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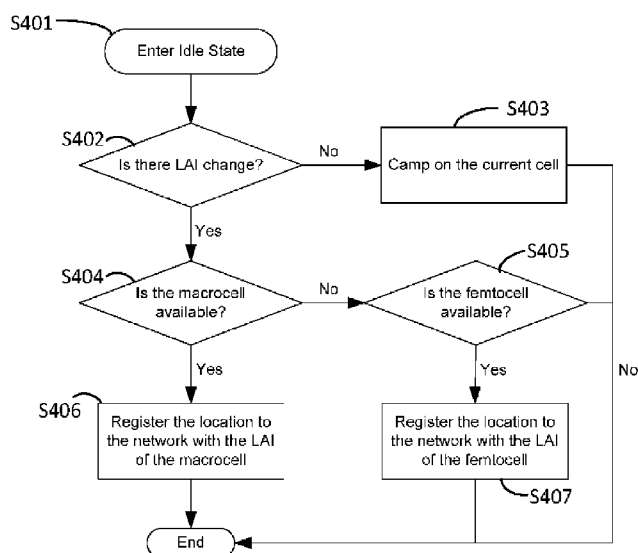


FIG.4

(57) Abstract: In a mobile network including cells assigned to different levels of a hierarchical cell structure, the mobile user equipment determines whether or not a location update is required based on a cell selection scheme which ranks the available cells in order of hierarchical level and then by an additional criterion relating to communication quality. One such network assigns cells different hierarchical levels based on their cell-size class, i.e. whether they are macrocells and femtocells. The number of location updates is reduced in the latter case because this cell selection scheme favours cells in the cell-size class for larger cells (e.g. macrocells) when they are available, even if a cell of a size-class relating to smaller cells (e.g. a femtocell) would give higher communication quality. When the user equipment is paged it can request a switch to the available cell having best communication quality.

LOCATION UPDATE AND PAGING BASED ON HIERARCHICAL LEVEL OF CELLS
IN MOBILE NETWORK

Field of the Invention

The present invention relates to the field of mobile communications and, in particular, to the field of mobility management in a hierarchical cellular mobile telecommunications network.

Background to the Invention

At present, various different types of cellular mobile telecommunications networks using different technologies co-exist with each other, and further developments of cellular network technology are being planned. Well-known technologies employed in mobile telecommunications networks include GSM ("Global System for Mobile Communications"), UMTS/GPRS ("Universal Mobile Telecommunications System"/"General Packet Radio Service"), CDMA2000®, WiMax ("World Interoperability for Microwave Access"), and so on, and the last few years have seen the introduction of LTE systems ("Long Term Evolution" systems) according to release 8 or release 9 specifications developed by the 3GPP (Third-Generation Partnership Project).

Irrespective of the network technologies being used, an important issue in a mobile cellular telecommunications network is how the mobility of the user equipment (UE) is managed. Although there are differences of detail (and in terminology) between the various technologies, a common feature of mobility management is the need for:

- a) a procedure whereby the UE reports its position to the network, and
- b) a procedure whereby the network manages to contact the UE when a call is directed to that UE.

In this document, procedures of type a) above shall be referred to as "location update" or "location registration" procedures, and procedures of type b) above shall be referred to as "paging" procedures.

In existing cellular mobile communications networks, location updates are used to enable the network to register information designating a particular region where the UE can be reached. In general, the registered information designates a group of one or more cells covering the UE's location at the time when the location update was performed. In this document, the expression "location area" (LA) shall be used to designate such a region/group of cells, and the expression "location area identifier" (LAI) shall be used to designate a code or identifier that identifies a location area. The cells of a given location area have the same LAI. It will be understood that the invention can be used advantageously without limit to the network technology, such that the expression "location area" and "LAI" cover any comparable region and its identifier irrespective of the nomenclature ("tracking area", etc.) used in the technology concerned.

When the network receives a call for a particular UE, a check is made of the UE's registered location area, and a paging message is broadcast in cells which have the LAI applicable to the registered location area.

It will be understood that the details of the location update procedure and paging procedure will vary between networks using different technologies. Fig.1 illustrates steps in a

typical location update procedure and Fig.2 illustrates steps in a typical paging procedure.

In step S101 of Fig.1 it is assumed that the UE enters an idle state at the end of a communications session. In this idle state the UE is camped on the cell which was handling communication with the UE at the time when the UE's last session ended. In the idle state, at certain times the UE monitors the radio transmissions being made by transceivers in its vicinity. This monitoring process detects different cells which could handle communications for this UE and monitors properties of the various cells including, but not limited to, signal strength. In step S102 illustrated in Fig.1 the UE determines, based on its monitoring, whether or not the UE has entered a location area having a new LAI compared to the cell on which the UE has been camped. If the UE determines that there has not been a change of LAI then the processing returns to step S101. Alternatively, if the UE determines in step S102 that the UE has entered a location area having a new LAI then the process moves to step S103.

In step S103 the UE makes a determination of which would be the best cell to camp on from now on. The UE's assessment of which cell is "best" may be performed by any convenient metric. For example, the UE may assign a rank to each potential cell with which it could communicate, basing the rank on one or more criteria such as signal strength, interference in the cell, and so on. When the UE has selected the "best" cell the UE camps on that cell and may perform various steps including tuning to the control channel of the new cell.

In step S104 of Fig.1, the UE communicates with the network infrastructure to register the LAI of the cell on which it is newly camped. Following procedures specified in standards applicable to various existing mobile networks, the UE performs the location update by signalling to the new cell so that a radio channel can be assigned and the UE can send a request, through the new cell, for the updated LAI to be registered by the network. The updated LAI may be registered by different components in the network. In general the LAI will be registered by a controller that manages mobility of UEs in a section of the mobile network that includes the new cell. The present description shall refer to controllers which manage mobility of UEs using the expression Mobility Management Entities (MMEs) using the same expression as is used in the LTE standard. The LAI and/or the MME where the UE is registered will also be registered in a network component which constitutes a home server or home register in respect of the subscriber who owns the relevant UE.

It will be understood that if a UE moves rapidly through several different cells belonging to different location areas then, according to the specifications of existing cellular mobile communications networks, the UE will make frequent location updates (see below).

When a call is made to a UE in the mobile telecommunications network, the registered LAI information is used so as to determine where to broadcast a paging message that may be detected by the relevant UE. The steps in a typical paging procedure are illustrated in Fig.2.

In step S201 illustrated in Fig.2 the network infrastructure has determined that a call is being made to a specific UE and the home server or home register for that UE is consulted so as to determine the MME where the UE in question is currently registered. In step S202 of Fig.2, the MME where the UE is currently registered transmits a paging request to transceivers in cells of the

location area whose LAI is currently registered for this UE. In step S203 of Fig.2, the transceivers covering the cells of the location area identified by the relevant LAI broadcast paging messages. In step S204 of Fig.2, the UE detects a paging message broadcast by a cell C of the location area and determines that the paging message is directed at itself. As a result, in step S205 the UE
5 sends a response to cell C. Various messages are then exchanged between the UE and cell C and between cell C and the network infrastructure so as to set up the subsequent call between the UE and the calling party through cell C (step S206 in Fig.2).

In recent years many mobile cellular communications networks have developed a hierarchical cell structure including cells in different cell-size classes, that is, including traditional
10 cells of relatively large size, and small cells of relatively much smaller size. Although the cells of the larger cell-size class, macrocells, can have different sizes they generally cover regions whose dimensions are of the order of one or several kilometres. The cells of the smaller cell-size class are often called "femtocells" and generally cover much smaller regions, for example, regions of the order of 10 metres in diameter. Typically, femtocells are installed to improve network coverage,
15 for example: in locations where there is a high density of users, or within a building, or at rural locations where signal coverage would be poor otherwise. Some businesses or organisations install a set of femtocells in a building or campus in order to provide good network coverage throughout the building or campus.

In this document, depending on the context, the expression "cell" is generally used to
20 designate an access node of the radio access network portion of a mobile network, or to designate the region of radio coverage of an access node.

According to the release 8 and release 9 LTE specifications, macrocells include a component designated eNB or eNodeB (which stands for "E-UTRAN Node B" or "Evolved Node B") which is connected to the core network and handles radio communications with the UEs in its
25 locality. Networks according to other technologies have comparable elements: NodeB in UMTS, base station transceiver/radio network controller in GSM, and so on. The corresponding element in an LTE femtocell is designated an HeNB (which stands for "Home eNodeB").

