A method comprises starting, in a user terminal (Y), a virtual user terminal application provided by a home network service operator. A connection may be established between a home network and the user terminal (Y), via a small cell gateway (femto-GW) of the home network by utilizing the virtual user terminal application installed in the user terminal (Y), wherein the user terminal (Y) establishes an internet connection and the virtual user terminal application establishes a connection to the small cell gateway (femto-GW) of the home network, for example, such that the virtual user terminal application interfaces with the small cell gateway (femto-GW) over the internet connection.
PROVIDING A NETWORK CONNECTION IN COMMUNICATIONS

FIELD OF THE INVENTION

The exemplary and non-limiting embodiments of this invention relate generally to wireless communications networks, and more particularly to providing a network connection to a user terminal.

BACKGROUND ART

The following description of background art may include insights, discoveries, understandings or disclosures, or associations together with disclosures not known to the relevant art prior to the present invention but provided by the invention. Some such contributions of the invention may be specifically pointed out below, whereas other such contributions of the invention will be apparent from their context.

WiFi technology allows an electronic device to exchange data wirelessly over a computer network, including high-speed internet connections. WiFi may be considered to involve any wireless local area network (WLAN) product based on IEEE 802.11 standards. A device with a WiFi capability (such as a personal computer, laptop, game console, smartphone, tablet, or digital audio player) connects to a network such as the internet via a wireless network access point (AP). A WiFi access point (or hotspot) may have a range of about 20 meters indoors and a greater range outdoors. Hotspot coverage may comprise of a single room with walls that block radio waves, or an area of several square kilometres by using multiple overlapping access points.

SUMMARY

The following presents a simplified summary of the invention in order to provide a basic understanding of some aspects of the invention. This summary is not an extensive overview of the invention. It is not intended to identify key/critical elements of the invention or to delineate the scope of the invention. Its sole purpose is to present some concepts of the invention in a simplified form as a prelude to the more detailed description that is presented later.

Various aspects of the invention comprise a method, apparatuses, computer program product, and a computer-readable storage medium as defined in the independent claims. Further embodiments of the invention are disclosed in the dependent claims.
An aspect of the invention relates to a method for providing a network connection to a user terminal, comprising starting a virtual user terminal application in the user terminal; establishing a connection between a home network and the user terminal, via a small cell gateway of the home network by utilizing the virtual user terminal application, such that the user terminal establishes an internet connection and the virtual user terminal application establishes a connection to the small cell gateway (femto-GW) of the home network over the internet connection.

A further aspect of the invention relates to a user terminal comprising at least one processor; and at least one memory including a computer program code, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the user terminal to start a virtual user terminal application; establish a connection between a home network and the user terminal, via a small cell gateway of the home network by utilizing the virtual user terminal application in the user terminal, such that the user terminal establishes an internet connection and the virtual user terminal application establishes a connection to the small cell gateway of the home network over the internet connection.

A still further aspect of the invention relates to a first apparatus comprising at least one processor; and at least one memory including a computer program code, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the first apparatus located in a home network to establish a connection between the home network and a user terminal, by utilizing a virtual user terminal application started in the user terminal, such that an internet connection is established by the user terminal and a connection to the first apparatus is established by the virtual user terminal application over the internet connection.

A still further aspect of the invention relates to a second apparatus comprising at least one processor; and at least one memory including a computer program code, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the second apparatus to transmit, to a user terminal, installation information on a virtual user terminal application, the virtual user terminal application enabling establishing a connection between a home network and the user terminal, via a small cell gateway of the home network by utilizing the virtual user terminal application installed in the user terminal, such that the user terminal establishes an internet connection and the virtual user terminal application establishes a connection to the small cell gateway of the home network over the internet connection.
A still further aspect of the invention relates to a computer program product comprising program code means configured to perform any of the method steps when the program is run on a computer.

A still further aspect of the invention relates to a computer-readable storage medium comprising program code means configured to perform any of the method steps when executed on a computer.

A still further aspect of the invention relates to an electromagnetic signal carrying computer-readable instructions for transmitting, from a network apparatus to a user terminal, installation information on a virtual user terminal application, the virtual user terminal application enabling establishing a connection between a home network and the user terminal, via a small cell gateway of the home network by utilizing the virtual user terminal application installed in the user terminal, such that the user terminal establishes an internet connection and the virtual user terminal application establishes a connection to the small cell gateway of the home network over the internet connection.

Although the various aspects, embodiments and features of the invention are recited independently, it should be appreciated that all combinations of the various aspects, embodiments and features of the invention are possible and within the scope of the present invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following the invention will be described in greater detail by means of exemplary embodiments with reference to the attached drawings, in which

Figure 1 illustrates a dual-SIM UE connected to a foreign operator’s network to form a secured IPsec tunnel over a public network;

Figure 2 illustrates a system comparison between an exemplary embodiment and an existing solution;

Figure 3 illustrates a UE - home node-B protocol stack;

Figure 4 illustrates a virtual UE protocol stack according to an exemplary embodiment;

Figure 5 shows a simplified block diagram illustrating exemplary apparatuses;

Figure 6 shows a messaging diagram illustrating an exemplary messaging event according to an embodiment of the invention;
Figure 7 shows a schematic diagram of a flow chart according to an exemplary embodiment of the invention;

Figure 8 shows a schematic diagram of a flow chart according to another exemplary embodiment of the invention.

5 DETAILED DESCRIPTION OF SOME EMBODIMENTS

A femtocell refers to a small, low-power cellular base station, designed e.g. for use in a home or small business. A more general term "small cell" may also be used, and the femtocell may be considered as a subset of a small cell concept. The femtocell or small cell connects to a service provider’s network via a broadband (such as DSL or cable) connection. The femtocell/small cell concept allows service providers to extend service coverage indoors or at the cell edge, especially where access is otherwise limited or unavailable. The femtocell/small cell concept is applicable to various standards including WCDMA, GSM, CDMA2000, TD-SCDMA, WiMAX, LTE and LTE-A solutions. A term home node-B (HNB) may be used to refer to a 3G femtocell. A term home eNode-B (HeNB) may be used to refer to an LTE (LTE-A) femtocell.

