicate that the UE position information is to include the measurements to enable a determination of the UE position by the SUPL server 106. As another example, the SUPL initiation message may indicate either that the UE 102 is to determine the UE position or that the UE position information is to include the measurements.

[0067] In some embodiments, the signal measurements may be based on reception of positioning signals from one or more satellites. For instance, global navigation satellite system (GNSS) signals, global positioning system (GPS) signals and/or other satellite signals may be used. In some embodiments, the signal measurements may be based on reception of one or more signals (such as cellular signals) received from one or more eNBs 104 or other components. For instance, measurements to enable triangulation techniques for determination of a position of the UE 102 may be used in some cases.

[0068] At operation 615, the UE 102 may determine whether data connectivity is available between the UE 102 and the eNB 104. As an example, the UE 102 may attempt to establish a data connection with the SUPL server 106 by transmitting one or more control messages. Accordingly, the success or failure of the attempted establishment of the data connection may be determined. As another example, a user of the UE 102 may disable a data connection manually, in which case the data connectivity may be unavailable. As another example, an established data connection may stop working or may be intermittent. As another example, a plan, contract or agreement with the network for the UE 102 (or for the user of the UE 102) may not support such data connections, but may support exchanging of SMS messages (or other text messages) with the network. As another example, it may be determined whether or not the UE 102 is capable of establishing a data connection with the SUPL server 106. The data connection in this example may be or may include a TCP/IP connection, although embodiments are not limited as such and other types of data connection may be used in some cases. In addition, success and/or failure of the data connectivity is not limited to these example scenarios. Accordingly, the data connectivity may fail in scenarios other than these example scenarios.

[0069] At operation 620, the UE 102 may transmit one or more control messages to the eNB 104 for forwarding to the SUPL server 106 for an intended establishment of a data connection between the UE 102 and the SUPL server 106. As previously described, some embodiments of the method 600 may not necessarily include all operations shown in FIG. 6. In some embodiments, the method 600 may include operation 620 when the UE 102 determines that data connectivity is available. In some embodiments, the method 600 may exclude operation 620 when the UE 102 determines that the data connectivity is unavailable and/or when an establishment of a data connection fails.

[0070] At operation 625, the UE 102 may determine the UE position information. In some embodiments, the determination may be based at least partly on positioning assistance information received from the SUPL server 106. For instance, a previous position of the UE 102 and/or other previous UE position information may be received at the UE 102 from the eNB 104 operating as a relay for the SUPL server 106. In addition, the determination of the UE position information may be based at least partly on a positioning method indicated in the SUPL initiation message. For instance, the message may indicate whether the UE 102 is to determine the UE position or whether the UE 102 is to send measurements to enable the SUPL server 106 to determine the UE position.

[0071] At operation 630, the UE 102 may transmit an SMS message that includes the UE position information when the data connectivity is unavailable and/or when the establishment of the data connection fails. In some embodiments, the SMS message may be transmitted to the SUPL server 106 over a wireless link between the UE 102 and the SUPL server 106. In some embodiments, the SMS message may be transmitted to the eNB 104 for forwarding to the SUPL server 106 as part of the emergency location session. As a non-limiting example, the SMS message may include control metadata for the SMS message and may further include a data payload that includes the UE position information. The control metadata may include control information such as a time stamp for the SMS message, an identifier of the UE 102 and/or other control information. For instance, the UE identifier may include a phone

number of the UE 102, such as a mobile station international subscriber directory number (MSISDN) or other phone number. In some embodiments, the SMS message may include a SUPL end message (which may be an uplink SUPL end message) that may indicate a termination of the emergency location session.

[0072] In some embodiments, the UE position information included in the SMS message may indicate a cell identifier of the eNB 104 and/or cell identifiers of one or more other eNBs 104 to which the UE 102 has previously communicated. Multiple location IDs may be included, in some cases, in the SUPL end message included in the SMS message transmitted from the UE 102 to the SUPL 106. As an example, multiple location IDs of cells and/or base stations (eNBs 104 and/or others) to which the UE 102 has previously communicated may be included in the UE position information. Such communication may occur during a particular duration of time in some cases. For instance, a recent time period, as defined by a time duration threshold, may be used to determine which location IDs are to be included in the UE position information included in the SMS message. As another example, a historical log of eNBs 104, UE locations, base stations or other information may be included in the UE position information. It should be noted that the UE position information may also include other information in addition to the location IDs and/or historical log, in some cases.

[0073] At operation 635, the UE 102 may transmit the UE position information on the data connection when the establishment of the data connection succeeds and/or when the data connectivity is available. At operation 640, when the establishment of the data connection succeeds and/or when the data connectivity is available, the UE 102 may receive a downlink SUPL end message from the SUPL server 106 that may indicate the termination of the emergency location session. As previously described, embodiments may not necessarily include all operations shown in FIG. 6. Accordingly, in some embodiments, when the establishment of the data connection succeeds and/or when the data connectivity is available, operations 635 and/or 640 may be included and operation 630 may be excluded. In addition, in some embodiments, when the establishment of the data connection fails and/or when

the data connectivity is unavailable, operations 635 and/or 640 may be excluded and operation 630 may be included. As an example, a SUPL end message may be transmitted from the SUPL server 106 to the UE 102 (downlink) when the data connectivity is available and a SUPL end message may be transmitted from the UE 102 to the SUPL server 106 (uplink) when the data connectivity is unavailable.

[0074] At operation 645, the UE 102 may exchange, as part of a non-emergency communication session, one or more data messages with the eNB 104. As a non-limiting example, the data messages may be exchanged according to a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) protocol. In some embodiments, the non-emergency communication session may be performed in addition to the emergency location session and/or emergency communication session. In some cases, any or all of these sessions may be performed during overlapping time periods.

[0075] FIG. 7 illustrates example scenarios for communication of UE position information in accordance with some embodiments. FIG. 8 illustrates another example scenario for communication of UE position information in accordance with some embodiments. It should be noted that embodiments are not limited by the example scenarios 700, 750, and 800 shown in FIGs. 7-8, in terms of the number, arrangement or type of components or messages. As an example, the SUPL server 106 may be or may operate as an Emergency SUPL Location Platform (E-SLP) component in some cases, although embodiments are not limited as such. As another example, the E-SLP 106 may be responsible for emergency sessions. In some embodiments, the SUPL server 106 may be used for communication with the UE 102 for exchanging UE position information and/or other information in non-emergency scenarios. As another example, the UE 102 may be or may operate as a Target SUPL Enabled Terminal (SET) component in some cases, although embodiments are not limited as such. In some embodiments, the UE 102 may exchange UE position information with the SUPL server 106 and/or other component in non-emergency scenarios.

[0076] Embodiments are also not limited to the ordering of messages as shown in the example scenarios 700, 750, and 800. Some embodiments may or

may not necessarily include all messages shown in the example scenarios 700, 750, and 800, and some embodiments may include additional messages not shown in the example scenarios 700, 750, and 800. It should also be noted that in some embodiments, communication of messages like those shown in the example scenarios 700, 750, and 800, may be performed using a base station component, such as an eNB 104, AP, or other component, as a relay. In some embodiments, communication of messages like those shown in the example scenarios 700, 750, and 800, may be performed over a wireless link between the UE 102 and the SUPL server 106.

[0077] In the example scenario 700, the SUPL server 106 may transmit, to the UE 102, a SUPL INIT message 710 that may include an identifier of the SUPL server 106 (like an E-SLP address). In addition, the SUPL INIT message 710 may include a positioning mode to be used by the UE 102 for determination and/or communication of UE position information. As an example, the positioning mode may indicate if the UE 102 is to determine and/or calculate a final position of the UE 102 (such as in a Mobile System Based mode) or if the UE 102 is to provide measurement information to the SUPL server 106 to enable the SUPL server 106 to determine and/or calculate the final position of the UE 102 (such as in a Mobile System Assisted mode).

[0078] In some cases, the SUPL INIT message 710 may include additional parameters and/or information. The SUPL INIT message 710 may be transmitted using any suitable technique, including, but not limited to, SMS, mobile terminated (MT) SMS, Wireless Application Protocol (WAP) push, Universal Data Protocol (UDP) socket or others. In some embodiments, the SUPL INIT message 710 may be encoded using ASN.1 standards. The UE 102 may decode the SUPL INIT message 710. In some embodiments, the UE 102 may process the SUPL INIT message 710 and may determine whether or not there are any discrepancies between decoded information and expected information.

[0079] At operation 715, data connectivity for the UE 102 may be determined. Although not limited as such, the UE 102 may proceed with operation 715 based at least partly on the result of the decoding of the SUPL

INIT message 710. For instance, the UE 102 may perform operation 715 when it is determined that there are no discrepancies between the decoded information and the expected information as described previously. Although not limited as such, some or all techniques described herein for determination of data connectivity and/or establishment of a data connection may be used. The data connection may be or may include a TCP/IP connection, although embodiments are not limited as such and other types of data connection may be used in some cases.

[0080] Returning to the example scenario 700, as indicated by 715, the data connection in the example scenario 700 may be successfully established. The UE 102 may transmit a SUPL POS INIT message 730 to the SUPL server 106 on the data connection when the data connection is successfully established. Various SUPL POS messages 740 may be exchanged between the UE 102 and the SUPL server 106. As an example, the SUPL POS messages 740 may include information such as assistance data that may be used by the UE 102 for the determination of the UE position information. As another example, the messages 740 may include UE position information transmitted from the UE 102 to the SUPL server 106.

[0081] The UE 102 may determine and/or calculate UE position information for transmission to the SUPL server 106, as previously described. In some embodiments, the UE position information may include a final position of the UE 102. In some embodiments, the UE position information may include position information that may enable the SUPL server 106 to determine the final position of the UE 102. These embodiments are not limiting, however, as other UE position information may be determined in some cases.

[0082] The SUPL server 106 may transmit a SUPL END message 745 to terminate the emergency session. Accordingly, in the example scenario 700, the UE 102 may transmit the UE position information to the SUPL server 106 over the established data connection when the data connection is successfully established.

[0083] In the example scenario 750, a SUPL INIT message 760 may be transmitted by the SUPL server 106 to the UE 102. Although embodiments are

not limited as such, the SUPL INIT message 760 may be the same or similar to the SUPL INIT message 710 used in the example scenario 700 and some or all techniques previously described for the transmission of the SUPL INIT message 710 may be used. At operation 765, data connectivity for the UE 102 may be determined using techniques previously described regarding operation 715. As shown in FIG. 7, the establishment of the data connection may fail in this example scenario 750.

[0084] At operation 770, the UE 102 may determine and/or calculate UE position information for transmission to the SUPL server 106, as previously described. In some embodiments, the UE position information may include a final position of the UE 102. In some embodiments, the UE position information may include position information that may enable the SUPL server 106 to determine the final position of the UE 102. In some embodiments, the UE 102 may use autonomous positioning techniques for the determination of the UE position information. In some embodiments, the UE 102 may use recently determined UE position information at operation 770. These embodiments are not limiting, however, as other UE position information may be determined in some cases.

[0085] Due to the inability of the UE 102 to support the data connection or the failure of the establishment of the data connection, there may be a restricted capability of the UE 102 to report UE position information to the SUPL server 106 in the example scenario 750. In some cases, it may not be possible for the UE 102 to report the UE position information to the SUPL server 106.

[0086] In the example scenario 800, the UE 102 may receive the SUPL INIT message 810, which may be the same as or similar to the previously described messages in example scenarios 700 and/or 750. As in the example scenario 750, a data connection failure may occur or may be determined, as shown at 815 in FIG. 8. The UE 102 may determine and/or calculate UE position information at operation 820 using previously described techniques.

[0087] The UE 102 may communicate the UE position information to the SUPL server 106 using a SUPL END message 830, which may be included as

part of an SMS message. Accordingly, the UE 102 may be able to communicate the UE position information to the SUPL server 106 as part of the emergency communication session, even when the establishment of the data connection fails or is not possible.

[0088] FIG. 9 illustrates an example of a short messaging service (SMS) message in accordance with some embodiments. It should be noted that embodiments are not limited to the arrangement and/or elements shown in the SMS message 900. For instance, all parameters and/or information shown in FIG. 9 for the example SMS message 900 may not necessarily be included in some embodiments. In addition, the organization of the parameters and/or information shown in the example SMS message 900 is not limiting. In some embodiments, the UE 102 may transmit the SMS message 900 or a similar SMS message, to the SUPL server 106 to indicate the UE position information.

