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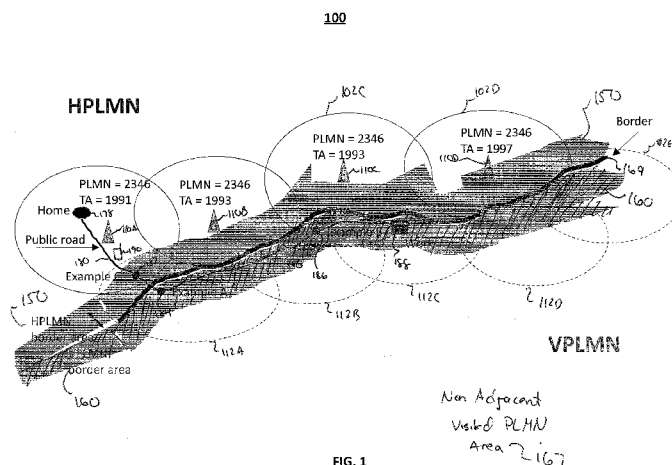
(54) Title: TRIGGERING A MORE AGGRESSIVE PLMN SEARCH ALGORITHM WHEN IN A VISITED PLMN ADJACENT
TO THE HOME PLMN

FIG. 1

(57) **Abstract:** When wireless user equipment, UE, such as a cell phone, a smart phone, and/or the like, travels to an area outside its home network, the UE may perform a roaming operation and search for and couple to a visited network. Most user equipment are configured to automatically roam to the visited network in accordance with a standard, such as 3GPP TS 23.122. The UE, carried by a user on a daily commute to work may encounter roaming when crossing a national border where the UE may roam for an extended period of time in a visited PLMN even though a home PLMN may still be able to serve the UE. Since cellular roaming charges can be very high, the application aims at reducing visited network roaming in such cases. This aim is achieved by defining a so-called "border area" and when the UE is located in this "border area", a modified PLMN selection algorithm is triggered which searches home PLMNs with a higher frequency than the default frequency.

TRIGGERING A MORE AGGRESSIVE PLMN SEARCH ALGORITHM WHEN IN A VISITED PLMN ADJACENT TO THE HOME PLMN

PUBLIC LAND MOBILE NETWORK SEARCH

FIELD

[001] The subject matter described herein relates to wireless network selection while roaming.

BACKGROUND

[002] When wireless user equipment, such as a cell phone, a smart phone, and/or the like, travels to an area outside its home network, the user equipment may perform a roaming operation and search for and couple to a visited network. Most user equipment are configured to automatically roam to the visited network in accordance with a standard, such as 3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; Non-Access-Stratum (NAS) functions related to Mobile Station (MS) in idle mode (Release 12), hereinafter 3GPP TS 23.122. From a user prospective, roaming enables the user to operate the cell phone for example despite traveling from a home network to a visited network.

SUMMARY

[003] In some example embodiments, there is provided a method. The method may include determining, by a user equipment, whether the user equipment is located in at least one border area; operating, at the user equipment, in a default search mode, when the determined location does not correspond to the at least one border area; and

operating, at the user equipment, in an alternative search mode for at least one home public land mobile network, when the determined location does correspond to the at least one border area.

[004] In some variations, one or more of the features disclosed herein including the following features can optionally be included in any feasible combination. The at least one border area may be adjacent to a national border and within radio range of the at least one home public land mobile network to enable reception of the at least one home public land mobile network while the user equipment is located in the at least one border area. The at least one home public land mobile network may be located in a first country, and the at least one visited public land mobile network is in a second country. The alternative search mode may include an aggressive search mode. The aggressive search mode may include a search time interval for the at least one home public land mobile network, wherein the search time interval may be less than another search time interval for searching in the default search mode. The at least one border area may include at least one of a geographical point, a geographical area, a geographical boundary, and/or one or more areas adjacent to a national border. The at least one border area may include one or more coordinates, one or more cell identifiers, one or more service identifiers, one or more radio frequency fingerprints, or a combination thereof. The at least one border area may be at least one of signaled by a network to the user equipment, defined at the user equipment, or a combination thereof. The alternative search mode may include searching for at least one pre-defined visited public land mobile network. The user

equipment may camp on the at least one pre-defined visiting public land mobile network, when the at least one pre-defined visiting public land mobile network is detected. The user equipment may implement the default search mode, when the at least one pre-defined visiting public land mobile network is not detected. The at least one pre-defined visited public land mobile network may be defined, by an end-user of the user equipment, for use in the at least one border area. When the determined location corresponds to the at least one border area, a selection may be performed for a public land mobile network list including at least one pre-defined public land mobile network to be searched in the alternative search mode. The selection may be performed from among a plurality of public land mobile network lists, each of which corresponds to a given border area.

[005] The above-noted aspects and features may be implemented in systems, apparatuses, methods, and/or computer-readable media depending on the desired configuration. The details of one or more variations of the subject matter described herein are set forth in the accompanying drawings and the description below. Features and advantages of the subject matter described herein will be apparent from the description and drawings, and from the claims. In some exemplary embodiments, one of more variations may be made as well as described in the detailed description below and/or as described in the following features.

DESCRIPTION OF DRAWINGS

[006] In the drawings,

[007] FIG. 1 depicts an example of a system 100 for border area public land mobile network search policy can be performed, in accordance with some example embodiments;

[008] FIG. 2 depicts an example of a process 200 for border area public land mobile network search policy can be performed, in accordance with some example embodiments; and

[009] FIG. 3 an example of an apparatus, in accordance with some example embodiments.

[010] Like labels are used to refer to the same or similar items in the drawings.

DETAILED DESCRIPTION

[011] In some areas, cellular roaming charges can be very high. For example, some users travel and/or commute in areas where roaming is relatively common. To illustrate further, a user equipment, such as a cell phone, a smart phone, a tablet, and/or the like, carried by a user on a daily commute to work may encounter roaming when crossing a national border where the user equipment may roam for an extended period of time in a visited public land mobile network (PLMN) even though a home PLMN may still be able to serve the user equipment.

[012] In some example embodiments, a PLMN selection algorithm and/or related parameters, such as time constants and/or the like, may be triggered for use at the user equipment, when the user equipment enters a given geographic area, such as a

border region. When triggered, the PLMN selection algorithm and/or related parameters may configure the user equipment to more aggressively search for home PLMN cells, when in the border region where visited PLMN cells would otherwise be used but for the triggered PLMN selection algorithm/related parameters.