An exemplary embodiment relates to a virtualized mobile UE that directly connects to subscriber’s home network without international roaming charges. An exemplary embodiment relates to a 3G or LTE/LTE-A network architecture, international roaming, and femtocell technology.

20 The mobile subscriber international ISDN number (MSISDN) is practically bind to the home country of a user terminal, and using it from abroad is often expensive. For a group of people that continuously live abroad but still like to keep on contact with friends and family at home, this may result in large phone bills. This customer segment is actively looking for a more affordable alternative to keep in touch with their buddies, and they may end up using VoIP services such as Skype. An exemplary embodiment provides an efficient way for a home country operator to win back revenues that are captured by others.

In Ubiquisys’s personal femtocell technology "Attocell", a Uu radio interface still exists between a femtocell base station and a physical mobile UE. The femtocell base station is not virtualized either but is real physical HW, although the size of the femtocell base station may be quite small. The BOM costs of that approach are thus considerably higher, a complex HW design is required to build such a device. In addition, it requires a separate device for that purpose. The mobile UE needs to be set on top of Attocell, and cannot be moved away. Attocell requires a USB connection to a laptop in order to function.
In an exemplary embodiment, a virtualized mobile phone is running as a (SW) service inside a real physical mobile phone, or in any other suitable hosting device (e.g. a laptop) providing internet connectivity. This is achieved by using standardized 3GPP interfaces and by neglecting those interfaces that are not anymore needed when the mobile UE and the femtocell base station (home node-B/home eNode-B) SWs are combined together to form a single unified SW stack. Radio interface related functionality vanishes when both the mobile UE SW and the femtocell SW are running on a same entity. The combined SW stack, now forming a virtual UE, may directly interface with a femtocell gateway by using a standardized IPsec-tunelled luh interface over an ordinary internet connection.

Having the virtual UE hosted by the physical UE enables that the virtual UE is able to host a homeland's USIM, while the physical UE may be still running with a foreign USIM. The virtual UE directly interfaces with a homeland network, by using a standard femtocell luh-interface, as if the virtual UE was physically located within borders of the home country. A connection to the homeland's network is over a foreign network's mobile broadband connection which is set up by the physical UE by utilizing the foreign network's own USIM. Hence, in this setup, international roaming fees are avoided and the user is able to benefit from local flat rate service of both of the countries.

For the virtual UE to have its own physical USIM, the hosting UE may need to be of an "enhanced-dual-SIM" model, allowing accessing both USIMs near-simultaneously. An UE-model independent solution may be to place an extra USIM for the virtual UE inside a SD memory card. In this case, USIM may be accessed via reading and writing a "magic" file in the SD memory card's file system. This way, a virtual UE application may be brought to already existing smartphone models just by inserting an integrated SD-memory/USIM-combo-card to the phone and by installing an application SW from a store.

UE refers to a USIM-enabled user equipment, a mobile phone for instance.

Figure 1 illustrates a situation in which a dual-SIM UE A is connected to a foreign operator's network B which is used to form a secured IPsec tunnel C over a public network (e.g. "internet cloud" J). A home country operator E may recognise that a virtual UE G is served by a femtocell gateway F which is part of a home country network E. IMSI of the virtual mobile phone is hosted by a home network's HLR H. Thus, no international roaming occurs when using the virtual UE for calls in home country network, although the physical UE device A is still hosted by the foreign network B.

Thus, a virtualized mobile phone runs as a (SW) service inside a real physical mobile phone, or in any other suitable hosting device providing internet connectivity. This is achieved by using standardized 3GPP interfaces, but neglecting those interfaces that are
not anymore needed when the mobile UE and a femtocell base station (home node-B) SWs are combined together to form a single unified protocol stack. The radio interface related functionality vanishes when both the mobile UE SW and the femtocell SW are running on the same entity. The combined SW stack, forming the basis of the virtual UE, may directly interface with the femtocell gateway by using the standardized IPsec-tunnelled luh interface over the ordinary internet connection. Additionally, an integrated SD-card & USIM-combo may be introduced.

Ubiquisys's Attocell connects via a USB connection to a laptop PC. A Windows or Linux operating system supports IPsec, just like TCP/IP. Ubiquisys uses IPsec tunnel established from the laptop PC to the femtocell gateway because this is a standard way in 3GPP to connect any home base station to the operator's network.

Ubiquisys Attocell enables receiving and making calls in the home country network when being in abroad. However, it is not allowed to borrow someone's licensed radio spectrum, thus in practice it is required that Ubiquisys Attocell's transmission power is kept so low that the mobile phone lays on top of an Attocell device. In other words, in Attocell, the user is not able to pick up the phone from the table when it rings, but needs to use e.g. a Bluetooth headset or hands-free speaker mode.

An exemplary embodiment also enables receiving and making calls in the home country network when being in abroad. An exemplary embodiment differs from Ubiquisys Attocell in mobility. An apparatus according to an exemplary embodiment provides better mobility as its functionality is not limited to the very close proximity of an external HW, as it is in Ubiquisys Attocell. An exemplary embodiment also enables avoiding legal concern of unauthorized "borrowing" of licensed radio spectrum as no radio interface is needed. An exemplary embodiment is also more cost effective as it may be realized as a SW alone implementation. Figure 2 illustrates a comparison of use cases regarding an exemplary embodiment and Ubiquisys Attocell. In Figure 2, a laptop Y may also be a mobile phone with WiFi or local 3G data capability (the laptop example is shown in Figure 2 to avoid a confusion of having a "mobile in a mobile").

Ubiquisys Attocell merely concentrates on describing radio interface functionality. It is irrelevant as in an exemplary embodiment there is no radio interface. Attocell also involves different versions of "wireless access devices" that are also irrelevant, as an exemplary embodiment does not include any separate device or gear. In an exemplary embodiment, SW may run on the mobile device with unlimited mobility without any close-proximity/indoors restrictions, and also more affordably.
One existing solution is an external "data dongle" with multiple USIM slots, involving an equipment offering wireless data access without roaming fees. The equipment ("Uros" apparatus) is an ordinary mobile hot spot/MiFi dongle but with an extra twist of supporting multiple USIM cards. The user attaches a local USIM for each country s/he plans to visit. When abroad, "Uros" apparatus uses the correct USIM to avoid roaming charges.

