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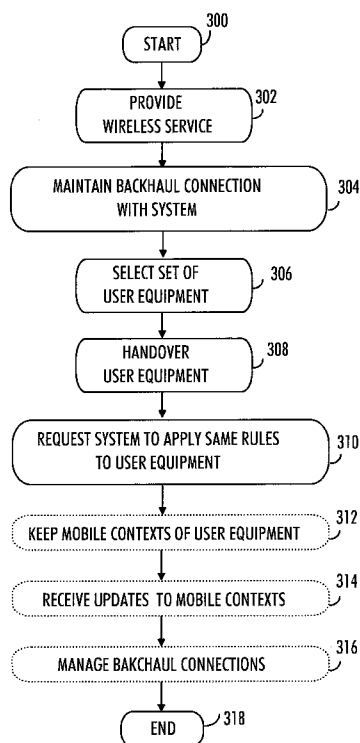


FIG. 3A

(57) Abstract: Apparatus and method for communication are provided. The solution comprises providing a radio access for at least one user equipment within a coverage area via at least one radio access connection; transmitting user data related to the radio access via at least one cellular radio access backhaul connection to at least one donor cellular system, selecting a set of user equipment within the coverage area, the user equipment having an active connection; performing a handover for the set of user equipment to the at least one donor cellular system; and requesting the at least one donor cellular system apply the set of user equipment same rules as the apparatus applies to the user equipment connected to the apparatus in all aspects except physical radio link parameters.



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Apparatus and method for communication

Field

The exemplary and non-limiting embodiments of the invention relate generally to wireless communication networks. Embodiments of the invention
5 relate especially to an apparatus and a method in communication networks.

Background

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 of such contributions of the invention may be
10 specifically pointed out below, whereas other such contributions of the invention will be apparent from their context.

With the ever increasing demand for increasing data rates and higher quality services in the world of mobile communications comes ever increasing demand for better performance of cellular network infrastructures.
15 People use their mobile equipment with support for high data rate services while they are at work, at home, and/or while traveling on a mass transportation vehicle, e.g. bus, train, and ship. Such a mass transportation vehicle may travel at a speed of up to 100 m/s, and a huge number of communicating mobile devices in the vehicle traveling at the same speed sets high demands for
20 network operators, because the users wish to preserve their high data rate connections regardless of the speed of the vehicle.

Long-term evolution (LTE) of the 3rd generation mobile communication system standardized within 3GPP (3rd Generation Partnership Project)
25 has introduced a relayed extension to cellular network infrastructure. Relaying links between user terminals and conventional base stations through mobile relays or relaying base stations improves capacity, coverage, and data rates. The mobile relays may be installed in buses, trains, cruisers and other mass transportation vehicles.

30 One problem associated with the deployment of mobile relay systems in especially high speed vehicles is the frequent need for handovers of mobile backhaul connections. The backhaul connections must support high data rate traffic even during a handover in order to provide adequate services to hundreds of potential mobile users abroad.

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
5 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 a more detailed description that is presented later.

According to an aspect of the present invention, there is provided an
10 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 at least to perform: provide a radio access for at least one user equipment within a coverage area via at least one radio access connection; transmit user
15 data related to the radio access via at least one cellular radio access backhaul connection to at least one donor cellular system, select a set of user equipment within the coverage area, the user equipment having an active connection; perform a handover for the set of user equipment to the at least one donor cellular system; and request the at least one donor cellular system apply the
20 set of user equipment same rules as the apparatus applies to the user equipment connected to the apparatus in all aspects except physical radio link parameters.

According to an aspect of the present invention, there is provided an apparatus, comprising: means for providing a radio access for at least one
25 user equipment within a coverage area via at least one radio access link; means for transmitting user data related to the radio access via at least one cellular radio access backhaul connection to at least one donor cellular system, means for selecting a set of user equipment within the coverage area; means for performing a handover for the set of user equipment to the at least
30 one donor cellular system; and means for requesting the at least one donor cellular system apply the set of user equipment same rules as the apparatus applies to the user equipment connected to the apparatus in all aspects except physical radio link parameters.

According to an aspect of the present invention, there is provided an
35 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 at least to perform: provide at least one cellular radio access backhaul connection for at least one relay node; perform handover for a set of user equipment from the at least one relay node; and apply the set of user equipment the same rules as the at least one relay node applies to the user equipment connected to the at least one relay node in all aspects except physical radio link parameters.

According to an aspect of the present invention, there is provided an apparatus, comprising: means for providing at least one cellular radio access backhaul connection for at least one relay node; means for performing handover for a set of user equipment from the at least one relay node; and means for applying the set of user equipment the same rules as the at least one relay node applies to the user equipment connected to the at least one relay node in all aspects except physical radio link parameters.

According to an aspect of the present invention, there is provided 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 at least to perform: receive user equipment handed over from another apparatus, receive information regarding identifier of the user equipment and information regarding a relay node, and the rules to be applied to the user equipment, the rules being the same as a relay node applies to the user equipment connected to the relay node in all aspects except physical radio link parameters and apply the received rules to the user equipment.

According to another aspect of the present invention, there is provided a method comprising: providing a radio access for at least one user equipment within a coverage area via at least one radio access connection; transmitting user data related to the radio access via at least one cellular radio access backhaul connection to at least one donor cellular system, selecting a set of user equipment within the coverage area, the user equipment having an active connection; performing a handover for the set of user equipment to the at least one donor cellular system; and requesting the at least one donor cellular system apply the set of user equipment same rules as the apparatus applies to the user equipment connected to the apparatus in all aspects except physical radio link parameters.

According to another aspect of the present invention, there is provided a method comprising: providing at least one cellular radio access back-haul connection for at least one relay node; performing handover for a set of user equipment from the at least one relay node; and applying the set of user
5 equipment the same rules as the at least one relay node applies to the user equipment connected to the at least one relay node in all aspects except physical radio link parameters.

According to another aspect of the present invention, there is provided a method comprising: receiving user equipment handed over from another apparatus, receiving information regarding identifier of the user equipment and information regarding a relay node, and the rules to be applied to the user equipment, the rules being the same as a relay node applies to the user equipment connected to the relay node in all aspects except physical radio link parameters and applying the received rules to the user equipment.

15 **List of drawings**

Embodiments of the present invention are described below, by way of example only, with reference to the accompanying drawings, in which

Figure 1 illustrates an example of an environment where mobile relays are used;

20 Figure 2 illustrates an example of a communication environment between a relay node and communication systems;

Figures 3A and 3B are flowcharts illustrating embodiments of the invention; and

Figures 4A and 4B illustrate examples of apparatuses according to
25 embodiments of the invention.

Description of some embodiments

Embodiments are applicable to any base station, user equipment (UE), server, corresponding component, and/or to any communication system or any combination of different communication systems that support required
30 functionality.

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 in-
35 tended to illustrate, not to restrict, embodiments.