Often a femtocell will connect to the core network using a residential DSL (Digital Subscriber Line), cable broadband connection, optical fibre, wireless last-mile technology, or other
30 connection using Internet Protocol connection and so on, in association with a gateway to the core network. Femtocells operate at frequencies that are licensed to specific telecommunications companies and so, in the same way as access network components, they handle voice and/or data calls for subscribers with the relevant company. Many femtocells are configured so that only specified UEs are allowed to communicate via the femtocell in question. For example, when a
35 femtocell is installed in a home setting, the femtocell may be configured so only mobile phones belonging to family members may access the femtocell. The present description uses the expression "closed subscriber group" (CSG) to designate a list of specified UEs who are the only ones allowed to make use of a given femtocell. A given CSG may be authorized to use a group of femtocells and the femtocells of the group share a common identifier (CSG ID).

Femtocells are small and are often located in clusters, for example in urban environments. Accordingly, when a UE moves about in such an environment, the UE may move rapidly through a relatively large number of femtocells and macrocells and these may be assigned different LAIs. In such circumstances, based on the methods used in conventional mobile cellular telecommunications networks, the UE will make frequent location updates. This is undesirable because the UE uses power to send location updates and so frequent updates lead to a need to re-charge the UE's battery more often. Also, location updates involve the transmission of messages between the UE and the network infrastructure, as well as messages between components in the network infrastructure, so that frequent location updates use up bandwidth and reduce the network's capacity to handle calls.

Various techniques have already been proposed for reducing the number of location updates that will be generated in mobile cellular telecommunications networks which have a hierarchical structure (e.g. which use macrocells and femtocells). For example, it has been recognized that there are circumstances where the same LAI can be assigned to different femtocells in a locality, for example in a case where plural femtocells are installed at different locations within a building belonging to one business all of these femtocells may use the same LAI. Accordingly, there will be no change of LAI when a UE moves from one of these femtocells to another and, thus, no need to make a location update at that time.

However, femtocells which belong to different organisations or households generally are assigned different LAIs from one another, and macrocells are assigned different LAIs from femtocells. Accordingly, as a UE moves between two such femtocells, or between a femtocell and a macrocell, frequent location updates will still be needed. This problem will now be discussed with reference to Fig.3.

Fig.3 is a diagram illustrating, in simplified form, an example of a region R of a mobile cellular telecommunications network in which there are two macrocells designated MACRO_1 and MACRO_2, as well as four groups of femtocells, designated CSG_0, CSG_1, CSG_2 and CSG_3. The four groups of femtocells correspond to four respective closed subscriber groups. As illustrated in Fig.3, there are three femtocells for each of the closed subscriber groups. The femtocells of groups CSG_0 and CSG_1 are all located within the coverage region of macrocell MACRO_1. The femtocells of groups CSG_2 and CSG_3 are all located within the coverage region of macrocell MACRO_2. A network component, designated MME in Fig.3, manages the mobility of UEs in the region R. A first UE, identified by a unique identifier (designated IMSI_1 in Fig.3), is connected to the mobile cellular telecommunications network but is not located in region R, whereas a second UE, identified by its own unique identifier (designated IMSI_2 in Fig.3) is located in region R and moves around within region R. These UEs shall be referred to from now on using their identifiers.

In the example illustrated in Fig.3, a single location area is assigned to the two macrocells MACRO_1 and MACRO_2 and so these macrocells both have the same LAI, designated LA_1 in Fig.3.

In the example illustrated in Fig.3, a single location area is assigned to the femtocells of groups CSG_0 and CSG_1 and so the femtocells of groups CSG_0 and CSG_1 all have the same LAI, designated LA_2 in Fig.3. It will be noticed that the femtocells of groups CSG_0 and CSG_1 are not assigned to the same location area as the macrocell MACRO_1 even though femtocells of groups CSG_0 and CSG_1 are located within the coverage region of macrocell MACRO_1.

In the example illustrated in Fig.3, a single location area is assigned to the femtocells of groups CSG_2 and CSG_3 and so the femtocells of groups CSG_2 and CSG_3 all have the same LAI, designated LA_3 in Fig.3. In this case also, it will be noticed that the femtocells of groups CSG_2 and CSG_3 are not assigned to the same location area as the macrocell MACRO_2 even though the femtocells of groups CSG_2 and CSG_3 are located within the coverage region of macrocell MACRO_2.

Consider a case where IMSI_2 is initially located at the position marked ① in Fig.3 and moves along a path indicated by the dashed arrow A in Fig.3 to the position marked ② in Fig.3. At the time when IMSI_2 starts moving at position ①, the last communication session IMSI_2 engaged in has terminated with IMSI_2 attached to a femtocell of group CSG_3. The mobility management entity MME of the network has LA_3 registered to identify the location area of IMSI_2. IMSI_2 is camped on one of the femtocells of group CSG_3 but can detect transmissions from the other femtocells of CSG_3 and from the macrocell MACRO_2.

When IMSI_2 moves out of range of the femtocells of CSG_3 travelling along path A, it enters an area where IMSI_2 is only reachable by MACRO_2. IMSI_2 chooses to camp on cell MACRO_2 and detects that the LAI for MACRO_2 is different from the LAI of the cell on which IMSI_2 was previously camped. Accordingly, IMSI_2 communicates with MACRO_2 to request performance of a location update that will register the LAI of MACRO_2 (i.e. LA_1) to the applicable mobility management entity MME. As IMSI_2 continues to move along path A it enters an area covered by the femtocells of CSG_2 and determines that it should camp on a femtocell of CSG_2. IMSI_2 detects that the LAI of the chosen CSG_2 femtocell is different from the LAI of the cell on which IMSI_2 was previously camped, and so communicates with the chosen CSG_2 femtocell to request performance of a second location update, this time to register LA_3 to the MME.

When IMSI_2 moves out of range of the femtocells of CSG_2 travelling along path A, it enters an area where, once again, IMSI_2 is only reachable by MACRO_2. IMSI_2 chooses to camp on cell MACRO_2, detects that the LAI for MACRO_2 is different from the LAI of the cell on which IMSI_2 was previously camped and communicates with MACRO_2 to request performance of a third location update, on this occasion to register LA_1 to the mobility management entity MME. As IMSI_2 continues to move along path A it enters an area where IMSI_2 is only reachable by MACRO_1. IMSI_2 chooses to camp on cell MACRO_1, but detects that the LAI for MACRO_1 is the same as the LAI for the previous cell on which IMSI_2 was camped and so no location update is required. Accordingly IMSI_2 does not send a location update request at this time.

As IMSI_2 continues to move along path A it enters an area covered by the femtocells of CSG_1 and determines that it should camp on a femtocell of CSG_1. IMSI_2 detects that the LAI of the chosen CSG_1 femtocell is different from the LAI of the cell on which IMSI_2 was previously camped, and so communicates with the chosen CSG_1 femtocell to request performance of a fourth location update, this time to register LA_3 to the MME. When IMSI_2 moves out of range of the femtocells of CSG_1 travelling along path A, it enters an area where, once again, IMSI_2 is only reachable by MACRO_1. IMSI_2 chooses to camp on cell MACRO_1 and detects that the LAI for MACRO_1 is different from the LAI of the cell on which IMSI_2 was previously camped. Accordingly, IMSI_2 contacts MACRO_1 to request performance of a fifth location update, to register the LAI of MACRO_1 (i.e. LA_1) to the mobility management entity MME. As IMSI_2 continues to move along path A it enters an area covered by the femtocells of CSG_0 and determines that it should camp on a femtocell of CSG_0. IMSI_2 detects that the LAI of the chosen CSG_0 femtocell is different from the LAI of the cell on which IMSI_2 was previously camped, and so contacts the chosen CSG_0 femtocell to request performance of a sixth location update, this time to register LA_2 to the MME.

It will be understood from the above explanation that the location update techniques that are applied in conventional mobile cellular networks may require a large number of location updates to be performed as a UE moves around in a region covered by macrocells and femtocells. In the example discussed above with reference to Fig.3, IMSI_2 performs 6 location updates as it moves along path A from location ① to location ②.

Considering paging procedures in the region R illustrated in Fig.3: if IMSI_1 places a call to IMSI_2 when IMSI_2 is at position ② at the end of path A, the MME has LA_2 registered as the identifier of the location area for IMSI_2 and so directs a paging request to the radio access network components covering the cells having the location area identifier LA_2. In this case, the femtocells of CSG_0 and CSG_1 are the cells having the location area identified LA_2 and so they respond to the paging request from the MME by broadcasting paging messages which include an identifier of IMSI_2. Let us say that IMSI_2 is camped on a femtocell FC of CSG_0 and detects a paging message identifying IMSI_2, broadcast by femtocell FC of CSG_0. In this case IMSI_2 sends its response to femtocell FC and a session connecting IMSI_1 to IMSI_2 is then established through femtocell FC.