[013] In some example embodiments, one or more geographic areas, such as border areas, may be defined. The geographic areas may correspond to regions in which roaming to a visited PLMN may take place. Moreover, the defined region(s) may correspond to an area near a border, such as a national border, although the defined regions may correspond to other areas where the control disclosed herein may be used as well.

[014] In some example embodiments, the border area may be defined as a geographical point, a geographical boundary, and/or one or more areas. Moreover, the border area may be defined using for example coordinates, coordinates provided by a global navigation satellite system (GNSS)/global positioning system (GPS), cell identifiers, service identifiers, radio frequency fingerprints (which can be used to detect or identify certain area at a border region, for example based on measurements of the signal strengths or other signal qualities from a radio cell or a set of radio cells), and/or the like. In some example embodiments, the defined geographic area and/or defined border area may be signaled to a user equipment by the network, defined at the user equipment (for example, via the user interface), and/or configured in other ways as well.

[015] In some example embodiments, a user equipment having one or more defined border areas may evaluate whether the user equipment is in at least one of these border areas. When in a defined border area, the user equipment may trigger a modified PLMN selection algorithm (also referred herein as a border area PLMN selection algorithm). The user equipment may then perform the modified PLMN selection algorithm, in accordance with some example embodiments. The modified PLMN selection algorithm may comprise a specific PLMN selection algorithm and/or the use of specific parameter(s) for the PLMN search. Moreover, the modified PLMN selection algorithm may be pre-provisioned at the user equipment, defined by a user, defined by the network, defined by standard, and/or a combination thereof.

[016] In some example embodiments, the modified PLMN selection algorithm may be configured to allow the user equipment to more aggressively search for cells in the home PLMN, when in the defined border region. For example, the modified home PLMN search algorithm may allow for more aggressive or more frequent searching for home PLMN cells. In this way, the user equipment may be able to camp to a cell in its home PLMN, rather than in a visited PLMN.

[017] FIG. 1 depicts an example system 100 including one or more cells 102A-D served by corresponding base stations 110A-D, in accordance with some example embodiments. The cells 102A-D may be in the home PLMN for user equipment 190 (or its associated subscriber). FIG. 1 depicts examples of border areas, such as a border 169, a home PLMN border area 150, and a visited PLMN border area 160. Cells 112A-D are,

in this example, part of the visited PLMN for user equipment 190 (or its associated subscriber).

[018] In the example of FIG. 1, user equipment 190 may include defined/configured border areas for border 169, home PLMN border area 150, and/or visited PLMN border area 160 (for example, location information for the border areas, such as geolocation coordinates, cell identifiers, and/or the like), in accordance with some example embodiments. Moreover, user equipment 190 may include a border area PLMN search algorithm and/or associated parameters for the border area search algorithm, in accordance with some example embodiments.

[019] When user equipment 190 enters defined/configured border area 169 and/or 160 for example, the border area PLMN selection algorithm may be triggered at the user equipment. When triggered, the user equipment may be configured to attempt to stay in its home PLMN, although the border area PLMN selection algorithm may enable selection of other PLMNs as well. For example, the border area PLMN selection algorithm may follow the principle of the manual PLMN selection mode in the border area 160, where the PLMN to be selected while in border area 160 may be pre-configured/defined and thus triggered for use when the user equipment's location is in the border area 160. Rather than the manual PLMN selection mode selected by the end user, the PLMN to be selected is pre-configured for the given border area(s). Alternatively or additionally, a search timer T may be used to check for the availability of the home PLMN, and this time may be pre-configured/defined to a significantly shorter value to

force the user equipment to more aggressively/frequently search for the home PLMN when the user equipment is located in border region 160.

[020] To illustrate further, when user equipment 190 is roaming and its current location is home PLMN border area 150, the user equipment may determine that border 169 has been crossed and the user equipment is currently in visited PLMN border area 160 adjacent to the user equipment's home PLMN. Alternatively or additionally, the user equipment 190 may determine that it is roaming and the current location of the user equipment is visited PLMN border area 160, which is adjacent to the user equipment's home PLMN. For example, when user equipment 190 is at point 184 (labeled example A), the user equipment may be roaming and thus able to acquire service from the visited PLMN at for example cell 112A. As the user equipment is in the visited PLMN border area 160, the user equipment may trigger the border area PLMN search algorithm, in which case the user equipment may initiate a more aggressive, higher priority home PLMN search than would otherwise be performed in accordance with for example, 3GPP TS 23.122, section 4.4.3.3. For example, a time value, T, for periodic attempts to search for a higher priority PLMN may be set to 60 minutes. But in the border area, the user equipment may be configured the timer with a value of 6 minutes, although other time intervals between searches may be used as well. By the time the user equipment 190 reaches point 186 (labeled example B) in the visited PLMN border area 160, the user equipment may, due in part to the border area PLMN search algorithm, find a cell 103C associated with the user equipment's home PLMN. In this example, the user equipment

190 may be in a visited PLMN for a brief period of time, but may then revert back to the home PLMN and cell 103C and/or the like, minimizing thus the time spent in the visited PLMN, consequently minimizing the probability for mobile originated and mobile terminated call events and for r chargeable events in the visited PLMN (which may minimize roaming and its associated fees).

[021] In the example of FIG. 1, when user equipment 190 reaches point 180 (labeled example C), the user equipment has crossed the border 169 into home PLMN border area 150. However, the user equipment may still be well within the range of one or more visited PLMN cells, such as cell 112A and/or the like having a mobile country code of the VPLM for example. As soon as the user equipment determines that it has arrived in the home PLMN border area 150, the user equipment may trigger the search for the home PLMN to avoid using cells 112A-E of the visited PLMN.

[022] When user equipment 190 is roaming and its current location is on visited PLMN border area that is not adjacent to home PLMN (for example, there are no home PLMN cells within range of the user equipment, such as locations 166, 167, 184 and/or other locations in the visited PLMN), the user equipment may determine that border 169 has been crossed and the user equipment is in the VLPMN border area 160 that is not adjacent to the home PLMN (so adjacent home PLMN cell service is not available). When this is the case, the user equipment may camp to visiting cells of the visited PLMN in accordance with a default PLMN selection such as 3GPP TS 23.122 procedures for example. Because there are no available home PLMN cells in this non-adjacent case, the

user equipment may not trigger the border area PLMN search algorithm to more aggressively find home PLMN cells but instead search in accordance with 3GPP TS 23.122 for example.

