(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
8 January 2009 (08.01.2009)

PCT

(10) International Publication Number
WO 2009/006041 A1

(51) International Patent Classification:
*H04Q 7/38* (2006.01)

(21) International Application Number:
PCT/US2008/067583

(22) International Filing Date: 20 June 2008 (20.06.2008)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0712628.7 29 June 2007 (29.06.2007) GB

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(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

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(54) Title: RELOCATION IN A CELLULAR COMMUNICATION SYSTEM

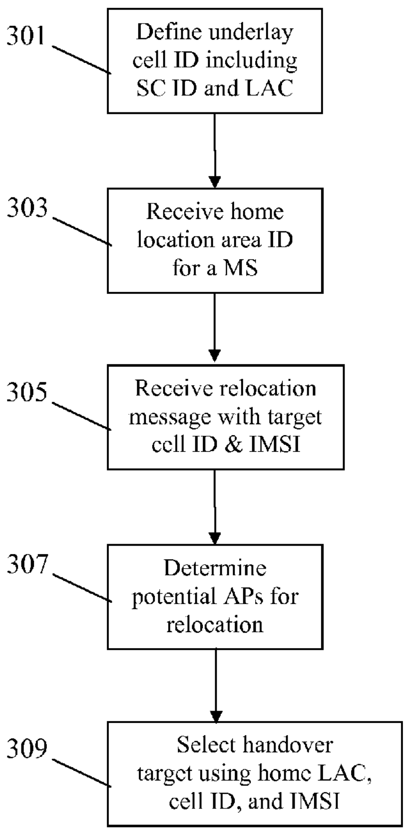



FIG. 3

(57) Abstract: A network element and method for a cellular communication system to support base stations with a shared pilot signal scrambling code. A first step (301) includes defining for underlaying cell a cell ID including a location area code, LAC, and a scrambling code, SC ID. A next step (303) includes receiving a home LAC of a home underlay cell for a mobile station. A next step (305) includes receiving a relocation message including the target cell ID and remote station ID. A next step (307) includes determining potential target base stations for the relocation request in response to the ID of the shared pilot signal SC from the target cell ID. A next step (309) includes selecting a target base station to hand-in to in response to the remote station ID and the SC ID and LAC of the target cell identification, wherein if the home LAC for the remote station ID is within the LAC of the target cell ID then relocation is permitted.

WO 2009/006041 A1

**Published:**
— *with international search report*

# RELOCATION IN A CELLULAR COMMUNICATION SYSTEM

## Field of the invention

The invention relates to relocation in a cellular communication system and in particular, but not exclusively, to handover from a macro-cell to an underlay cell in a cellular communication system.

## Background of the Invention

A method which has been used to increase the capacity of cellular communication systems is the concept of hierarchical cells wherein a macro-cell layer is underlayed by a layer of typically smaller cells having coverage areas within the coverage area of the macro-cell. In this way, smaller cells, known as micro-cells, pico-cells, or femto-cells, are located within the same coverage area as larger macro cells. The pico-cells and femto-cells have much smaller coverage thereby allowing a much closer reuse of resources. Frequently, the macro-cells are used to provide coverage over a large area, and the smaller underlay cells are used to provide additional capacity in e.g. densely populated areas and hotspots. Furthermore, femto-cells can also be used to provide coverage in specific locations such as within a residential home or office.

In order to efficiently exploit the additional resource, it is important that relocation performance between the macro-cell layer and the underlying layer is optimized. The process of relocation can be separated into three phases. Firstly, identifying that a relocation might be required, secondly, identifying a suitable relocation candidate and finally, switching the mobile user from one base station to another.

Currently $3^{rd}$ generation (3G) cellular communication systems based on Code Division Multiple Access (CDMA) technology, such as the Universal Mobile Telecommunication System (UMTS), are being deployed. In these systems, each cell is allocated a unique scrambling code which is used to spread the air interface signals in order to provide cell separation. The mobile stations of such systems receive a neighbour list identifying a number of scrambling codes for neighbour cells and the mobile stations apply the neighbour scrambling codes to the received signal in order to measure receive levels. The signal level for each neighbour scrambling code is measured and reported back to the network. The network then uses these measurements to determine if a relocation should be performed, and if so to which cell the UE should be handed over.

The current trend is towards introducing a large number of femto-cells to 3G systems. For example, it is envisaged that residential access points (RAP) may be deployed having a target coverage area of only a single residential dwelling or house. A widespread introduction of such systems would result in a very large number of small underlay cells within a single macro-cell.

However, underlaying a macro-layer of a 3G network with a femto-cell (or pico-cell) layer creates several issues. For example, the introduction of a large number of underlay cells creates a number of issues related to the identification of individual underlay cells when e.g. handing over to an underlay cell. In particular, 3G communication systems are developed based on each cell having a relatively low number of neighbours and extending the current approach to scenarios wherein the mobile station may need to consider large numbers of potential neighbour cells is not practical.

One problem of extending current approaches to scenarios where there are many underlaying femto-cells is how to uniquely and efficiently identify a femto-cell (or pico-cell). Specifically, it is not practically feasible to assign individual pilot signal scrambling codes or frequency/base station identity combinations to each underlay cell and to identify all potential relocation underlay cells as neighbours of the macro-cell as this would require very large neighbour lists. These large neighbour lists would e.g. result in the neighbour list exceeding the maximum allowable number of neighbours in the list, slow mobile station measurement performance as a large number of measurements would need to be made, increased resource usage etc. It would furthermore require significant operations and management resource in order to configure each macro-cell with the large number of neighbours and would complicate network management, planning and optimisation. However, sharing scrambling codes for the pilot signals of the femto-cells results in a target ambiguity and prevents the mobile station from uniquely identifying a potential relocation target. For example, if a group of base stations supporting different underlay cells underlaying a given macro-cell use an identical shared pilot signal scrambling code, a mobile station detecting the presence of this shared scrambling code will be aware that a potential relocation target has been detected but will not be able to uniquely identify which of the group of underlay cells has been detected.