In the previous example, when IMSI_2 is at position ② in Fig.3 the MME sends requests for paging messages to be broadcast to IMSI_2 from six femtocells, that is the femtocells of CSG_0 and CSG_1. In the case of closed subscriber group femtocells, it is possible to obtain a reduction in the number of femtocells broadcasting paging messages by taking into account which CSGs the called UE belongs to. For example, if IMSI_2 in Fig.3 is only a member of CSG_1 and CSG_3 then paging overhead may be reduced by making sure that paging messages are broadcast only in femtocells which, as well as having the appropriate LAI, also belong to a CSG that IMSI_2 is authorized to access. Thus, in the previous example, when IMSI_2 is at position ② in Fig.3 the

MME could request paging messages to be broadcast to IMSI_2 from only the three femtocells of CSG_1 because, although the femtocells of CSG_0 are in the appropriate location area, IMSI_2 is not authorized to access CSG_0.

In conventional mobile cellular communications networks, if a single location area includes a large number of macrocells or femtocells this can reduce the number of location updates that are performed but, conversely, a large number of cells may need to broadcast paging messages when a call is directed to a UE in this location area. However, if a single location area includes only a small number of macrocells or femtocells then, although this can reduce the paging load, there is an increased requirement for frequent location updates.

The present invention has been conceived in the light of the above and other problems.

Summary of the Invention

The present invention provides a method of managing a location updating procedure within a mobile network comprising different location areas (LAs) where mobile devices may be located, said mobile network having a hierarchical structure comprising cells assigned to different levels in a cell hierarchy, each location area (LA) of the network including at least one cell, each location area (LA) of the network being associated to an location area identifier (LAI), the method being executed by a mobile device connected to the mobile network, the mobile device being configured to register to the network the area identifier of an area where the mobile device is located, the method comprising the acts of: monitoring for candidate cells available to handle communications with the mobile device, associating a hierarchical level in said cell hierarchy and an additional criterion to each candidate cell, said additional criterion being associated with cell quality, ordering the candidate cells firstly in order of hierarchical level and then, for candidate cells associated with the same hierarchical level, according to the value of the additional criterion, and selecting the area identifier of the first of the ordered cells as the registered area identifier for this mobile device.

In certain location-updating-procedure management methods embodying the invention, when the registered location area of the mobile device is based on a cell that is chosen from among the candidate cells based, firstly, on the level of the cell in a cell hierarchy and, secondly, based on an additional criterion relating to quality, then the area updates (and, in particular, their frequency) can be controlled based on the cell hierarchy. Depending on the specific cell hierarchy of the network (notably, depending on the parameter by which a cell's hierarchical level is set) this approach can lead to a reduction in the overall number of area updates that are required in the network and/or can ensure that certain types of cell are used preferentially for paging/location-update.

The cell quality may be assessed by any convenient method including, but not limited to: methods in which the mobile device measures or computes a parameter indicating cell quality (for example, a parameter indicating the power, signal-to-noise ratio or other appropriate property of a signal received from the cell), and methods in which the cell computes a parameter indicating quality and the quality parameter is transmitted to the mobile device (for example the cell may

measure or compute a quality parameter based on the characteristics – signal strength, and so on – of a signal transmitted by the mobile device).

The invention may be used both in hierarchical networks where there is a “natural” hierarchy among the cells, for example they have different sizes, and in networks where the cells are different but the differences do not imply any particular ordered relationship between the cells of different types. In the latter case the designer assigns cells of different types to different levels of a hierarchy by indicating an order of preference in which the cells of different types should be selected by the UEs.

Certain embodiments of the above-described location-updating-procedure management methods according to the invention may be implemented in a network where the cells are assigned to hierarchical levels that correspond to different classes of cell size, and the step of associating a hierarchical level to a candidate cell then comprises associating a cell-size class to the candidate cell. This approach enables the number of location updates in a mobile cellular network to be reduced, because in these methods there is a preferential selection, as the cells whose locations areas are registered to the network, of cells in a cell-size class relating to physically-larger cells (e.g. macrocells), when they are available, even if a cell of a size-class relating to physically-smaller cells (e.g. a femtocell) would give higher communication quality.

In some embodiments of the invention, when the mobile device receives a paging request the mobile device implements a protocol to switch to the candidate cell having the highest value of the additional criterion, unless such switch is unnecessary because the cell that sent the paging message is already the candidate cell having the highest value of said additional criterion.

In the latter embodiments, although paging tends to take place in cells (e.g. macrocells) belonging to a higher hierarchical level (e.g. having a cell-size class relating to larger cells), the mobile device can switch to a cell (e.g. a femtocell) belonging to a lower hierarchical level (e.g. a cell-size class relating to smaller cells), if use of the latter cell for the subsequent call would be beneficial, for example, if use of the latter cell would provide better communication quality.

In certain embodiments of the invention the step of associating a hierarchical level to each candidate cell comprises determining if the candidate cell is a macrocell or a femtocell. In such embodiments it is possible for paging to take place preferentially using macrocells but for communication still to be performed using femtocells (when their use for the call would be beneficial, for example, when they would provide better communication quality).

In certain methods embodying the invention, a determination of whether the detected cell is a macrocell or a femtocell is made by analyzing identifier information transmitted by the detected cell. In certain other embodiments this determination is made by analyzing the characteristics of the transmissions made by the various detected cells.

According to certain specifications developed by standardization bodies, macrocells and femtocells transmit identifier information which takes different values for macrocells compared to the values applicable to femtocells, allowing the size-class of the cell to be determined in a simple manner by examination of this identifier information. Likewise, according to certain standards

macrocells and femtocells make transmissions using signals having specific characteristic properties (frequencies, scrambling codes, time slots, etc.). Accordingly, in such cases the size-class of the cell can be determined in a simple manner by analyzing these properties of the signals transmitted by cells.

5 The present invention further provides a mobile device configured to be connectable to a mobile network comprising different areas (LAs) where mobile devices may be located, said mobile network having a hierarchical structure comprising cells assigned to different levels in a cell hierarchy cell-size classes, each area (LA) of the network including at least one cell, each area (LA) of the network being associated to an area identifier (LAI), the mobile device comprising: a
10 receiver configured to monitor for transmissions from candidate cells available to handle communications with the mobile device; a processor configured: to register to the network the area identifier of an area where the mobile device is located, to associate a hierarchical level in said cell hierarchy and an additional criterion to each candidate cell, said additional criterion being associated with cell quality, to order the candidate cells firstly in order of hierarchical level in the
15 cell hierarchy and then, for candidate cells associated with the same hierarchical level, according to the value of the additional criterion, and to select the area identifier of the first of the ordered cells as the registered area identifier for this mobile device.

In certain mobile devices embodying the invention, when the mobile device registers a new area based on a cell that is chosen from among the candidate cells based, firstly, on the level
20 of the cell in a cell hierarchy, the area updates can be controlled based on the cell hierarchy. This approach can lead to a reduction in the overall number of area updates that are required in the network and/or can ensure that certain types of cell are used preferentially for paging/location-update.

Certain embodiments of mobile device according to the invention enable the number of
25 location updates in a mobile cellular network to be reduced, because these devices are configured to make a preferential selection of cells in a cell-size class for larger cells (e.g. macrocells), when these are available (i.e. when they offer good enough quality), as the cells whose locations areas the mobile device will register to the network.

Yet further embodiments of the invention provide a computer program comprising
30 instructions for performing the above-mentioned method, and a recording medium storing the computer program.

Further features and advantages of the present invention will become apparent from the following description of certain embodiments thereof, given by way of example only, not limitation, and illustrated with reference to the drawings described hereinafter.

35 **Brief Description of the Drawings**

Fig.1 is a flow diagram illustrating steps in a typical location update procedure in a mobile cellular telecommunications network;

Fig.2 is a flow diagram illustrating steps in a typical paging procedure in a mobile cellular telecommunications network;

Fig.3 is a diagram illustrating an example of a configuration of macrocells and femtocells in a hierarchical mobile cellular telecommunications network;

Fig.4 is flow diagram illustrating steps in a location update procedure according to one embodiment of the present invention;

5 Fig.5 is a flow diagram illustrating steps in a paging procedure according to an embodiment of the present invention;

Fig.6 shows examples of a configuration of macrocells and femtocells connected to network infrastructure, in which:

10 Fig.6A illustrates a configuration of macrocells and femtocells all connected to a common mobility management entity, and

Fig.6B illustrates a configuration of macrocells and femtocells in which the femtocells are connected to a femtocell gateway which connects to the mobility management entity that is connected to the macrocells; and

15 Fig.7 is a diagram illustrating schematically some components in a mobile device according to one embodiment of the invention.

Detailed Description of Certain Embodiments

Certain embodiments of the present invention will now be described with reference to a cellular mobile communications network having a hierarchical structure whose levels correspond to different cell-size classes and, in particular, to a network that includes macrocells and femtocells.
20 However, it is to be understood that the invention is not limited to networks whose hierarchical structure is based on cell-size classes.