Many different radio protocols to be used in communications systems exist. Some examples of different communication systems are the universal mobile telecommunications system (UMTS) radio access network (UT-RAN or E-UTRAN), long term evolution (LTE, known also as E-UTRA), long term evolution advanced (LTE-A), Wireless Local Area Network (WLAN) based on IEEE 802.11 standard, worldwide interoperability for microwave access (Wi-MAX), Bluetooth®, personal communications services (PCS) and systems using ultra-wideband (UWB) technology. IEEE refers to the Institute of Electrical and Electronics Engineers.

Figure 1 illustrates an example of an environment where mobile relays are used between user equipment and a telecommunication system. In the illustrated scenario, a mobile relay or a relay base station is installed in a mobile vehicle and configured to relay communication links between fixed network infrastructure and user equipment.

Figure 1 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 1 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.

The example of Figure 1 shows a relay node 100 installed in a mobile vehicle 102. The relay node 100 is configured to provide network access to user equipment 104, 106 and 108 in the moving vehicle. Thus, it serves a moving cell. The user equipment is connected 112, 114 and 116 to the relay node 100. The relay node 100 is connected 118 to a core network of a donor cellular system by means of a mobile wireless backhaul connection.

User equipment refers to a portable computing device. Such computing devices include wireless mobile communication devices operating with or without a subscriber identification module (SIM), including, but not limited to, the following types of devices: mobile phone, smartphone, personal digital assistant (PDA), handset, laptop computer.

The relay node 100 may comprise a wireless transceiver 120 providing an out-band wireless access for the user equipment in the coverage area of the relay node. The out-band wireless access may also be called non-cellular radio access as the frequency band utilised by the out-band wireless access is different compared to cellular services. A non-limiting example of a

non-cellular or out-band access type is Wireless Local Area Network (WLAN) or WiFi.

In an embodiment, the mobile relay 100 may comprise a cellular transceiver 122 providing a cellular wireless access for the user equipment in the coverage area of the mobile relay. The access technology may be LTE or LTE-A, for example. The mobile relay 100 may have the full functionality of e.g. LTE-A eNode B towards the user equipment 104, 106, 108, but it is attached to the network side using a mobile wireless backhaul.

Embodiments of the invention are not limited by the number of transceivers or wireless access types provided by the relay node. The number of the access types may be one or more.

Figure 2 illustrates an example of a communication environment between relay nodes and communication systems. Figure 2 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 2 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 protocols used in or for group communication are irrelevant to the actual invention. Therefore, they need not be discussed in more detail here.

The example of Figure 2 comprises a communication system 200, an operator. The system comprises a core network 202. In this example, system 200 comprises more than one radio access network of different radio access technologies (RAT). The system comprises a 3G based network comprising a Radio Network Controller RNC 204 and one or more base stations or NodeBs 206 connected to the RNC 204. In addition, the system comprises LTE or LTE-A based access network comprising eNodeB 208 connected to a MME (Mobility Management Entity) 210 of the core network 202.

The core network comprises following elements: an MME (Mobility Management Entity) 210, an SAE GW (SAE Gateway) 212, and an OAM (Operations, Administration and Management system) 214. The core network further comprises an ANDSF (Access Network Discovery and Selection Function) 216. It should be appreciated that a communication system may also comprise other core network elements besides the illustrated such as a Gateway Mobile Service Switching Centre, GMSC, a Serving GPRS Support Node, SGSN, for

example. Furthermore, not all systems necessarily comprise all the above illustrated elements.

Base stations that may also be called eNodeBs (Enhanced node Bs) of a communication system may host the functions for Radio Resource Management: Radio Bearer Control, Radio Admission Control, Connection Mobility Control, Dynamic Resource Allocation (scheduling). This applies to LTE or LTE-A based systems. For the 3G based systems the Radio Network Controller 204 may comprise some of the above mentioned functions. The MME 210 is responsible for distributing paging messages to the eNodeBs. The SAE GW 212 is an entity configured to act as a gateway between the network and other parts of communication network such as the Internet for example. The SAE GW may be a combination of two gateways, a serving gateway (S-GW) and a packet data network gateway (P-GW). The ANDSF 216 is a network-protocol functionality which is configured to assist user equipment of the network to make mobility decisions between 3GPP and non-3GPP access technologies on the basis of the network operator policy. For example, the ANDSF enables user equipment supporting multiple access technologies to select most suitable access network in the area where different access technologies such WLAN or WiMAX are available.

The communication system 200 is operated as a closed system from radio network management point of view. The networks of different operators are connected with each other using a Global Roaming Interface (GRX) (not shown). The system 200 may be roaming partners allowing visiting user equipment of another network to get service. Visiting user equipment is authenticated from the home network of the user equipment.

Figure 2 only illustrates a simplified example. In practice, the system may include more base stations and more cells may be formed by the base stations. The access networks of two or more operators may overlap, the sizes and form of the cells may vary from what is depicted, etc.

The embodiments are not 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.

In the example of Figure 2, a vehicle 220 comprising one or more section or car 102, 224 is travelling on a path 226. Each car comprises a relay

node 100, 228. In an embodiment, the relay nodes 100, 228 are configured to operate in co-operation. The relay nodes may communicate with each other using the crX2 interface 229 regarding the wireless access services provided by the relay nodes and the backhaul connections of the relay nodes. A system comprising or more co-operative relay nodes may also be called a mobile relay.

The relay nodes may be a dual function relay as in Figure 1 providing both LTE/LTE-A access and non-cellular wireless access or the relays may offer only the latter access for the passengers of the vehicle. The number of wireless access types provided by the relay nodes is not relevant regarding the embodiments of the invention.

In the example of Figure 2, user equipment 104, 106 are connected 112, 114 to the relay node 100 via a wireless access provided by the relay node. Likewise, user equipment 234, 236 are connected 230, 232 to the relay node 228 via a wireless access provided by the relay node. The relay node 100 is configured to setup and maintain a backhaul connection 238 with a radio access network of a donor cellular system supporting in-band cellular access relays. An example of such is LTE or LTE-A network and the relay node 100 is connected to eNodeB 208. In addition, the mobile relay may have additional connections to radio access networks of donor cellular systems. The connections may be set up with a same or different radio access network, donor system or operator. In the example of Figure 2, the relay node has a connection 240 with the base station 204.

The relay node 228 is configured to setup and maintain a backhaul connection 242 with a radio access network of a donor cellular system supporting in-band cellular access relays. An example of such is LTE or LTE-A network and the relay node 242 is connected to eNodeB 208. The relay node could be connected to a radio access network of another operator as well, but due to simplicity Figure 2 comprises the communication system 200 of only one operator.

A mobile relay comprising several interconnected cooperative relay nodes may comprise several connections. In an embodiment, the mobile relay may transmit both user data and control data of a given relay node through another interconnected relay node in whole or in part.

In an embodiment, the mobile relay is configured to select a set of user equipment from the user equipment it is serving and which have an active

connection with the communication system. The mobile relay may take the position, capabilities subscription profile and status information of user equipment into a count when making the selection. In an embodiment the mobile relay is configured to select the user equipment of the set within the different parts of the coverage area served by the relay. When the mobile relay comprises several interconnected cooperative relay nodes wherein the coverage areas of the relay units are at least in part different from each other, the relay may select the user equipment of the set within the coverage areas of different relay units.