[0089] The SMS message 900 may include metadata 920 for the SMS message, which may include a mobile station international subscriber directory number (MSISDN) 921 (or other phone number of the UE 102), SMS center information 922, a time stamp 923 and/or any number (including zero) of other parameters, information or data blocks 924. In some cases, the metadata may be or may include a header for the SMS message 900.

[0090] The SMS message 900 may include an SMS payload 930. In some embodiments, the SMS payload 930 may be or may include a SUPL END message. The SMS payload 930 may also include UE position information, such as a SET position, UE position or other. Although embodiments are not limited as such, the SMS payload may be encoded using ASN1 or other techniques. The SMS message 900 may also include any number (including zero) of other parameters, information or data blocks 940.

[0091] FIG. 10 illustrates the operation of another method of communication of UE position information in accordance with some embodiments. As mentioned previously regarding the method 600, embodiments of the method 1000 may include additional or even fewer operations or processes in comparison to what is illustrated in FIG. 10 and embodiments of the method 1000 are not necessarily limited to the chronological

order that is shown in FIG. 10. In describing the method 1000, reference may be made to FIGs. 1-9 and 11-12, although it is understood that the method 1000 may be practiced with any other suitable systems, interfaces and components. In addition, embodiments of the method 1000 may refer to UEs 102, eNBs 104, SUPL servers, APs, STAs or other wireless or mobile devices. The method 1000 may also refer to an apparatus for a SUPL server 106, eNB 104 and/or UE 102 or other device described above.

[0092] It should be noted that the method 1000 may be practiced at a SUPL server 106 and may include exchanging of signals or messages with a UE 102 and/or eNB 104. Similarly, the method 600 may be practiced at a UE 102 and may include exchanging of signals or messages with a SUPL server 106 and/or eNB 104. In some cases, operations and techniques described as part of the method 600 may be relevant to the method 1000. In addition, embodiments may include operations performed at the SUPL server 106 that are reciprocal or similar to other operations described herein performed at the UE 102. For instance, an operation of the method 1000 may include reception of a message by the SUPL server 106 while an operation of the method 600 may include transmission of the same message or similar message by the UE 102.

[0093] In addition, previous discussion of various techniques and concepts may be applicable to the method 1000 in some cases, including the emergency communication session, emergency location session, UE position information, positioning assistance information, SUPL protocol, SUPL messages, data connectivity, and others. In addition, the example scenarios shown in FIGs. 7-8 and/or the example SMS message 900 shown in FIG. 9 may also be applicable, in some cases.

[0094] At operation 1005, the SUPL server 106 may receive, from an eNB 104, an emergency location initiation message for an initiation of an emergency location session between a UE 102 and the SUPL server 106. As previously described, messages and/or data exchanged between the SUPL server 106 and the UE 102 in the operations included in the method 1000 may be exchanged using the eNB 104 as a relay, although embodiments are not limited as such. Accordingly, as part of such operation as a relay, the eNB 104 may

receive messages and/or data from one of the components and may forward the messages and/or data to another component.

[0095] At operation 1010, the SUPL server 106 may transmit, to the eNB 104 for forwarding to the UE 102, a SUPL initiation message for the emergency location session. At operation 1015, the SUPL server 106 may receive one or more control messages from the eNB 104 for an intended establishment of a data connection between the UE 102 and the SUPL server 106.

[0096] At operation 1020, the SUPL server 106 may receive, from the UE 102, a short message service (SMS) message that includes UE position information for the emergency location session. In some embodiments, the SMS may be received from the UE 102 over a wireless link between the UE 102 and the SUPL server 106. These embodiments are not limiting, however, as the SMS may be received from the eNB 104 operating as a relay for the UE 102 in some embodiments.

[0097] In some embodiments, the SMS message may be received from the UE 102 when the attempted establishment of the data connection is unsuccessful. In some embodiments, the SMS message may be received from the UE 102 when data connectivity is unavailable to the UE 102 for any suitable reason, including but not limited to reasons described previously. In some cases, the UE position information included in the SMS message may indicate a cell identifier of the eNB 104 and/or cell identifiers of other eNBs 104 to which the UE 102 has previously communicated. Accordingly, the SUPL server 106 may be configured to parse the SMS message to extract such information.

[0098] At operation 1025, the SUPL server 106 may receive, from the eNB 104 operating as a relay for the UE 102, the UE position information over the data connection when the establishment of the data connection is successful.

[0099] At operation 1030, the SUPL server 106 may determine a UE position based at least partly on the received UE position information. In some cases, the UE position information may include a UE position that has been determined by the UE 102. At operation 1035, the SUPL server 106 may transmit the UE position and/or UE position information to a Public Safety Answering Point (PSAP) or other component.

[00100] In some embodiments, the SUPL server 106 may be configured to receive, from the UE 102, the UE position information either as part of an SMS message or over a data connection. The technique used by the UE 102 may depend on whether or not data connectivity is available to the UE 102. As an example, the SUPL server 106 may receive first UE position information from a first UE 102 as part of an SMS message and may receive second UE position information from a second UE 102 over a data connection with the second UE 102.

[00101] FIG. 11 illustrates the operation of another method of communication of UE position information in accordance with some embodiments. Some embodiments of the method 1100 may include additional or even fewer operations or processes in comparison to what is illustrated in FIG. 11 and embodiments of the method 1100 are not necessarily limited to the chronological order that is shown in FIG. 11. In describing the method 1100, reference may be made to FIGs. 1-10 and 12, although it is understood that the method 1000 may be practiced with any other suitable systems, interfaces and components. In addition, embodiments of the method 1100 may refer to UEs 102, eNBs 104, SUPL servers 106, APs, STAs or other wireless or mobile devices. The method 1100 may also refer to an apparatus for a SUPL server 106 and/or eNB 104 and/or UE 102 or other device described above.

[00102] It should be noted that the method 1100 may be practiced at a UE 102 and may include exchanging of signals or messages with a SUPL server 106 and/or eNB 104. In some embodiments, a SUPL server 106 may be configured to perform related operations and/or reciprocal operations. In some embodiments, an eNB 104 may be configured to perform related operations and/or reciprocal operations. For instance, an operation of the method 1100 may include reception of a message by the UE 102 received from the SUPL server 106 through the eNB 104 operating as a relay. In some embodiments, a SUPL server 106 may be configured to transmit the same message or similar message. In some embodiments, an eNB 104 may be configured to receive the same message or similar message from the SUPL server 106 and to forward it to the UE 102.

[00103] In addition, previous discussion of various techniques and concepts may be applicable to the method 1100 in some cases, including the emergency communication session, emergency location session, UE position information, positioning assistance information, SUPL protocol, SUPL messages, data connectivity, non-emergency communication sessions, non-emergency location sessions, other SUPL sessions, and other techniques and concepts.

[00104] In some embodiments of the method 1100, a SUPL location session may be initiated for the UE 102. The SUPL location session may be a non-emergency location session in some cases, although embodiments are not limited as such. As previously described, messages may be exchanged between the UE 102 and the SUPL server 106 using the eNB 104 as a relay, in some cases, although embodiments are not limited as such. In some embodiments, an AP or other base station component may be used as a relay.

[00105] At operation 1105, the UE 102 may transmit, to the SUPL server 106, a SUPL initiation message for a SUPL location session between the UE 102 and the SUPL server 106. At operation 1110, the UE 102 may receive, from the SUPL server 106, a SUPL response message that indicates a positioning method to be used, by the UE, for determination of a UE position. In some embodiments, the positioning method may indicate whether the UE 102 is to determine the UE position or determine one or more UE position measurements to enable a determination of the UE position by the SUPL server 106.

[00106] As a non-limiting example, the UE position may be determined by the UE 102 based on one or more measurements for reception of global navigation satellite system (GNSS) signals at the UE 102. As another non-limiting example, the UE position may be determined by the UE 102 based on one or more measurements for reception, at the UE 102, of downlink signals from one or more eNBs 104. It should be noted that embodiments are not limited to determination and/or communication of a UE position, as other related UE position information may also be determined and/or communicated in some cases. For instance, measurements may be transmitted to the SUPL server 106 to enable the SUPL server 106 to determine the UE position in some cases.

[00107] At operation 1115, the UE 102 may transmit, to the SUPL server 106, a SUPL position initialization message that indicates a request for positioning assistance information for usage in the determination of the UE position. In some embodiments, when a previous UE position is available to the UE 102, the SUPL position initialization message may include the previous UE position. Accordingly, the previous UE position may be included for usage, by the SUPL server 106, in a determination of the positioning assistance information to be sent to the UE 102. That is, the information may assist the SUPL server 106 in determining the appropriate positioning assistance information to send to the UE 102. In some embodiments, the SUPL position initialization message may include the previous UE position when the previous UE position is also determined to be current based on an elapsed time since a determination of the previous UE position. That is, when the UE position is not older than a certain time duration, it may be considered current and may be included.

[00108] At operation 1120, the UE 102 may receive the positioning assistance information from the SUPL server 106. At operation 1125, the UE 102 may determine the UE position. At operation 1130, the UE 102 may transmit, to the SUPL server 106, one or more SUPL position messages that include the determined UE position. It should be noted that other UE position information may be used instead of or in addition to the UE position. In some cases, the UE position and/or other UE position information may be determined based at least partly on the received positioning assistance information.

[00109] In some embodiments, the UE 102 may store one or more previous UE positions and/or other UE position information. When the UE 102 is to update the UE position through the SUPL location session or otherwise, the UE 102 may determine if the stored UE position may still be relevant for the updating. That is, the UE 102 may determine whether the stored UE position is current based on an elapsed time since it was determined or other measure. In some cases, the stored UE position may be considered a coarse location of the UE 102. The UE 102 may send the stored UE position, a time at which the stored UE position was determined, a location ID for the eNB 104, and/or other

related information. The SUPL server 106 may determine if it can use the coarse location sent by the UE 102. The SUPL server 106 may also determine whether the positioning assistance information sent to the UE 102 is to be based on the coarse location sent by the UE 102 or on the location ID sent by the UE 102. Accordingly, the SUPL server 106 may be provided with a coarse location of the UE 102 by the UE 102. The stored UE position (coarse location) may be determined by the UE 102 using any suitable technique such as SUPL techniques, autonomous positioning determination techniques and/or other techniques. In some cases, the SUPL server 106 may store the coarse location and the location ID as part of an information repository for usage in determination of locations for the UE 102, other UEs 102 and/or other devices, or for usage in other tasks.

[00110] FIG. 12 illustrates examples of communication of UE position information in accordance with some embodiments. It should be noted that embodiments are not limited to the components shown in the example scenarios 1200, 1250 and are also not limited to the ordering or type of messages shown in FIG. 12. For instance, the UE 102 is illustrated as a SUPL Agent / Target SET and the SUPL server 106 is illustrated as a Home SLP in the example scenario 1200, but embodiments are not limited to such components or configurations.

[00111] In the example scenario 1200, the UE 102 may initiate a SUPL session by transmitting the SUPL START message 1210. Although embodiments are not limited as such, the SUPL session may be or may be similar to the SUPL location session or other location sessions previously described. In addition, the SUPL START message 1210 may be or may be similar to the SUPL initiation message or other initiation messages previously described. The SUPL START message 1210 may include information about the session, capabilities and/or configuration information of the UE 102, a location ID and/or other information.

[00112] The SUPL server 106 may respond with a SUPL RESPONSE message 1220 that may include a positioning method to be used by the UE 102 and/or other information. The UE 102 may respond with a SUPL POS INIT message 1225 that may indicate a request for assistance data, such as positioning

assistance data or other data. One or more SUPL POS messages 1230 may be exchanged between the UE 102 and the SUPL server 106, and may include information such as the assistance data.

[00113] Based on the positioning method sent in the SUPL RESPONSE message 1220, the UE 102 or the SUPL server 106 may determine a final position of the UE 102. Accordingly, the SUPL server 106 may transmit a SUPL END message 1235 that may either indicate the end of the assistance data delivery or provide the UE position (as determined by the SUPL server 106) to the UE 102. The SUPL session may end after the transmission of the SUPL END message 1235.

[00114] As an example, the SUPL POS INIT message 1225 may include an optional “position” field. In some cases, the field may be used by the UE 102 to send its determined position to the SUPL server 106. For instance, when the UE 102 determines that a previously determined UE position is sufficiently accurate, the UE 102 may use the position field to send the UE position to the SUPL server 106. In some cases, such as when a sufficiently accurate UE position is not stored and/or available to the UE 102, the position field may be used by the UE 102 to transmit a coarse location to the SUPL server 106. Accordingly, if the position field is populated with a valid (or sufficiently accurate) UE position and if a “requestedAssistData” field is also present, the SUPL server 106 may assume that the UE position sent in the SUPL POS INIT message 1225 is the coarse location and may use it accordingly (such as to determine which assistance data to send to the UE 102). The UE 102 may send its previously determined UE position, the “requestedAssistData” field may be set to FALSE or other value to indicate to the SUPL server 106 that the UE 102 does not require the assistance data.