A method of managing a location-update procedure according to one embodiment of the present invention, in a network that includes macrocells and femtocells, will now be described with reference to Fig.4. Fig.4 is a flow chart illustrating steps in the method.

25 In step S401 of Fig.4 it is assumed that a UE enters an idle state at the end of a communications session, but the Fig.4 processing may be performed when the UE enters the idle state at different times and, in particular, may be periodic. In the idle state in this case the UE is camped on the cell which was handling communication with the UE at the time when the UE's last session ended. Thus, if the UE ended the session in a macrocell (outside any femtocell) then the
30 UE will remain camped on the macrocell and if the UE terminated the session in a femtocell then it will remain camped on that femtocell.

In the idle state, at certain times the UE monitors the radio transmissions being made by transceivers in its vicinity. This monitoring process detects different cells which could handle communications for this UE and monitors properties of the various cells including, but not limited
35 to, signal strength. According to this embodiment of the invention, the UE also notes the type of the different available cells, notably their cell-size class (macrocell or femtocell).

The UE may determine that a certain condition indicates that it might be expedient to change cell or LAI. For example, the quality of the previous cell may have become insufficient. According to conventional procedures in mobile networks, at this stage a selection would be made

of the "best" cell for the UE to use (see step S103 in Fig.1), with the assessment of which cell is "best", being based on factors such as signal strength. However, in the method according to the current embodiment, the UE does not simply choose the current "best" cell as its new cell. In step S402 illustrated in Fig.4 the UE determines, whether the current "best" cell has a new LAI compared to the previous cell on which the UE has been camped. If no change of LAI would arise the UE camps on the current best cell (step S403). Alternatively, if the UE determines in step S402 that there would be an LAI change then the process moves on to step S404. In step S404 the UE determines whether any of the available cells are macrocells (i.e. cells in a cell-size class relating to larger cells). If the UE detects in step S404 that one or more macrocells are available then the UE selects the "best" of these macrocells to use as the new cell for this UE (the criteria used to determine which macrocell is "best" may be the same as in existing networks – for example, based on best signal quality - or may be any other convenient criterion, for example the size of the location area covered by this macrocell). The UE then registers the LAI of the selected macrocell to the network (step S406 in Fig.4.) as the identifier of the location area currently applicable to this UE.

If in step S404 the UE does not detect any available macrocells then the UE checks, in step S405 of Fig.4, whether any femtocells are available. If the UE detects in step S405 that one or more femtocells are available then the UE selects the "best" of these femtocells as the new cell for this UE (once again, the criteria for selecting which femtocell is "best" may be the same as in existing networks, or any other convenient criterion). The UE then registers the LAI of the selected femtocell to the network (step S407 in Fig.4.) as the identifier of the location area currently applicable to this UE.

In the above description of Fig.4, when references are made to the UE detecting "available" cells, the "available" cells do not include cells which, although they are detectable, offer unacceptable communications quality. In other words the "available cells" are intended to mean cells having a certain minimum acceptable level of quality.

It will be understood that steps S404-S407 of Fig.4 correspond to a selection method in which a UE ranks available cells firstly in terms of the cell-size class to which they belong and, secondly, if there are plural cells in the same cell-size class, according to some other criterion, typically a criterion relating to the quality of the communications available using this cell (e.g. signal strength, interference, and so on). Location-update is then based on selecting a cell of highest rank in terms of cell-size class and then, if plural cells in the same size-class are available, based on factors such as quality. Because the UE will preferentially register LAIs for large location areas, the frequency of changes in location area tends to reduce, leading to a smaller number of location updates. This saves battery power in the UE, because it expends less energy performing location updates. Also, this leads to a reduction in the network bandwidth that is occupied by signalling relating to location-updates.

The location-update management method according to the present embodiment preferentially selects cells in a cell-size class relating to larger size cells and so it can arise that a

UE selects to register the LAI of a large cell (e.g. a macrocell) even though there is an available small cell (e.g. femtocell) offering better communications quality. One embodiment of paging procedure will now be described, with reference to Fig.5, which can ensure good quality in the communications established by a UE even when the UE employs the location-update management method illustrated in Fig.4

Fig.5 is a flow diagram illustrating an example of a sequence of steps that may be performed by the UE when a paging request is received. It is assumed that the UE concerned by Fig.5 employs the location-update method described above with reference to Fig.4.

It will be recalled that the network infrastructure arranges for paging messages to be broadcast by some or all of the cells whose LAI is the same as the LAI that is registered for the UE that is being called. In step S501 of Fig.5 the UE detects a paging message and determines that the paging message identifies this UE and is broadcast by a particular cell. In step S502 of Fig.5 the UE determines whether the received paging message was broadcast by a femtocell (i.e. a cell whose cell-size class designates a smaller cell in the hierarchy of cell sizes). If the UE determines in step S502 that the paging message was received from a femtocell, this means that the location area the network has registered for this UE resulted from performance of step S407 in Fig.4. In other words, the LAI registered for this UE relates to a femtocell which was determined to be the "best" available femtocell to handle communications for this UE. Accordingly, good communications quality can be expected if the call is handled through this femtocell. Therefore, in step S503, after the UE sends a paging response through the femtocell from which it received the paging message, the UE then continues to set up the call through this same femtocell.

If in step S502 of Fig.5 the UE determines that the received paging message was not broadcast by a femtocell the UE proceeds to step S504 where it determines whether the paging message was received from a macrocell (i.e. a cell whose cell-size class designates a larger cell in the hierarchy of cell sizes). If the UE determines in step S504 that the paging message was not received from a macrocell then some error has occurred and either the UE fails to respond to the paging message or the UE takes some convenient remedial action.

Alternatively, if the UE determines in step S504 that the paging message was received from a macrocell, this means that the location area the network has registered for this UE resulted from performance of step S406 in Fig.4. In other words, the LAI registered for this UE relates to a macrocell that was deemed to be the "best" in its size-class; it is possible that a cell of a different cell-size class is available which would be better to use for the ensuing call, for example because it offers better communications quality. Therefore, when the UE determines in step S504 that the paging message was received from a macrocell, it first proceeds to step S505 of Fig.5 - and responds to the paging message by sending its response back to the macrocell from which it received the paging message - and next the UE checks in step S506 of Fig.5 whether any of the available cells is a femtocell (i.e. a cell of a size-class relating to smaller cells). If the UE determines in step S506 that no femtocells are available then it can be concluded that the macrocell from which the paging message was received is not just the "best" macrocell but, more

generally, the "best" available cell. Accordingly, the UE proceeds to set up the call through this same macrocell.

If the UE determines in step S506 that one or more femtocells are available then it is possible that it may be preferable to set up the ensuing call through a femtocell rather than the macrocell, for example, perhaps better communications quality would be obtained by using the femtocell rather than by using the macrocell for the call that is being set up. Accordingly, the UE determines which is the "best" femtocell and triggers execution of a handoff protocol with the network infrastructure in order to switch the call so that it will be handled through the "best" femtocell. Typically the UE triggers the handoff procedure by sending a measurement report to the macrocell from which it received the paging message, to require the execution of an inter-cell handoff. Of course, if the UE is not authorized to access the "best" femtocell, then it may request to switch to the best femtocell that it is authorized to access and, if no authorized femtocells are available, it may simply remain on the macrocell and continue call set-up.

When a paging procedure such as that illustrated in Fig.5 is used by a UE which also employs a location-update management method such as that explained above with reference to Fig.4, the optimal cell can be used to handle the call directed to the UE even if the UE has not selected the location area identifier of this optimal cell as the LAI to register to the network. Accordingly, the signalling overhead associated with location update can be reduced without compromising the quality of the communications that the UE engages in.

It will be understood that, according to the embodiment illustrated in Fig.5, in the case where the UE receives a paging message from a femtocell, or receives a paging message from a macrocell when no better femtocell is available, the ensuing signalling between the UE and the network infrastructure may follow procedures that are standard in mobile networks (i.e. the UE will send a paging response to the cell from which it received the paging message and will execute protocols to set-up the call through that cell). However, in a case where the UE receives a paging message from a macrocell and a better femtocell is available the ensuing signalling is new because the UE requests handoff to the "better" femtocell after it has sent the paging response to the macrocell from which it received the paging message.

Furthermore, UEs applying methods specified in existing specifications that have been established by standardization bodies do not perform a check of the class-size of the cell from which a paging message is received, neither do they adjust their subsequent functioning based on the cell-size class of the cell from which the paging message was received.