Hence, an improved cellular communication system for handover would be advantageous and in particular a system allowing increased flexibility, improved suitability for large numbers of potential handover targets/neighbour cells, improved suitability for overlay/underlay handovers, reduced neighbour lists, increased practicality, reduced measurement requirements, facilitated and/or improved handover target detection/identification and/or improved performance would be advantageous.

## Summary of the Invention

Accordingly, the Invention seeks to preferably mitigate, alleviate or eliminate one or more of the above mentioned disadvantages singly or in any combination.

According to a first aspect of the invention there is provided a network element for a cellular communication system in accordance with some embodiments of the invention. The cellular communication system includes a number of base stations supporting macro cells and with unique cell scrambling codes within a region. The system also includes a number of access points supporting underlay cells and with shared cell scrambling codes within the region. The network element includes means for defining a cell identification for each underlaying cell, wherein such cell identification includes a location area code and a scrambling code identification for that underlay cell. The network element also includes means for receiving a home location area identifier of a home underlay cell for a mobile station. The network element also includes means for receiving a relocation message for a remote station supported by a first base station, the relocation message including the target cell identification and remote station identification. The network element also includes means for determining a group of potential target access points for the relocation request in response to the identification of the shared pilot signal scrambling code from the target cell identification. The network element also includes means for selecting a target base station from the group of base stations to hand-in to in response to the remote station identification and the scrambling code and location area code of the target cell identification, wherein if the home location area identifier for the remote station identification is within the location area code of the target cell identification then relocation is permitted.

The invention may allow improved and/or facilitated operation in a cellular communication system and may in particular allow improved identification of a handover target from a group of cells sharing a pilot signal scrambling code thereby improving e.g. handover or relocation performance. In particular, the invention may allow improved identification of an underlay target handover cell for a remote station currently served by a macro-cell. The invention may allow highly robust underlay cell identification while using a reduced amount of resources. In particular, the invention may require fewer scrambling codes while still allowing a given number of underlay cells to be identified. The invention may in some embodiments facilitate handover and relocation. The invention may in some embodiments facilitate or enable support of large numbers of underlay cells.

The invention may e.g. allow improved handover in a cellular communication system. In particular, the invention may facilitate or improve handovers in systems wherein a remote station may have a large number of possible handover targets. In particular, the invention may allow a reduced number of measurements being required by a remote station to determine a suitable handover target, may allow reduced neighbour lists, and/or may reduce the required number of scrambling codes.

The underlay cells supported by the group of base stations may e.g. be micro-cells, pico-cells, and/or femto-cells. The cellular communication system may be a Code Division Multiple Access cellular communication system such as a Universal Mobile Telecommunication System (UMTS). The remote station may for example be a User Equipment or a mobile communication unit, e.g. of a 3rd generation cellular communication system.

The network element may in some embodiments appear to the network as a proxy Radio Network Controller (RNC) which supports a plurality of base stations sharing a pilot signal scrambling code. Following identification of the handover target base station, the routing/handover setup may switch to the actual RNC supporting the handover target base station and a conventional handover process may e.g. be used between this RNC and the RNC supporting the remote station prior to the handover. Specifically, the identification of the handover target base station may result in a message being transmitted to the RNC serving the handover target base station in response to which the RNC may proceed in setting up the relocation process.

A relocation of a remote station may be any process or activity wherein the remote station moves from being supported by one cell to being supported by another cell. Specifically, the relocation request message may be any indication that a movement or switch of the remote station from the first base station to the handover target base station may be desired. This movement/switch may for example be a handover of the remote station to the handover target base station from the first cell. The relocation may be associated with a modification of information relating an identity and location in the fixed network for the remote terminal (e.g. from a core network element to the handover target access point).

According to another aspect of the invention there is provided a method of operation for a cellular communication system in accordance with some embodiments of the invention. The cellular communication system includes a number of base stations supporting macro cells and with unique cell scrambling codes within a region. The system also includes a number of access points supporting underlay cells and with shared cell scrambling codes within the region. The method includes a step of defining a cell identification for each underlaying cell, wherein such cell identification includes a location area code and a scrambling code identification for that underlay cell. The method includes another step of receiving a home location area identifier of a home underlay cell for a mobile station. The method includes another step of receiving a relocation message for a remote station supported by a first base station, the relocation message including the target cell identification and remote station identification. The method includes another step of determining a group of potential target access points for the relocation request in response to the identification of the shared pilot signal scrambling code from the target cell identification. The method includes another step of selecting a target base station from the group of base stations to hand-in to in response to the remote station identification and the scrambling code and location area code of the target cell identification, wherein if the home location area identifier for the remote station identification is within the location area code of the target cell identification then relocation is permitted.

The generated relocation message may be represented by different relocation required and request messages at different locations/stages of the communication and may be modified by intervening network elements. The specified means for the method steps may be located at any suitable physical or logical location in the network including in a Mobile Switching Centre (MSC) and/or in the source radio network controller.

For example, the source radio network controller may generate a relocation request message in the form of a 3GPP Relocation Required message which does not specifically address any destination. A serving MSC may convert this message into a relocation request message in the form of a 3GPP Relocation Request message and may further comprise the address means arranged to address the 3GPP Relocation Request message to the network element.

The term relocation message may be considered a common generic term comprising all specific messages used to communicate a relocation required or relocation request message from the source radio network controller to the network element and/or a radio network controller supporting the handover target base station. As such it encompasses different messages used at different stages of the path and/or may include a plurality of parallel messages used to indicate the request for a relocation.

These and other aspects, features and advantages of the invention will be apparent from and elucidated with reference to the embodiment(s) described hereinafter.

**Brief Description of the Drawings**

Embodiments of the invention will be described, by way of example only, with reference to the drawings, in which

FIG. 1 illustrates an example of a cellular communication system in accordance with some embodiments of the invention;

FIG. 2 illustrates an example of a network element in accordance with some embodiments of the invention; and

FIG. 3 illustrates an example of a method of operation for a network element in accordance with some embodiments of the invention.