[023] When roaming and the current location is in home PLMN border area 150, the user equipment (via a user interface for example) may be able to configure one or more aspects of the border area PLMN selection algorithm, in accordance with some example embodiments. The user equipment may, as noted, operate using the user's configured border area PLMN selection algorithm, when the user equipment triggers use of border area PLMN selection algorithm. To avoid accidental/temporary roaming when the user equipment is in the home PLMN border area 150, the user equipment (which may be user/subscriber selectable as well) may be configured to have as the target the home PLMN. In this example, the user equipment may behave as in the manual PLMN selection mode, with the exception that the target PLMN has been pre-set for the border area 150 rather than selected by the end user at the time when entering the border area 150. Consequently, the user equipment may lock the PLMN to home PLMN, so long as the user equipment stays in the home PLMN border area 150. If however the user equipment leaves the home PLMN border area 150, the PLMN selection may revert back to a default or follow some other behavior as disclosed herein.

[024] When the user equipment is roaming and its current location is in visited PLMN border area that is not adjacent to home PLMN, the user equipment (via a user interface for example) may be allowed to be pre-set/configured for the target PLMN

operator in the similar fashion to the manual PLMN selection mode noted above. For example, if the end user is about to travel to a foreign country where there are 4 different PLMN operators available for selection and the end user (via a user interface for example) may choose to roam to a certain operator (for example, operator #4's visiting network), irrespective of the home PLMN operator's preferred roaming partners, the end user may configure the visited PLMN border area accordingly and set the PLMN selection target to the certain operator's PLMN (for example, operator #4) while in that specific visited PLMN border area. If the selection option in the user equipment had been misconfigured, for example to an unavailable PLMN, the user equipment may then revert back to a default automatic or manual selection mode in that particular visited PLMN border area.

[025] In some example embodiments, the end user (via a user interface for example) may configure more than one user controlled PLMN selector list (as defined by for example 3GPP TS 22.011), which may be stored to the user equipment at a subscriber identity module (SIM), and/or universal subscriber identity module (USIM) in the UICC. For each such selector list containing the list of preferred PLMNs in priority order, one or more border areas may be assigned. When this is the case, whenever the user equipment determines its location in any of the designated border areas, the user equipment may apply the corresponding user controlled PLMN selector list. In such scenarios where a selector list is mapped to a border area, the selector list may be used over any other corresponding operator controlled PLMN selector list. This behavior is a variation of the

manual PLMN selection mode enabled by the border area definition and by the ability to map such border area to a specific PLMN selection behavior.

[026] FIG. 2 depicts an example process 200 for a modified border area PLMN search, in accordance with some example embodiments. The description of FIG. 2 also refers to FIG. 1.

[027] At 210, the user equipment 190 may obtain one or more border regions and/or obtain parameters for the border area PLMN search, in accordance with some example embodiments. For example, the defined border regions may be signaled by the network (via for example, a network access stratum management object), configured at the user equipment (for example, via a user interface by a user), obtained from a database providing border regions, and/or obtained in other ways as well. Moreover, the border area PLMN search including its parameters may be provisioned by the network, defined by a standard, configured at the user equipment (for example, via a user interface by a user), and/or the like.

[028] As noted, the border area may be one or more geographic areas/boundaries. Moreover, the border area may correspond to an area where the user equipment may camp to a visited PLMN, despite the fact that a home PLMN may be able to serve the user equipment. In the example of FIG. 1, while in the border region 160, a user equipment operating using the border area PLMN search may more aggressively search for home PLMN cells 102A-D. In contrast, a user equipment (which is configured with a default automatic PLMN search in accordance with for example 3GPP TS 23.122)

may seek cells in the VPLM given that the VPLM is in the country belonging to the VPLM.

[029] To define a border area, one or more borders, such as a national boundary, may be defined by geolocation coordinates, such as latitude, longitude, GPS/GNSS coordinates, and/or any other type of coordinates (although the border area may also be defined in other ways as well including using for example, cell identifiers, RF fingerprinting, and/or the like). The coordinates may be acquired from for example a database including map information, although other sources of coordinate information may be used as well including a mapping application. Alternatively or additionally, the user equipment may include an application that enables graphically defining a geographical area, such as a border area, via a graphical user interface. The border areas may also be provided by the network. For example, the network may signal the user equipment with candidate border areas which may be selected at the user equipment for use with the border area PLMN search. The border area may be defined as an area, which may comprise a state, a province, a city, a national boundary, a country, a neighborhood, and/or any other area that can be designated a border area and configured to trigger at the user equipment a border area PLMN search. Moreover, the user equipment may be able to determine its home PLMN and thus determine its home country (for example, the home country of the corresponding subscriber). For example, the user equipment may obtain the home PLMN and/or mobile country code (MCC) information from for example a SIM and/or USIM for example, in the UICC at the user

equipment (wherein the MCC defines the country). As such, the user equipment may be able to determine, at 210, its home PLMN border area 150 and visited PLMN border area 160.

[030] At 220, the user equipment may determine whether its location is within a designated border region, in accordance with some example embodiments. The user equipment 190 may from time to time determine whether its location is within any of the border areas obtained at 210. To illustrate, user equipment 190 may monitor geolocation coordinates (which may be obtained from a GPS/GNSS chip set) and/or cell identifiers for example to determine its current location, and then compare the current location to the border areas to determine whether the user equipment is within one of those border areas.

[031] If the user equipment is not within a border region, the user equipment may proceed to perform visiting PLMN searching in a default mode in accordance with for example 3GPP TS 23.122 (no at 220 and 230), in accordance with some example embodiments.

[032] If the user equipment is determined to be within a border region, the user equipment may trigger the border area PLM search (yes at 220 and 240), in accordance with some example embodiments. For example, when user equipment is in a border area 160 that is adjacent to the HPLMN, the user equipment may more aggressively for the home cells 102A-D in order to attempt to avoid roaming by coupling to the home cells. When user equipment is in a border area 150 that is in the HPLMN, the user equipment

may preconfigure the HPLMN so that the user equipment does not inadvertently couple to the visiting cells 112A-E.