10 The mobile relay may be configured to perform a handover for the set of user equipment to the donor cellular system the mobile relay is connected to. If the mobile relay is connected to more than one donor system the handovers may be performed to one of the systems. All user equipment of the set need not perform handover to the same donor system. The donor system(s) receiving the user equipment may be denoted as target donor system(s). The user equipment transferred to the target donor system may be denoted as guiding user equipment.

 The relay may communicate with the target donor system(s) prior performing or requesting the handover. The mobile relay may request the target donor system(s) to consider the guiding user equipment to remain as virtual users of the mobile relay as long as the user equipment stay within the coverage area of the mobile relay.

 Considering the example of Figure 2, the mobile relay comprising interconnected relay nodes 100 and 228 may handover user equipment 106 from the first car and the user equipment 234 from the last car to a target donor system, to eNodeB 208 for example.

 After the handover, the user equipment 106 communicates with eNodeB 208 using connection 244 and the user equipment 234 communicates with eNodeB 208 using connection 246. After performing the handover the eNodeB creates a mobile context for the user equipment. The context data may be transmitted by the relay nodes 100, 228 to the eNodeB. Usually after user equipment has been transferred to another base station the mobile context of the user equipment is deleted from the donating base station. In this case however, as the guiding user equipment is considered to be a virtual user of the relay node, the relay node does not delete the mobile context but retains it.

The eNodeB 208 and the relay nodes 100, 228 may communicate with each other regarding the mobile context. In an embodiment, the eNodeB 208 updates the mobile contexts kept by the relay nodes. The updating may be performed periodically or it may be event-based. The relay nodes and the
5 eNodeB may identify or address the guiding user equipment to another using unique Radio Network Temporary Identifier RNTI agreed between the relay nodes and the target donor system.

In an embodiment, the relay nodes may request the target donor system(s) to apply the set of user equipment considered to be virtual users of
10 the relay nodes the same rules as the relay nodes apply to the user equipment connected to the apparatus in all aspects except physical radio link parameters. The target donor system(s) may provide the user equipment the same services as the relay node provided and the same Policy, Charging and Rule Functions apply to the user equipment as they still were connected to the relay
15 nodes. For example, if free IP access were provided by the relay node to the users aboard the vehicle served by the node then the same service should be available to the guiding user equipment considered to be virtual users of the relay nodes.

In an embodiment, the mobile relay may request the target donor
20 system (and vice versa) to hand back the guiding user equipment and to replace it with another at any time. Upon a radio link failure (RLF) at the target donor system the guiding UE may be configured to fall back to the mobile relay. The target donor system may inform the mobile relay if there is a change in active state or Automatic Neighbour Relation (ANR) relation of the guiding
25 user equipment towards the mobile relay. For an example, the guiding user equipment may terminate the current connection and service with the target donor system and become idle while remaining aboard. In this case, the targeted donor system may redirect the guiding UE to camp on the mobile relay while being idle and aboard, as all other idle user equipment aboard.

30 If the guiding user equipment gets off the train while being served by the target donor system, the eNodeB, based on UE measurement towards the mobile relay, may detect that the guiding user equipment is no longer aboard the vehicle served by the mobile relay and inform the mobile relay about the situation. In such a case, the mobile relay is configured to release or delete the
35 mobile context of the guiding user equipment. The mobile relay and the target

donor system will no longer treat the user equipment as a virtual user of the mobile relay but a regular UE by the target donor system.

In an embodiment, a guiding user equipment is handed over from a eNodeB (denoted as source eNodeB) to another eNodeB (denoted as target eNodeB) within the target donor system, as the guiding user equipment is travelling on board of the vehicle such as an intercity high-speed train carrying a mobile relay. One option is that the source eNodeB informs the target eNodeB during the handover of the guiding user equipment that this user equipment is a guiding user equipment for a certain mobile relay served by the source eNodeB. Then during the handover process of the mobile relay between the source and target eNodeBs the target eNodeB can get the mapping information between the mobile relay and the guiding user equipment, both the mobile relay and the guiding user equipment may still be served by the target eNodeB. The aforementioned RNTI, originally agreed between the mobile relay and the serving eNodeB, may be used as the identifier to map the mobile relay and the guiding user equipment in the eNodeBs. The other alternative may be that the mobile relay is informing the new eNodeB (the serving eNodeB after the handover of the mobile relay) about the relation to certain guiding user equipment.

The eNodeB the guiding UEs are connected to keeps mobile contexts of the user equipment. As stated above, the eNodeB transmits updates of the context to the mobile relay. In an embodiment, the mobile relay and the target donor system may establish or derive certain association in mobile contexts between mobile connections of the guiding UEs and corresponding mobile backhaul connections of the mobile relay. The mobile relay and the target donor system may compare parameters of the different mobile contexts and determine relations between the parameters. Examples of relevant parameters in question are handover timing, received carrier signal strength, uplink synchronization timing or timing-advance, resource allocation scaling-up for mobile relay providing that certain number of users abroad and Quality of Service (QoS) scaling is known and updated, roaming restriction extended with multi-operator multi-RAT supports of mobile relay, etc. Some of these relations can be represented by simple corresponding offset parameters.

The mobile access backhaul connections of the mobile relay may be controlled and managed on the basis of the determined relations. When serving the guiding UEs after handover, the target donor system, based on radio

measurement, connection and mobility management of the guiding UEs and the aforementioned established relations, may coordinate within intra-system mobile backhaul connections of the mobile relay. In addition, if the mobile relay has backhaul connections with several target systems, all these connections
5 may be managed, with inter-system control server or in co-operation with the other serving donor systems of the mobile relay for efficient predictive control and management.

For example, the on-the-run mobile contexts of guiding UEs monitored by the target donor systems can be used for predictive and pro-active
10 control and update of relevant mobile backhaul contexts of the mobile relay including optimized resource allocation, system information and configuration update, pro-active handover control or RLF recovery (as long as the guiding UEs remaining active and aboard).

For an example, a guiding UE 106 in the front car 102 be handed
15 over to a new target cell considerably earlier (up to seconds depending on e.g. travelling speed of the train and distance from the front to the antenna position) than that of a backhaul connection of relay node provided by backhaul-link antennas placed in the back car 224.

In another example, the relay node 100 serving users in the front
20 car 102 due to half-duplex relay operation may be allowed to miss a handover with possible fast RLF recovery in the new targeted cell based on proper guiding UE contexts and other backhaul connections of interconnected relay nodes in the back car 224.

Yet another example, the donor system may scale resource allocation for a mobile relay based on resource needed to serve a guiding UE. Further examples may explore advanced relations or correlations among the guiding UEs and monitored contexts thereof for predictive control. For instance, two neighbouring guiding UEs could be handed over to the target donor system, one to remain at the current donor eNodeB and one to a handover candidate eNodeB. Since they are neighbouring UEs, the measurements can be
30 used to derive the differences between being connected to the current eNodeB and that to the candidate eNodeB. Such the differences can be used for hand-over or cell reselection control of the backhaul link.