**Detailed Description of Some Embodiments of the Invention**

The following description focuses on embodiments of the invention applicable to a CDMA cellular communication system and in particular to a 3rd Generation Cellular communication system such as a UMTS System. However, it will be appreciated that the invention is not limited to this application but may be applied to many other cellular communication systems. Also, the description will focus on scenarios where a remote station is relocated from a macro-cell to an underlay cell such as a pico-cell or a femto-cell. However, it will be appreciated that the described principles apply equally to other scenarios including e.g. some scenarios where a relocation or handover is made to a macro-cell out of a group of macro-cells using a shared pilot signal scrambling code. The term "handover" as described herein can be a 3GPP internal handover, external handover and/or relocation, which can be used interchangeably, where a base station is selected to hand-in to.

FIG. 1 illustrates an example of a cellular communication system which in the specific example is a UMTS cellular communication system. In the system, a macro-layer is formed by macro-cells supported by base stations. Furthermore, an underlay layer of pico-cells or femto-cells are supported by a large number of small base stations which henceforth will also be referred to as wireless access points. Such wireless access points can include Residential Access Points, Home Node-Bs, or other type of wireless access points, for example. Specifically, each access point may have an intended coverage of a single house or dwelling, and for a typical macro-cell coverage area of ten to thirty kilometres there may be hundreds or even thousands of these underlay cells each supported by an individual access point.

In the system, the macro base stations each have a cell separation code in the form of a scrambling code (SC) that is unique within a given region which e.g. may be a reuse area for the cell scrambling codes. Specifically the macro base stations have an assigned scrambling code which is unique within the reuse area such that a set of defined neighbours for each cell always have unique cell scrambling codes. Furthermore, each macro-cell base station has a unique hierarchical network address given by a unique base station ID for a given serving RNC, which itself has a unique RNC ID for a given MSC. Furthermore, each MSC has a unique identity in the network.

Typically, the neighbour lists transmitted by the base stations comprise indications of macro-cells which all have different cell scrambling codes. Furthermore, for each macro neighbour cell, a unique network address of the base station supporting the macro-cell can be determined from the detection of a specific neighbour cell pilot signal. Accordingly, a handover to a target macro-cell may be initiated with an explicit and unique identification of the handover target base station.

In contrast, the access points (which in the specific example are base stations supporting femto-cells) use a scrambling code which is shared between a plurality of access points within the reuse area and specifically a given neighbour list may comprise indications of shared pilot signal scrambling codes for a plurality of underlay cells that are all considered as neighbours/potential handover targets for the current cell. By sharing a pilot signal scrambling code between a plurality of access points, a much reduced number of scrambling codes is required by the system. Furthermore, by keeping the number of scrambling codes low, the number of scrambling codes that must be evaluated by the remote station for handover determination can be reduced substantially thereby reducing the measurement time, power consumption and/or complexity of the remote station.

However, the use of a shared pilot signal scrambling code means that the remote station (or supporting network nodes) cannot uniquely identify the access point which has been detected by the remote station simply from the detected scrambling code. Rather, a remote station detecting a scrambling code does not uniquely identify a given target access point for a handover but at best identifies only a group of access points which all use the same shared pilot signal scrambling code.

In some embodiments, all access points within a coverage area supported by a single macro-RNC can use the same scrambling code. However, it will be appreciated that in other embodiments, a plurality of shared scrambling codes can be available for the access points. Therefore, the access points can be divided into a number of groups with the access points of each group sharing a scrambling code but with different scrambling codes being used for different groups. In such embodiments, the scrambling codes can be allocated to the access points such that a reuse pattern is established with the interference between femto-cells having the same shared scrambling code being reduced or minimised.

In the specific example of FIG. 1, one macro-base station 101 which supports a macro-cell with a typical coverage area of ten to thirty kilometres is illustrated. The macro base station 101 is coupled to a macro RNC 103 which is furthermore coupled to other macro base stations (not shown). The macro RNC 103 is furthermore coupled to a core network 105 which interfaces to other radio access networks and RNCs. In the example, the macro RNC 103 is coupled to a first (source) MSC 107 of the macro-layer which is further coupled to a second (target) MSC 109 of the underlayer cells serving a different set of RNCs than the first MSC 107.

The system furthermore comprises a large number of underlay base stations/access points 111, 113 (for clarity only three access points are illustrated in FIG. 1). Each of the access points 111, 113 supports a femto-cell, for example, having a coverage area of typically ten to fifty meters. The access points 111, 113 implement the required functionality of a UMTS base station in order to support UMTS communications within the femto-cell. However, in contrast to conventional UMTS base stations, the access points 111, 113 use a common shared pilot signal scrambling code.

Furthermore, in the example, each of the access points 111, 113 comprises some RNC functionality such that the network interface to the access points 111, 113 is the same as to an RNC. In other words, each access point 111, 113 appears as an RNC to the network and each access point 111, 113 has an individual RNC identity (RNC ID) encoded with its location area code and scrambling code. In particular, the underlayer cells are organized and assigned location area codes (LAC), such as a Residential Access Point Location Area Code (RAP LAC), where each RAP LAC corresponds to an area covered by the macro layer cell. RAP assignment to a RAP LAC will be carried out during commissioning by the RAP Registration Server (RRS) based upon geographical location. In the specific example, the access points/femto base stations 111, 113 are accordingly coupled directly to a serving MSC which in this case is the second MSC 109.

The system of FIG. 1 furthermore comprises a network element which operates as a proxy Radio Network Controller (RNC) 115 for the access points 111, 113 during the initial phases of a relocation. Specifically, when a remote station detects a shared pilot signal scrambling code, a relocation request message may be transmitted to the proxy RNC 115 which then may resolve the ambiguity and identify the detected access point 111, 113 as a suitable handover target. It should be recognized that the network element of the invention can be represented equally as an Access Point Concentrator or Controller (APC), Residential Access Point Server (RRS), Virtual Private Network (VPN), Generic Access Network (GAN), Universal Mobile Access (UMA), or any other server, network gateway, or authority as are known in the art.

In operation, in the system of FIG. 1, a remote station 117 is initially be served by the macro base station 101. The remote station 117 receives the neighbour list broadcast by the macro base station 101 and performs receive level measurements of pilot signals for the scrambling codes of the neighbour list. One of the monitored pilot signals (CPICHs) of the neighbour list may be the pilot signal of a first access point 111 of the access points 111, 113. The shared pilot signal scrambling code may be decoded to provide cell identification data for the first access point 111. However, as the scrambling code is shared by a large number of access points 111, 113, it is not possible for the source system to uniquely determine the identity of the first access point 111.