[033] FIG. 3 depicts an example of an apparatus 300, in accordance with some example embodiments. The apparatus 300 may comprise a user equipment, such as a smart phone, a tablet, a cell phone, a wearable radio device, and/or any other radio based device including for example a wireless access point/base station.

[034] In some example embodiments, apparatus 300 may also include a radio communication link to a cellular network, or other wireless network. The apparatus 300 may include at least one antenna 12 in communication with a transmitter 14 and a receiver 16. Alternatively transmit and receive antennas may be separate.

[035] The apparatus 300 may also include a processor 20 configured to provide signals to and from the transmitter and receiver, respectively, and to control the functioning of the apparatus. Processor 20 may be configured to control the functioning of the transmitter and receiver by effecting control signaling via electrical leads to the transmitter and receiver. Likewise, processor 20 may be configured to control other elements of apparatus 130 by effecting control signaling via electrical leads connecting processor 20 to the other elements, such as a display or a memory. The processor 20 may, for example, be embodied in a variety of ways including circuitry, at least one processing core, one or more microprocessors with accompanying digital signal processor(s), one or more processor(s) without an accompanying digital signal processor, one or more coprocessors, one or more multi-core processors, one or more controllers,

processing circuitry, one or more computers, various other processing elements including integrated circuits (for example, an application specific integrated circuit (ASIC), a field programmable gate array (FPGA), and/or the like), or some combination thereof. Apparatus 300 may include a location processor and/or an interface to obtain location information, such as positioning and/or navigation information. Accordingly, although illustrated in as a single processor, in some example embodiments the processor 20 may comprise a plurality of processors or processing cores.

[036] Signals sent and received by the processor 20 may include signaling information in accordance with an air interface standard of an applicable cellular system, and/or any number of different wireline or wireless networking techniques, comprising but not limited to Wi-Fi, wireless local access network (WLAN) techniques, such as, Institute of Electrical and Electronics Engineers (IEEE) 802.11, 802.16, and/or the like. In addition, these signals may include speech data, user generated data, user requested data, and/or the like.

[037] The apparatus 300 may be capable of operating with one or more air interface standards, communication protocols, modulation types, access types, and/or the like. For example, the apparatus 300 and/or a cellular modem therein may be capable of operating in accordance with various first generation (1G) communication protocols, second generation (2G or 2.5G) communication protocols, third-generation (3G) communication protocols, fourth-generation (4G) communication protocols, Internet Protocol Multimedia Subsystem (IMS) communication protocols (for example, session

initiation protocol (SIP) and/or the like. For example, the apparatus 300 may be capable of operating in accordance with 2G wireless communication protocols IS-136, Time Division Multiple Access TDMA, Global System for Mobile communications, GSM, IS-95, Code Division Multiple Access, CDMA, and/or the like. In addition, for example, the apparatus 300 may be capable of operating in accordance with 2.5G wireless communication protocols General Packet Radio Service (GPRS), Enhanced Data GSM Environment (EDGE), and/or the like. Further, for example, the apparatus 300 may be capable of operating in accordance with 3G wireless communication protocols, such as, Universal Mobile Telecommunications System (UMTS), Code Division Multiple Access 2000 (CDMA2000), Wideband Code Division Multiple Access (WCDMA), Time Division-Synchronous Code Division Multiple Access (TD-SCDMA), and/or the like. The apparatus 130 may be additionally capable of operating in accordance with 3.9G wireless communication protocols, such as, Long Term Evolution (LTE), Evolved Universal Terrestrial Radio Access Network (E-UTRAN), and/or the like. Additionally, for example, the apparatus 300 may be capable of operating in accordance with 4G wireless communication protocols, such as LTE Advanced and/or the like as well as similar wireless communication protocols that may be subsequently developed.

[038] It is understood that the processor 20 may include circuitry for implementing audio/video and logic functions of apparatus 300. For example, the processor 20 may comprise a digital signal processor device, a microprocessor device, an analog-to-digital converter, a digital-to-analog converter, and/or the like. Control and

signal processing functions of the apparatus 300 may be allocated between these devices according to their respective capabilities. The processor 20 may additionally comprise an internal voice coder (VC) 20a, an internal data modem (DM) 20b, and/or the like. Further, the processor 20 may include functionality to operate one or more software programs, which may be stored in memory. In general, processor 20 and stored software instructions may be configured to cause apparatus 300 to perform actions. For example, processor 20 may be capable of operating a connectivity program, such as, a web browser. The connectivity program may allow the apparatus 300 to transmit and receive web content, such as location-based content, according to a protocol, such as, wireless application protocol, wireless access point, hypertext transfer protocol, HTTP, and/or the like.

[039] Apparatus 300 may also comprise a user interface including, for example, an earphone or speaker 24, a ringer 22, a microphone 26, a display 28, a user input interface, and/or the like, which may be operationally coupled to the processor 20. The display 28 may, as noted above, include a touch sensitive display, where a user may touch and/or gesture to make selections, enter values, and/or the like. The processor 20 may also include user interface circuitry configured to control at least some functions of one or more elements of the user interface, such as, the speaker 24, the ringer 22, the microphone 26, the display 28, and/or the like. The processor 20 and/or user interface circuitry comprising the processor 20 may be configured to control one or more functions of one or more elements of the user interface through computer program instructions, for

example, software and/or firmware, stored on a memory accessible to the processor 20, for example, volatile memory 40, non-volatile memory 42, and/or the like. The apparatus 300 may include a battery for powering various circuits related to the mobile terminal, for example, a circuit to provide mechanical vibration as a detectable output. The user input interface may comprise devices allowing the apparatus 300 to receive data, such as, a keypad 30 (which can be a virtual keyboard presented on display 28 or an externally coupled keyboard) and/or other input devices.