However, "Uros" apparatus does not support roaming-free calls. Its scope is limited only to providing wireless internet access affordably, and it is not a home node-B nor does it rely on IPsec.

"Uros" apparatus is like a MiFi dongle and MiFi dongles closely resemble the mobile UE with a WiFi-tethering feature available in Android phones, the UE side. "Uros" apparatus is a sort of a multi-SIM UE that is able to connect to home node-B by itself, as UEs do. So, "Uros" does not connect to femto-GW nor does it support luh/IPsec.

Figure 3 illustrates a home node-B protocol stack, showing an ordinary protocol stack of HNB and UE. A phone application - in its simplest form, the number UI to dial in calls - resides on top of an L3 signaling layer.

Figure 4 illustrates a virtual UE protocol stack according to an exemplary embodiment, showing a radio interface consisting of RRC, RLC, MAC, Rf interface modules removed, and a L3 signaling layer and a phone application of the UE side moved on top of a RANAP layer. Taking into account that the remaining lowest layers up to IPsec are directly supported by a Linux/Windows/Android OS, the remaining layers SCTP, HNBAO, RUA, RANAP, MM, CC/SS/SMS and the phone dial application itself are the protocol stack of the virtual UE application that is to be installed on top of e.g. the Android OS as an application. As a further optimization it may also be possible to get rid of the RANAP and RUA layers and fit a mobility management layer directly on top of a HNBAP layer.

Ubiquisys Attocell and an exemplary embodiment partly utilize a similar network infrastructure, i.e. up to a WiFi access point (e.g. of a hotel room, a use case scenario for Attocell). Following example situation illustrates the differences between Attocell and the virtual UE according to an exemplary embodiment (in addition to having the virtual UE running on a real UE in an exemplary embodiment):

Alice is in a hotel room abroad and luckily having an internet connection. Alice is home sick and she wants to call home but she knows that in this country the local operator may rip her badly. Alice first connects her laptop X to a WiFi network of the hotel, and then plugs Attocell with a USB cable to her laptop. She places her real UE on top of Attocell, and voila, the phone says that she is now connected to the home country network and she is able to call to her mother now. Alice’s friend Jill wants to call her mother too. Jill does
not have Attocell with her, so instead Jill downloads a virtual UE application from her
home country operator’s web site and installs it on her laptop Y. On Jill’s laptop screen,
there may soon be displayed information on (e.g. an image of) a mobile UE that looks like
a real one. Jill dials in the number and calls to her mother.

5 Jill wakes up in the morning and she decides to go to the beach. Jill does not want to take
her laptop with her, so she installs a virtual UE application onto her phone over WiFi in the
same way as she installed it on her laptop in the evening. While walking to the beach,
Alice drops into a local store to buy an affordable prepaid SIM card and she inserts it to
her mobile phone. On the beach, Alice’s phone establishes a 3G data connection to a cell
near the beach. This does not cost much as the phone is now running on a local prepaid
SIM. The phone obtains an internet connection and the virtual UE application running on
Alice’s phone establishes a connection to the home country femto-GW. “Look, mother is
calling”, Alice has no reason not to answer mother’s call as the virtual UE application
enables avoiding roaming charges. Just like being at home.

10 Both Alice and Jill are able to call to their mothers affordably, because in both cases, their
phones “travel over the internet” to their home countries, by utilizing a standard femto-GW
technology provided by the 3G partnership project.

An exemplary embodiment is missing the radio interface making it different compared to
Ubiquisys Attocell; i.e. an exemplary embodiment is missing a Uu-radio interface.

20 Uros apparatus is an ordinary mobile hot spot/MiFi dongle with an extra twist of supporting
multiple USIM cards. The user may attach to a local USIM for each country s/he plans to
visit. When abroad, Uros apparatus uses the correct USIM to avoid roaming charges.
However, Uros apparatus does not support roaming fee free calls like an exemplary
embodiment does. Uros apparatus is only limited to providing wireless internet access
affordably.

An exemplary embodiment enables receiving and making calls in the home country
network when being in abroad. An exemplary embodiment is not limited to the very close
proximity of external HW. An exemplary embodiment also enables avoiding legal concern
of unauthorized “borrowing” of licensed radio spectrum as no radio interface is needed. It
is also more cost effective as it may be a SW alone implantation.

An exemplary embodiment involves no radio interface functionality, nor does it include any
separate device or gear.
An exemplary embodiment may utilize SW, instead of HW home node-B. In an exemplary embodiment, SW runs on a mobile device providing affordable roaming, but with unlimited mobility (no close-proximity/indoors restriction).

An exemplary embodiment may use a Uu interface wrapper.

An exemplary embodiment uses an IPsec tunnel and a virtual connection to the femtocell GW.

Exemplary embodiments of the present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which some, but not all embodiments of the invention are shown. Indeed, the invention may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements. Although the specification may refer to "an", "one", or "some" embodiment(s) in several locations, this does not necessarily mean that each such reference is to the same embodiment(s), or that the feature only applies to a single embodiment. Single features of different embodiments may also be combined to provide other embodiments. Like reference numerals refer to like elements throughout.

The present invention is applicable to any user terminal, server, gateway, corresponding component, and/or to any communication system or any combination of different communication systems that support network roaming. The communication system may be a fixed communication system or a wireless communication system or a communication system utilizing both fixed networks and wireless networks. The protocols used, the specifications of communication systems, servers and user terminals, especially in wireless communication, develop rapidly. Such development may require extra changes to an embodiment. Therefore, all words and expressions should be interpreted broadly and they are intended to illustrate, not to restrict, the embodiment.