In mobile networks which include cells of different size-classes the cells of the different classes may be connected to the network infrastructure in different ways. For example, Fig.6A illustrates a configuration of macrocells and femtocells in which all of the cells are connected to a common mobility management entity MME. By way of contrast, Fig.6B illustrates a similar configuration of macrocells and femtocells but this time the macrocells are connected directly to a common mobility management entity MME whereas the femtocells are connected to a femtocell gateway and the femtocell gateway is connected to the MME to which the macrocells are

connected.

An example of location-update management as in Fig.4 combined with a paging procedure as in Fig.5 will now be described for a UE that is mobile in the example cell configuration illustrated in Fig.6A. It will be assumed that a UE designated IMSI_2 initially resides in the area LA_3 which is covered both by macrocell MACRO_2 and a group of femtocells CSG_3. The LAI of MACRO_2 is LA_1, while the LAI of the femtocells in CSG_3 is LA_3. IMSI_2 camps on CSG_3 because its previous session terminated in CSG_3, and it registers LA_3 to the MME.

As IMSI_2 moves out of CSG_3, it detects the change in the LAI broadcast from the network. Specifically, only cell MACRO_2 can be reached by IMSI_2. Then, IMSI_2 chooses to camp on MACRO_2 and requests a first location update to register LA_1 to the MME. As IMSI_2 moves to CSG_0 while crossing CSG_2, CSG_1 and CSG_0 sequentially, it does not launch any location update because, although changes in LAI are detected, IMSI_2 is still reachable by macrocells of location area LA_1 and, according to the location-update management method of Fig.4, when a macrocell is available the UE does not perform a location update based on the LAI of a femtocell. Thus, IMSI_2 still camps on the location area of LA_1 composed of MACRO_2 and MACRO_1. Finally, as a result of its motion IMSI_2 resides in an area covered by both CSG_0 and MACRO_1 and LA_1 is still the LAI the network registers for IMSI_2.

If a UE designated IMSI_1 calls up IMSI_2 at this time, the call request arrives at MME and, since MME knows that IMSI_2 is in the location area identified by LA_1, it forwards a paging request to MACRO_1 and MACRO_2, which are the cells having LAI equal to LA_1. MACRO_1 and MACRO_2 broadcast appropriate paging messages. IMSI_2 receives the paging message broadcast through MACRO_1. IMSI_2 sends back a paging response through MACRO_1, which yields a session through MACRO_1. However, applying the procedure of Fig.5 IMSI_2 finds that CSG_0 is available and determines that it would be better to use CSG_0, rather than MACRO_1, for the impending call. Accordingly, IMSI_2 requires the network to handoff the incoming call from MACRO_1 to CSG_0. Finally, the session between IMSI_1 and IMSI_2 is established through CSG_0.

It will be understood from the above explanation referring to Fig.6A, that by using the method of managing location-update according to the embodiment of Fig.4 the number of location updates that need to be performed as the a UE moves around in region R has been reduced to one. This is a large reduction compared to the six location updates that are required when employing conventional methods for managing location-update (as described above with reference to Fig.3).

Another example of location-update management as in Fig.4 combined with paging procedure as in Fig.5 will now be described for a UE that is mobile in the example cell configuration illustrated in Fig.6B which makes use of a femtocell gateway. Once again it is assumed that IMSI_2 initially resides in the area LA_3 covered both by macrocell MACRO_2 and the femtocells of CSG_3. In this case the latter femtocells connect to the MME through Femtocell-GW. IMSI_2 camps on CSG_3 because its previous session terminated in CSG_3, and it registers

LA_3 to the MME via Femtocell-GW.

The procedure in this case is mainly as described above with reference to Fig.6A. As IMSI_2 moves out of CSG_3, to an area where the only available cell is MACRO_2, IMSI_2 chooses to camp on MACRO_2 and requests a first location update to register LA_1 to the MME; IMSI_2
5 sends this first location-update request via MACRO_2. As IMSI_2 moves from CSG_3 to CSG_0 it crosses CSG_2, CSG_1 and CSG_0 sequentially but IMSI_2 does not launch a location update because, based on the location-update management procedure of Fig.4, it still camps on the location area of LA_1. Finally, IMSI_2 resides in the area co-covered by CSG_0 and MACRO_1.

If IMSI_1 calls up IMSI_2 at this time, the call request is processed by MME and, because
10 MME knows that IMSI_2 is the location area of LA_1, MME sends a paging request to MACRO_1 and MACRO_2. IMSI_2 receives the paging message broadcast by MACRO_1 and sends back the paging response through MACRO_1 which yields a session through MACRO_1. Once again because, according to the paging method of Fig.5, IMSI_2 has previously found that CSG_0 is available and would be better to use for the call, IMSI_2 immediately requires the network to handoff the
15 incoming call from MACRO_1 to CSG_0 after sending the paging response and, in the end, the session between IMSI_1 and IMSI_2 is established through Femtocell-GW and CSG_0. Once again, use of the location-update management method according to the Fig.4 embodiment has reduced the number of required location updates in this example to one.

The methods discussed above relate to procedures implemented in a mobile user
20 equipment to manage location-update and to manage response to paging messages. These procedures can be implemented without making any changes in the network infrastructure and, thus, the methods are compatible with legacy networks. Because location-update management methods according to certain embodiments of the invention enable the number of location updates to be reduced, without requiring any change outside the user equipment, the signaling overhead in
25 the network associated with location update can be reduced in a simple and cost-effective manner.

Typically, user equipment is configured to perform the above-described methods for managing location-update and for managing response to paging messages by suitable programming of a processor in the user equipment. Fig.7 is a simplified diagram illustrating some of the components in a user device 1 configured to perform a location-update method according to
30 an embodiment of the present invention.

As illustrated in Fig.7, the user device 1 is configured to communicate with transceivers 2a and 2b of a mobile network. Transceivers 2a may be relatively long-range radio equipment of a macrocell, whereas transceivers 2b may be relatively short-range equipment of femtocells. The UE 1 includes a radio sub-system 3 configured to handle communications between the UE and the
35 transceivers 2a, 2b, as well as including a baseband sub-system 4. The radio sub-system 3 may be configured to provide the functions of acting as a receiver configured to detect transmissions from cells available to handle communications with the mobile device, and acting as a transmitter sub-system for transmitting various signals to the network, including transmissions of requests to register area identifiers as the location of the mobile device within the mobile network.

The baseband sub-system 4 includes a processor 5 as well as associated components which may include a memory 6 and one or more interfaces 10 (for example, an interface to device elements (not shown) such as a keyboard, touchscreen, and so on that may be operated by a user, an interface to a loudspeaker (not shown), and other interfaces). Other UE components may also be provided, as in conventional mobile devices, but these are not shown in Fig.7 because their description is not pertinent to the explanation of the invention. The processor 5 of the UE 1 may be programmed to create in the memory 6 a cell ranking table 7. The cell ranking table 7 associates with each available cell that the radio sub-system 3 has detected a cell-size class and at least one additional criterion. Typically, the additional criterion relates to cell quality and may, for example, indicate signal strength detected for the cell, interference, and so on. In the cell-ranking table 7, available cells are ranked in order, firstly based on the general cell-size of the cell-size class to which they belong (i.e. cells of a cell-size class relating to relatively larger cells will be ranked above cells of a cell-size class that relates to relatively smaller sized cells). Cells that have the same rank according to cell-size are then assigned ranks relative to each other according to one of more criteria relating to how good this cell would be to use for a call. As indicated above, typically the criterion or criteria used for ranking cells of the same cell-size class relative to each other may include: the cell's remaining capacity to accommodate accessing UEs, the signal strength of the cell, the peak data rate supported by the cell, and so on.

Typically the processor 5 is configured to update the rankings in the cell ranking table 7 based on measurements on the different available cells. For a given detected cell the ranking associated to cell-size class is unlikely to change, but the ranking based on criteria such as signal quality may change with time, notably as the mobile moves relative to the transceivers of the detected cells, as traffic in the cells varies, and so on. The processor 5 may be programmed to refer to the current data in the cell ranking table 7 when implementing a location-update management process such as that described above with reference to Fig.4.

The skilled person will readily understand that user equipment according to the present invention is not limited to devices which create an explicit cell ranking table in memory.

In the description above reference has been made to the UE determining whether a detected cell is a macrocell or a femtocell. The present invention is not particularly limited having regard to the technique that may be used for making this determination. However, it is particularly simple to implement the methods according to the invention if the determination is made by exploiting differences that already exist between macrocells and femtocells as defined by the specifications established by standardization bodies.

For example, identifier information is assigned to different cells in a mobile network and, according to the specifications established by various standardization bodies, the identifiers assigned to cells of different cell-size classes may have different characteristics (for example, cell identities associated with the respective cells may be selected from different ranges of values depend on whether the cell is a macrocell or a femtocell). In such cases the UE can determine the

cell-size class of a detected cell by determining whether the characteristics of identifier information applicable to this cell are characteristics that the relevant standard defines as applicable to one cell-size class or another of the possible cell-size classes. Typically the UE is provided with information defining the relationship between the cell identifier information and the cell-size class, for example at the time of manufacture or commissioning of the UE, or in an update. For example, this information can be programmed into the UE.