[040] Moreover, the apparatus 300 may include a short-range radio frequency (RF) transceiver and/or interrogator 64, so data may be shared with and/or obtained from electronic devices in accordance with RF techniques. The apparatus 300 may include other short-range transceivers, such as an infrared (IR) transceiver 66, a Bluetooth (BT) transceiver 68 operating using Bluetooth wireless technology, a wireless universal serial bus (USB) transceiver 70, and/or the like. The Bluetooth transceiver 68 may be capable of operating according to low power or ultra-low power Bluetooth technology, for example, Wibree, Bluetooth Low-Energy, and other radio standards. In this regard, the apparatus 300 and, in particular, the short-range transceiver may be capable of transmitting data to and/or receiving data from electronic devices within proximity of the apparatus, such as within 10 meters. The apparatus 300 including the Wi-Fi or wireless local area networking modem may also be capable of transmitting and/or receiving data from electronic devices according to various wireless networking techniques, including

6LoWpan, Wi-Fi, Wi-Fi low power, WLAN techniques such as IEEE 802.11 techniques, IEEE 802.15 techniques, IEEE 802.16 techniques, and/or the like.

[041] The apparatus 300 may comprise memory, such as, a subscriber identity module (SIM) 38, a removable user identity module (R-UIM), and/or the like, which may store information elements related to a mobile subscriber. In addition to the SIM, the apparatus 300 may include other removable and/or fixed memory. The apparatus 300 may include volatile memory 40 and/or non-volatile memory 42. For example, volatile memory 40 may include Random Access Memory (RAM) including dynamic and/or static RAM, on-chip or off-chip cache memory, and/or the like. Non-volatile memory 42, which may be embedded and/or removable, may include, for example, read-only memory, flash memory, magnetic storage devices, for example, hard disks, floppy disk drives, magnetic tape, optical disc drives and/or media, non-volatile random access memory (NVRAM), and/or the like. Like volatile memory 40, non-volatile memory 42 may include a cache area for temporary storage of data. At least part of the volatile and/or non-volatile memory may be embedded in processor 20. The memories may store one or more software programs, instructions, pieces of information, data, and/or the like which may be used by the apparatus for performing operations as described herein at for example process 200. The memories may comprise an identifier, such as an international mobile equipment identification (IMEI) code, capable of uniquely identifying apparatus 300. The functions may include one or more of the operations disclosed herein with respect to the border area PLM searching. The memories may comprise an identifier,

such as an international mobile equipment identification (IMEI) code, capable of uniquely identifying apparatus 300. In the example embodiment, the processor 20 may be configured using computer code stored at memory 40 and/or 42 to provide the operations, such as determining, by a user equipment, whether the user equipment is located in at least one border area; operating, at the user equipment, in a default search mode for at least one visited public land mobile network, when the determined location does not correspond to the at least one border area; and operating, at the user equipment, in an aggressive search mode for at least one home public land mobile network, when the determined location does correspond to the at least one border area.

[042] Some of the embodiments disclosed herein may be implemented in software, hardware, application logic, or a combination of software, hardware, and application logic. The software, application logic, and/or hardware may reside in memory 40, the control apparatus 20, or electronic components disclosed herein, for example. In some example embodiments, the application logic, software or an instruction set is maintained on any one of various conventional computer-readable media. In the context of this document, a "computer-readable medium" may be any non-transitory media that can contain, store, communicate, propagate or transport the instructions for use by or in connection with an instruction execution system, apparatus, or device, such as a computer or data processor circuitry. A computer-readable medium may comprise a non-transitory computer-readable storage medium that may be any media that can contain or store the instructions for use by or in connection with an instruction

execution system, apparatus, or device, such as a computer. Furthermore, some of the embodiments disclosed herein include computer programs configured to cause methods as disclosed herein (see, for example, the process 200 and the like).

[043] Without in any way limiting the scope, interpretation, or application of the claims appearing below, a technical effect of one or more of the example embodiments disclosed herein is reduction in visited network roaming, improved user equipment behavior in a border area adjacent to a home PLMN, and/or better control of user equipment roaming.

[044] The subject matter described herein may be embodied in systems, apparatus, methods, and/or articles depending on the desired configuration. For example, the systems, apparatus, methods, and/or articles described herein can be implemented using one or more of the following: electronic components such as transistors, inductors, capacitors, resistors, and the like, a processor executing program code, an application-specific integrated circuit (ASIC), a digital signal processor (DSP), an embedded processor, a field programmable gate array (FPGA), and/or combinations thereof. These various example embodiments may include implementations in one or more computer programs that are executable and/or interpretable on a programmable system including at least one programmable processor, which may be special or general purpose, coupled to receive data and instructions from, and to transmit data and instructions to, a storage system, at least one input device, and at least one output device. These computer programs (also known as programs, software, software applications, applications,

components, program code, or code) include machine instructions for a programmable processor, and may be implemented in a high-level procedural and/or object-oriented programming language, and/or in assembly/machine language. As used herein, the term “machine-readable medium” refers to any computer program product, computer-readable medium, computer-readable storage medium, apparatus and/or device (for example, magnetic discs, optical disks, memory, Programmable Logic Devices (PLDs)) used to provide machine instructions and/or data to a programmable processor, including a machine-readable medium that receives machine instructions. Similarly, systems are also described herein that may include a processor and a memory coupled to the processor. The memory may include one or more programs that cause the processor to perform one or more of the operations described herein.

[045] Although a few variations have been described in detail above, other modifications or additions are possible. In particular, further features and/or variations may be provided in addition to those set forth herein. Moreover, the example embodiments described above may be directed to various combinations and subcombinations of the disclosed features and/or combinations and subcombinations of several further features disclosed above. In addition, the logic flow depicted in the accompanying figures and/or described herein does not require the particular order shown, or sequential order, to achieve desirable results. Other embodiments may be within the scope of the following claims.

WHAT IS CLAIMED:

1. A method comprising:
 - determining, by a user equipment, whether the user equipment is located in at least one border area;
 - operating, at the user equipment, in a default search mode, when the determined location does not correspond to the at least one border area; and
 - operating, at the user equipment, in an alternative search mode for at least one home public land mobile network, when the determined location does correspond to the at least one border area.
2. The method of claim 1, wherein the at least one border area is adjacent to a national border and within radio range of the at least one home public land mobile network to enable reception of the at least one home public land mobile network while the user equipment is located in the at least one border area.
3. The method of claim 2, wherein the at least one home public land mobile network is located in a first country, and the at least one visited public land mobile network is in a second country.
4. The method of claims 1-3, wherein the alternative search mode comprises an aggressive search mode.
5. The method of claim 4, wherein the aggressive search mode comprises a search time interval for the at least one home public land mobile network, wherein the

search time interval is less than another search time interval for searching in the default search mode.