[00115] In the example scenario 1250, the UE 102 and the SLP 106 may exchange SUPL messages 1260-1280, which may be similar to messages described regarding the scenario 1200, although embodiments are not limited as such. The UE 102 may determine and/or calculate a UE position or other UE position information as shown at operation 1285.

[00116] FIG. 13 illustrates a block diagram of an example machine in accordance with some embodiments. The machine 1300 is an example machine upon which any one or more of the techniques and/or methodologies discussed herein may be performed. In alternative embodiments, the machine 1300 may operate as a standalone device or may be connected (e.g., networked) to other machines. In a networked deployment, the machine 1300 may operate in the capacity of a server machine, a client machine, or both in server-client network environments. In an example, the machine 1300 may act as a peer machine in peer-to-peer (P2P) (or other distributed) network environment. The machine 1300 may be a UE 102, eNB 104, access point (AP), station (STA), mobile device, base station, personal computer (PC), a tablet PC, a set-top box (STB), a personal digital assistant (PDA), a mobile telephone, a smart phone, a web appliance, a network router, switch or bridge, or any machine capable of executing instructions (sequential or otherwise) that specify actions to be taken by that machine. It should be noted that in some embodiments, an eNB or other base station may include some or all of the components shown in either FIG. 3 or FIG. 13 or both. It should be noted that in some embodiments, a UE or other mobile device may include some or all of the components shown in either FIG. 2 or FIG. 13 or both. Further, while only a single machine is illustrated, the term “machine” shall also be taken to include any collection of machines that individually or jointly execute a set (or multiple sets) of instructions to perform any one or more of the methodologies discussed herein, such as cloud computing, software as a service (SaaS), other computer cluster configurations.

[00117] Examples as described herein, may include, or may operate on, logic or a number of components, modules, or mechanisms. Modules are tangible entities (e.g., hardware) capable of performing specified operations and may be configured or arranged in a certain manner. In an example, circuits may be arranged (e.g., internally or with respect to external entities such as other circuits) in a specified manner as a module. In an example, the whole or part of one or more computer systems (e.g., a standalone, client or server computer system) or one or more hardware processors may be configured by firmware or software (e.g., instructions, an application portion, or an application) as a module

that operates to perform specified operations. In an example, the software may reside on a machine readable medium. In an example, the software, when executed by the underlying hardware of the module, causes the hardware to perform the specified operations.

[00118] Accordingly, the term “module” is understood to encompass a tangible entity, be that an entity that is physically constructed, specifically configured (e.g., hardwired), or temporarily (e.g., transitorily) configured (e.g., programmed) to operate in a specified manner or to perform part or all of any operation described herein. Considering examples in which modules are temporarily configured, each of the modules need not be instantiated at any one moment in time. For example, where the modules comprise a general-purpose hardware processor configured using software, the general-purpose hardware processor may be configured as respective different modules at different times. Software may accordingly configure a hardware processor, for example, to constitute a particular module at one instance of time and to constitute a different module at a different instance of time.

[00119] The machine (e.g., computer system) 1300 may include a hardware processor 1302 (e.g., a central processing unit (CPU), a graphics processing unit (GPU), a hardware processor core, or any combination thereof), a main memory 1304 and a static memory 1306, some or all of which may communicate with each other via an interlink (e.g., bus) 1308. The machine 1300 may further include a display unit 1310, an alphanumeric input device 1312 (e.g., a keyboard), and a user interface (UI) navigation device 1314 (e.g., a mouse). In an example, the display unit 1310, input device 1312 and UI navigation device 1314 may be a touch screen display. The machine 1300 may additionally include a storage device (e.g., drive unit) 1316, a signal generation device 1318 (e.g., a speaker), a network interface device 1320, and one or more sensors 1321, such as a global positioning system (GPS) sensor, compass, accelerometer, or other sensor. The machine 1300 may include an output controller 1328, such as a serial (e.g., universal serial bus (USB), parallel, or other wired or wireless (e.g., infrared (IR), near field communication (NFC),

etc.) connection to communicate or control one or more peripheral devices (e.g., a printer, card reader, etc.).

[00120] The storage device 1316 may include a machine readable medium 1322 on which is stored one or more sets of data structures or instructions 1324 (e.g., software) embodying or utilized by any one or more of the techniques or functions described herein. The instructions 1324 may also reside, completely or at least partially, within the main memory 1304, within static memory 1306, or within the hardware processor 1302 during execution thereof by the machine 1300. In an example, one or any combination of the hardware processor 1302, the main memory 1304, the static memory 1306, or the storage device 1316 may constitute machine readable media. In some embodiments, the machine readable medium may be or may include a non-transitory computer-readable storage medium.

[00121] Various embodiments may be implemented fully or partially in software and/or firmware. This software and/or firmware may take the form of instructions contained in or on a non-transitory computer-readable storage medium. Those instructions may then be read and executed by one or more processors to enable performance of the operations described herein. The instructions may be in any suitable form, such as but not limited to source code, compiled code, interpreted code, executable code, static code, dynamic code, and the like. Such a computer-readable medium may include any tangible non-transitory medium for storing information in a form readable by one or more computers, such as but not limited to read only memory (ROM); random access memory (RAM); magnetic disk storage media; optical storage media; and/or a flash memory.

[00122] While the machine readable medium 1322 is illustrated as a single medium, the term "machine readable medium" may include a single medium or multiple media (e.g., a centralized or distributed database, and/or associated caches and servers) configured to store the one or more instructions 1324. The term "machine readable medium" may include any medium that is capable of storing, encoding, or carrying instructions for execution by the machine 1300 and that cause the machine 1300 to perform any one or more of

the techniques of the present disclosure, or that is capable of storing, encoding or carrying data structures used by or associated with such instructions. Non-limiting machine readable medium examples may include solid-state memories, and optical and magnetic media. Specific examples of machine readable media may include: non-volatile memory, such as semiconductor memory devices (e.g., Electrically Programmable Read-Only Memory (EPROM), Electrically Erasable Programmable Read-Only Memory (EEPROM)) and flash memory devices; magnetic disks, such as internal hard disks and removable disks; magneto-optical disks; Random Access Memory (RAM); and CD-ROM and DVD-ROM disks. In some examples, machine readable media may include non-transitory machine readable media. In some examples, machine readable media may include machine readable media that is not a transitory propagating signal.

[00123] The instructions 1324 may further be transmitted or received over a communications network 1326 using a transmission medium via the network interface device 1320 utilizing any one of a number of transfer protocols (e.g., frame relay, internet protocol (IP), transmission control protocol (TCP), user datagram protocol (UDP), hypertext transfer protocol (HTTP), etc.). Example communication networks may include a local area network (LAN), a wide area network (WAN), a packet data network (e.g., the Internet), mobile telephone networks (e.g., cellular networks), Plain Old Telephone (POTS) networks, and wireless data networks (e.g., Institute of Electrical and Electronics Engineers (IEEE) 802.11 family of standards known as Wi-Fi®, IEEE 802.16 family of standards known as WiMax®, IEEE 802.15.4 family of standards, a Long Term Evolution (LTE) family of standards, a Universal Mobile Telecommunications System (UMTS) family of standards, peer-to-peer (P2P) networks, among others. In an example, the network interface device 1320 may include one or more physical jacks (e.g., Ethernet, coaxial, or phone jacks) or one or more antennas to connect to the communications network 1326. In an example, the network interface device 1320 may include a plurality of antennas to wirelessly communicate using at least one of single-input multiple-output (SIMO), multiple-input multiple-output (MIMO), or multiple-input single-output (MISO) techniques. In some examples, the network interface device 1320 may

wirelessly communicate using Multiple User MIMO techniques. The term “transmission medium” shall be taken to include any intangible medium that is capable of storing, encoding or carrying instructions for execution by the machine 1300, and includes digital or analog communications signals or other intangible medium to facilitate communication of such software.

[00124] In Example 1, an apparatus for User Equipment (UE) may comprise transceiver circuitry and hardware processing circuitry. The hardware processing circuitry may configure the transceiver circuitry to receive, from an Evolved Node-B (eNB), a Secure User Plane Location (SUPL) initiation message for an emergency location session between the UE and a SUPL server. The hardware processing circuitry may further configure the transceiver circuitry to transmit one or more control messages to the eNB for forwarding to the SUPL server for an intended establishment of a data connection between the UE and the SUPL server. The hardware processing circuitry may further configure the transceiver circuitry to, when the establishment of the data connection succeeds, transmit, on the data connection, UE position information for the emergency location session. The hardware processing circuitry may further configure the transceiver circuitry to, when the establishment of the data connection fails, transmit a short message service (SMS) message to the SUPL server, wherein the SMS message includes the UE position information.

[00125] In Example 2, the subject matter of Example 1, wherein the UE position information may be based on one or more measurements for reception, at the UE, of positioning signals from one or more satellites.

[00126] In Example 3, the subject matter of one or any combination of Examples 1-2, wherein the SUPL initiation message may indicate either that the UE is to determine, based on the measurements, a UE position for inclusion in the UE position information or that the UE position information is to include the measurements to enable a determination of the UE position by the SUPL server.

[00127] In Example 4, the subject matter of one or any combination of Examples 1-3, wherein the UE position information included in the SMS message may indicate a cell identifier of the eNB and/or cell identifiers of one or more other eNBs to which the UE has previously communicated.

[00128] In Example 5, the subject matter of one or any combination of Examples 1-4, wherein the data connection may include a Transport Control Protocol / Internet Protocol (TCP/IP) data connection.

[00129] In Example 6, the subject matter of one or any combination of Examples 1-5, wherein the SMS message may include control metadata for the SMS message and may further include a data payload that includes the UE position information. The control metadata may include an identifier of the UE and a time stamp for the SMS message.

[00130] In Example 7, the subject matter of one or any combination of Examples 1-6, wherein the identifier of the UE may include a mobile station international subscriber directory number (MSISDN) of the UE.

[00131] In Example 8, the subject matter of one or any combination of Examples 1-7, wherein the SMS message may include an uplink SUPL end message that indicates a termination of the emergency location session. The hardware processing circuitry may further configure the transceiver circuitry to, when the establishment of the data connection succeeds, receive a downlink SUPL end message from the SUPL server that indicates the termination of the emergency location session.

[00132] In Example 9, the subject matter of one or any combination of Examples 1-8, wherein the hardware processing circuitry may be configured to determine the UE position information based at least partly on positioning assistance information received from the SUPL server. The positioning assistance information may be based on previous UE position information.

[00133] In Example 10, the subject matter of one or any combination of Examples 1-9, wherein the SUPL initiation message received at the UE may be included in an SMS message that is forwarded to the UE by the eNB operating as a relay for the SUPL server.

[00134] In Example 11, the subject matter of one or any combination of Examples 1-10, wherein the hardware processing circuitry may further configure the transceiver circuitry to transmit, to the eNB, an emergency communication initiation message for an initiation of an emergency communication session between the UE and a Public Safety Answering Point (PSAP). The emergency

location session may be established in response to the initiation of the emergency communication session.

[00135] In Example 12, the subject matter of one or any combination of Examples 1-11, wherein the emergency communication initiation message may be transmitted at least partly in response to a reception, at the UE, of user input that indicates a request for the emergency communication session.

[00136] In Example 13, the subject matter of one or any combination of Examples 1-12, wherein the UE may be configured to operate as a SUPL Enabled Terminal (SET) to support the emergency location session.

[00137] In Example 14, the subject matter of one or any combination of Examples 1-13, wherein the UE and the eNB may be arranged to operate according to a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) protocol. The hardware processing circuitry may further configure the transceiver circuitry to transmit, as part of a non-emergency communication session, one or more data messages to the eNB according to the 3GPP LTE protocol.

[00138] In Example 15, the subject matter of one or any combination of Examples 1-14, wherein the apparatus may further include one or more antennas coupled to the transceiver circuitry for the reception of the SUPL initiation message and for the transmission of the control messages for the intended establishment of the data connection.