The guiding UEs may be configured to perform measurements for
35 possible neighbouring cells. However, it may be difficult for the guiding UE to find new neighbours due to interference from the mobile relay transmissions. In

an embodiment, enhanced inter-cell interference coordination (eICIC) may be applied to ensure that the guiding UEs may perform measurements. The eNodeB communicating with the guiding UEs may inform the UEs about subframes with which have less interference both for CQI measurements (only
5 during those subframes the guiding UE may be able to receive the eNodeBs with good quality) and for neighbour cell search (only in those subframes the guiding UE may be able to find new cells).

The proposed solution has virtually no impact on the user equipment side. Extra messages and measurements are not required when an UE is considered as a guiding UE. The proposed solution provides effective
10 means of enhancing efficiency and robustness of mobile backhaul connection for challenging mobile relay operation.

In an embodiment, the guiding UE may be implemented as a built-in devices mounted on transportation vehicle or and as an integrated part of the
15 mobile relay (or a system comprising mobile relay and guiding UE) as well.

Figure 3A is a flowchart illustrating an embodiment of the invention. The embodiment starts at step 300.

In step 302, a mobile relay or relay node is configured to provide a radio access for at least one user equipment within a coverage area via at
20 least one radio access connection.

In step 304, the mobile relay is configured to transmit user data related to the radio access via at least one cellular radio access backhaul connection to at least one donor cellular system.

In step 306, the mobile relay is configured to select a set of user
25 equipment within the coverage area, the user equipment having an active connection;

In step 308, the mobile relay is configured to perform a handover for the set of user equipment to the at least one donor cellular system.

In step 310, the mobile relay is configured to request the at least
30 one donor cellular system apply the set of user equipment same rules as the apparatus applies to the user equipment connected to the apparatus in all aspects except physical radio link parameters. Thus, the set of user equipment are considered to be virtual users of the mobile relay.

In an embodiment, the mobile relay is configured to keep the active
35 mobile context of the user equipment after the handover in step 312 and re-

ceive updates of the mobile contexts from the at least one donor cellular system in step 314.

In an embodiment, the mobile relay is configured to control and manage in step 316 the at least one cellular radio access backhaul connection on the basis on the updates of the mobile contexts of the set of user equipment received from the at least one donor system.

The process ends in step 318.

Figure 3B is a flowchart illustrating an embodiment of the invention. The embodiment starts at step 320.

In step 322, a network element of a communication system is configured to provide at least one cellular radio access backhaul connection for at least one relay node or mobile relay. The network element may be an eNodeB, for example.

In step 324, the network element of a communication system is configured to perform handover for a set of user equipment from the at least one relay node.

In step 326, the network element of a communication system is configured to apply the set of user equipment the same rules as the at least one relay node applies to the user equipment connected to the at least one relay node in all aspects except physical radio link parameters.

In an embodiment, the network element of a communication system is configured to maintain and update the mobile contexts of set of user equipment and transmit information on the updates to the at least one relay node in step 328.

In an embodiment, the network element of a communication system is configured to in step 330 control and manage the at least one cellular radio access backhaul connection on the basis on the updates of the mobile contexts of the set of user equipment.

The process ends in step 332.

Figure 4A illustrates a simplified example of an apparatus 216 of an embodiment. In some embodiments, the apparatus may be an eNodeB of a communications system. In an embodiment, it is a separate network element.

It should be understood that the apparatus is depicted herein as an example illustrating some embodiments. It is apparent to a person skilled in the art that the apparatus may also comprise other functions and/or structures.

Although the apparatus has been depicted as one entity, different modules and memory may be implemented in one or more physical or logical entities.

The apparatus of the example includes a communication control circuitry 400 configured to control at least part of the operation of the apparatus.

5 The apparatus may comprise a memory 402 for storing data. Furthermore the memory may store software 404 executable by the control circuitry 400. The memory may be integrated in the control circuitry. The software may comprise a computer program comprising program code means adapted to perform any of features described above in relation to the eNodeB 208.

10 The apparatus may further comprise interface circuitry 406 configured to connect the apparatus to other devices of communication network, for example to core network. The interface may provide a wired or wireless connection to the communication network. The apparatus may be in connection with a mobile relay, core network elements and with respective apparatuses of communication systems of other operators.

15 The apparatus further comprises a transceiver 408 configured to communicate with user equipment, mobile relays and relay nodes in the service area of the apparatus. The transceiver may be a LTE or LTE-A transceiver, for example. The transceiver is operationally connected to the control circuitry 400. It may be connected to an antenna arrangement (not shown).

20 Figure 4B illustrates a simplified example of a mobile relay or a relay node 100. It should be understood that the apparatus is depicted herein as an example illustrating some embodiments. It is apparent to a person skilled in the art that the mobile relay node may also comprise other functions and/or structures. Although the mobile relay has been depicted as one entity, different modules and memory may be implemented in one or more physical or logical entities.

25 The mobile relay may be implemented in part or in whole as an electronic digital computer, which may comprise a working memory (RAM), a central processing unit (CPU), and a system clock. The CPU may comprise a set of registers, an arithmetic logic unit, and a control unit. The control unit is controlled by a sequence of program instructions transferred to the CPU from the RAM. The control unit may contain a number of microinstructions for basic operations. The electronic digital computer may also have an operating system, which may provide system services to a computer program written with the program instructions.

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The mobile relay of the example includes a communication control circuitry 410 configured to control at least part of the operation of the mobile relay node.

5 The mobile relay further comprises a first transceiver 418A configured to provide a cellular wireless access service or in-band cellular access communication as well as the access backhaul links. The transceiver may be a LTE or LTE-A transceiver. The transceiver is operationally connected to the control circuitry 410. It may be connected to an antenna arrangement (not shown).

10 In an embodiment, the mobile relay may further comprise a second transceiver 418B configured to provide a non-cellular or out-band wireless access service. The transceiver may be a WLAN or WiFi transceiver, for example. The transceiver is operationally connected to the control circuitry 410. It may be connected to an antenna arrangement (not shown).

15 The transceivers may be separate entities in the mobile relay 100 or they may be realized as circuitries in a common transceiver. In addition, the number of transceivers or circuitries is not limited. There may be separate circuitries providing the backhaul links and the access services, for example. The transceivers or circuitries may have separate antenna arrangements or they
20 may use the same antenna arrangement.

As one skilled in the art is aware, transceivers may be realized as separate transmitters and receivers. In an embodiment, the apparatus 100 comprises only one transceiver.

The apparatus may further comprise a memory 412 for storing data.
25 Furthermore the memory may store software 414 executable by the control circuitry 410. The memory may be integrated in the control circuitry. The software may comprise a computer program comprising program code means adapted to perform any of features described above in relation to the mobile relay 100.

30 In an embodiment, the apparatus may further comprise user interface 416 with which the apparatus may be configured by hand if need arises. The user interface may comprise a display and a keypad or keyboard, for example.