The remote station 117 is also able to determine an underlay cell identification associated with the received pilot signals. Upon detection of a pilot signal, the remote station 117 generates a detection message that includes the underlay cell ID and measurement results, which is transmitted from the remote station 117 to the base station 101 which forwards it to the RNC 103. As explained above, the cell ID included in the detection message includes a LAC identifier and scrambling code identifier of the detected access point 111 encoded therein.

In this example, the macro RNC 103 associates the shared scrambling code with the static address (RNC ID) of the proxy RNC 115 serving the access points 111, 113 with that scrambling code. In this case, the macro RNC 103 can determine the preference for a relocation handover (based on the reported pilot signal measurements from the remote station 117) and may accordingly transmit a Relocation Required message addressed to the proxy RNC 115. In particular, the Relocation Required message includes in the body of the message a Target Cell ID (which includes the RAP LAC and SC ID), a Source RNC ID, a Target RNC ID (i.e. Proxy RNC ID). Preferably, the macro RNC 103 is arranged to transmit an identification of the remote station 117 to the proxy RNC 115, which is known from an initial registration of the remote station 117. At initialization of a remote station, its International Mobile Subscriber Identity (IMSI) is registered to its home base station and the co-located home RAP LAC. For example, an IMSI of the remote station 117 is provided to the home base station 101 and proxy RNC 115.

The source MSC 107 then generates a relocation request (e.g. a MAP_Prepare_Handover) message to send to the proxy RNC 115 (through the destination MSC 109 in the example shown in FIG. 1, although other connections are possible. For example, it will be appreciated that in other embodiments, the proxy RNC 115 may be physically, logically or structurally located elsewhere. For example, the proxy RNC 115 may be located in the path between the second MSC 109 and the access points 111, 113 and the request message may be sent directly to the access point 111, 113). The relocation request message includes the Target (proxy) RNC ID (or RAP neighbour RNC ID), the remote station IMSI, and the Target Cell ID. When this message is received at the proxy RNC 115, it proceeds to narrow down which of the access points 111, 113 is the detected target handover access point 111.

Specifically, the proxy RNC 115 first uses the indication of the shared pilot signal scrambling code to determine a group of base stations/access points which are potential targets base stations/access points. For example, the group may be determined as all the access points 111, 113 using the shared pilot signal scrambling code. The proxy

RNC 115 uses the location information (e.g. LAC) provided in the Target Cell ID to determine which of the access points 111, 113 have been detected.

In particular, the proxy RNC 115 includes a look-up table that transposes the Target Cell ID and IMSI into a RAP address. If the home RAP for the IMSI of the remote station 117 is within the RAP LAC of the Target Cell ID, then a relocation is permitted to the access point 111. Otherwise, relocation is not permitted and the source MSC 107 is so informed.

If the underlay cells are reasonably spaced apart (i.e. location area codes are distinct in an area, it is likely that the detected access point 111 with that RAP LAC is the proper access point for relocation of the remote station 117. Accordingly, the proxy RNC 115 can select this access point as the target handover access point 111.

The proxy RNC 115 can then transmit a message to the selected target handover access point 111 identifying the source of the relocation request. The target access point 111 accordingly initiates a relocation handover procedure by directly communicating with the macro RNC 103 currently serving the remote station 117. Such a handover process may follow a conventional handover procedure between a serving and target RNC in a UMTS system.

In particular, the proxy RNC 115 generates a relocation request message which is transmitted to the identified access point 111 by the target MSC 109. If the identified access point 111 accepts the relocation request, it transmits a relocation acknowledgement message back to the RNC 103. In response, the proxy RNC 115 generates a handover command message which is transmitted to the remote station 117 by the base station 101. When the remote station 117 receives the handover command, it proceeds to a handover to the identified access point using conventional UMTS handover procedures.

An exemplary relocation will in the following be described in more detail with reference to FIG. 2 which illustrates the proxy RNC in more detail.

Initially, the remote station 117 is served by the macro base station 101 and performs user data transmissions supported by the macro base station 101. At the same time, the remote station 117 scans for the pilot signals of the cells indicated in the neighbour list previously received from the macro base station 101. This includes the shared pilot signal scrambling code. At some stage, the remote station 117 detects the presence of the shared pilot signal scrambling code and transmits a measurement report including that cell ID. For example, if the macro-cell level drops below a threshold and the remote station 117 measures the shared pilot signal scrambling code. The remote station 117 transmits a message which is an indication of the detection and identification of the shared pilot signal scrambling code.

The message is received by the macro base station 101 and forwarded to the macro RNC 103. In response, the macro RNC 103 generates a relocation request message which is specifically implemented in the form of a UMTS Relocation Required message which is transmitted from the macro RNC 103 to the first MSC 107. The Relocation Required message may not comprise any specific addressing of a target RNC (such as the proxy RNC 115) but may comprise various characterising data that allows the address of an RNC to be determined. The message can specifically include a Radio Resource Control (RRC) transparent container which comprises information that may enable or assist the routing of the message and/or the identification of a suitable set of target access points.

In the specific example, the RRC container comprises an identification of the detected pilot signal scrambling code, identifying the detected cell and the LAC or other location identifier. It will be appreciated that the RRC container may comprise other or additional information in other embodiments.

The Relocation Request message including the RRC transparent container is transmitted to the first MSC 107 which proceeds to determine the network element address of the proxy RNC 115 based on the information received in the RRC transparent container. The MSC 107 also determines the IMSI of the requesting remote station.

Specifically, in some embodiments, the proxy RNC 115 may support all access points 111, 113 that share a given shared pilot signal scrambling code and includes list linking a given shared pilot signal scrambling code and LAC to a specific network element address for the corresponding proxy RNC 115. Furthermore, the network element address of the proxy RNC 115 is in the example unique within the network such that the routing of the relocation request message to the proxy RNC 115 may be performed based only on this address.