[00139] In Example 16, a non-transitory computer-readable storage medium may store instructions for execution by one or more processors to perform operations for communication by a User Equipment (UE). The operations may configure the one or more processors to determine whether data connectivity is available between the UE and an Evolved Node-B (eNB). The operations may further configure the one or more processors to configure the UE to, when it is determined that the data connectivity is unavailable, transmit a short message service (SMS) message to a Secure User Plane Location (SUPL) server. The SMS may include UE position information for an emergency location session between the UE and the SUPL server. The operations may further configure the one or more processors to configure the UE to, when it is

determined that the data connectivity is available, transmit the UE position information in one or more data messages on a data connection between the UE and the eNB. The data messages may be transmitted to the eNB for forwarding to the SUPL server.

[00140] In Example 17, the subject matter of Example 16, wherein the operations may further configure the one or more processors to configure the UE to transmit one or more control messages to the eNB for forwarding to the SUPL server for an intended establishment of a data connection between the UE and the SUPL server. The availability of the data connectivity may be based on whether the establishment of the data connection succeeds.

[00141] In Example 18, the subject matter of one or any combination of Examples 16-17, wherein the availability of the data connectivity may be based at least partly on whether the UE is configured to support a data connection between the UE and the eNB.

[00142] In Example 19, the subject matter of one or any combination of Examples 16-18, wherein the data connectivity may be based on an establishment of a Transport Control Protocol / Internet Protocol (TCP/IP) data connection between the UE and the SUPL server.

[00143] In Example 20, the subject matter of one or any combination of Examples 16-19, wherein the SMS message may include control metadata for the SMS message and may further include a data payload that includes the UE position information.

[00144] In Example 21, the subject matter of one or any combination of Examples 16-20, wherein the operations may further configure the one or more processors to configure the UE to receive, from the eNB, a SUPL initiation message for the emergency location session. The operations may further configure the one or more processors to determine the UE position information based at least partly on a positioning method indicated by the SUPL initiation message.

[00145] In Example 22, an apparatus for a Secure User Plane Location (SUPL) server may comprise transceiver circuitry and hardware processing circuitry. The hardware processing circuitry may configure the transceiver

circuitry to receive, from an Evolved Node-B (eNB), an emergency location initiation message for an initiation of an emergency location session between the SUPL server and a User Equipment (UE). The hardware processing circuitry may further configure the transceiver circuitry to transmit, to the eNB for forwarding to the UE, a SUPL initiation message for the emergency location session. The hardware processing circuitry may further configure the transceiver circuitry to receive, from the UE, a short message service (SMS) message that includes UE position information for the emergency location session. The SMS message may be received over a wireless link between the UE and the SUPL server. The SMS message may include control metadata for the SMS message and further includes a data payload that includes the UE position information.

[00146] In Example 23, the subject matter of Example 22, wherein the control metadata may include an identifier of the UE and a time stamp for the SMS message.

[00147] In Example 24, the subject matter of one or any combination of Examples 22-23, wherein the UE position information included in the SMS message may indicate a cell identifier of the eNB and/or cell identifiers of other eNBs to which the UE has previously communicated.

[00148] In Example 25, the subject matter of one or any combination of Examples 22-24, wherein the hardware processing circuitry may be configured to determine a UE position based at least partly on the received UE position information.

[00149] In Example 26, the subject matter of one or any combination of Examples 22-25, wherein the hardware processing circuitry may further configure the transceiver circuitry to receive, from the eNB, an emergency location initiation message for an initiation of a second emergency location session between the SUPL server and a second UE. The hardware processing circuitry may further configure the transceiver circuitry to receive, from the eNB operating as a relay for the second UE, second UE position information for the second emergency location session. The second UE position information may be received on a Transport Control Protocol / Internet Protocol (TCP/IP) data connection between the second UE and the SUPL server.

[00150] In Example 27, the subject matter of one or any combination of Examples 22-26, wherein the apparatus further includes one or more antennas coupled to the transceiver circuitry for the reception of the SMS message from the UE.

[00151] In Example 28, an apparatus for User Equipment (UE) may comprise transceiver circuitry and hardware processing circuitry. The hardware processing circuitry may configure the transceiver circuitry to transmit, to a Secure User Plane Location (SUPL) server, a SUPL initiation message for a SUPL location session between the UE and the SUPL server. The hardware processing circuitry may configure the transceiver circuitry to receive, from the SUPL server, a SUPL response message that indicates a positioning method to be used, by the UE, for determination of a UE position. The hardware processing circuitry may configure the transceiver circuitry to transmit, to the SUPL server, a SUPL position initialization message that indicates a request for positioning assistance information for usage in the determination of the UE position. When a previous UE position is available to the UE, the SUPL position initialization message may include the previous UE position.

[00152] In Example 29, the subject matter of Example 28, wherein the previous UE position may be included for usage, by the SUPL server, in a determination of the positioning assistance information to be sent to the UE.

[00153] In Example 30, the subject matter of one or any combination of Examples 28-29, wherein the UE position may be based on one or more measurements for reception of global navigation satellite system (GNSS) signals at the UE.

[00154] In Example 31, the subject matter of one or any combination of Examples 28-30, wherein the SUPL initiation message, the SUPL response message, and the SUPL position initialization message may be exchanged between the UE and the SUPL server using an Evolved Node-B (eNB) as a relay. The SUPL position initialization message may include a location identifier based on an identifier of the eNB.

[00155] In Example 32, the subject matter of one or any combination of Examples 28-31, wherein the SUPL initiation message, the SUPL response

message, and the SUPL position initialization message may be exchanged between the UE and the SUPL server using a Wireless Local Area Network (WLAN) access point (AP) as a relay. The SUPL position initialization message may include a location identifier based on an identifier of the WLAN AP.

[00156] In Example 33, the subject matter of one or any combination of Examples 28-32, wherein the SUPL position initialization message may include the previous UE position when the previous UE position is also determined to be current based on an elapsed time since a determination of the previous UE position.

[00157] In Example 34, the subject matter of one or any combination of Examples 28-33, wherein the hardware processing circuitry may further configure the transceiver circuitry to receive the positioning assistance information from the SUPL server. The hardware processing circuitry may be configured to determine the UE position based at least partly on the received positioning assistance information. The hardware processing circuitry may further configure the transceiver circuitry to transmit, to the SUPL server, one or more SUPL position messages that include the UE position.

[00158] In Example 35, the subject matter of one or any combination of Examples 28-34, wherein the positioning method indicates either that the UE is to determine the UE position or that the UE is to determine one or more UE position measurements to enable a determination of the UE position by the SUPL server.

[00159] In Example 36, the subject matter of one or any combination of Examples 28-35, wherein the UE may be configured to operate as a SUPL Enabled Terminal (SET) to support the SUPL location session.

[00160] In Example 37, the subject matter of one or any combination of Examples 28-36, wherein the apparatus may further include one or more antennas coupled to the transceiver circuitry for the transmission of the SUPL initiation message, the transmission of the SUPL position initialization message, and the reception of the SUPL response message.

[00161] The Abstract is provided to comply with 37 C.F.R. Section 1.72(b) requiring an abstract that will allow the reader to ascertain the nature and

gist of the technical disclosure. It is submitted with the understanding that it will not be used to limit or interpret the scope or meaning of the claims. The following claims are hereby incorporated into the detailed description, with each claim standing on its own as a separate embodiment.

CLAIMS

What is claimed is:

1. An apparatus for User Equipment (UE), the apparatus comprising transceiver circuitry and hardware processing circuitry, the hardware processing circuitry to configure the transceiver circuitry to:

receive, from an Evolved Node-B (eNB), a Secure User Plane Location (SUPL) initiation message for an emergency location session between the UE and a SUPL server;

transmit one or more control messages to the eNB for forwarding to the SUPL server for an intended establishment of a data connection between the UE and the SUPL server;

when the establishment of the data connection succeeds, transmit, on the data connection, UE position information for the emergency location session; and

when the establishment of the data connection fails, transmit a short message service (SMS) message to the SUPL server, wherein the SMS message includes the UE position information.

2. The apparatus according to claim 1, wherein the UE position information is based on one or more measurements for reception, at the UE, of positioning signals from one or more satellites.

3. The apparatus according to claim 2, wherein the SUPL initiation message indicates either:

that the UE is to determine, based on the measurements, a UE position for inclusion in the UE position information, or

that the UE position information is to include the measurements to enable a determination of the UE position by the SUPL server.

4. The apparatus according to claim 1, wherein the UE position information included in the SMS message indicates a cell identifier of the eNB and/or cell identifiers of one or more other eNBs to which the UE has previously communicated.

5. The apparatus according to claim 1, wherein the data connection includes a Transport Control Protocol / Internet Protocol (TCP/IP) data connection.

6. The apparatus according to claim 1, wherein:
the SMS message includes control metadata for the SMS message and further includes a data payload that includes the UE position information, and
the control metadata includes an identifier of the UE and a time stamp for the SMS message.

7. The apparatus according to claim 6, wherein the identifier of the UE includes a mobile station international subscriber directory number (MSISDN) of the UE.

8. The apparatus according to claim 1, wherein:
the SMS message includes an uplink SUPL end message that indicates a termination of the emergency location session, and
the hardware processing circuitry is to further configure the transceiver circuitry to, when the establishment of the data connection succeeds, receive a downlink SUPL end message from the SUPL server that indicates the termination of the emergency location session.

9. The apparatus according to claim 1, wherein:
the hardware processing circuitry is configured to determine the UE position information based at least partly on positioning assistance information received from the SUPL server, and

the positioning assistance information is based on previous UE position information.

10. The apparatus according to claim 1, wherein the SUPL initiation message received at the UE is included in an SMS message that is forwarded to the UE by the eNB operating as a relay for the SUPL server.

11. The apparatus according to claim 1, wherein:
the hardware processing circuitry is to further configure the transceiver circuitry to transmit, to the eNB, an emergency communication initiation message for an initiation of an emergency communication session between the UE and a Public Safety Answering Point (PSAP), and
the emergency location session is established in response to the initiation of the emergency communication session.

12. The apparatus according to claim 11, wherein the emergency communication initiation message is transmitted at least partly in response to a reception, at the UE, of user input that indicates a request for the emergency communication session.

13. The apparatus according to claim 1, wherein the UE is configured to operate as a SUPL Enabled Terminal (SET) to support the emergency location session.

14. The apparatus according to claim 1, wherein:
the UE and the eNB are arranged to operate according to a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) protocol, and
the hardware processing circuitry is to further configure the transceiver circuitry to transmit, as part of a non-emergency communication session, one or more data messages to the eNB according to the 3GPP LTE protocol.

15. The apparatus according to claim 1, wherein the apparatus further includes one or more antennas coupled to the transceiver circuitry for the reception of the SUPL initiation message and for the transmission of the control messages for the intended establishment of the data connection.

16. A computer-readable storage medium that stores instructions for execution by one or more processors to perform operations for communication by a User Equipment (UE), the operations to configure the one or more processors to:

determine whether data connectivity is available between the UE and an Evolved Node-B (eNB);

configure the UE to, when it is determined that the data connectivity is unavailable, transmit a short message service (SMS) message to a Secure User Plane Location (SUPL) server, wherein the SMS includes UE position information for an emergency location session between the UE and the SUPL server; and

configure the UE to, when it is determined that the data connectivity is available, transmit the UE position information in one or more data messages on a data connection between the UE and the eNB, the data messages transmitted to the eNB for forwarding to the SUPL server.

17. The computer-readable storage medium according to claim 16, wherein:

the operations further configure the one or more processors to configure the UE to transmit one or more control messages to the eNB for forwarding to the SUPL server for an intended establishment of a data connection between the UE and the SUPL server, and

the availability of the data connectivity is based on whether the establishment of the data connection succeeds.

18. The computer-readable storage medium according to claim 16, wherein the availability of the data connectivity is based at least partly on

whether the UE is configured to support a data connection between the UE and the eNB.

19. The computer-readable storage medium according to claim 16, wherein the data connectivity is based on an establishment of a Transport Control Protocol / Internet Protocol (TCP/IP) data connection between the UE and the SUPL server.

20. The computer-readable storage medium according to claim 16, wherein the SMS message includes control metadata for the SMS message and further includes a data payload that includes the UE position information.

21. The computer-readable storage medium according to claim 16, the operations to further configure the one or more processors to:

configure the UE to receive, from the eNB, a SUPL initiation message for the emergency location session; and

determine the UE position information based at least partly on a positioning method indicated by the SUPL initiation message.