As another example, according to the specifications established by various standardization bodies, cells of different cell-size classes may transmit signals having different characteristics. For example, depending on their cell-size class cells may transmit using different frequencies, different scrambling codes, different time slots, and so on. In such cases the UE can determine the cell-size class of a detected cell by examining the characteristics of the signals transmitted by the cell and determining according to the applicable standard or specification which cell-size class has the detected characteristics. Typically the UE is provided with information defining the relationship between the signal characteristics and the cell-size class, for example at the time of manufacture or commissioning of the UE, or in an update. For example, this information can be programmed into the UE.

Although the invention has been described, in its various aspects, with reference to certain specific embodiments it is to be understood that various modifications and developments can be made without departing from the scope of the invention as defined in the appended claims.

For example, although the specific embodiments described above relate to mobile networks comprising cells of two different cell-size classes, that is macrocells and femtocells, the skilled person will understand that the principles of the invention may be extended to hierarchical networks that employ a in different number of cell-size classes and the invention is not limited to the case where the dimensions of cells in certain of the classes have dimensions matching those of existing macrocells and femtocells. Thus, the invention may be applied in mobile networks which define three cell-size classes corresponding to three different size levels (short-range, medium-range and long-range), as well as in networks that include four or more cell-size classes, and so on.

Moreover, the invention is not limited to methods and devices used in mobile networks whose hierarchical structure is based on cell-size class. The invention applies in general to networks having a hierarchical structure in which cells are assigned to different levels in a cell hierarchy, especially to such networks in which the different hierarchical levels assigned to the cells reflect differing capabilities of the cells to handle location update/paging requests. For example, a cell's level in the hierarchy may be set dependent on reliability, dependent on latency (e.g. relating to the nature of the connection between the cell base station and the network), and/or other factors.

In the above-described specific embodiments where different hierarchical levels are assigned to macrocells and femtocells, the UEs can deduce or infer the hierarchical levels of the cells based on existing features of transmissions from macrocells and femtocells. However, both in networks using a cell-sized based hierarchy and in networks using cell hierarchies based on other

factors, if it is necessary or desirable, the cells may be configured to transmit information that identifies the hierarchical level explicitly.

CLAIMS

1. A method of managing a location updating procedure within a mobile network comprising different areas where mobile devices may be located, said mobile network having a hierarchical
5 structure comprising cells assigned to different levels in a cell hierarchy, each area of the network including at least one cell, each area of the network being associated to an area identifier, the method being executed by a mobile device connected to the mobile network, the mobile device being configured to register to the network the area identifier of an area where the mobile device is located, the method comprising the acts of:

- 10 - monitoring for candidate cells available to handle communications with the mobile device,
- associating a hierarchical level in said cell hierarchy and an additional criterion to each candidate cell, said additional criterion being associated with cell quality,
- ordering the candidate cells firstly in order of hierarchical level in said cell hierarchy and then, for candidate cells associated with the same hierarchical level, according to the value
15 of the additional criterion, and
- selecting the area identifier of the first of the ordered cells as the registered area identifier for this mobile device.

2. Method according to 1, wherein the cells of the network are assigned to hierarchical levels corresponding to different classes of cell size and the step of associating a hierarchical level to a
20 candidate cell comprises associating a cell-size class to the candidate cell.

3. Method according to 1 wherein, when the mobile device receives a paging message the mobile device implements a protocol to switch to the candidate cell having the highest value of said additional criterion unless such switch is unnecessary because the cell that sent the paging message already is the candidate cell having the highest value of said additional criterion.

25 4. Method according to claim 2, wherein the step of associating a cell-size class to each candidate cell comprises determining if the candidate cell is a macrocell or a femtocell.

5. Method according to claim 4, wherein the step of determining if the candidate cell is a macrocell or a femtocell comprises analyzing identifier information transmitted by the candidate cell.

30 6. Method according to claim 4, wherein the step of determining if the candidate cell is a macrocell or a femtocell comprises analyzing signal characteristics of a transmission made by the candidate cell.

7. A mobile device configured to be connectable to a mobile network comprising different areas where mobile devices may be located, said mobile network having a hierarchical structure
35 comprising cells assigned to different levels in a cell hierarchy, each area of the network including at least one cell, each area of the network being associated to an area identifier, the mobile device comprising:

a receiver configured to monitor for transmissions from candidate cells available to handle communications with the mobile device;

a processor configured:

to register to the network the area identifier of an area where the mobile device is located,

to associate a hierarchical level in said cell hierarchy and an additional criterion to each candidate cell, said additional criterion being associated with cell quality,

to order the candidate cells firstly in order of hierarchical level in said cell hierarchy and then, for detected cells associated with the same hierarchical level, according to the value of the additional criterion, and

to select the area identifier of the first of the ordered cells as the registered area identifier for this mobile device.

8. Mobile device according to 7, configured to be connectable to a mobile network having a cell hierarchy based on cell-size classes, wherein the processor is configured to associate a hierarchical level in the cell hierarchy to a candidate cell by associating a cell-size class to the candidate cell.

9. Mobile device according to claim 7, wherein the processor is configured to implement a protocol to switch to the candidate cell having the highest value of said additional criterion when the receiver receives a paging message, unless such switch is unnecessary because the cell that sent the paging message already is the candidate cell having the highest value of said additional criterion.

10. Mobile device according to claim 8, wherein the processor is configured to associate a cell-size class to each candidate cell by determining if the candidate cell is a macrocell or a femtocell.

11. Mobile device according to claim 10, wherein the processor is configured to determine if the candidate cell is a macrocell or a femtocell by analyzing identifier information transmitted by the candidate cell.

12. Mobile device according to claim 10, wherein the processor is configured to determine if the candidate cell is a macrocell or a femtocell by analyzing signal characteristics of a transmission made by the candidate cell.

13. Computer program comprising instructions for performing the method according to claim 1 when executed by a processor.

14. Recording medium storing the computer program according to claim 13.

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FIG.1
PRIOR ART

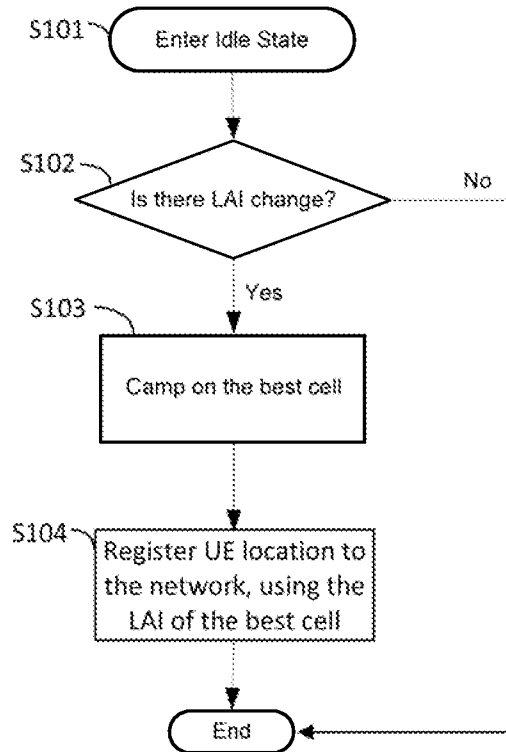
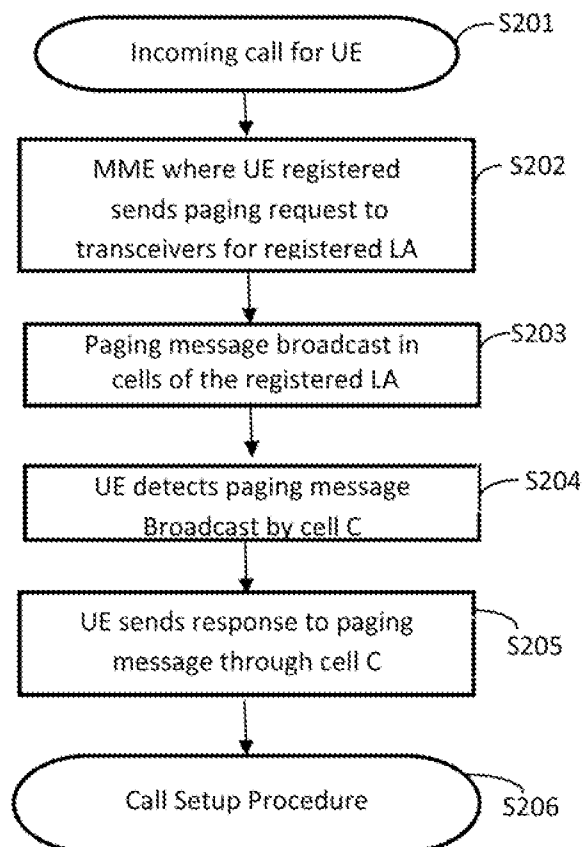