6. The method of claims 1-5, wherein the at least one border area comprises at least one of a geographical point, a geographical area, a geographical boundary, and/or one or more areas adjacent to a national border.
7. The method of claims 1-6, wherein the at least one border area comprises one or more coordinates, one or more cell identifiers, one or more service identifiers, one or more radio frequency fingerprints, or a combination thereof.
8. The method of claims 1-7, wherein the at least one border area is at least one of signaled by a network to the user equipment, defined at the user equipment, or a combination thereof.
9. The method of claim 1, wherein the alternative search mode comprises searching for at least one pre-defined visited public land mobile network.
10. The method of claims 1 and 9, wherein the user equipment camps on the at least one pre-defined visiting public land mobile network, when the at least one pre-defined visiting public land mobile network is detected.
11. The method of claims 1 and 9, wherein the user equipment implements the default search mode, when the at least one pre-defined visiting public land mobile network is not detected.

12. The method of claims 9-11, wherein the at least one pre-defined visited public land mobile network is defined, by an end-user of the user equipment, for use in the at least one border area.
13. The method of claims 1-12 further comprising:
 - selecting, when the determined location corresponds to the at least one border area, a public land mobile network list including at least one pre-defined public land mobile network to be searched in the alternative search mode.
14. The method of claim 13, wherein the selection is performed from among a plurality of public land mobile network lists, each of which corresponds to a given border area.
15. An apparatus comprising:
 - at least one processor; and
 - at least one memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus to perform at least the following:
 - determine, by the apparatus, whether the apparatus is located in at least one border area;
 - operate, at the apparatus, in a default search mode, when the determined location does not correspond to the at least one border area; and

operate, at the apparatus, in an alternative search mode for at least one home public land mobile network, when the determined location does correspond to the at least one border area.

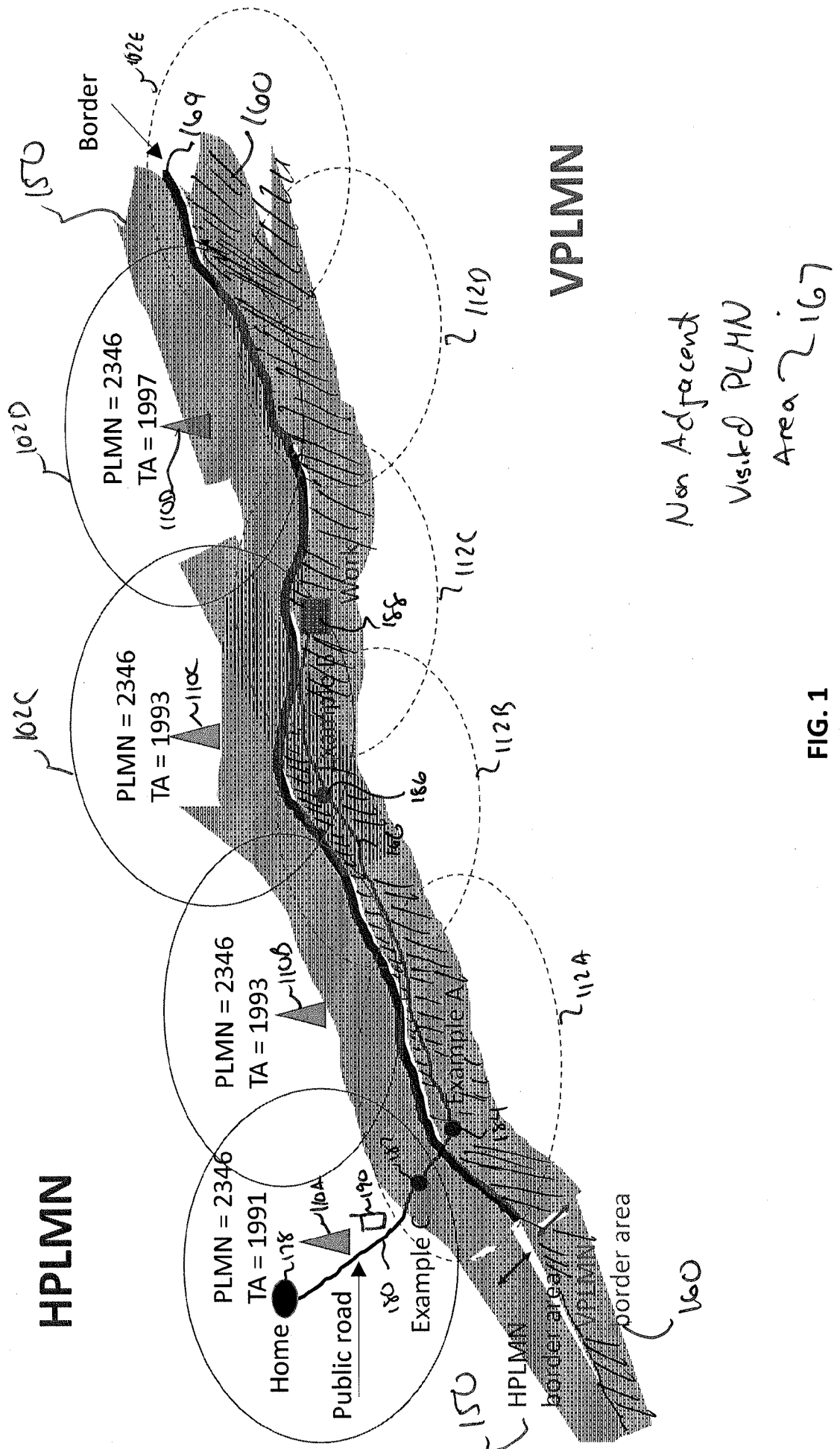
16. The apparatus of claim 15, wherein the at least one border area is adjacent to a national border and within radio range of the at least one home public land mobile network to enable reception of the at least one home public land mobile network while the apparatus is located in the at least one border area.
17. The apparatus of claim 16, wherein the at least one home public land mobile network is located in a first country, and the at least one visited public land mobile network is in a second country.
18. The apparatus of claims 15-17, wherein the alternative search mode comprises an aggressive search mode.
19. The apparatus of claim 18, wherein the aggressive search mode comprises a search time interval for the at least one home public land mobile network, wherein the search time interval is less than another search time interval for searching in the default search mode.
20. The apparatus of claims 15-19, wherein the at least one border area comprises at least one of a geographical point, a geographical area, a geographical boundary, and/or one or more areas adjacent to a national border.