In a more typical scenario, the same shared pilot signal scrambling code may be re-used in the cellular communication system such that different proxy RNCs may support different access points using the same shared pilot signal scrambling code. For example, each proxy RNC could support 256 residential access points. However, the proxy RNCs will typically be distributed geographically such that all access points within a (potentially large) geographic area using the same shared pilot signal scrambling code will be served by the same proxy RNC. Specifically, all access points that can be accessed from a given macro-cell will typically be served by the same proxy RNC 115 and accordingly, the MSC 107 may determine the proxy RNC 115 address by a unique link from the combination of the identity of the first macro-cell, the detected shared pilot signal scrambling code, and/or the LAC. The linking information may be provided manually by the network operator as part of the operations and maintenance process. In addition, the MSC 107 and proxy RNC are provided the IMSI of a remote station 117 upon its registration at a home base station 101.

Once the network element address of the proxy RNC 115 has been identified, the relocation request message is transmitted to the proxy RNC 115 using this address. Specifically, the first MSC 107 generates a UMTS

Relocation Request message addressed to the proxy RNC 115 and comprising the RRC transparent container received from the macro RNC 103. The first MSC 107 may in some embodiments modify the transparent container and may specifically add or delete specific information elements. Specifically, the MSC 107 adds the IMSI of the remote station 117 and includes the target cell ID, which includes the scrambling code ID and the RAP LAC.

The Relocation Request message is routed to the proxy RNC 115 via the second MSC 109. The proxy RNC 115 comprises an MSC interface 201 which is arranged to exchange messages with the MSC 201. The MSC interface 201 is coupled to a relocation processor 203 which extracts the information contained in the RRC transparent container. In particular, it extracts the shared pilot signal scrambling code, LAC, and IMSI.

The relocation processor 203 is coupled to a group processor 205 which determines a group of base stations/access points 111, 113 as potential target base stations/access points for the relocation request. The group of access points are the potential target access points for the relocation request of the remote station 117.

The group processor 205 determines the potential target access points in response to only the shared pilot signal scrambling code. In some embodiments, only relatively few access points share the same pilot signal scrambling code and the group processor 205 may determine the group of access points as all access point using the identified shared pilot signal scrambling code.

Typically when a remote station detects the presence of a pilot signal from a femto-cell it will be located very close to that femto-cell and substantially further away from any other femto-cell using the same shared pilot signal scrambling code (e.g. a reuse pattern for a plurality of shared pilot signal scrambling codes may be applied). Accordingly, the uplink transmission from the remote station is likely to be received at a high signal level at only one of the femto-cells. Furthermore, even if the uplink transmission was detected with a high signal level at more than one access point, this is likely to be due to the remote station being located close to more than one access point with all of these access points being likely to be acceptable handover targets.

The relocation processor 203 is coupled to a selection processor 211 which performs a relocation handover of a target access point 111 selected from the group of potential target access points 111, 113 in response to the measurement reports and LAC. Specifically, the identification of the target cell comprised in the RRC transparent container can be used to determine a reduced group of access points using the shared pilot signal scrambling code and LAC. For example, in many scenarios, the underlay cells supported by the access points using the same scrambling code may be distributed within the coverage area of a relatively large number of macro-cells with different LACs. In this case, a remote station within a home macro-cell will only be able to detect pilot signals from femto-cells within that macro-cell (or potentially within neighbouring macro-cells if the remote station is close to the border of the macro-cell). Accordingly, the selection processor 211 can determine the group of access points which are potential targets as the access points which are located within the currently serving macro-cell and LAC. Any access points with a differing LAC can be discarded as they currently cannot be potential handover targets for the remote station. Thus, the selection processor 211 uses the indication of the home serving cell and LAC to determine a reduced group of potential target access points. In particular, if the home location area identifier for the remote station IMSI is within the location area code of the target cell identification then relocation is permitted.

In this case, the selection processor 211 then proceeds to transmit a relocation message to the radio network controller which supports the handover procedures for the selected target access point 111. In the specific example, each of the access points 111, 113 comprise RNC functionality and the relocation message may therefore be transmitted directly to the target access point 111. The relocation message is in the specific example the UMTS Relocation Request message which was received by the proxy RNC 115 from the first MSC 107.

When the target RNC (i.e. the RNC functionality of the access point 111 or an RNC supporting the selected access point) receives the Relocation Request, it proceeds to respond as if the message had been received directly from the first MSC 107. Specifically, the target RNC can transmit a relocation acknowledge message (e.g. a Relocation Request Acknowledge) to the macro-RNC thereby initiating a handover procedure generally following a conventional approach. However, as the macro RNC 103 and/or the first MSC 107 has previously used the network element address of the proxy RNC 115, the routing path may be changed to use the network address of the target RNC.

As a specific example, when receiving the Relocation Request message, the target RNC allocates resources in the target underlay cell for the incoming hard handover and returns the matching configuration in e.g. a Physical Channel Reconfiguration message in an RRC transparent container to the macro RNC 103 (possibly via the proxy RNC 115).

The macro RNC 103 then passes the reconfiguration to the remote station 117 which then attempts to access the target access point using the specified configuration. Thus, the source RNC (i.e. the macro RNC 103) transmits an access characteristic for the handover target base station to the remote station 117 when receiving the relocation acknowledge message from the target RNC. The remote station 117 then initiates an attachment to the target access point 111 using the indicated configuration/access characteristic.

The single selected access point 111 then receives an access from the remote station 117 and specifically the access point 111 detects uplink synchronisation at layer

1 and then receives the RRC reconfiguration confirm message from the remote station 117. A relocation detect and relocation complete is then signalled to the core network.

Furthermore, a second rapid relocation (without the remote station 117 being involved) can be executed to relocate the Iu signalling connection from the proxy RNC 115 to the target RNC.

It will be appreciated that in some embodiments, the proxy RNC 115 may instead of (or as well as) transmitting the relocation message to the target RNC, transmit a relocation message back to a network element supporting the macro base station 101 with an identification of at least one network element supporting communications in the target cell.