FIG.2
PRIOR ART



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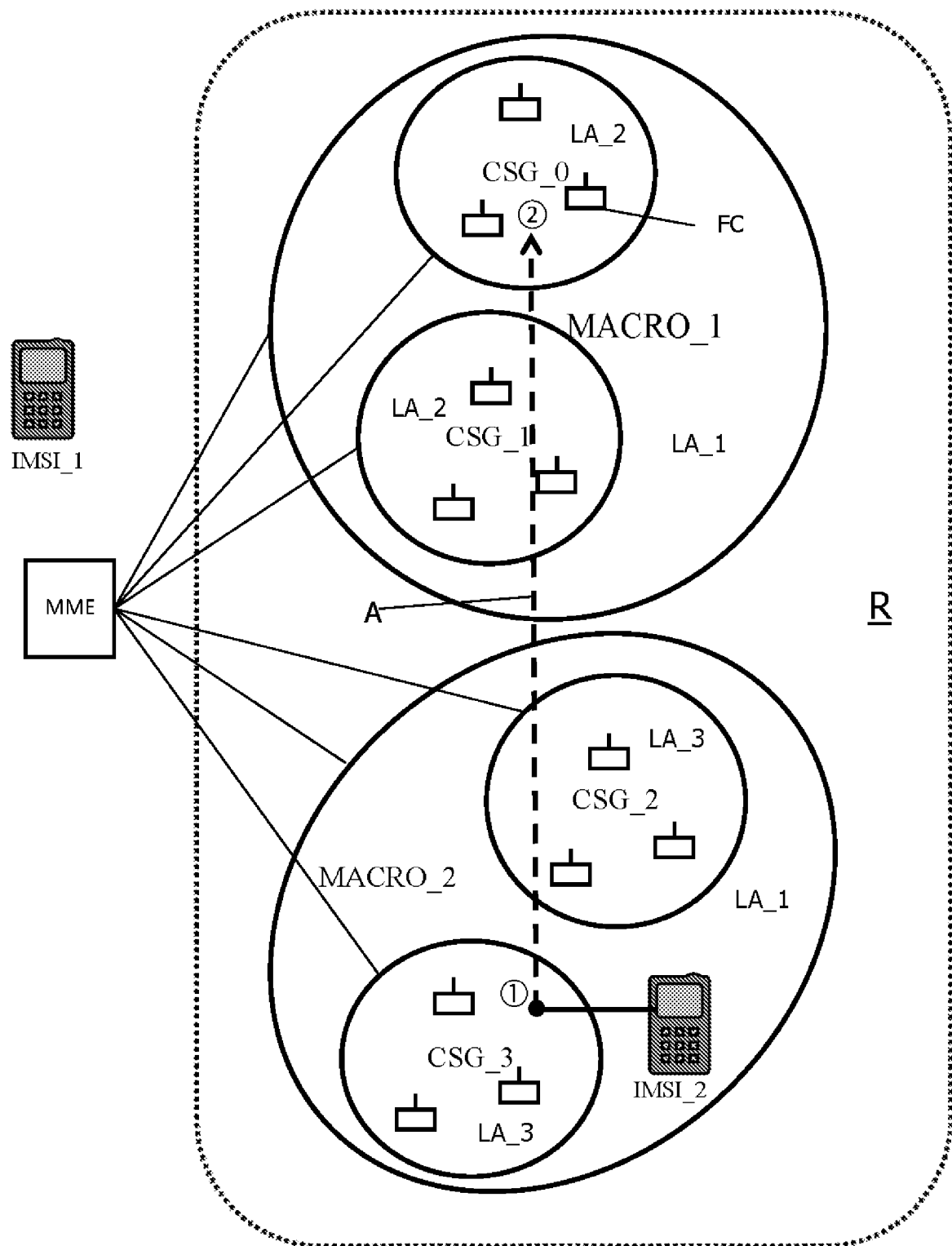


FIG.3

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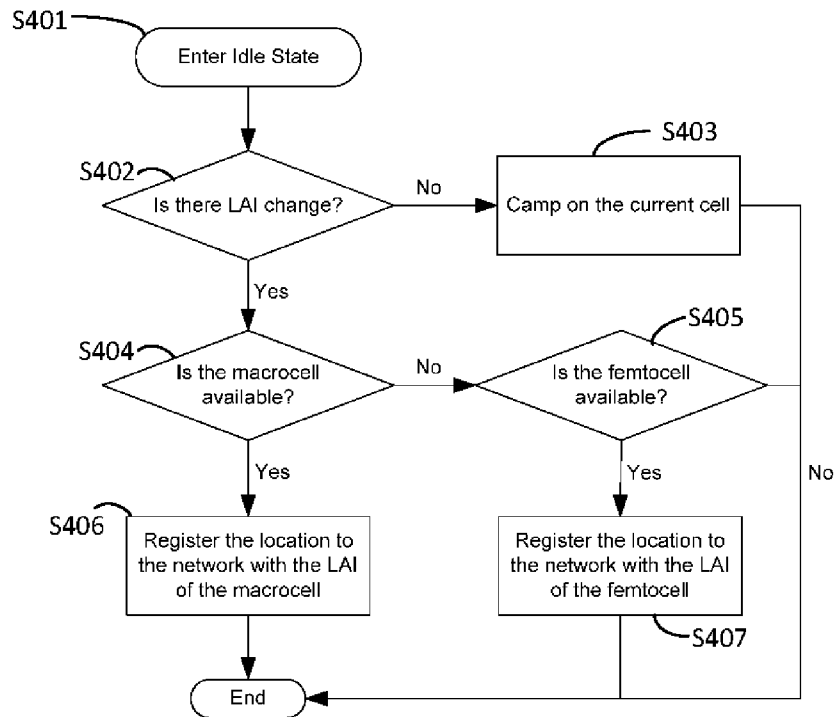