22. An apparatus for a Secure User Plane Location (SUPL) server, the apparatus comprising transceiver circuitry and hardware processing circuitry, the hardware processing circuitry to configure the transceiver circuitry to:

receive, from an Evolved Node-B (eNB), an emergency location initiation message for an initiation of an emergency location session between the SUPL server and a User Equipment (UE);

transmit, to the eNB for forwarding to the UE, a SUPL initiation message for the emergency location session; and

receive, from the UE, a short message service (SMS) message that includes UE position information for the emergency location session, the SMS message received over a wireless link between the UE and the SUPL server,

wherein the SMS message includes control metadata for the SMS message and further includes a data payload that includes the UE position information.

23. The apparatus according to claim 22, wherein the control metadata includes an identifier of the UE and a time stamp for the SMS message.

24. The apparatus according to claim 22, wherein the UE position information included in the SMS message indicates a cell identifier of the eNB and/or cell identifiers of other eNBs to which the UE has previously communicated.

25. The apparatus according to claim 22, wherein the hardware processing circuitry is configured to determine a UE position based at least partly on the received UE position information.

26. The apparatus according to claim 22, the hardware processing circuitry to further configure the transceiver circuitry to:

receive, from the eNB, an emergency location initiation message for an initiation of a second emergency location session between the SUPL server and a second UE;

receive, from the eNB operating as a relay for the second UE, second UE position information for the second emergency location session,

wherein the second UE position information is received on a Transport Control Protocol / Internet Protocol (TCP/IP) data connection between the second UE and the SUPL server.

27. The apparatus according to claim 22, wherein the apparatus further includes one or more antennas coupled to the transceiver circuitry for the reception of the SMS message from the UE.

28. An apparatus for User Equipment (UE), the apparatus comprising transceiver circuitry and hardware processing circuitry, the hardware processing circuitry to configure the transceiver circuitry to:

transmit, to a Secure User Plane Location (SUPL) server, a SUPL initiation message for a SUPL location session between the UE and the SUPL server;

receive, from the SUPL server, a SUPL response message that indicates a positioning method to be used, by the UE, for determination of a UE position; and

transmit, to the SUPL server, a SUPL position initialization message that indicates a request for positioning assistance information for usage in the determination of the UE position;

wherein when a previous UE position is available to the UE, the SUPL position initialization message includes the previous UE position.

29. The apparatus according to claim 28, wherein the previous UE position is included for usage, by the SUPL server, in a determination of the positioning assistance information to be sent to the UE.

30. The apparatus according to claim 28, wherein the UE position is based on one or more measurements for reception of global navigation satellite system (GNSS) signals at the UE.

31. The apparatus according to claim 28, wherein:

the SUPL initiation message, the SUPL response message, and the SUPL position initialization message are exchanged between the UE and the SUPL server using an Evolved Node-B (eNB) as a relay, and

the SUPL position initialization message includes a location identifier based on an identifier of the eNB.

32. The apparatus according to claim 28, wherein:

the SUPL initiation message, the SUPL response message, and the SUPL position initialization message are exchanged between the UE and the SUPL server using a Wireless Local Area Network (WLAN) access point (AP) as a relay, and

the SUPL position initialization message includes a location identifier based on an identifier of the WLAN AP.

33. The apparatus according to claim 28, wherein the SUPL position initialization message includes the previous UE position when the previous UE position is also determined to be current based on an elapsed time since a determination of the previous UE position.

34. The apparatus according to claim 28, wherein the hardware processing circuitry is configured to:

configure the transceiver circuitry to receive the positioning assistance information from the SUPL server;

determine the UE position based at least partly on the received positioning assistance information; and

configure the transceiver circuitry to transmit, to the SUPL server, one or more SUPL position messages that include the UE position.

35. The apparatus according to claim 28, wherein the positioning method indicates either:

that the UE is to determine the UE position, or

that the UE is to determine one or more UE position measurements to enable a determination of the UE position by the SUPL server.

36. The apparatus according to claim 28, wherein the UE is configured to operate as a SUPL Enabled Terminal (SET) to support the SUPL location session.

37. The apparatus according to claim 28, wherein the apparatus further includes one or more antennas coupled to the transceiver circuitry for the transmission of the SUPL initiation message, the transmission of the SUPL position initialization message, and the reception of the SUPL response message.

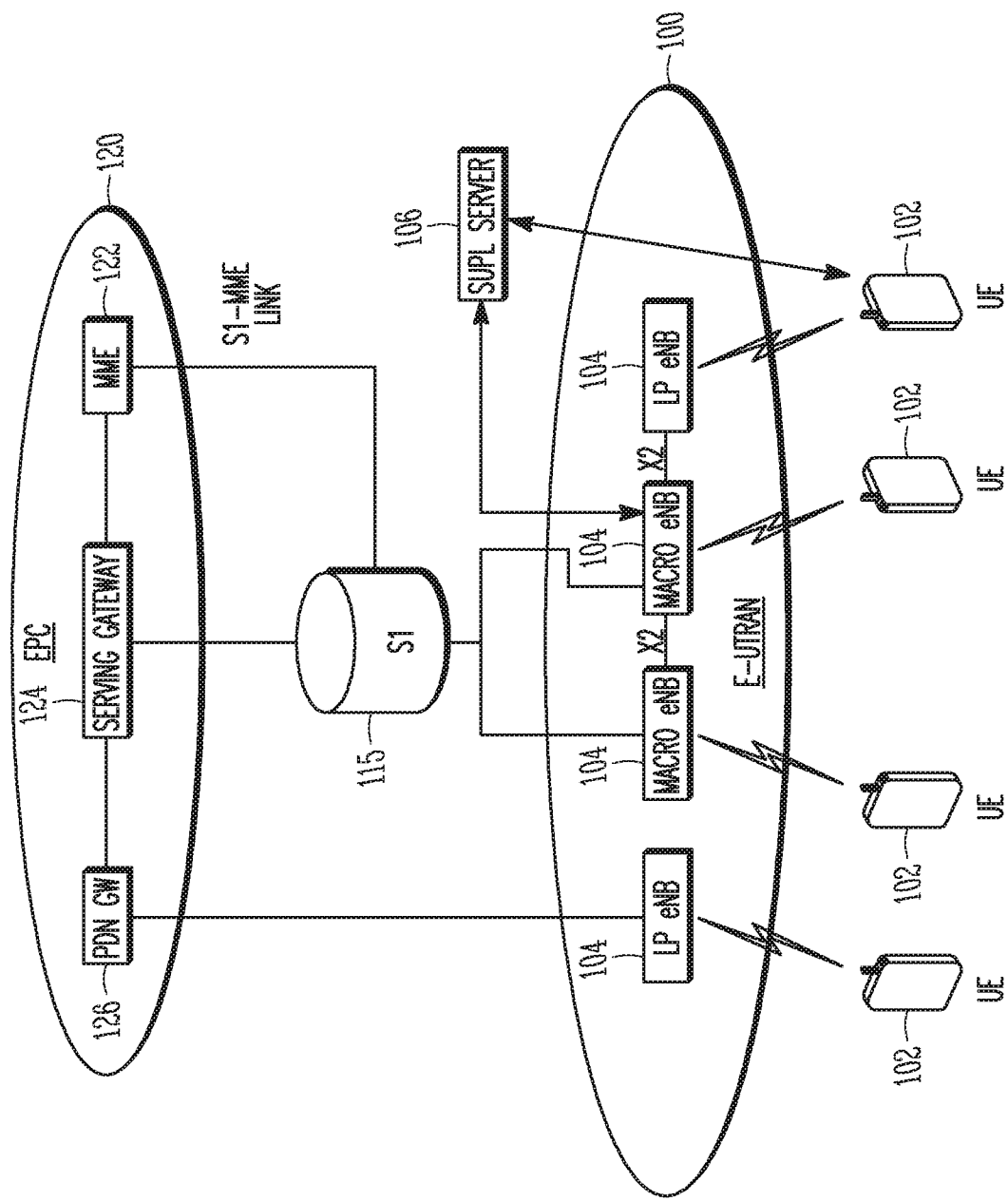


FIG. 1

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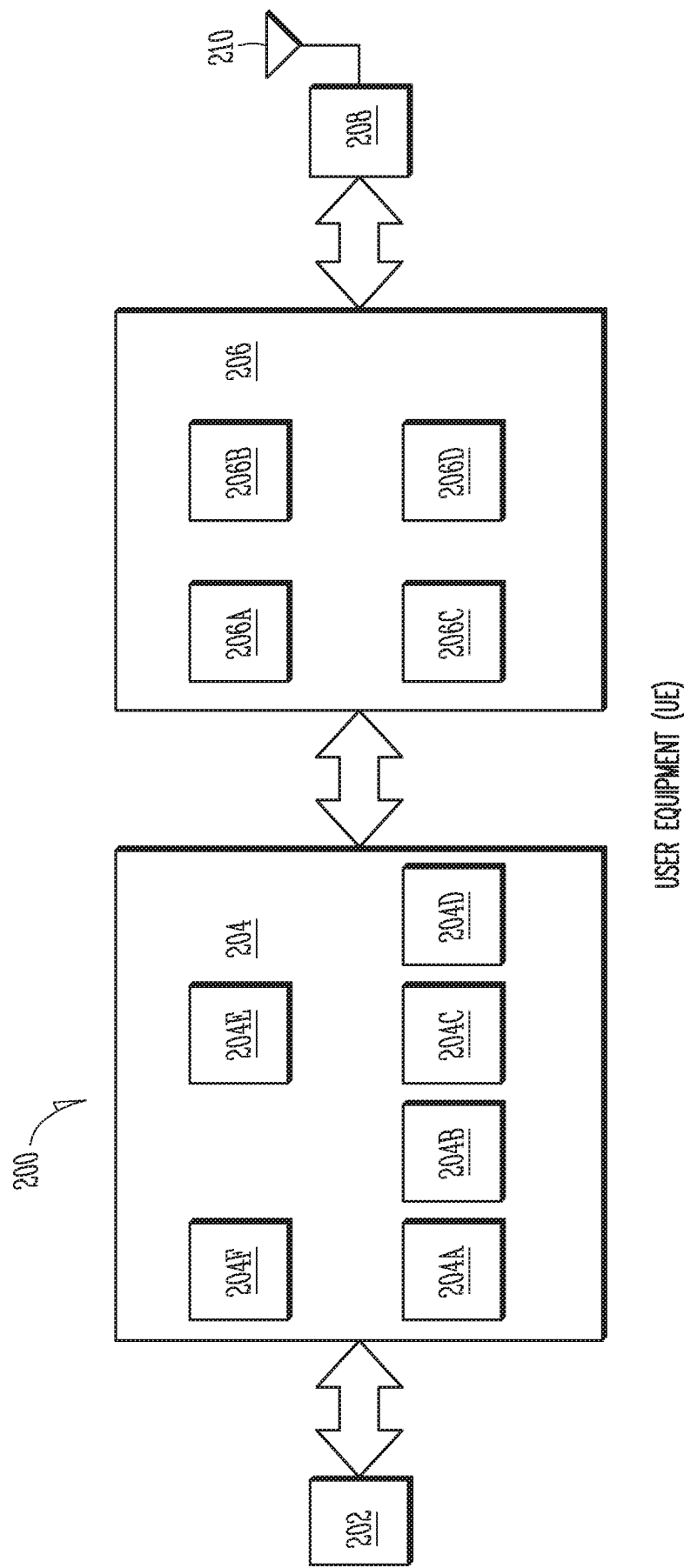