In the following, different embodiments will be described using, as an example of a system architecture where to the embodiments may be applied, an architecture based on WLAN network elements, without restricting the embodiment to such an architecture, however. The embodiments described in these examples are not limited to the WLAN systems but can also be implemented in other radio systems, such as UMTS (universal mobile telecommunications system), LTE, LTE-A GSM, EDGE, WCDMA, bluetooth network, WLAN or other fixed, mobile or wireless network. In an embodiment, the presented solution may be applied between elements belonging to different but compatible systems such as WLAN or LTE-A.
A general architecture of a communication system is illustrated in Figure 5. Figure 5 is a simplified system architecture only showing some elements and functional entities, all being logical units whose implementation may differ from what is shown. The connections shown in Figure 5 are logical connections; the actual physical connections may be different. It is apparent to a person skilled in the art that the systems also comprise other functions and structures. It should be appreciated that the functions, structures, elements and the protocols used in or for network roaming, are irrelevant to the actual invention. Therefore, they need not to be discussed in more detail here.

Figure 5 is a block diagram of an apparatus according to an embodiment of the invention. Figure 5 shows a user equipment 501 located in the area of a radio network node 502 (e.g. a WLAN access point AP, LTE base station eNB, radio network controller (RNC), or any other network element, or a combination of network elements). The user equipment 501 is configured to be in connection with the radio network node 502. The user equipment or UE 501 comprises a controller 503 operationally connected to a memory 504 and a transceiver 505. The controller 503 controls the operation of the user equipment 501. The memory 504 is configured to store software and data. The transceiver 505 is configured to set up and maintain a wireless connection 506 to the radio network node 502. The transceiver 505 is operationally connected to a set of antenna ports 507 connected to an antenna arrangement 508. The antenna arrangement 508 may comprise a set of antennas. The number of antennas may be one to four, for example. The number of antennas is not limited to any particular number. The user equipment 501 may also comprise various other components, such as a user interface, camera, and/or media player. They are not displayed in Figure 5 due to simplicity.

The radio network node 502, such as a WLAN access point AP (WiFi access point AP), comprises a controller 509 operationally connected to a memory 510, and a transceiver 511. The controller 509 controls the operation of the radio network node 502. The memory 510 is configured to store software and data. The transceiver 511 is configured to set up and maintain a wireless connection 506 to the user equipment 501 within the service area of the radio network node 502. The transceiver 511 is operationally connected to an antenna arrangement 512. The antenna arrangement 512 may comprise a set of antennas. The number of antennas may be two to four, for example. The number of antennas is not limited to any particular number. The radio network node 502 may be operationally connected (directly or indirectly) to another network element of the communication system, such as a further radio network node, small cell gateway (such as a femtocell gateway (femto-GW)), radio network controller (RNC), a mobility management entity (MME), an MSC server (MSS), a mobile switching centre (MSC), a radio resource
management (RRM) node, an operations, administrations and maintenance (OAM) node, a
home location register (HLR), a visitor location register (VLR), a serving GPRS support
node, gateway GPRS support node (GGSN), serving GPRS support node (SGSN), home
subscriber server (HSS), a gateway and/or a server, via an interface. The embodiments
are not, however, restricted to the network given above as an example, but a person
skilled in the art may apply the solution to other communication networks provided with the
necessary properties. For example, the connections between different network elements
may be realized with internet protocol (IP) connections.

Although the apparatus 501, 502, femto-GW has been depicted as one entity, different
modules and memory may be implemented in one or more physical or logical entities. The
apparatus may also be a user terminal which is a piece of equipment or a device that
associates, or is arranged to associate, the user terminal and its user with a subscription
and allows a user to interact with a communications system. The user terminal presents
information to the user and allows the user to input information. In other words, the user
terminal may be any terminal capable of receiving information from and/or transmitting
information to the network, connectable to the network wirelessly or via a fixed connection.
Examples of the user terminals include a personal computer, a game console, a laptop
(notebook) computer, a personal digital assistant (PDA), a mobile station (mobile phone),
a smart phone, a tablet, a handset, mp3 player, and a line telephone.

The apparatus 501, 502, femto-GW may generally include a processor, controller, control
unit or the like connected to a memory and to various interfaces of the apparatus.
Generally the processor is a central processing unit, but the processor may be an
additional operation processor. The processor may comprise a computer processor,
application-specific integrated circuit (ASIC), field-programmable gate array (FPGA),
and/or other hardware components that have been programmed in such a way to carry
out one or more functions of an embodiment.

The memory 504, 510 may include volatile and/or non-volatile memory and typically stores
content, data, or the like. For example, the memory 504, 510 may store computer program
code such as software applications or operating systems, information, data, content, or
the like for a processor to perform steps associated with operation of the apparatus in
accordance with embodiments. The memory may be, for example, random access
memory (RAM), a hard drive, or other fixed data memory or storage device. Further, the
memory, or part of it, may be removable memory detachably connected to the apparatus.

The techniques described herein may be implemented by various means so that an
apparatus implementing one or more functions of a corresponding mobile entity described
with an embodiment comprises not only prior art means, but also means for implementing the one or more functions of a corresponding apparatus described with an embodiment and it may comprise separate means for each separate function, or means may be configured to perform two or more functions. For example, these techniques may be implemented in hardware (one or more apparatuses), firmware (one or more apparatuses), software (one or more modules), or combinations thereof. For a firmware or software, implementation can be through modules (e.g. procedures, functions, and so on) that perform the functions described herein. The software codes may be stored in any suitable, processor/computer-readable data storage medium(s) or memory unit(s) or article(s) of manufacture and executed by one or more processors/computers. The data storage medium or the memory unit may be implemented within the processor/computer or external to the processor/computer, in which case it can be communicatively coupled to the processor/computer via various means as is known in the art.

The signalling chart of Figure 6 illustrates the required signalling. In the example of Figure 6, a user terminal UE 501, may install (e.g. in response to recognising a predetermined command from the user or the network) a virtual UE application in the user terminal from a home network in item 601. In item 602, the user terminal may start the virtual UE application installed in the user terminal by transmitting a message 603 to a small cell gateway (such as a femtocell gateway femto-GW) located in the home network via an internet access point AP 502 (e.g. WiFi access point or 3G base station) located in the home network or in a the visited network. In item 604, the access point 502 may forward the message to the small cell gateway. In item 605, 606, the small cell gateway may respond to the user terminal 501 via the access point 502. In item 607, 608, a connection is established between the home network and the user terminal 501, via the small cell gateway, by utilizing the virtual user terminal application installed in the user terminal 501, wherein the user terminal 501 establishes an internet connection and the virtual UE application establishes a connection to the small cell gateway over the internet connection. The virtual UE application may interface with the small cell gateway e.g. by using a IPsec-tunneled luh interface (or VPN connection or any other secured or non-secured connection) over the internet connection.