21. The apparatus of claims 15-20, wherein the at least one border area comprises one or more coordinates, one or more cell identifiers, one or more service identifiers, one or more radio frequency fingerprints, or a combination thereof.
22. The apparatus of claims 15-21 wherein the at least one border area is at least one of signaled by a network to the apparatus, defined at the apparatus, or a combination thereof.
23. The apparatus of claim 15, wherein the alternative search mode comprises searching for at least one pre-defined visited public land mobile network.
24. The apparatus of claims 15 and 23, wherein the apparatus camps on the at least one pre-defined visiting public land mobile network, when the at least one pre-defined visiting public land mobile network is detected.
25. The apparatus of claims 15 and 23, wherein the apparatus implements the default search mode, when the at least one pre-defined visiting public land mobile network is not detected.
26. The apparatus of claims 23-25, wherein the at least one pre-defined visited public land mobile network is defined, by an end-user of the apparatus, for use in the at least one border area.
27. The apparatus of claims 15-26, wherein the apparatus is further configured to at least select, when the determined location corresponds to the at least one border area, a public land mobile network list including at least one pre-defined public land mobile network to be searched in the alternative search mode.

28. The apparatus of claim 27, wherein the selection is performed from among a plurality of public land mobile network lists, each of which corresponds to a given border area.
29. The apparatus of claims 15-28, wherein the apparatus comprises a user equipment.
30. An apparatus comprising:
- means for determining, by the apparatus, whether the apparatus is located in at least one border area;
 - means for operating, at the apparatus, in a default search mode, when the determined location does not correspond to the at least one border area; and
 - means for operating, at the apparatus, in an alternative search mode for at least one home public land mobile network, when the determined location does correspond to the at least one border area.
31. The apparatus of claim 30, further comprising means for performing any of claims 16-29.
32. A non-transitory computer-readable storage medium including program code which when executed by at least one processor causes operations comprising:
- determining, by a user equipment, whether the user equipment is located in at least one border area;
 - operating, at the user equipment, in a default search mode, when the determined location does not correspond to the at least one border area; and

operating, at the user equipment, in an alternative search mode for at least one home public land mobile network, when the determined location does correspond to the at least one border area.