35 The steps, messages and related functions described in the above and attached figures are in no absolute chronological order, and some of the steps may be performed simultaneously or in an order differing from the given

one. Other functions can also be executed between the steps or within the steps. Some of the steps can also be left out or replaced with a corresponding step.

The apparatuses or controllers able to perform the above-described steps may be implemented as an electronic digital computer, which may comprise a working memory (RAM), a central processing unit (CPU), and a system clock. The CPU may comprise a set of registers, an arithmetic logic unit, and a controller. The controller is controlled by a sequence of program instructions transferred to the CPU from the RAM. The controller may contain a number of microinstructions for basic operations. The implementation of microinstructions may vary depending on the CPU design. The program instructions may be coded by a programming language, which may be a high-level programming language, such as C, Java, etc., or a low-level programming language, such as a machine language, or an assembler. The electronic digital computer may also have an operating system, which may provide system services to a computer program written with the program instructions.

As used in this application, the term 'circuitry' refers to all of the following: (a) hardware-only circuit implementations, such as implementations in only analog and/or digital circuitry, and (b) combinations of circuits and software (and/or firmware), such as (as applicable): (i) a combination of processor(s) or (ii) portions of processor(s)/software including digital signal processor(s), software, and memory(ies) that work together to cause an apparatus to perform various functions, and (c) circuits, such as a microprocessor(s) or a portion of a microprocessor(s), that require software or firmware for operation, even if the software or firmware is not physically present.

This definition of 'circuitry' applies to all uses of this term in this application. As a further example, as used in this application, the term 'circuitry' would also cover an implementation of merely a processor (or multiple processors) or a portion of a processor and its (or their) accompanying software and/or firmware. The term 'circuitry' would also cover, for example and if applicable to the particular element, a baseband integrated circuit or applications processor integrated circuit for a mobile phone or a similar integrated circuit in a server, a cellular network device, or another network device.

An embodiment provides a computer program embodied on a distribution medium, comprising program instructions which, when loaded into an

electronic apparatus, are configured to control the apparatus to execute the embodiments described above.

The computer program may be in source code form, object code form, or in some intermediate form, and it may be stored in some sort of carrier, which may be any entity or device capable of carrying the program. Such carriers include a record medium, computer memory, read-only memory, an electrical carrier signal, a telecommunications signal, and a software distribution package, for example. Depending on the processing power needed, the computer program may be executed in a single electronic digital computer or it may be distributed amongst a number of computers.

The apparatus may also be implemented as one or more integrated circuits, such as application-specific integrated circuits ASIC. Other hardware embodiments are also feasible, such as a circuit built of separate logic components. A hybrid of these different implementations is also feasible. When selecting the method of implementation, a person skilled in the art will consider the requirements set for the size and power consumption of the apparatus, the necessary processing capacity, production costs, and production volumes, for example.

It will be obvious to a person skilled in the art that, as 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.

Claims

1. An apparatus, comprising:
at least one processor; and
at least one memory including computer program code,
5 the at least one memory and the computer program code configured
to, with the at least one processor, cause the apparatus at least to perform:
provide a radio access for at least one user equipment within a coverage area via at least one radio access connection;
transmit user data related to the radio access via at least one cellular
10 lar radio access backhaul connection to at least one donor cellular system,
select a set of user equipment within the coverage area, the user equipment having an active connection;
perform a handover for the set of user equipment to the at least one donor cellular system; and
15 request the at least one donor cellular system apply the set of user equipment same rules as the apparatus applies to the user equipment connected to the apparatus in all aspects except physical radio link parameters.
2. The apparatus of claim 1, the apparatus being configured to store
20 the active mobile context of the user equipment after the handover and receive updates of the mobile contexts from the at least one donor cellular system.
3. The apparatus of claim 1, the apparatus being configured to select the user equipment of the set within the different parts of the coverage
25 area of the apparatus.
4. The apparatus of claim 1, the apparatus comprising more than relay nodes configured to
provide coordinated radio access for at least one user equipment
30 within the coverage area of each relay node, the coverage areas of the relay nodes being at least in part different from each other,
communicate with at least one donor cellular system, the relay nodes being configured to communicate with each other.

5. The apparatus of claims 3 and 4, the apparatus being configured to select the user equipment of the set within the coverage areas of different relay nodes.

5 6. The apparatus of any preceding claim, the apparatus being configured to request the at least one donor system to handover user equipment of the set back to the apparatus and select another user equipment to perform a handover to the at least one donor system.

10 7. The apparatus of claim 2, the apparatus being configured to control and manage the at least one radio access link on the basis on the updates of the mobile contexts of the set of user equipment received from the at least one donor system.

15 8. An apparatus, comprising:
 means for providing a radio access for at least one user equipment within a coverage area via at least one radio access link;
 means for transmitting user data related to the radio access via at least one cellular radio access backhaul connection to at least one donor cellular system,
20 means for selecting a set of user equipment within the coverage area;
 means for performing a handover for the set of user equipment to the at least one donor cellular system; and
25 means for requesting the at least one donor cellular system apply the set of user equipment same rules as the apparatus applies to the user equipment connected to the apparatus in all aspects except physical radio link parameters.

30 9. 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 at least to perform:
35 provide at least one cellular radio access backhaul connection for at least one relay node;

perform handover for a set of user equipment from the at least one relay node; and

apply the set of user equipment the same rules as the at least one relay node applies to the user equipment connected to the at least one relay node in all aspects except physical radio link parameters.

10. The apparatus of claim 9, the apparatus being configured to maintain and update the mobile contexts of set of user equipment and transmit information on the updates to the at least one relay node.

10

11. The apparatus of claim 10, the apparatus being configured to control and manage the at least one cellular radio access backhaul connection on the basis on the updates of the mobile contexts of the set of user equipment.

15

12. The apparatus of claim 10, the apparatus being configured to control and manage the mobile context of at least one relay node on the basis on the updates of the mobile contexts of the set of user equipment.

20

13. The apparatus of claim 11, the apparatus being configured to control the handovers of the at least one cellular radio access backhaul connection on the basis on the updates of the mobile contexts of the set of user equipment.

25

14. The apparatus of claim 11, the apparatus being configured to control the resources allocated to the at least one cellular radio access backhaul link on the basis on the updates of the mobile contexts of the set of user equipment.

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15. The apparatus of any preceding claim 9 to 14, the apparatus being configured to maintain at least one cellular backhaul connection with each relay node of more than one relay node serving the same vehicle or operationally connected vehicles.

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16. The apparatus of claim 15, the apparatus being configured to

control and manage the at least one cellular radio access backhaul connection of each relay node on the basis on the updates of the mobile contexts of the set of user equipment.

5 17. The apparatus of claim 10, the apparatus being configured to communicate with network elements of other donor cellular systems a relay node is communicating with relating to the control and management of the at least one cellular radio access backhaul connection.

10 18. The apparatus of claim 9, the apparatus being configured to assign the user equipment of the set an identifier agreed between the mobile relay and the apparatus.

15 19. The apparatus of claims 9 and 18, the apparatus being configured to
perform a handover of user equipment of the set to another apparatus and transmit the apparatus information regarding identifier of the user equipment and the rules to be applied to the user equipment.