Figure 7 is a flow chart illustrating an exemplary embodiment. The apparatus 501, which may comprise e.g. a user equipment 501 located in the service area of a (home or visited) radio network node 502, may request (e.g. in response to recognising a predetermined command from the user) downloading of a virtual UE application from a home network by transmitting 701 a request message e.g. to a download server located in a home network. In item 702, the user terminal may receive the virtual UE application transmitted by the
download server to the user terminal 501 via an internet access point 502 (e.g. WiFi
access point or 3G base station). Herein, UE may receive information on an IP address of
a small cell gateway (such as a femtocell GW) or other identification information. Thus, in
item 702, the user terminal may install the virtual UE application in the user terminal 501 .
In item 703, the user terminal may start the virtual UE application installed in the user
terminal 501, wherein in item 703, a connection is established between the home network
and the user terminal 501, via the small cell gateway, by utilizing the virtual user terminal
application downloaded in the user terminal 501, wherein the user terminal 501
establishes an internet connection and the virtual UE application establishes a connection
to the small cell gateway over the internet connection. Thus, in the user terminal 501 a 2G
data connection, 3G data connection, 4G data connection, LTE connection, LTE-A
connection, personal area network (e.g. bluetooth) PAN connection, or a WiFi connection
to a cell/access point/base station may be established, by using the virtual UE application.
Alternatively a wired connection such as LAN or Ethernet connection may be established.
The virtual UE application may interface with the small cell gateway e.g. by using a IPsec-
tunnelled luh interface over the internet connection.

Figure 8 is a flow chart illustrating an exemplary embodiment. The apparatus, which may
comprise e.g. a small cell gateway (such as a femtocell gateway), may, in item 801,
receive a request for starting a virtual UE application, the request being transmitted from a
user terminal 501, via an internet access point AP 502 (e.g. WiFi access point or 3G base
station) located in the home network or in the visited network. In item 802, the small cell
gateway may respond to the user terminal 501 via the access point 502. In item 803, a
connection is established between the home network and the user terminal 501, via the
small cell gateway, by utilizing the virtual user terminal application started in the user
terminal 501, wherein the user terminal 501 establishes an internet connection and the
virtual UE application establishes a connection to the small cell gateway over the internet
connection. The virtual UE application may interface with the small cell gateway e.g. by
using a IPsec-tunnelled luh interface over the internet connection.

It should be noted that the downloading/installing of the virtual UE application in the user
terminal 501 is not necessarily carried out via the small cell gateway/femtocell gateway,
but may be carried out via any other home or visited network apparatus, such as by
means of a download server or via a home node-B or home eNode-B or any other suitable
network element. The virtual UE application may also be preinstalled/preconfigured in the
user terminal 501 during manufacturing, purchasing, and/or operating of the user terminal
501. The user of the user terminal may, for example, download the virtual UE application
from the (home) operator’s web site.
The virtual user terminal application may be specific for the home network (i.e. the network to which the virtual UE application connects to). However, the virtual user terminal application need not be specific for a certain roaming network, but instead the same virtual user terminal application may be used in the home network and different roaming networks (i.e. networks in which the WiFi access point is located).

A small cell gateway, such as a femtocell gateway, may comprise a security gateway for terminating encrypted IP data connections from femtocells, and a signalling gateway for aggregating and validating signalling traffic, authenticating femtocells and interfacing with mobile network core switches using standard protocols, such as lu. In a lu/h architecture, the femtocell gateway may interface the femtocell to the core network, and perform translations to ensure that the femtocells appear as a radio network controller to existing mobile switching centres. However, it should be noted that the term small cell gateway used herein is not limited to a femtocell gateway, but instead of/in addition to the femtocell gateway, the term small cell gateway may be used to refer to any other suitable small cell apparatus or other network element capable of interfacing an access point of a small cell to a core network. Thus it should be noted that instead of a small cell gateway (such as a femtocell gateway) the apparatus operations may be carried out in any other suitable network element capable of interfacing a small cell (access point) to a core network.

In an exemplary embodiment, the home network operator may transmit, to the user terminal, installation information on the virtual user terminal application. The installation information may be transmitted e.g. via short message service (SMS) or email, automatically in response to a home network apparatus (e.g. MSC/VLR, HLR, gateway, server) detecting that the user terminal is roaming in a visited network. The installation information may include e.g. instructions and/or a web link to the application download/installation site.

In an exemplary embodiment, a specific file is encrypted to secure exchange of identity data between USIM and the virtual user terminal application.

The steps/points, signalling messages and related functions de-scribed above in Figures 1 to 8 are in no absolute chronological order, and some of the steps/points may be performed simultaneously or in an order differing from the given one. Other functions can also be executed between the steps/points or within the steps/points and other signalling messages sent be-tween the illustrated messages. Some of the steps/points or part of the steps/points can also be left out or replaced by a corresponding step/point or part of the step/point. The apparatus operations illustrate a procedure that may be implemented in one or more physical or logical entities. The signalling messages are only exemplary and
may even comprise several separate messages for transmitting the same information. In addition, the messages may also contain other information.

Thus, according to an exemplary embodiment, there is provided a method for providing a network connection to a user terminal, comprising starting a virtual user terminal application in the user terminal; establishing a connection between a home network and the user terminal, via a small cell gateway of the home network by utilizing the virtual user terminal application, such that the user terminal establishes an internet connection and the virtual user terminal application establishes a connection to the small cell gateway (femto-GW) of the home network over the internet connection.

According to another exemplary embodiment, the internet connection and the connection to the small cell gateway of the home network are established such that the virtual user terminal application interfaces with the small cell gateway over the internet connection.

According to yet another exemplary embodiment, the virtual user terminal application includes information on the home network and is provided by a home network service operator.