Specifically, the selection processor 111 may generate a message which comprises the network address of the target RNC and transmit this message to the first MSC 107. In response, the first MSC 107 may initiate a retransmission of the original UMTS Relocation Request message but this time directly addressing the appropriate target RNC. A conventional handover process between the source and the target network elements may then proceed.

The above description has focussed on embodiments wherein the source MSC 107 processes the message from the macro RNC 103 in order to address the proxy RNC 115, and in order to provide additional information. However, it will be appreciated that the invention is not limited to this example and that in other embodiments the MSC 107 may e.g. be arranged to merely forward messages from the macro RNC 103 without processing these. Specifically, the macro RNC 103 may generate the message comprising all relevant information and directly address this to the proxy RNC 115. This data packet may be routed unmodified to the proxy RNC 115 via the macro MSC 107.

FIG. 3 illustrates an example of a method of operation for a cellular communication system in accordance with some embodiments of the invention. The cellular communication system includes a number of base stations supporting macro cells and with unique cell scrambling codes within a region. The system also includes a number of access points supporting underlay cells and with shared cell scrambling codes within the region.

The method initiates in step 301 of defining a cell identification for each underlaying cell, wherein such cell identification includes a location area code and a scrambling code identification for that underlay cell.

A next step 303 includes receiving a home location area identifier of a home underlay cell for a mobile station.

A next step 305 includes receiving a relocation message for a remote station supported by a first base station, the relocation message including the target cell identification and remote station identification.

A next step 307 includes determining a group of potential target access points for the relocation request in response to the identification of the shared pilot signal scrambling code from the target cell identification.

A next step 309 includes selecting a handover target base station from the group of base stations in response to the remote station identification and the scrambling code and location area code of the target cell identification, wherein if the home location area identifier for the remote station identification is within the location area code of the target cell identification then relocation is permitted.

It will also be appreciated that although the above description focuses on a UMTS embodiment, it is equally applicable to other systems and is specifically applicable to hybrid communication systems using different radio access technologies. For example, the macro base station 101 may be a UMTS base station whereas the access point 111 may be a GSM base station capable of supporting GSM air interface communications but not UMTS air interface communications. However, the access point 111 may still transmit a pilot signal using the shared pilot signal scrambling code which can be detected by the remote station 117. Furthermore, the access point 111 may be arranged to monitor for the UMTS uplink transmission to determine a signal level.

Thus, the same method of determining the handover target may be used. However, in the example, the remote terminal 117 is a dual mode remote station and the handover is an intersystem handover where the remote terminal 117 hands over from UMTS to GSM.

Also, although the above description has focussed on a macro RNC 103 remote from the proxy RNC 115, it will be appreciated that the described principles are equally applicable to a situation where these are integrated in the same physical or logical network element. For example, a proxy RNC may be built into a macro RNC. In such an example, the detection of the shared pilot signal scrambling code by a remote station may be evaluated by a subroutine which generates a relocation request message (e.g. by setting a flag) if the pilot signal is detected. In response thereto another routine can initiate the transmission of measurement requests to the access points and proceed to use these to identify the appropriate handover target. Once, the handover target is identified the handover can be performed.

Advantageously, the present invention provides the advantage of using a scheme where no changes are required to the legacy network.  In particular, all lookup and LAC association is carried out on servers (RRS) within the RAP layer and APC/GAN.   Also, a change to the Marco network planning can be accommodated easily, by reloading the new plan of Macro network and re-generating the RAP LAC associations.

To mitigate the effects of interference from Macro users it may be beneficial to utilize the present invention for a non-registered user.  In this case a RAP experiencing Interference can indicate this to the RAP RRS/APC and be considered as a temporary ‘Home RAP’, and as a result have resource allocated for potential relocation. If handover fails the resources are then freed.

In practice, if a RAP market shared by four Operators, this would give forty-eight RAPs per cell and with a six SC reuse pattern. As a result there would only be eight total candidates per Operator per Cell, which is much less than in the prior art. Therefore, the impact of checking candidate associations on processing time should be low.

It will be appreciated that the above description for clarity has described embodiments of the invention with reference to different functional units and processors. However, it will be apparent that any suitable distribution of functionality between different functional units or processors may be used without detracting from the invention. For example, functionality illustrated to be performed by separate processors or controllers may be performed by the same processor or controllers. Hence, references to specific functional units are only to be seen as references to suitable means for providing the described functionality rather than indicative of a strict logical or physical structure or organization.

The invention can be implemented in any suitable form including hardware, software, firmware or any combination of these. The invention may optionally be implemented at least partly as computer software running on one or more data processors and/or digital signal processors. The elements and components of an embodiment of the invention may be physically, functionally and logically implemented in any suitable way. Indeed the functionality may be implemented in a single unit, in a plurality of units or as part of other functional units. As such, the invention may be implemented in a single unit or may be physically and functionally distributed between different units and processors.

Although the present invention has been described in connection with some embodiments, it is not intended to be limited to the specific form set forth herein. Rather, the scope of the present invention is limited only by the accompanying claims. Additionally, although a feature may appear to be described in connection with particular embodiments, one skilled in the art would recognize that various features of the described embodiments may be combined in accordance with the invention. In the claims, the term comprising does not exclude the presence of other elements or steps.

Furthermore, although individually listed, a plurality of means, elements or method steps may be implemented by e.g. a single unit or processor. Additionally, although individual features may be included in different claims, these may possibly be advantageously combined, and the inclusion in different claims does not imply that a combination of features is not feasible and/or advantageous. Also the inclusion of a feature in one category of claims does not imply a limitation to this category but rather indicates that the feature is equally applicable to other claim categories as appropriate. Furthermore, the order of features in the claims does not imply any specific order in which the features must be worked and in particular the order of individual steps in a method claim does not imply that the steps must be performed in this order. Rather, the steps may be performed in any suitable order.