20 20. An apparatus, comprising:
means for providing at least one cellular radio access backhaul connection for at least one relay node;
means for performing handover for a set of user equipment from the at least one relay node; and
25 means for applying the set of user equipment the same rules as the at least one relay node applies to the user equipment connected to the at least one relay node in all aspects except physical radio link parameters.

30 21. 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 at least to perform:
receive user equipment handed over from another apparatus,
35 receive information regarding identifier of the user equipment and information regarding a relay node, and the rules to be applied to the user

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equipment, the rules being the same as a relay node applies to the user equipment connected to the relay node in all aspects except physical radio link parameters and

apply the received rules to the user equipment.

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22. The apparatus of claim 21, the apparatus being configured to maintain and update the mobile contexts of the user equipment and transmit information on the updates to the relay node.

10

23. A method, comprising:

providing a radio access for at least one user equipment within a coverage area via at least one radio access connection;

transmitting user data related to the radio access via at least one cellular radio access backhaul connection to at least one donor cellular system,

15

selecting a set of user equipment within the coverage area, the user equipment having an active connection;

performing a handover for the set of user equipment to the at least one donor cellular system; and

20

requesting the at least one donor cellular system apply the set of user equipment same rules as the apparatus applies to the user equipment connected to the apparatus in all aspects except physical radio link parameters.

25

24. The method of claim 23, further comprising:

the apparatus being configured to storing the active mobile context of the user equipment after the handover and receive updates of the mobile contexts from the at least one donor cellular system.

30

25. The method of claim 23, further comprising: selecting the user equipment of the set within the different parts of the coverage area of the apparatus.

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26. The method of claim 23, further comprising:

providing coordinated radio access for at least one user equipment with more than one relay nodes, the coverage area of each relay unit being at

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least in part different from each other, the relay units being configured to communicate with each other and communicate with at least one donor cellular system.

5 27. The method of claims 25 and 26, further comprising:
 selecting the user equipment of the set within the coverage areas of
different relay units.

 28. The method of claim 23, further comprising:
10 requesting the at least one donor system to handover user equip-
ment of the set back to the apparatus and select another user equipment to
perform a handover to the at least one donor system.

 29. The method of claim 23, further comprising:
15 controlling and managing the at least one radio access link on the
basis on the updates of the mobile contexts of the set of user equipment re-
ceived from the at least one donor system.

 30. The method of any preceding claim 23 to 29, further comprising:
20 setting up and maintaining more than one mobile backhaul connec-
tions to more than one radio access networks of at least one donor cellular
system.

 31. The method of any preceding claim 23 to 30, further comprising:
25 setting up and maintaining more than one mobile backhaul connec-
tions to radio access networks of more than one donor cellular systems.

 32. A method, comprising:
 providing at least one cellular radio access backhaul connection for
30 at least one relay node;
 performing handover for a set of user equipment from the at least
one relay node; and
 applying the set of user equipment the same rules as the at least
one relay node applies to the user equipment connected to the at least one
35 relay node in all aspects except physical radio link parameters.

33. The method of claim 32, further comprising:
maintain and update the mobile contexts of set of user equipment
and transmit information on the updates to the at least one relay node.

5 34. The method of any preceding claim 32 to 33, further comprising:
controlling and manage the at least one cellular radio access back-
haul connection on the basis on the updates of the mobile contexts of the set
of user equipment.

10 35. The method of any preceding claim 32 to 34, further comprising:
controlling and managing the mobile context of at least one relay
node on the basis on the updates of the mobile contexts of the set of user
equipment.

15 36. The method of any preceding claim 32 to 35, further comprising:
controlling the handovers of the at least one cellular radio access
backhaul connection on the basis on the updates of the mobile contexts of the
set of user equipment.

20 37. The method of any preceding claim 32 to 36, further comprising:
controlling the resources allocated to the at least one cellular radio
access backhaul link on the basis on the updates of the mobile contexts of the
set of user equipment.

25 38. The method of any preceding claim 32 to 37, further comprising:
maintaining at least one cellular backhaul connection with each re-
lay node of more than one relay node serving the same vehicle or operationally
connected vehicles.

30 39. The method of any preceding claim 32 to 38, further comprising:
controlling and managing the at least one cellular radio access
backhaul connection of each relay node on the basis on the updates of the
mobile contexts of the set of user equipment.

35 40. The method of any preceding claim 32 to 39, further comprising:

communicating with network elements of other donor cellular systems a radio node is communicating with relating to the and control and management of the at least one cellular radio access backhaul connection.

5 41. The method of any preceding claim 32 to 40, further comprising:
performing a handover of user equipment of the set to another apparatus and transmitting the apparatus information regarding the rules to be applied to the user equipment.

10 42. A method, comprising:
receiving user equipment handed over from another apparatus,
receiving information regarding identifier of the user equipment and
information regarding a relay node, and the rules to be applied to the user
equipment, the rules being the same as a relay node applies to the user
15 equipment connected to the relay node in all aspects except physical radio link
parameters and
applying the received rules to the user equipment.

20 43. The method of claim 42, further comprising: maintaining and up-
dating the mobile contexts of the user equipment and transmitting information
on the updates to the relay node.

25 44. A computer program comprising program code means adapted
to perform any of steps of claim 23 to 41 when the program is run on a com-
puter.

30 45. An article of manufacture comprising a computer readable me-
dium and embodying program instructions thereon executable by a computer
operably coupled to a memory which, when executed by the computer, per-
form any of steps of claim 23 to 41.