According to yet another exemplary embodiment, there is provided a method comprising providing displaying information on a virtual user terminal on a display screen of the user terminal to enable a user of the user terminal to establish a call by utilizing the virtual user terminal application in the user terminal.

According to yet another exemplary embodiment, there is provided a method comprising establishing in the user terminal a 2G data connection, 3G data connection, 4G data connection, LTE connection, LTE-A connection, personal area network PAN connection, or a WiFi connection to a cell.

According to yet another exemplary embodiment, there is provided a method comprising user terminal software protocol stack and small cell base station software protocol stack are combined together to form a unified software protocol stack of a virtual user terminal.

According to yet another exemplary embodiment, there is provided a method comprising using the combined unified software protocol stack of the virtual user terminal, to directly interface with the small cell gateway by using a standardized interface secured by using an IPsec protocol or any other secured or non-secured protocol over an ordinary internet connection.
According to yet another exemplary embodiment, there is provided a method comprising using, in the user terminal, an enhanced-dual-SIM in order the virtual user terminal application to have its own physical USIM, allowing accessing both USIMs simultaneously.

According to yet another exemplary embodiment, there is provided a method comprising using, in a SD memory card of the user terminal, an extra USIM for the virtual user terminal, wherein USIM is accessible via reading and writing a specific file in a SD memory card's file system.

According to yet another exemplary embodiment, there is provided a method comprising having the virtual user terminal hosted by a physical user terminal such that the virtual user terminal hosts a home country USIM, and the physical user terminal hosts a visited country USIM, wherein the user terminal is located in a visited network.

According to yet another exemplary embodiment, there is provided a method comprising installing, in the user terminal, the virtual user terminal application.

According to yet another exemplary embodiment, there is provided a method comprising encrypting a specific file to secure the exchange of identity data between USIM and the virtual user terminal application.

According to yet another exemplary embodiment, there is provided a method comprising establishing, in the user terminal, a connection to the home network without a Uu radio interface.

According to yet another exemplary embodiment, there is provided a user terminal comprising at least one processor; and at least one memory including a computer program code, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the user terminal to start a virtual user terminal application; establish a connection between a home network and the user terminal, via a small cell gateway of the home network by utilizing the virtual user terminal application in the user terminal, such that the user terminal establishes an internet connection and the virtual user terminal application establishes a connection to the small cell gateway of the home network over the internet connection.

According to yet another exemplary embodiment, the at least one memory and the computer program code are configured to, with the at least one processor, cause the user terminal to display information on a virtual user terminal on a display screen of the user terminal to enable a user of the user terminal to establish a call by utilizing the virtual user terminal application in the user terminal.
According to yet another exemplary embodiment, the at least one memory and the computer program code are configured to, with the at least one processor, cause the user terminal to establish a 2G data connection, 3G data connection, 4G data connection, LTE connection, LTE-A connection, personal area network PAN connection, or a WiFi connection to a cell.

According to yet another exemplary embodiment, user terminal software protocol stack and small cell base station software protocol stack are combined together to form a unified software protocol stack of a virtual user terminal.

According to yet another exemplary embodiment, the at least one memory and the computer program code are configured to, with the at least one processor, cause the user terminal to use the combined unified software protocol stack of the virtual user terminal, to directly interface with the small cell gateway by using a standardized interface secured by using an IPsec protocol or any other secured or non-secured protocol over an ordinary internet connection.

According to yet another exemplary embodiment, the at least one memory and the computer program code are configured to, with the at least one processor, cause the user terminal to use an enhanced-dual-SIM in order the virtual user terminal application to have its own physical USIM, allowing accessing both USIMs simultaneously.

According to yet another exemplary embodiment, the at least one memory and the computer program code are configured to, with the at least one processor, cause the user terminal to use, in a SD memory card of the user terminal, an extra USIM for the virtual user terminal, wherein USIM is accessible via reading and writing a specific file in s SD memory card's file system.

According to yet another exemplary embodiment, the at least one memory and the computer program code are configured to, with the at least one processor, cause the user terminal to have the virtual user terminal hosted by a physical user terminal such that the virtual user terminal hosts a home country USIM, and the physical user terminal hosts a visited country USIM, the user terminal being located in a visited network.

According to yet another exemplary embodiment, the at least one memory and the computer program code are configured to, with the at least one processor, cause the user terminal to install, in the user terminal, the virtual user terminal application.

According to yet another exemplary embodiment, the at least one memory and the computer program code are configured to, with the at least one processor, cause the user terminal to establish a connection to the home network without a Uu radio interface.
According to yet another exemplary embodiment, there is provided a first apparatus comprising at least one processor; and at least one memory including a computer program code, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the first apparatus located in a home network to establish a connection between the home network and a user terminal, by utilizing a virtual user terminal application started in the user terminal, such that an internet connection is established by the user terminal and a connection to the first apparatus is established by the virtual user terminal application over the internet connection.

According to yet another exemplary embodiment, the internet connection and the connection to the first apparatus are established such that the virtual user terminal application interfaces with the first apparatus over the internet connection.

According to yet another exemplary embodiment, the first apparatus comprises a small cell gateway, such as a femtocell gateway.

According to yet another exemplary embodiment, there is provided a second apparatus comprising at least one processor; and at least one memory including a computer program code, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the second apparatus to transmit, to a user terminal, installation information on a virtual user terminal application, the virtual user terminal application enabling establishing a connection between a home network and the user terminal, via a small cell gateway of the home network by utilizing the virtual user terminal application installed in the user terminal, such that the user terminal establishes an internet connection and the virtual user terminal application establishes a connection to the small cell gateway of the home network over the internet connection.

According to yet another exemplary embodiment, the at least one memory and the computer program code are configured to, with the at least one processor, cause the second apparatus to transmit, to the user terminal, said installation information via short message service, internet, or email, in response to detecting that the user terminal is roaming in a visited network, wherein the second apparatus is located in the home network.

According to yet another exemplary embodiment, there is provided a computer program product comprising program code means configured to perform any of the method steps when the program is run on a computer.
According to yet another exemplary embodiment, there is provided a computer-readable storage medium comprising program code means configured to perform any of the method steps when executed on a computer.