FIG. 2

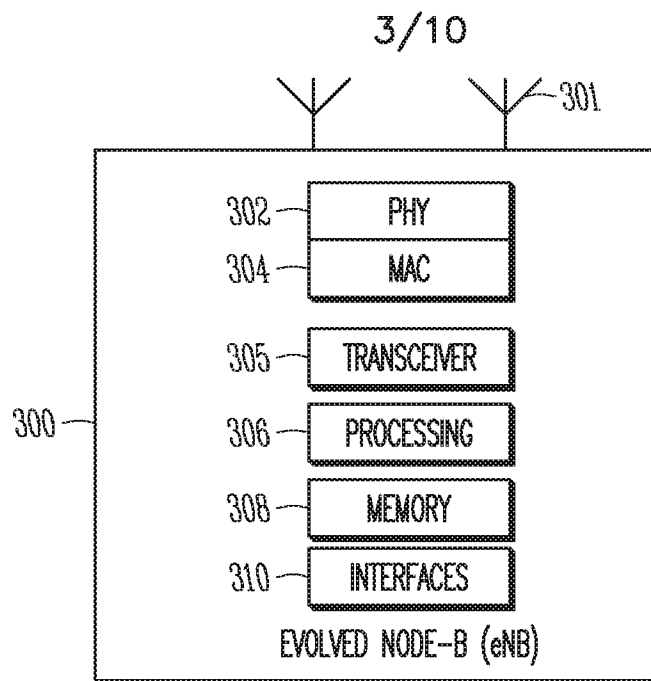


FIG. 3

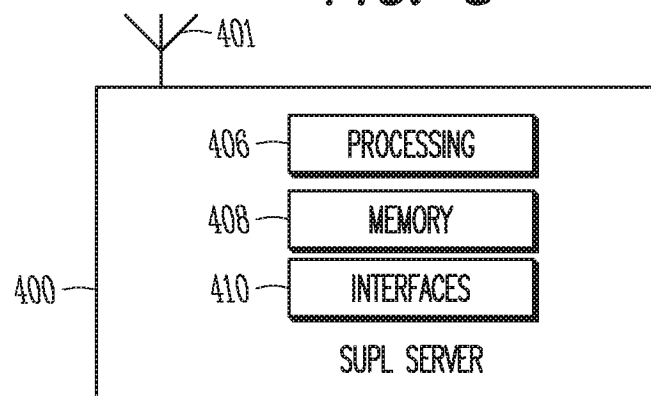


FIG. 4

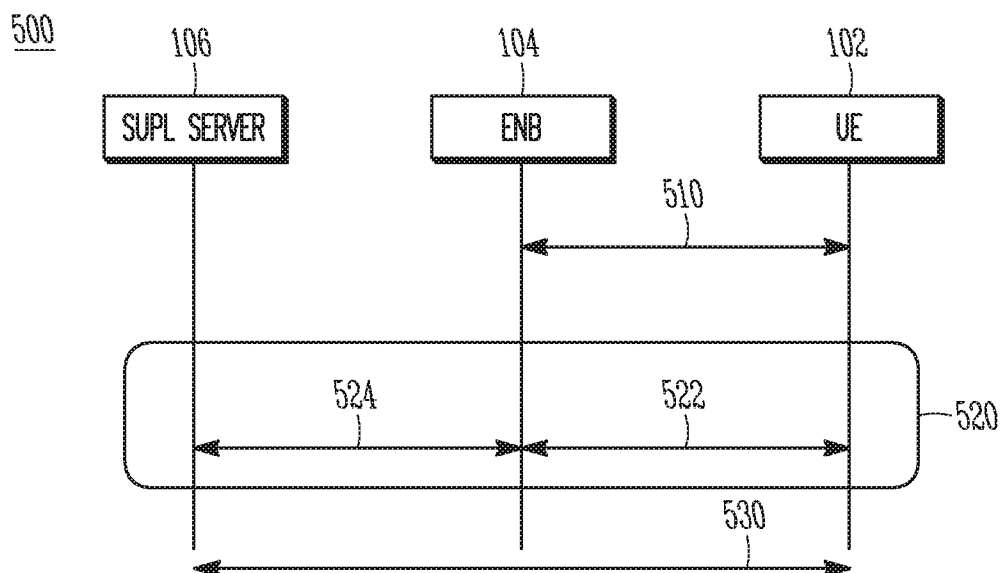


FIG. 5

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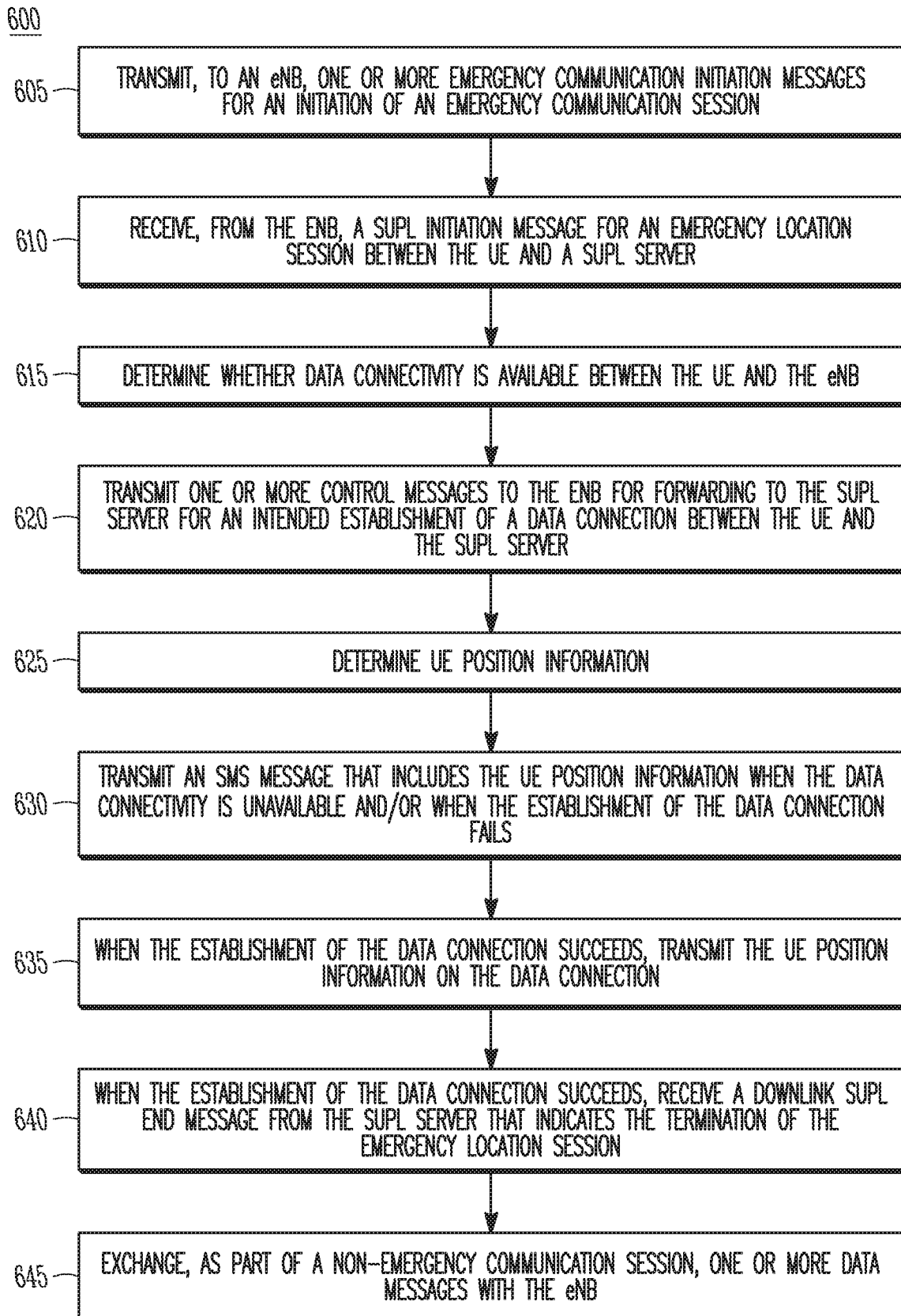


FIG. 6

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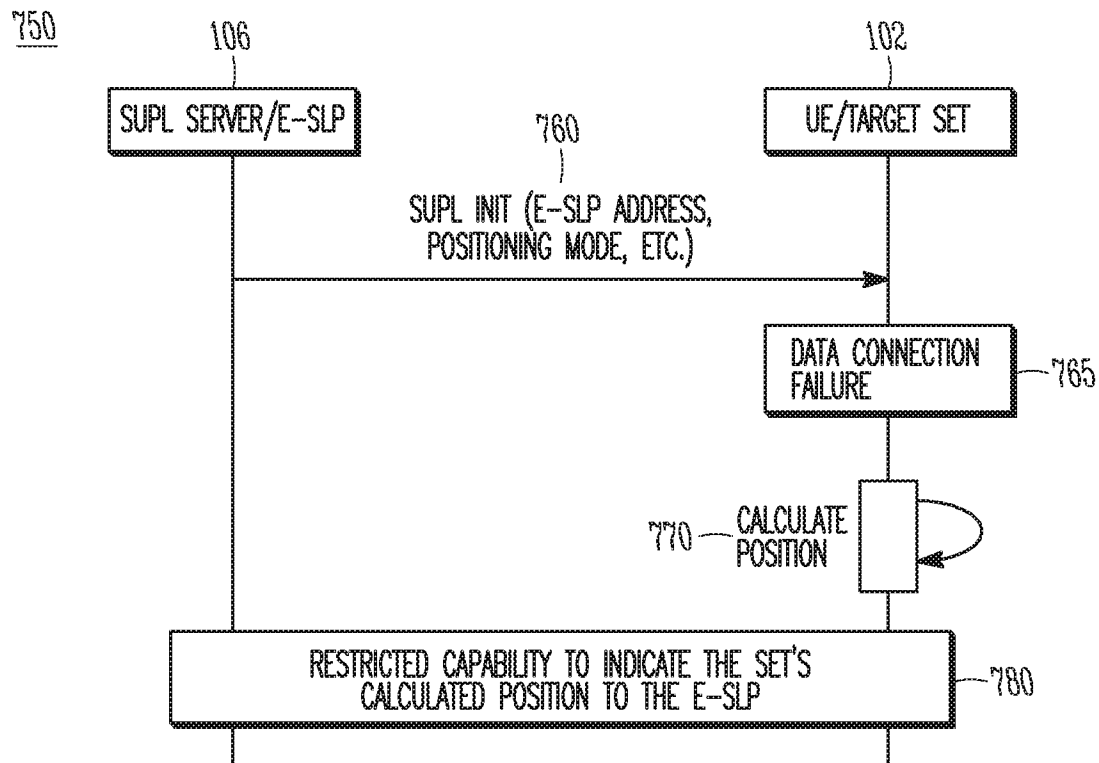
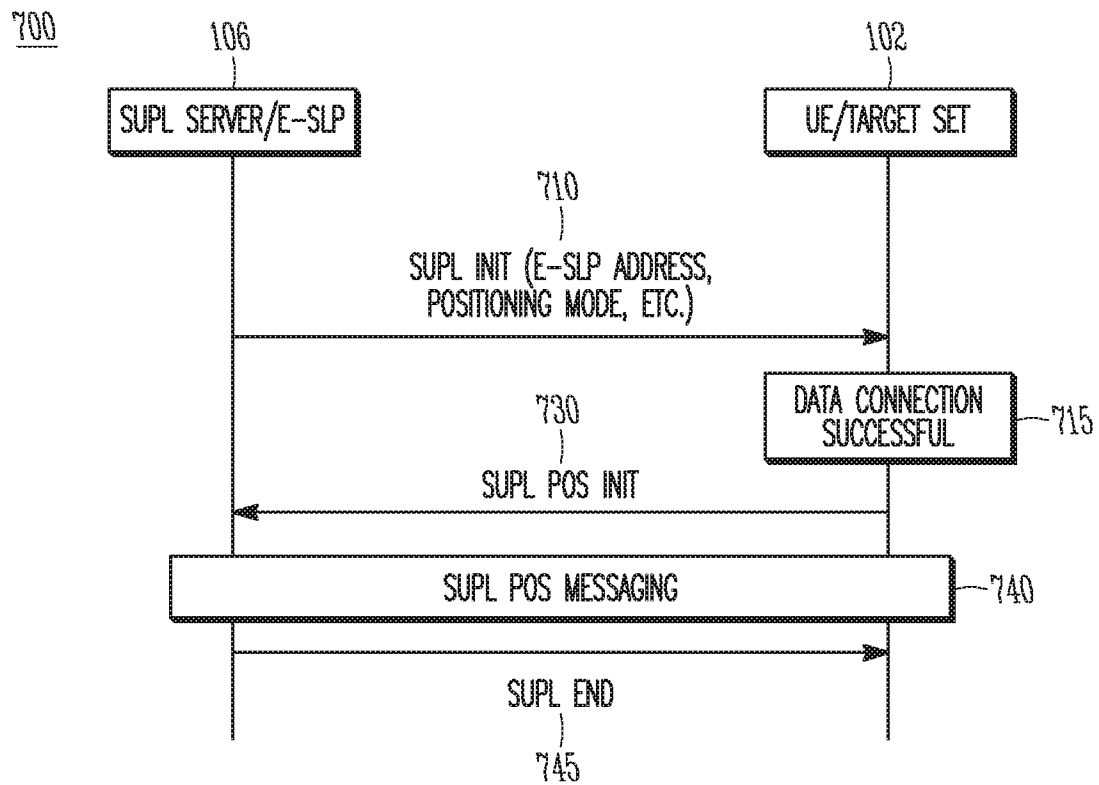