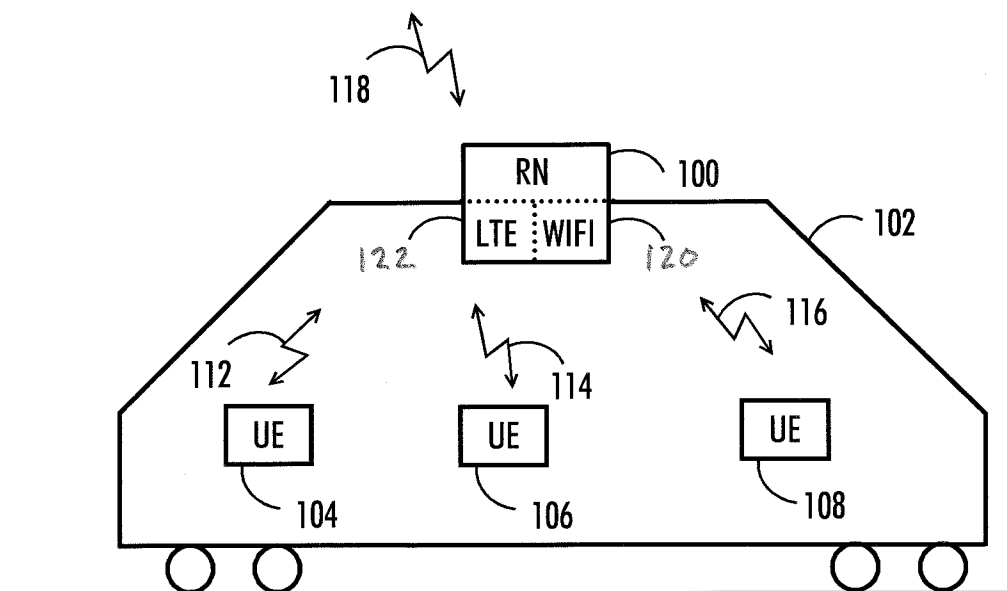


FIG. 1

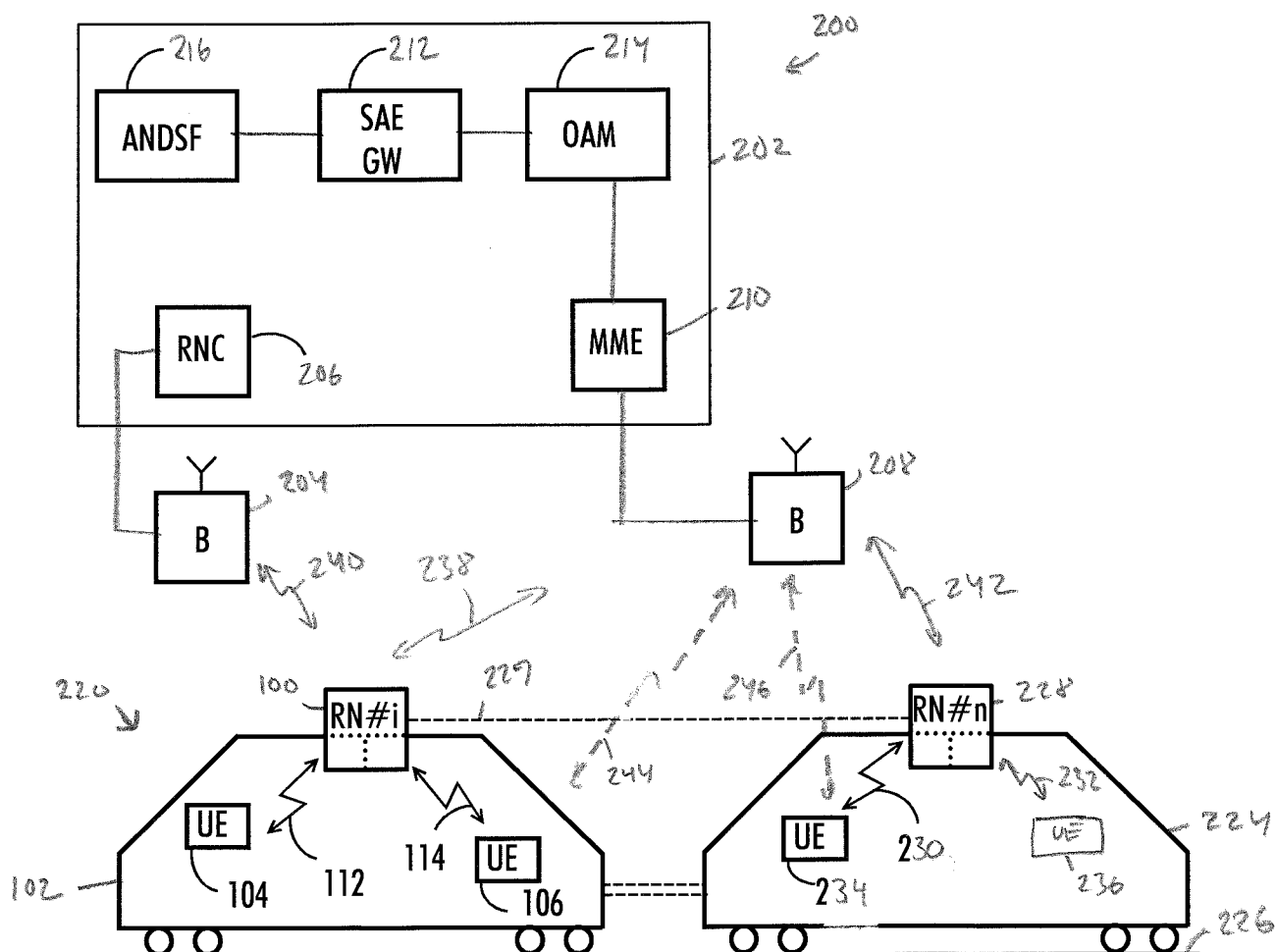


FIG. 2

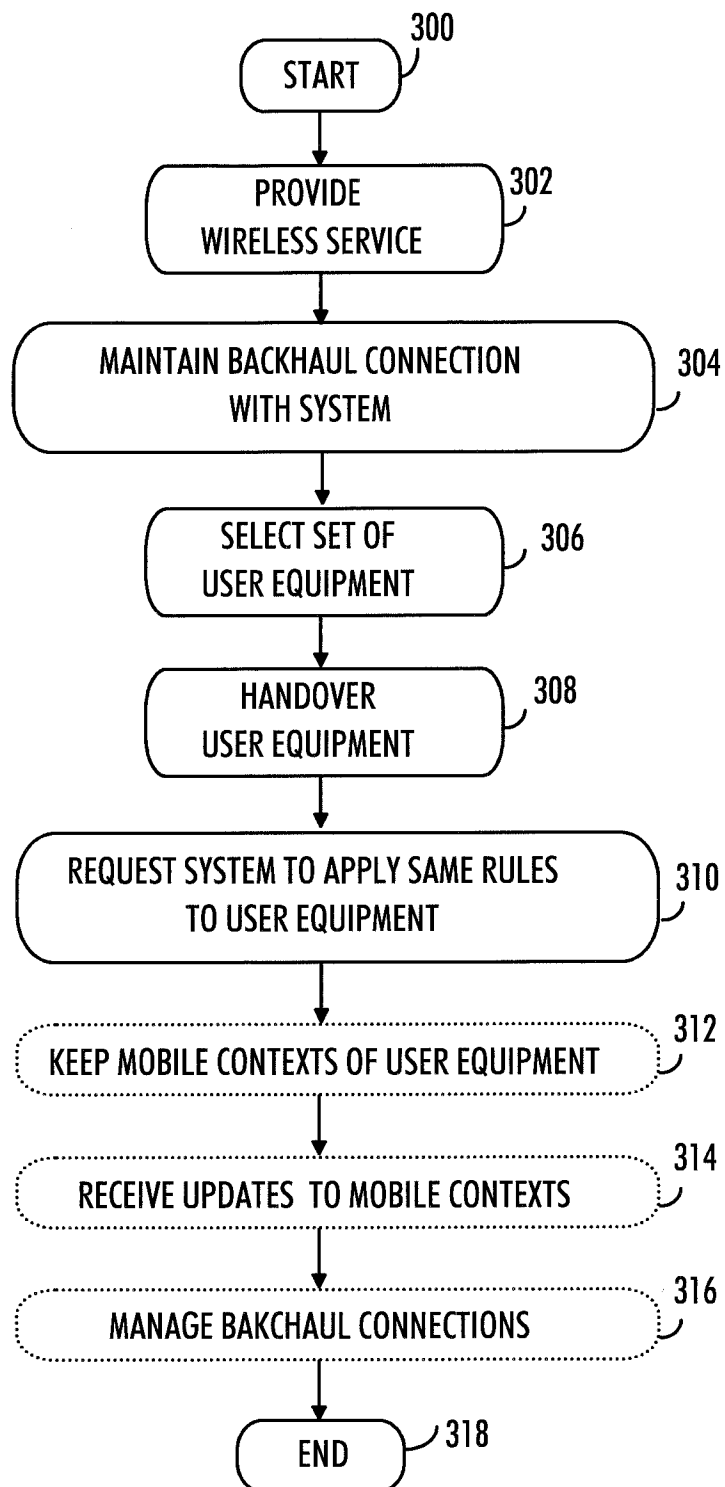


FIG. 3A

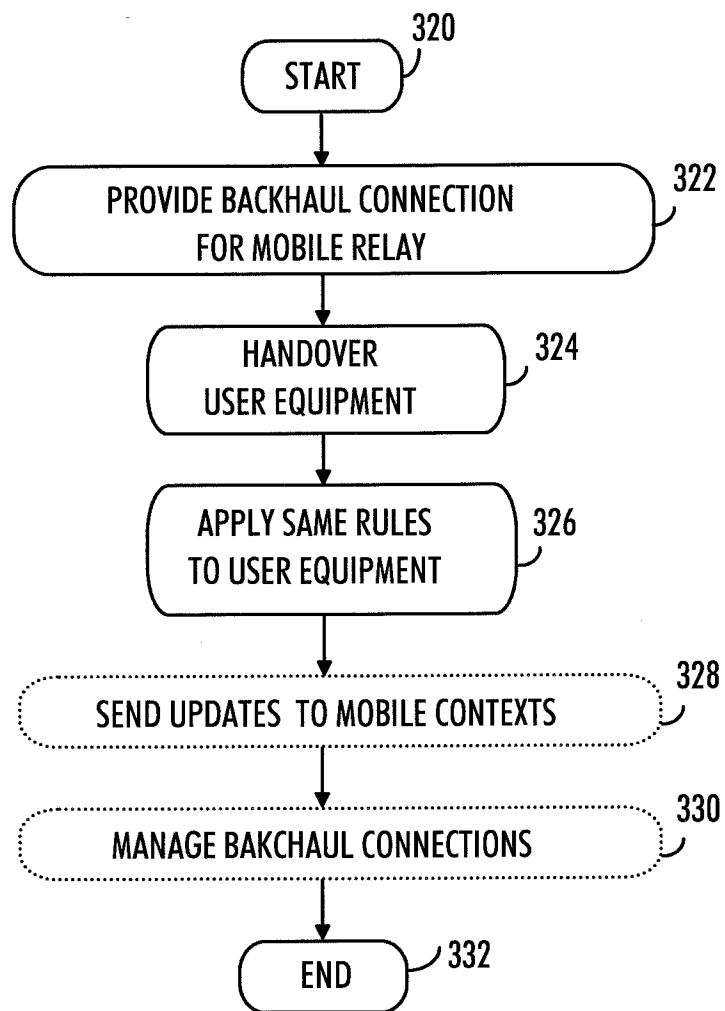


FIG. 3B

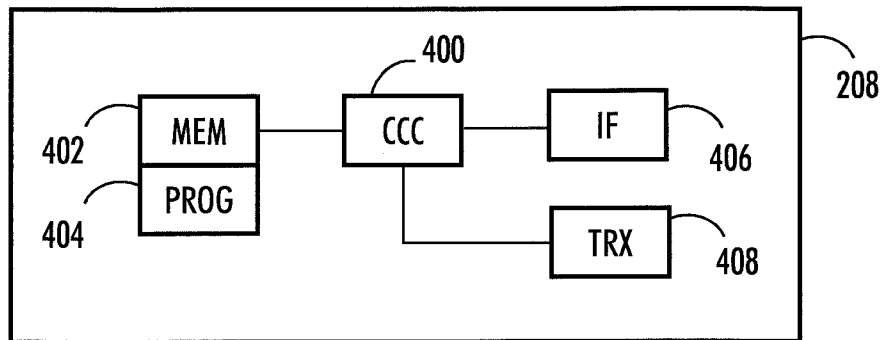


FIG. 4A

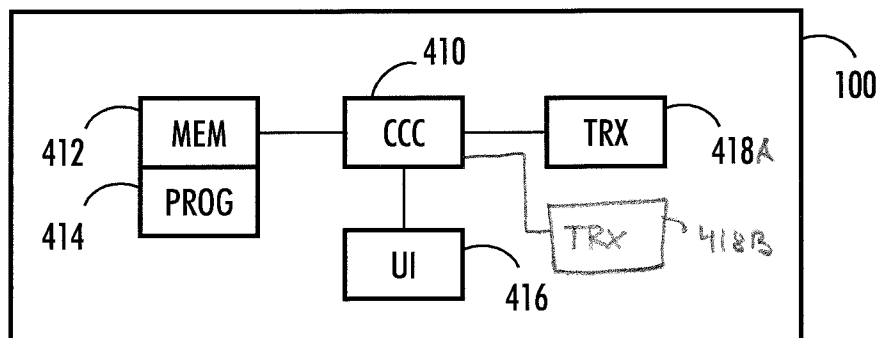


FIG. 4B

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/055914

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W84/04
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 practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2 306 767 A1 (RESEARCH IN MOTION LTD [CA]) 6 April 2011 (2011-04-06)	1,8,9, 20,21, 23,32, 42,44,45
Y	paragraph [0047] - paragraph [0048] figure 7	2-7, 10-19, 22, 24-31, 33-41,43
	----- -/--	



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

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"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

21 February 2012

Date of mailing of the international search report

05/03/2012

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Brezmes Alonso, J

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2011/055914

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2011/038783 A1 (NOKIA SIEMENS NETWORKS OY [FI]; VAN PHAN VINH [FI]; YU LING [FI]; HORN) 7 April 2011 (2011-04-07)	2-7, 10-19, 22, 24-31, 33-41,43
A	page 19, line 31 - page 20, line 22 page 27, line 25 - page 31, line 32 figures 4,7,8	1,8,9, 20,21, 23,32, 42,44,45
X	----- US 2010/311419 A1 (BI HAO [US]) 9 December 2010 (2010-12-09) paragraph [0017] - paragraph [0022] paragraph [0034] - paragraph [0038] figures 1,5	1,8,9, 20,21, 23,32, 42,44,45
A	----- TEYEB O ET AL: "Dynamic Relaying in 3GPP LTE-Advanced Networks", EURASIP JOURNAL ON WIRELESS COMMUNICATIONS AND NETWORKING, HINDAWI PUBLISHING CORPORATION, NEW YORK, NY, US, vol. 2009, no. Art. ID 731317, 1 January 2009 (2009-01-01), pages 1-11, XP002572643, ISSN: 1687-1472, DOI: 10.1155/2009/731317 [retrieved on 2009-01-01] the whole document	1-43
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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