According to yet another exemplary embodiment, there is provided an electromagnetic signal carrying computer-readable instructions for transmitting, from a network apparatus to a user terminal, installation information on a virtual user terminal application, the virtual user terminal application enabling establishing a connection between a home network and the user terminal, via a small cell gateway of the home network by utilizing the virtual user terminal application installed in the user terminal, such that the user terminal establishes an internet connection and the virtual user terminal application establishes a connection to the small cell gateway of the home network over the internet connection.

According to yet another exemplary embodiment, the electromagnetic signal carries computer-readable instructions for transmitting, from the network apparatus to the user terminal, said installation information via short message service, internet, or email, in response to detecting that the user terminal is roaming in a visited network.

It will be obvious to a person skilled in the art that, as the technology advances, the inventive concept can be implemented in various ways. The invention and its embodiments are not limited to the examples described above but may vary within the scope of the claims.

List of abbreviations

MSISDN mobile subscriber international ISDN number

ISDN integrated services digital network

UE user equipment

VoIP voice over internet protocol

GW gateway

3G 3rd generation

SW software

WiFi wireless fidelity

SD secure digital
IPsec  secured internet protocol
HW  hardware
USIM  UMTS subscriber identity module
3GPP  3rd generation partnership project
UI  user interface
BOM  bill of materials
USB  universal serial bus
MiFi  my WiFi
RRC  radio resource control
RLC  radio link control
MAC  media access control
L3  layer 3
RANAP  radio access network application part
OS  operating system
SCTP  signalling common transport protocol
RUA  RAN user adaptation
MM  mobility management
CC  call control
SS  supplementary service
SMS  short message service
HNBAP  home node-B application part
VPN  virtual private network
IF  interface
CLAIMS

1. A method of providing a network connection to a user terminal, characterized by
   starting (602) a virtual user terminal application in the user terminal (501);
   establishing (607) a connection between a home network and the user terminal (501), via
   a small cell gateway (femto-GW) of the home network by utilizing the virtual user terminal
   application,
   such that the user terminal (501) establishes an internet connection and the virtual user
   terminal application establishes a connection to the small cell gateway (femto-GW) of the
   home network over the internet connection.

2. A method according to claim 1, characterized in that the internet connection
   and the connection to the small cell gateway (femto-GW) of the home network are
   established such that the virtual user terminal application interfaces with the small cell
   gateway (femto-GW) over the internet connection.

3. A method according to claim 1 or 2, characterized in that the virtual user
   terminal application includes information on the home network and is provided by a home
   network service operator.

4. A method according to claim 1, 2 or 3, characterized by displaying information
   on a virtual user terminal on a display screen of the user terminal (501) to enable a user of
   the user terminal (501) to establish a call by utilizing the virtual user terminal application in
   the user terminal (501).

5. A method according to any of claims 1 to 4, characterized by establishing in
   the user terminal (501) a 2G data connection, 3G data connection, 4G data connection,
   LTE connection, LTE-A connection, personal area network PAN connection, or a WiFi
   connection to a cell.

6. A method according to any of claims 1 to 5, characterized in that user terminal
   (501) software protocol stack and small cell base station software protocol stack are
   combined together to form a unified software protocol stack of a virtual user terminal.

7. A method according to claim 6, characterized by using the combined unified
   software protocol stack of the virtual user terminal, to directly interface with the small cell
   gateway by using a standardized interface secured by using an IPsec protocol or any
   other secured or non-secured protocol over an ordinary internet connection.
8. A method according to any of claims 1 to 7, characterized by using, in the user terminal (501), an enhanced-dual-SIM in order the virtual user terminal application to have its own physical USIM, allowing accessing both USIMs simultaneously.

9. A method according to any of claims 1 to 9, characterized by using, in a SD memory card of the user terminal (501), an extra USIM for the virtual user terminal, wherein USIM is accessible via reading and writing a specific file in SD memory card's file system.

10. A method according to any of claims 1 to 10, characterized by having the virtual user terminal hosted by a physical user terminal (501) such that the virtual user terminal hosts a home country USIM, and the physical user terminal (501) hosts a visited country USIM, wherein the user terminal (501) is located in a visited network.

11. A method according to any of claims 1 to 11, characterized by installing (605), in the user terminal (501), the virtual user terminal application.

12. A method according to any of claims 1 to 11, characterized by encrypting a specific file to secure the exchange of identity data between USIM and the virtual user terminal application.

13. A method according to any of claims 1, 2, 3, 4, 5, 6, 7, 9 or 11, characterized by establishing, in the user terminal (501), a connection to the home network without a Uu radio interface.

14. A user terminal (501) comprising at least one processor; and at least one memory including a computer program code, characterized in that the at least one memory and the computer program code are configured to, with the at least one processor, cause the user terminal (501) to start a virtual user terminal application;

15. A user terminal according to claim 14, characterized in that the internet connection and the connection to the small cell gateway (femto-GW) of the home network
are established such that the virtual user terminal application interfaces with the small cell gateway (femto-GW) over the internet connection.

16. A user terminal according to claim 14 or 15, characterized in that the virtual user terminal application includes information on the home network and is provided by a home network service operator.

17. A user terminal according to claim 14, 15 or 16, characterized in that the at least one memory and the computer program code are configured to, with the at least one processor, cause the user terminal to display information on a virtual user terminal on a display screen of the user terminal (501) to enable a user of the user terminal (501) to establish a call by utilizing the virtual user terminal application in the user terminal (501).

18. A user terminal according to any of claims 14 to 17, characterized in that the at least one memory and the computer program code are configured to, with the at least one processor, cause the user terminal to establish a 2G data connection, 3G data connection, 4G data connection, LTE connection, LTE-A connection, personal area network PAN connection, or a WiFi connection to a cell.

19. A user terminal according to any of claims 14 to 18, characterized in that user terminal (501) software protocol stack and small cell base station software protocol stack are combined together to form a unified software protocol stack of a virtual user terminal.