**CLAIMS**

1. A network element for a cellular communication system, the network element being arranged to support at least a plurality of base stations having a shared pilot signal scrambling code; the network element comprising:

means for defining a cell identification for each of a plurality of underlay cells, wherein such cell identification includes a location area identifier and a scrambling code identification for each underlay cell;

means for receiving a home location area identifier of a home underlay cell for a remote station;

means for receiving a relocation message for the remote station supported by a first base station, the relocation message including the target cell identification and remote station identification;

means for determining a group of potential target base stations for the relocation request in response to the identification of the shared pilot signal scrambling code from the target cell identification; and

means for selecting a target base station from the group of base stations to hand-in to in response to the remote station identification and the scrambling code and location area identifier of the target cell identification, wherein if the home location area identifier for the remote station is within the location area identifier of the target cell then relocation is permitted.

2. The network element of claim 1 wherein the underlay cells are femto-cells comprising wireless access points.

3. The network element of claim 1 wherein the remote station identification is an International Mobile Subscriber Identity.

4. The network element of claim 1 wherein location area identifier is a location area code.

5. The network element of claim 1 wherein the relocation message comprises a 3rd Generation Partnership Project Radio Resource Control transparent container.

6. The network element of claim 1 further comprising means for rejecting the relocation request, wherein relocation is rejected if the proxy RNC can not be found.

7. The network element of claim 1 further comprising means for rejecting the relocation request, wherein relocation is rejected if the target cell can not be found.

8. The network element of claim 1 further comprising means for rejecting the relocation request, wherein relocation is rejected if the IMSI is not registered to the target cell.

9. The network element of claim 1 wherein the selection means is arranged to map the Target RNC ID, Target Cell ID and IMSI to the Target Cell address.

10. A method for a cellular communication system to support at least a plurality of base stations having a shared pilot signal scrambling code, the method comprising the steps of:

defining a cell identification for each of a plurality of underlay cells, wherein such cell identification includes a location area identifier and a scrambling code identification for each underlay cell;

receiving a home location area identifier of a home underlay cell for a remote station;

receiving a relocation message for the remote station supported by a first base station, the relocation message including the target cell identification and the remote station identification;

determining a group of potential target base stations for the relocation request in response to the identification of the shared pilot signal scrambling code from the target cell identification; and

selecting a target base station from the group of base stations to hand-in to in response to the remote station identification and the scrambling code and location area code of the target cell identification, wherein if the home location area identifier for the remote station is within the location area code of the target cell then relocation is permitted.

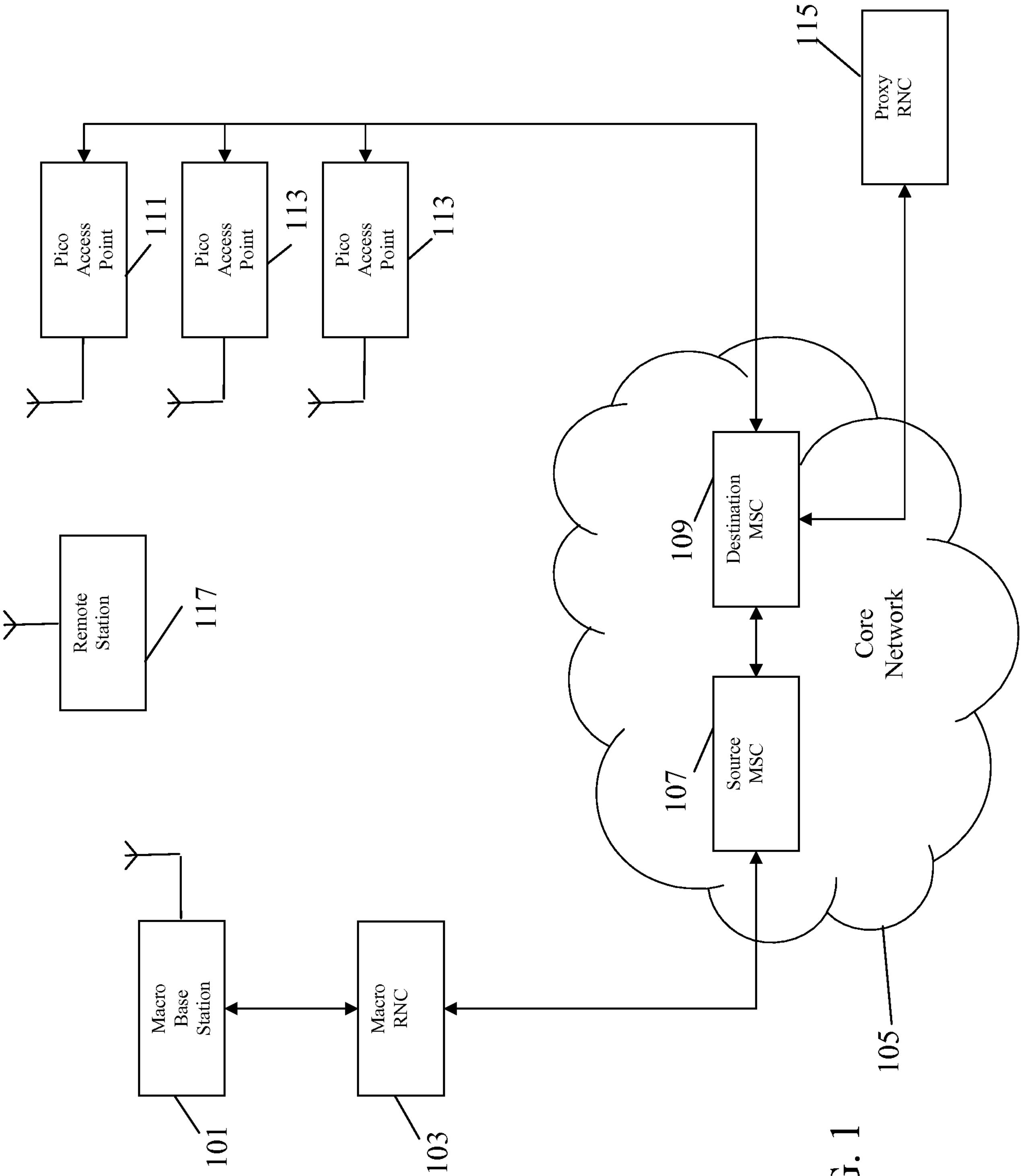

Pico Access Point
111
Pico Access Point
113
Pico Access Point
113
Proxy RNC
115
Remote Station
117
Destination MSC
109
Source MSC
107
Core Network
105
Macro Base Station
101
Macro RNC
103