100



200

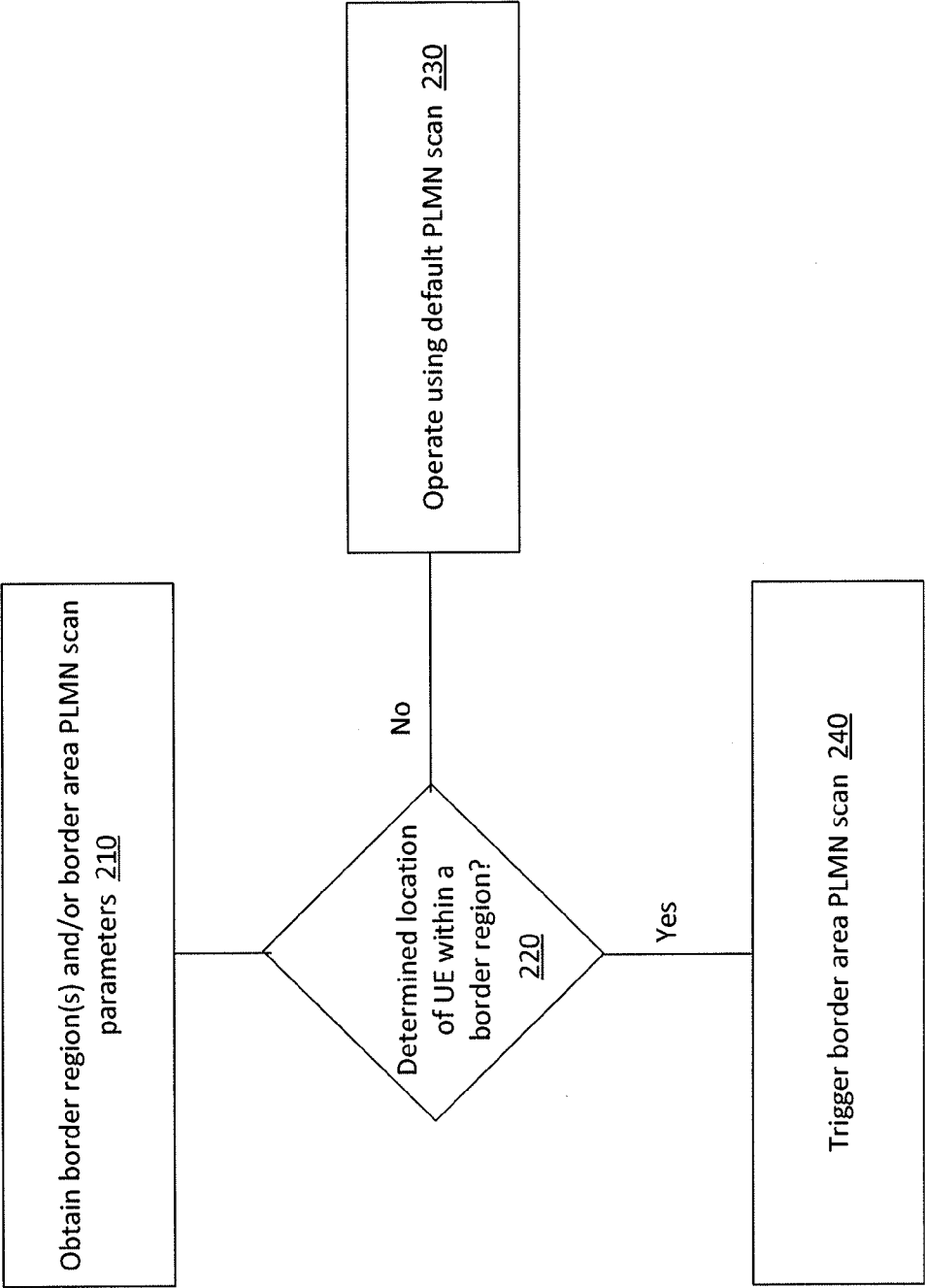


FIG. 2

300

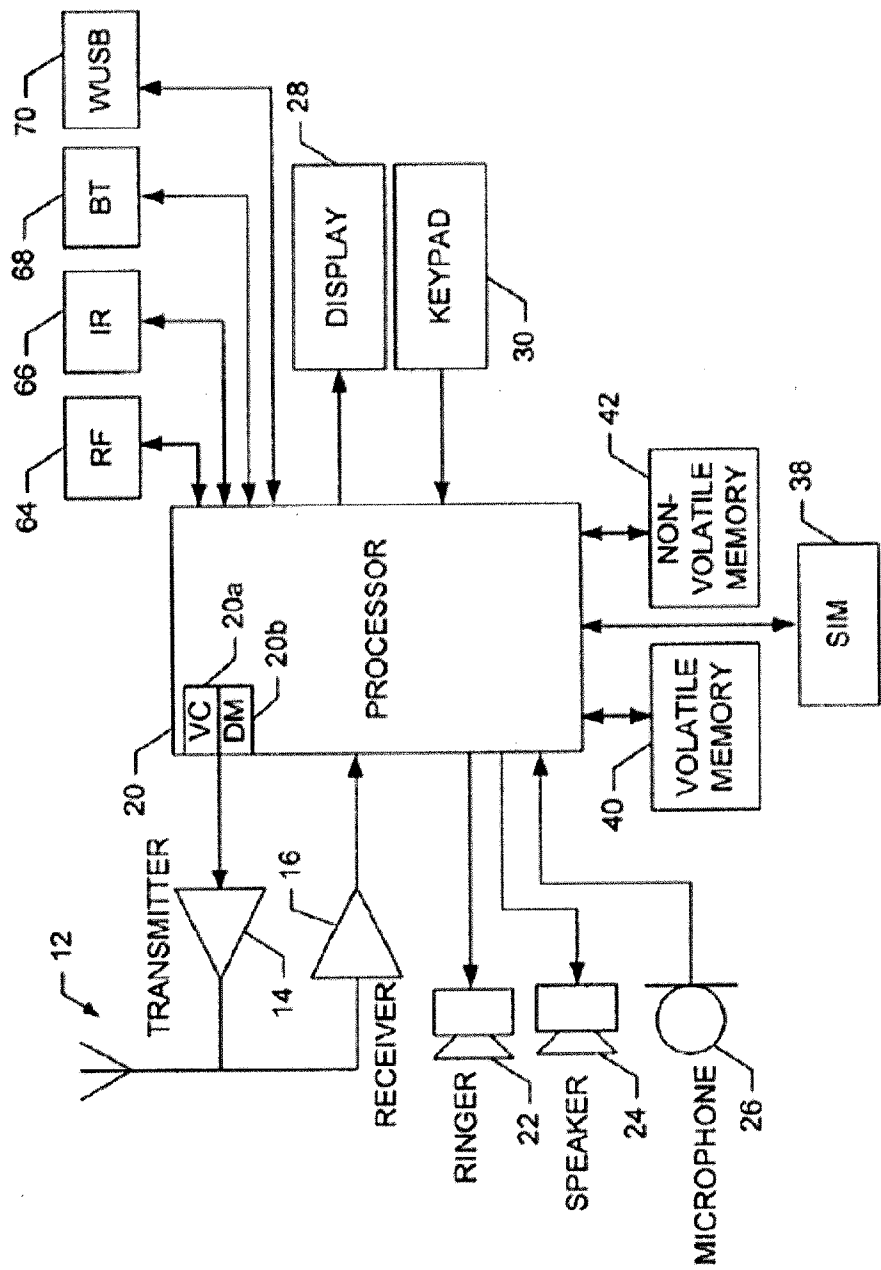


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/010483

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W48/18
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EP0-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2008/087251 A1 (ELISA OYJ [FI]; ISOTALO LAURI [FI]; HENRIKSSON KIM [FI]; JOKELA JARI []) 24 July 2008 (2008-07-24) page 9 - page 10; figure 1 page 16 - page 18; figure 3 -----	1-8, 13-22, 27-32
X	GB 2 470 194 A (EVOLVED INTELLIGENCE LTD [GB]) 17 November 2010 (2010-11-17) page 4, line 32 - page 6, line 14; figure 1 page 10, line 6 - page 13, line 7; figure 4 -----	1-8, 13-22, 27-32
A	EP 1 469 696 A1 (SAMSUNG ELECTRONICS CO LTD [KR]) 20 October 2004 (2004-10-20) paragraph [0037] - paragraph [0048] ----- -/--	1-8, 13-22, 27-32



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"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

10 September 2015

Date of mailing of the international search report

18/09/2015

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No

PCT/US2015/010483

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2012/084053 A1 (ERICSSON TELEFON AB L M [SE]; SPEKS OLIVER [DE]) 28 June 2012 (2012-06-28) page 9, line 18 - page 12, line 3; figure 2 -----	1-8, 13-22, 27-32

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/010483

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☒ Claims Nos.: 9-12, 23-26
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.2

Claims Nos.: 9-12, 23-26

Claims 10 and 11 refers to "the at least one predefined visiting public land mobile network" as mentioned by claim 9. Hence claim 10 & 11 are dependent on claim 9 and should refer to claim 9 only instead of referring also to claims 1-8. Claim 9 specifies that "the alternative search mode comprises searching for .. one pre-defined visited public land mobile network" whereby "the alternative search mode" of claim 1 is an "alternative search mode for .. one home public land mobile network". Hence, claims 1 & 9 specify different "alternative search modes" and therefore the relation to the features of claim 1 is unclear and the features specified by claims 9-12 can not be determined. The same applies to claims 23-26.

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guidelines C-IV, 7.2), should the problems which led to the Article 17(2) declaration be overcome.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2015/010483

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2008087251 A1	24-07-2008	FI 20075036 A WO 2008087251 A1	20-07-2008 24-07-2008
GB 2470194 A	17-11-2010	GB 2470194 A WO 2010130759 A1	17-11-2010 18-11-2010
EP 1469696 A1	20-10-2004	DE 602004006045 T2 EP 1469696 A1 KR 20040069573 A US 2004192254 A1	16-08-2007 20-10-2004 06-08-2004 30-09-2004
WO 2012084053 A1	28-06-2012	EP 2656665 A1 US 2013273914 A1 WO 2012084053 A1	30-10-2013 17-10-2013 28-06-2012