20. A user terminal according to claim 19, characterized in that the at least one memory and the computer program code are configured to, with the at least one processor, cause the user terminal to use the combined unified software protocol stack of the virtual user terminal, to directly interface with the small cell gateway by using a standardized interface secured by using an IPsec protocol or any other secured or non-secured protocol over an ordinary internet connection.

21. A user terminal according to any of claims 14 to 20, characterized in that the at least one memory and the computer program code are configured to, with the at least one processor, cause the user terminal to use an enhanced-dual-SIM in order the virtual user terminal application to have its own physical USIM, allowing accessing both USIMs simultaneously.

22. A user terminal according to any of claims 14 to 21, characterized in that the at least one memory and the computer program code are configured to, with the at least one processor, cause the user terminal to use, in a SD memory card of the user terminal (501), an extra USIM for the virtual user terminal, wherein USIM is accessible via reading and writing a specific file in the SD memory card's file system.
23. A user terminal according to any of claims 14 to 22, characterized in that the
at least one memory and the computer program code are configured to, with the at least
one processor, cause the user terminal to have the virtual user terminal hosted by a
physical user terminal (501) such that the virtual user terminal hosts a home country
USIM, and the physical user terminal (501) hosts a visited country USIM, the user terminal
(501) being located in a visited network.

24. A user terminal according to any of claims 14 to 23, characterized in that the
at least one memory and the computer program code are configured to, with the at least
one processor, cause the user terminal to install, in the user terminal (501), the virtual
user terminal application.

25. A user terminal according to claim 14, 15, 16, 17, 18, 19, 20 or 24,
characterized in that the at least one memory and the computer program code
are configured to, with the at least one processor, cause the user terminal to establish a
connection to the home network without a Uu radio interface.

26. A first apparatus (femto-GW) comprising at least one processor; and at least one
memory including a computer program code, characterized in that the at least
one memory and the computer program code are configured to, with the at least one
processor, cause the first apparatus (femto-GW) located in a home network to
establish a connection between the home network and a user terminal (501), by utilizing a
virtual user terminal application started in the user terminal (501),
such that an internet connection is established by the user terminal (501) and a
connection to the first apparatus (femto-GW) is established by the virtual user terminal
application over the internet connection.

27. A first apparatus according to claim 26, characterized in that the internet
connection and the connection to the first apparatus (femto-GW) are established such that
the virtual user terminal application interfaces with the first apparatus (femto-GW) over the
internet connection.

28. A first apparatus according to claim 26 or 27, characterized in that it
comprises a small cell gateway, such as a femtocell gateway.

29. A second apparatus comprising at least one processor; and at least one memory
including a computer program code, characterized in that the at least one
memory and the computer program code are configured to, with the at least one
processor, cause the second apparatus to
transmit, to a user terminal, installation information on a virtual user terminal application, the virtual user terminal application enabling establishing a connection between a home network and the user terminal (501), via a small cell gateway (femto-GW) of the home network by utilizing the virtual user terminal application installed in the user terminal (501), such that the user terminal (501) establishes an internet connection and the virtual user terminal application establishes a connection to the small cell gateway (femto-GW) of the home network over the internet connection.

30. A second apparatus according to claim 29, characterized in that the at least one memory and the computer program code are configured to, with the at least one processor, cause the second apparatus to transmit, to the user terminal, said installation information via short message service, internet, or email, in response to detecting that the user terminal is roaming in a visited network, wherein the second apparatus is located in the home network.

31. A computer program product, characterized by comprising program code means configured to perform any of method steps of claims 1 to 13 when the program is run on a computer.

32. A computer-readable storage medium, characterized by comprising program code means configured to perform any of method steps of claims 1 to 13 when executed on a computer.

33. An electromagnetic signal carrying computer-readable instructions for transmitting, from a network apparatus to a user terminal, installation information on a virtual user terminal application, the virtual user terminal application enabling establishing a connection between a home network and the user terminal (501), via a small cell gateway (femto-GW) of the home network by utilizing the virtual user terminal application installed in the user terminal (501), such that the user terminal (501) establishes an internet connection and the virtual user terminal application establishes a connection to the small cell gateway (femto-GW) of the home network over the internet connection.

34. An electromagnetic signal according to claim 33, characterized in that it carries computer-readable instructions for transmitting, from the network apparatus to the user terminal, said installation information via short message service, internet, or email, in response to detecting that the user terminal is roaming in a visited network.
Fig. 4
Fig. 5
Fig. 6
### INTERNATIONAL SEARCH REPORT

**PCT/EP2013/056096**

**A. CLASSIFICATION OF SUBJECT MATTER**

INV. H04W4/00

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

EPO-Internal, INSPEC, WPI Data

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>US 2012/044908 AI (SPINELLI VINCENT [US] ET AL) 23 February 2012 (2012-02-23) paragraphs [0032] - [0045]; figure 1</td>
<td>1-34</td>
</tr>
</tbody>
</table>

X: 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

* 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 to be obvious to a person skilled in the art

*’Y*’ document of particular relevance; the claimed invention cannot be considered to be obvious to a person skilled in the art

*’Z*’ document member of the same patent family

Date of the actual completion of the international search: 12 November 2013

Date of mailing of the international search report: 21/11/2013

Authorized officer: Milano, Massimo
<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>EP 2 485 564 A1 (ALCATEL LUCENT [FR]) 8 August 2012 (2012-08-08) paragraphs [0038] - [0049]; figure 1</td>
<td>1-34</td>
</tr>
<tr>
<td>Patent document cited in search report</td>
<td>Publication date</td>
<td>Patent family member(s)</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>-----------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>WO 2011127224 A1</td>
<td>13-10-2011</td>
<td>NONE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CN 101138204 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP 4490487 B2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP 2008529379 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>KR 20070091237 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 2006168656 A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WO 2006079891 A1</td>
</tr>
<tr>
<td>US 2012044908 A1</td>
<td>23-02-2012</td>
<td>CN 101919303 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EP 2204066 A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 2009156213 A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 2012044908 A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WO 2009055827 A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 7624437 B1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 2009031404 A1</td>
</tr>
<tr>
<td>EP 2485564 A1</td>
<td>08-08-2012</td>
<td>NONE</td>
</tr>
</tbody>
</table>