FIG. 1

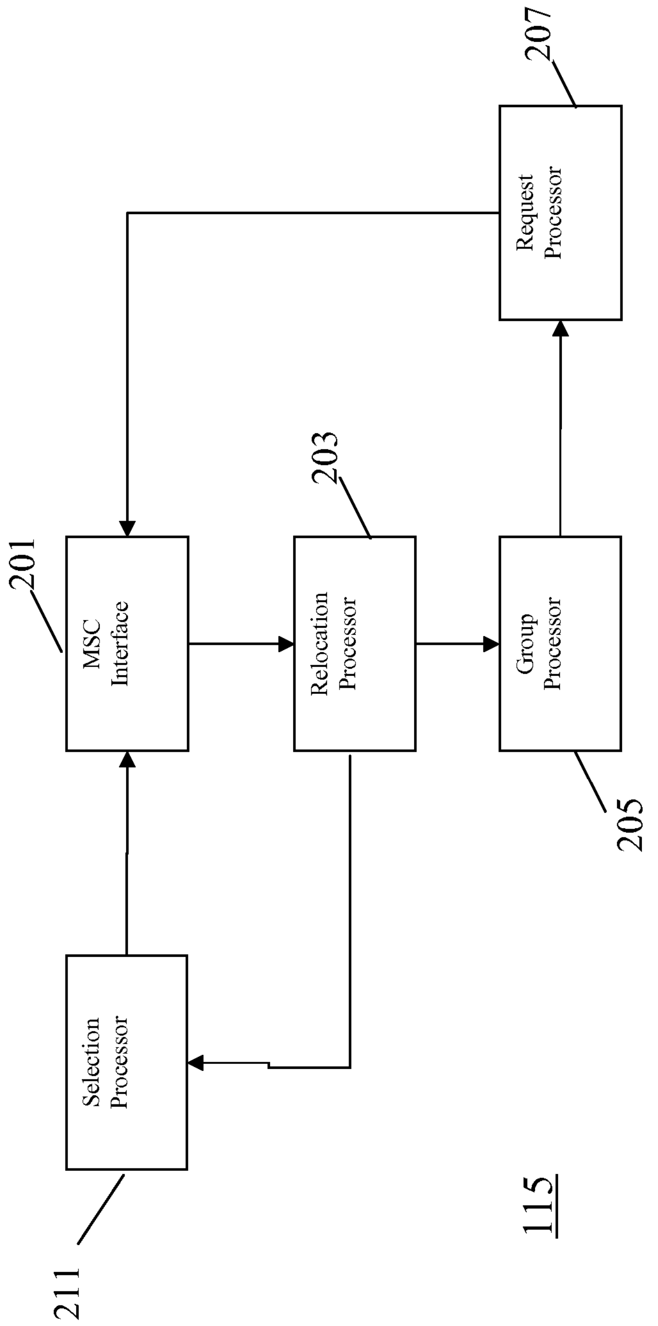
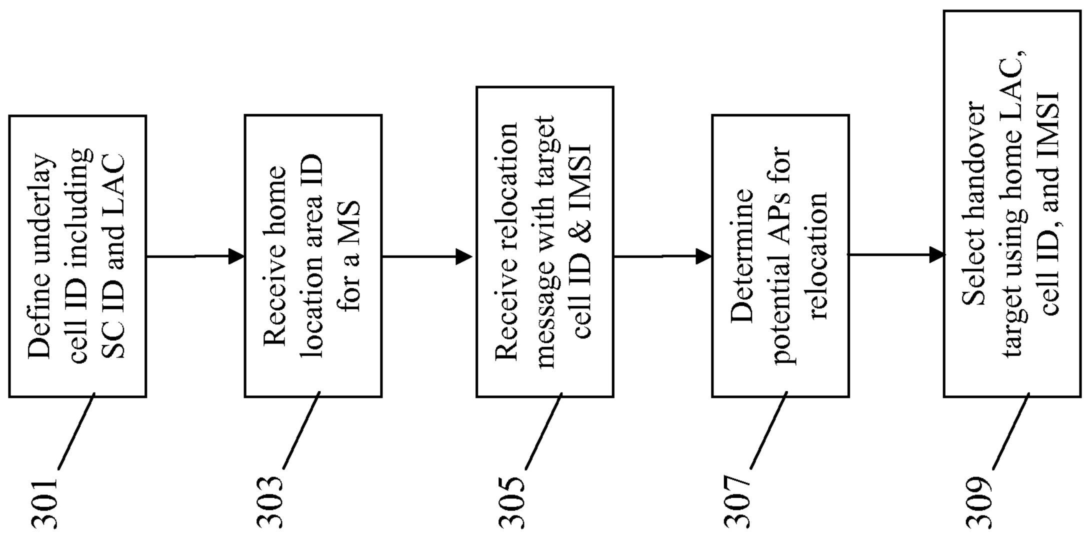

207
Request Processor
201
MSC Interface
203
Relocation Processor
Group Processor
205
Selection Processor
211
115

FIG. 2

FIG. 3


Define underlay cell ID including SC ID and LAC
Receive home location area ID for a MS
Receive relocation message with target cell ID & IMSI
Determine potential APs for relocation
Select handover target using home LAC, cell ID, and IMSI
301
303
305
307
309

# INTERNATIONAL SEARCH REPORT

International application No
PCT/US2008/067583

**A. CLASSIFICATION OF SUBJECT MATTER**
INV. H04Q7/38

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)
H04Q

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. |
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[X] Further documents are listed in the continuation of Box C.

[X] 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 document but published on or after the international filing date

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

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

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

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

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

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

"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 16 September 2008 | 26/09/2008 |

| Name and mailing address of the ISA/ | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,<br>Fax: (+31-70) 340-3016 | Hegeman, Hans |

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International application No
PCT/US2008/067583

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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| E | WO 2008/088592 A (MOTOROLA INC [US]; PADFIELD DAVID C [GB]; FOSTER GERARD T [GB]; LOPES) 24 July 2008 (2008-07-24)<br>the whole document<br>----- | 1-10 |
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