FIG. 7

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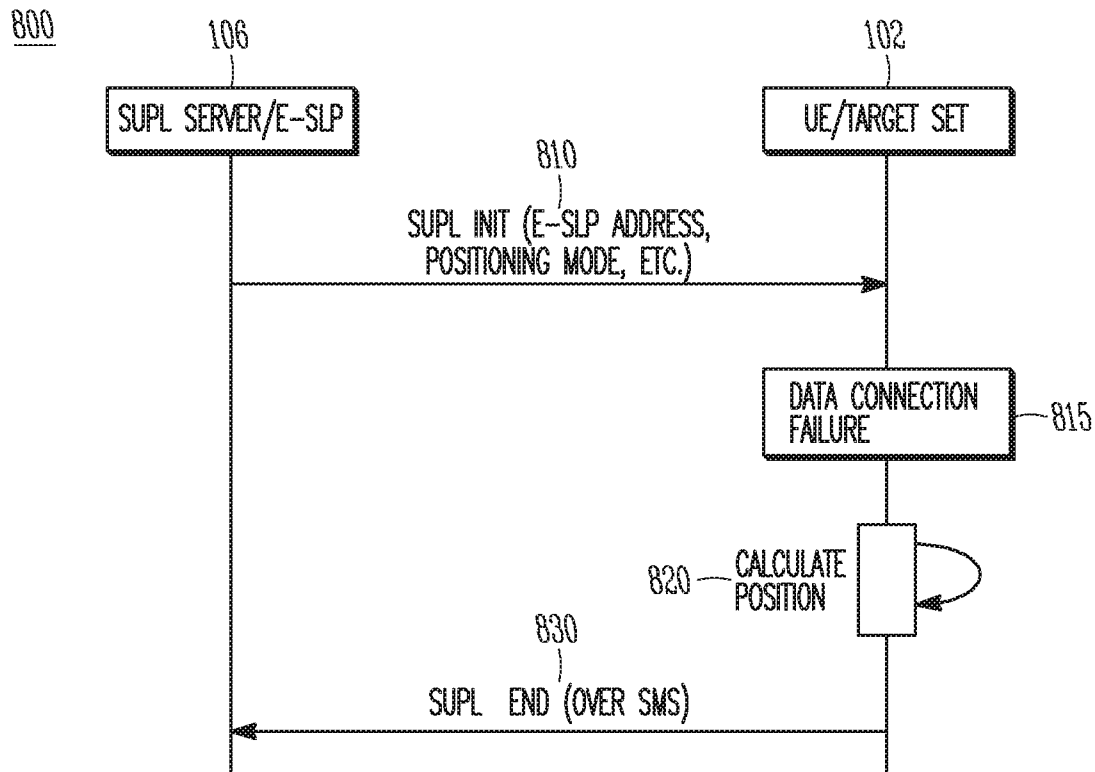


FIG. 8

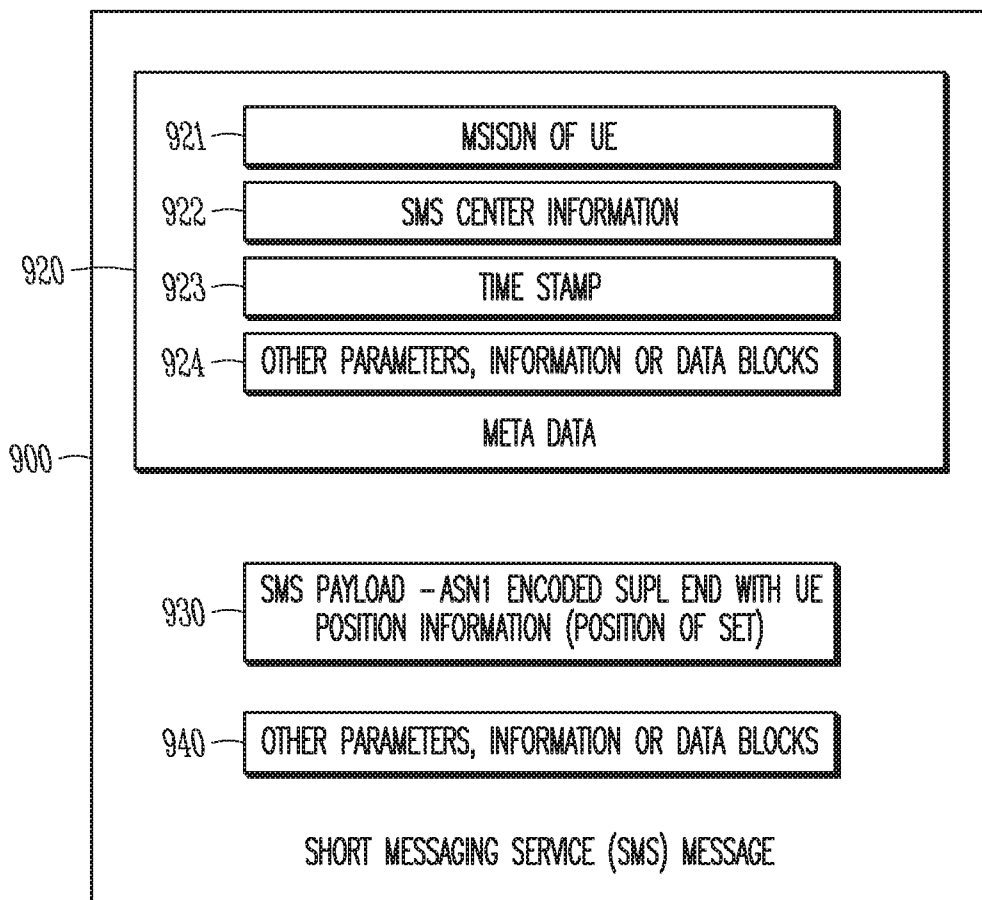


FIG. 9

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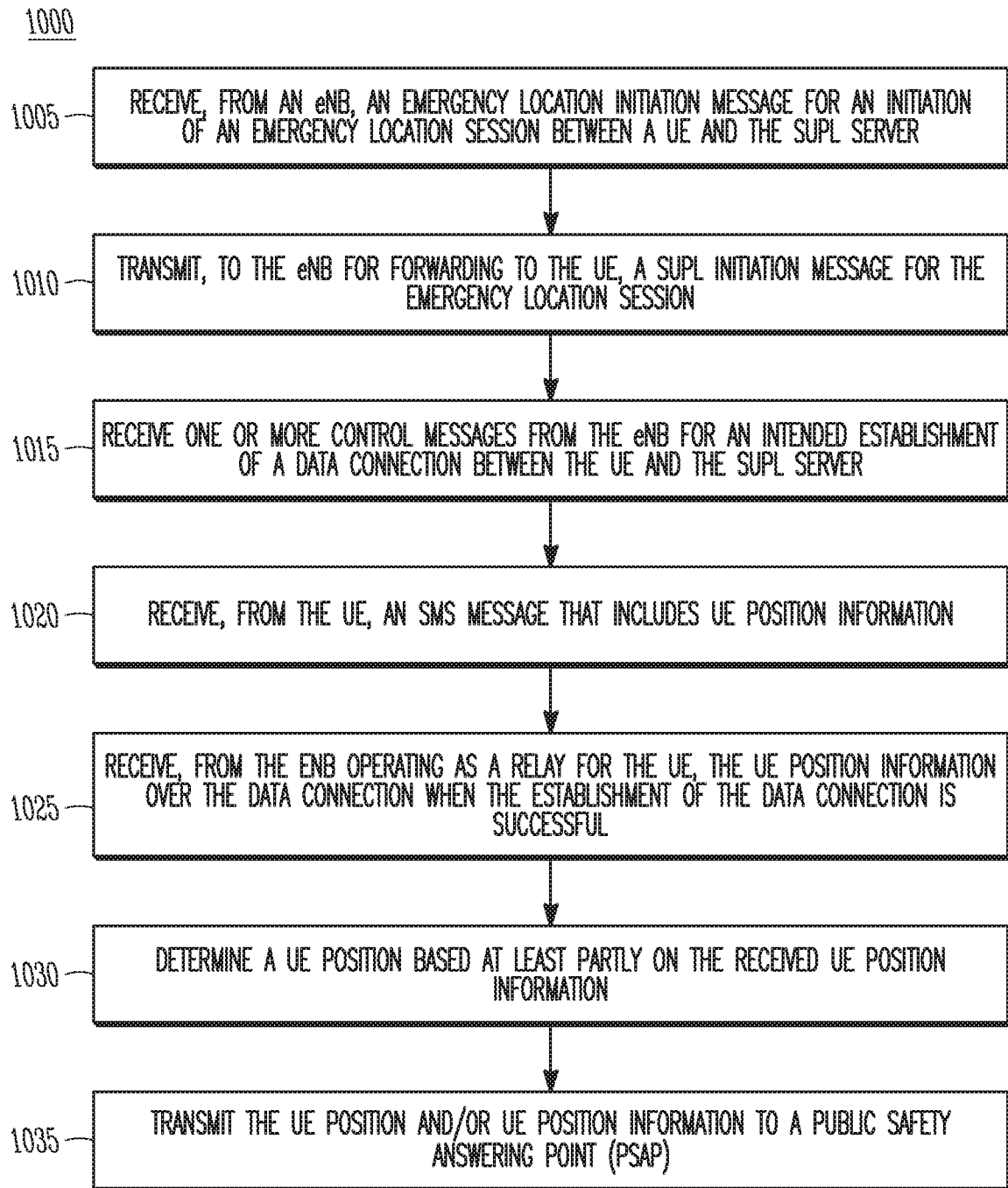
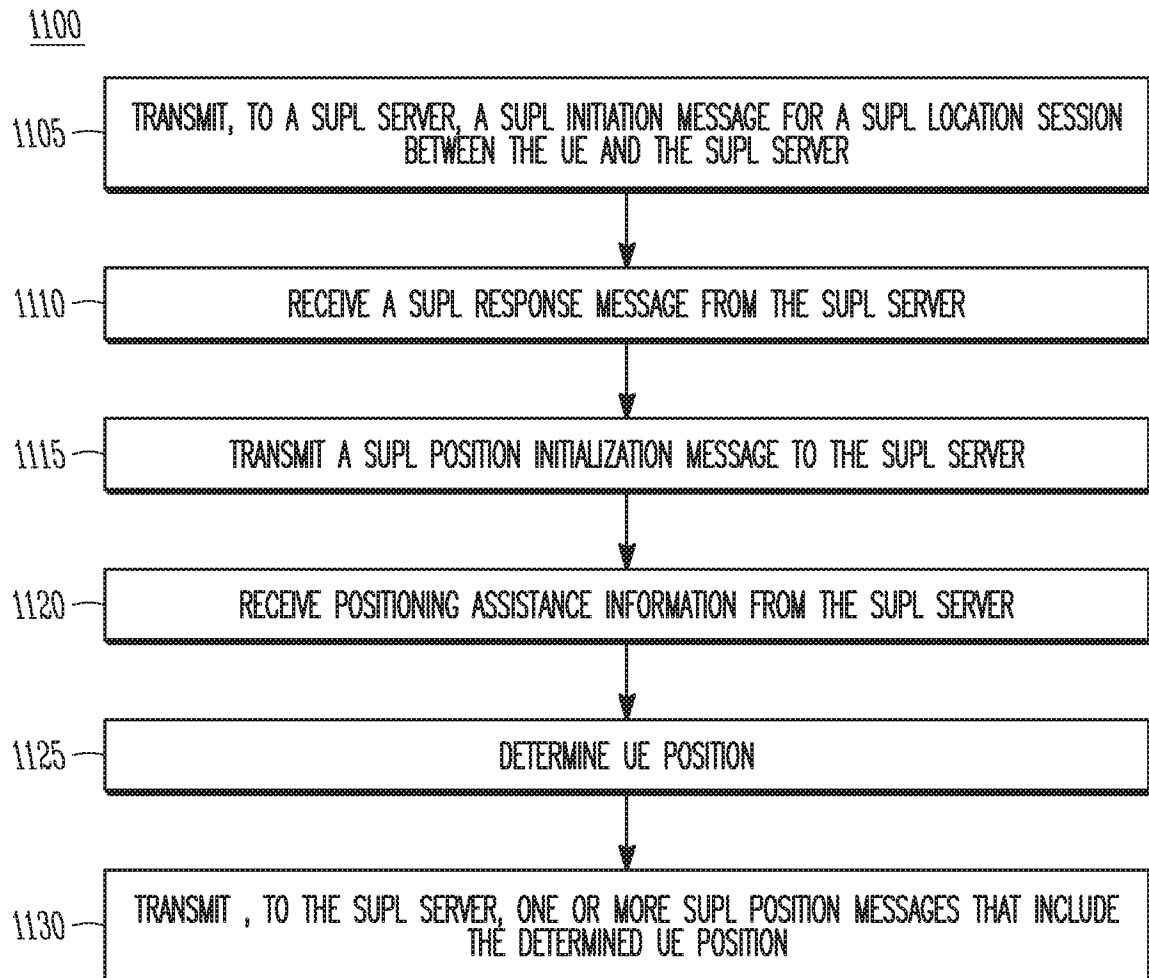


FIG. 10

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**FIG. 11**

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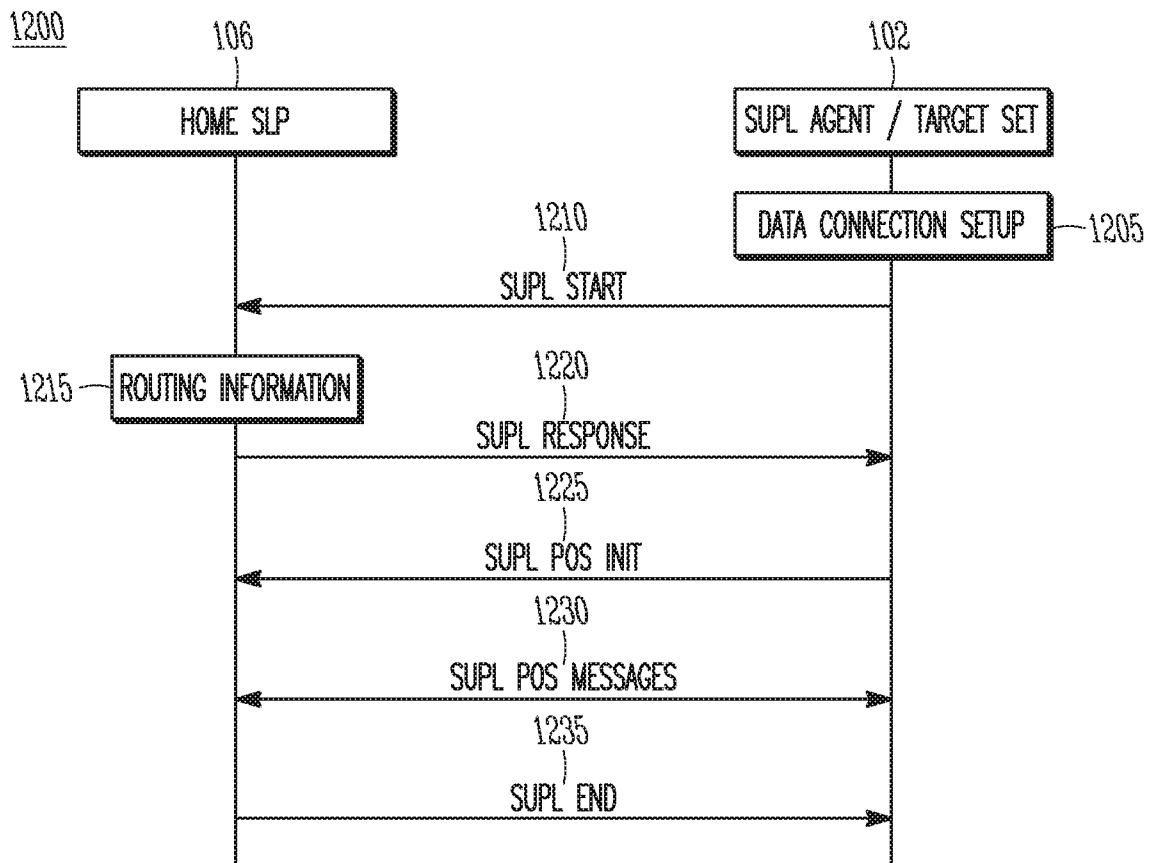


FIG. 12A

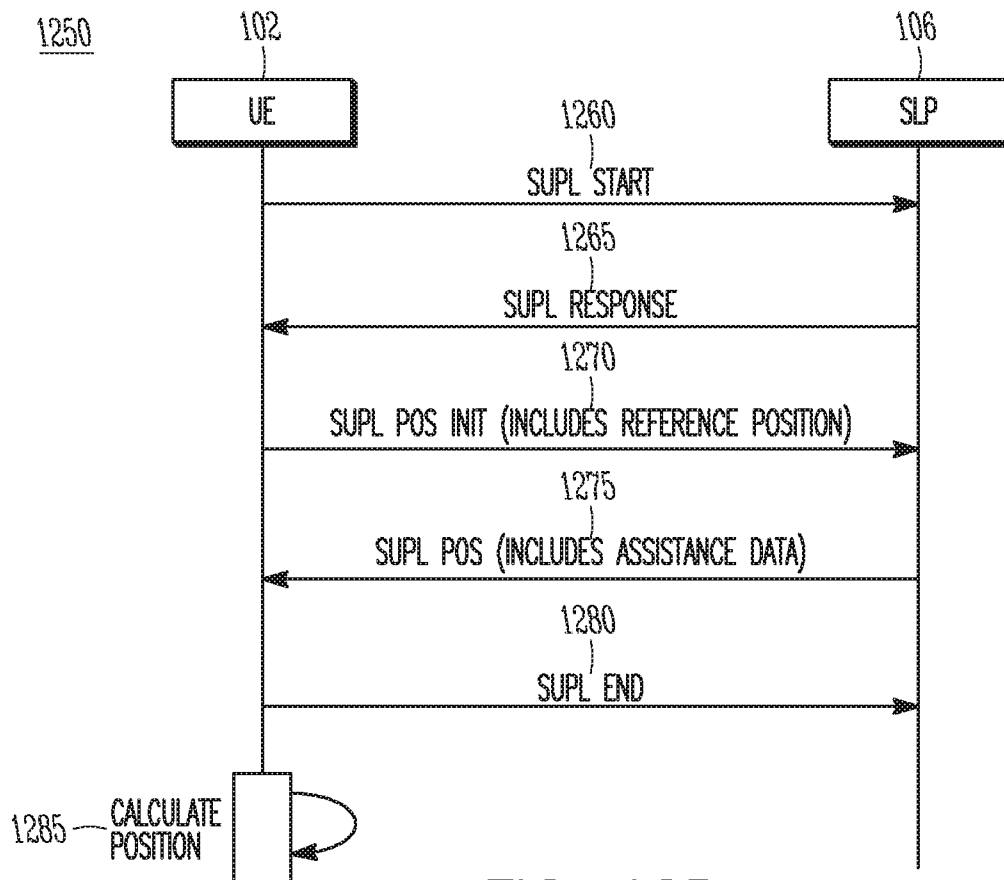


FIG. 12B

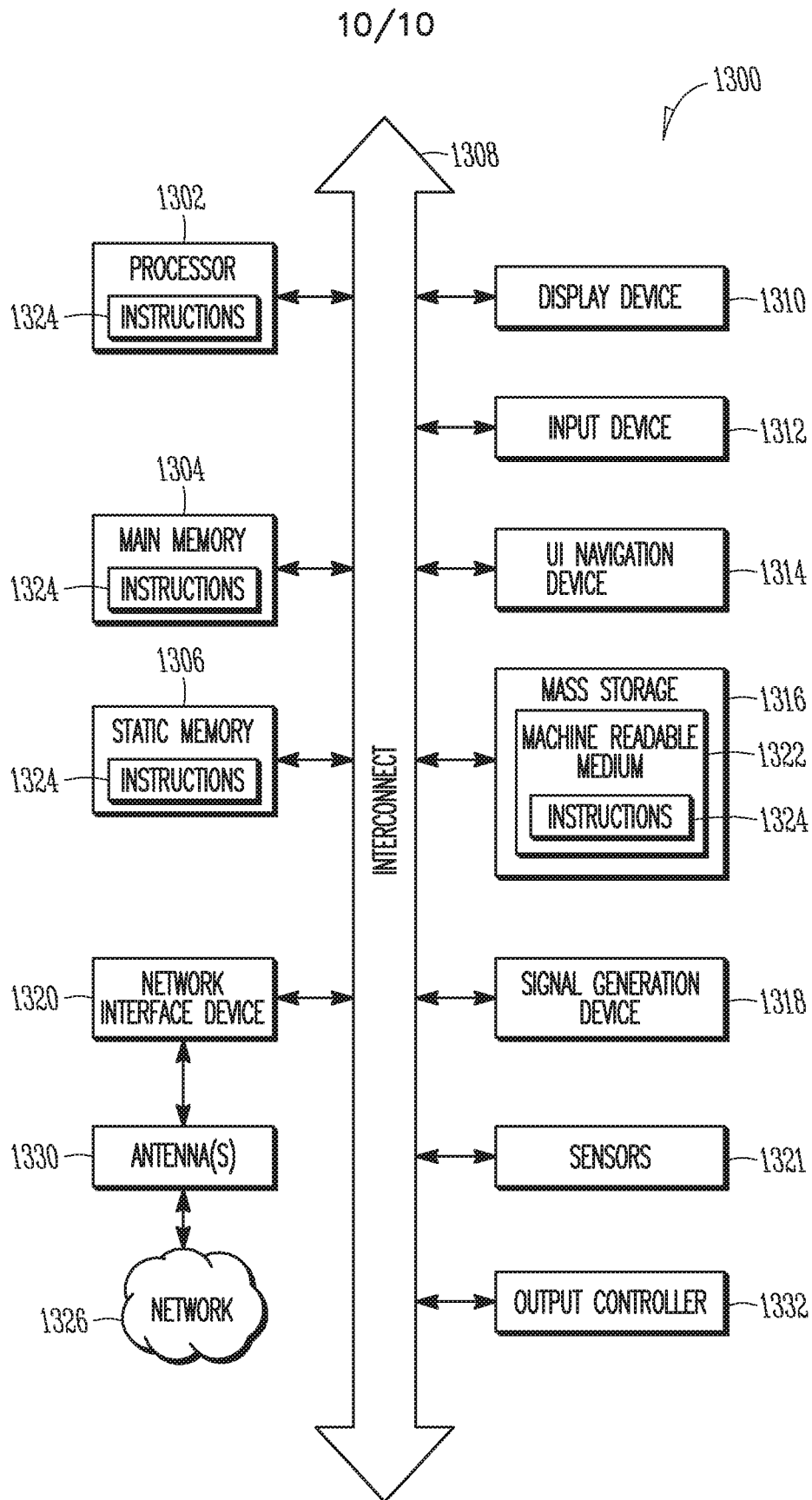


FIG. 13

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/064405**A. CLASSIFICATION OF SUBJECT MATTER****H04W 76/00(2009.01)i, H04W 4/22(2009.01)i, H04W 4/14(2009.01)i, H04W 64/00(2009.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHEDMinimum documentation searched (classification system followed by classification symbols)
H04W 76/00; H04Q 7/20; H04W 4/02; H04W 64/00; G01S 5/02; H04W 4/22; H04W 4/14Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility modelsElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & keywords: SUPL(Secure User Plane Location), emergency, connection, succeed, transmit, UE position information, fail, SMS message**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	US 2014-0256282 A1 (QUALCOMM INCORPORATED) 11 September 2014 See paragraphs [0021]-[0033]; and figures 2, 3.	1-7, 9, 13-17, 19-25 , 27 8, 10-12, 18, 26 , 28-37
Y	US 2013-0178193 A1 (AT&T MOBILITY II LLC) 11 July 2013 See paragraphs [0030]-[0046]; and figure 6.	1-7, 9, 13-17, 19-25 , 27-30, 34-37
Y	US 2008-0254809 A1 (SEBASTIAN KRAUFVELIN et al.) 16 October 2008 See paragraphs [0029]-[0037]; and figure 6.	5, 7, 19
Y	US 2015-0005006 A1 (QUALCOMM INCORPORATED) 01 January 2015 See paragraphs [0019]-[0104]; and figure 6.	28-30, 34-37
A	KR 10-2010-0050809 A (SAMSUNG ELECTRONICS CO., LTD.) 14 May 2010 See paragraphs [0032]-[0060]; and figures 3, 4.	1-37



Further documents are listed in the continuation of Box C.



See patent family annex.

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

24 August 2016 (24.08.2016)

Date of mailing of the international search report

24 August 2016 (24.08.2016)

Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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INTERNATIONAL SEARCH REPORT

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datePatent family
member(s)Publication
date

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