FIG.4

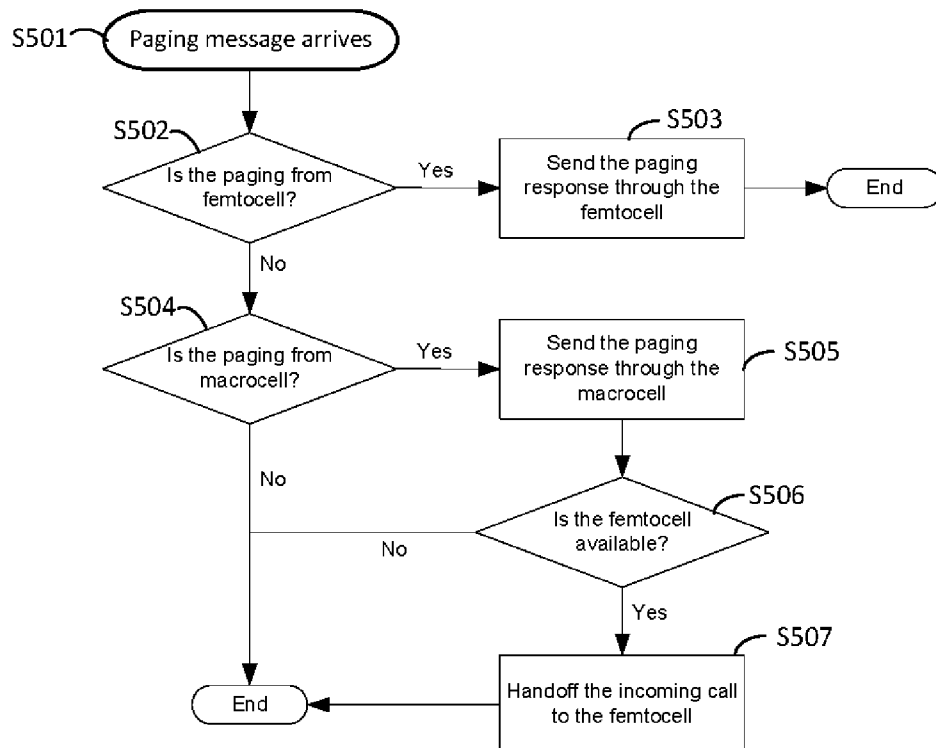


FIG.5

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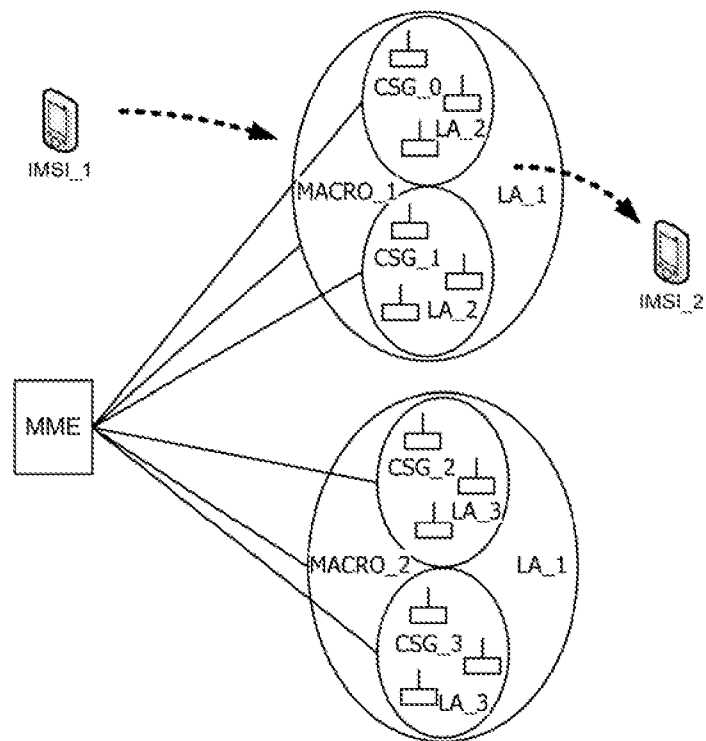


FIG.6A

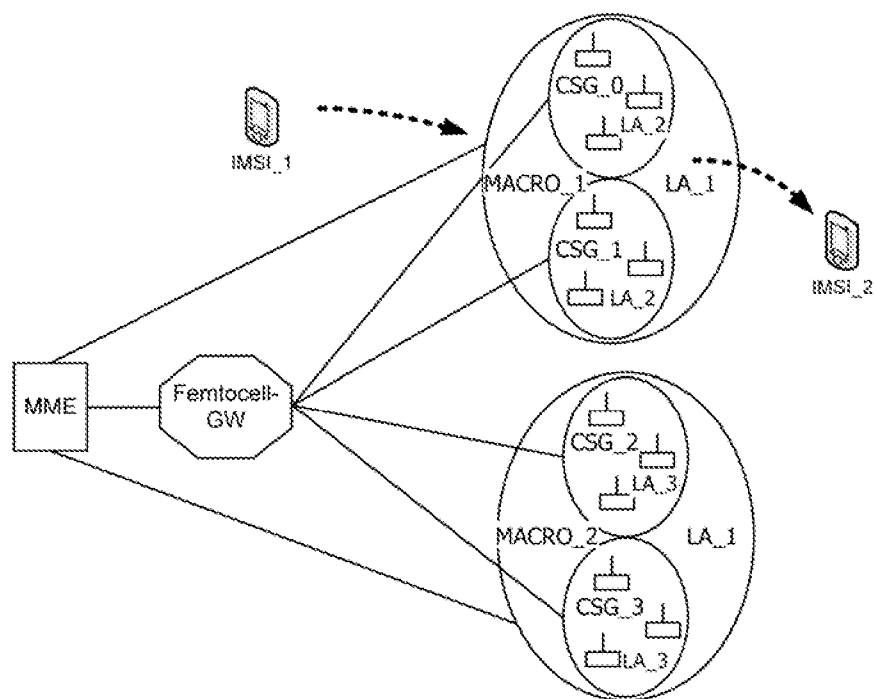


FIG.6B

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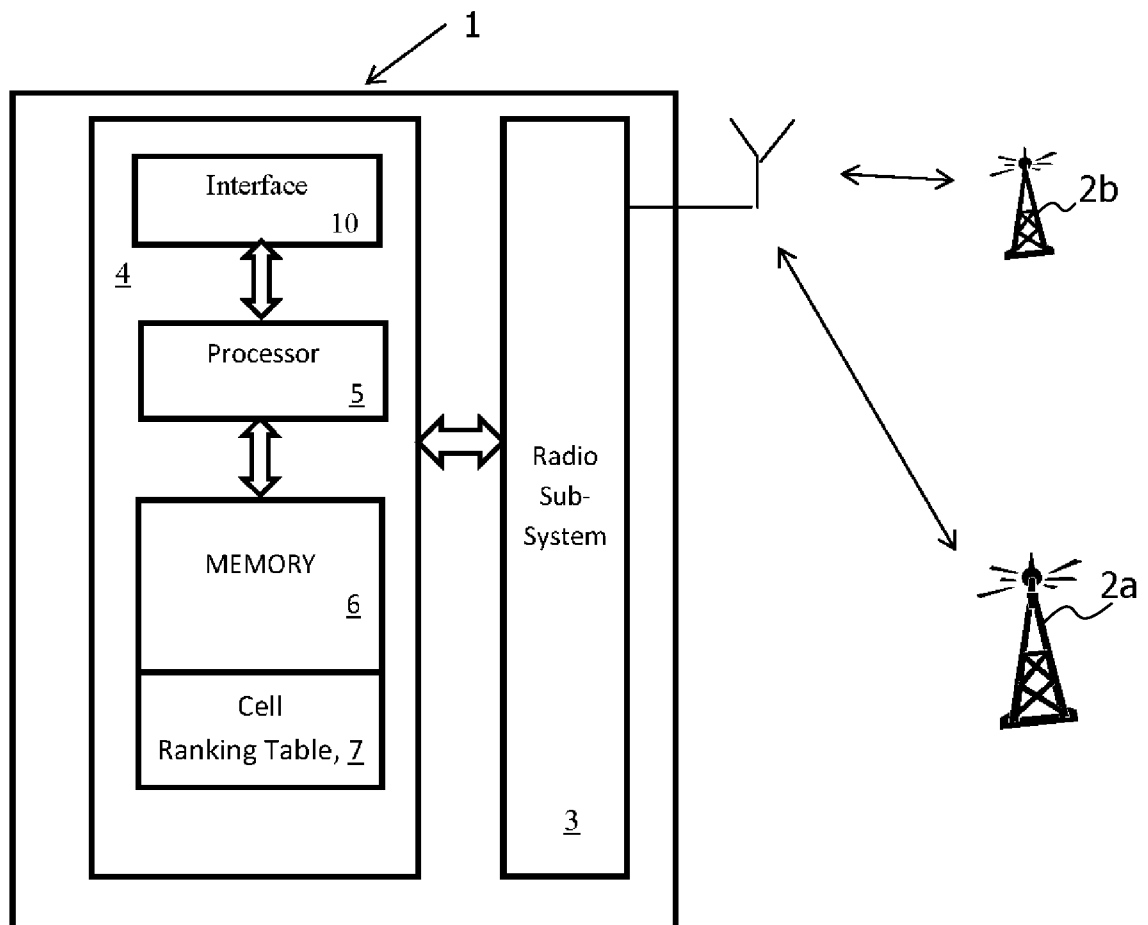


FIG.7

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2013/000360

A. CLASSIFICATION OF SUBJECT MATTER

H04W 36/04 (2009.01) i

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)

IPC: H04W; 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 practicable, search terms used)

WPI, EPODOC, CNPAT: location updating, hierarchy, hierarchical, heterogeneous, location area, tracing area, LAI, TAI, paging

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5832381 A (NOKIA TELECOM. OY) 03 November 1998 (03.11.1998) description column 4 line 60 to column 5 line 11, column 6 lines 48-60, column 6 lines 7 to 10, claim 4	1-2, 4-8, 10-14
A	WO 00/28771 A1 (TELEFONAKTIEBOLAGET LM ERICSSON (publ)) 18 May 2000 (18.05.2000) the whole document	1-14
A	CN 101588545 A (HUAWEI TECHNOLOGIES CO., LTD.) 25 November 2009 (25.11.2009) the whole document	1-14
A	CN 101409898 A (CHINA MOBILE COMMUNICATION GROUP CORP.) 15 April 2009 (15.04.2009) the whole document	1-14

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:	“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
“A” document defining the general state of the art which is not considered to be of particular relevance	“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
“E” earlier application or patent but published on or after the international filing date	“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
“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)	“&” document member of the same patent family
“O” document referring to an oral disclosure, use, exhibition or other means	
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Information on patent family members

International application No.
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Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
US 5832381 A	03.11.1998	WO 9511577 A1	27.04.1995
		FI 934629 A	21.04.1995
		AU 7857494 A	08.05.1995
		EP 0724817 A1	07.08.1996
		JP H09507005 A	08.07.1997
		CN 1133668 A	16.10.1996
		AU 684842 B2	08.01.1998
		DE 69432520 T2	29.01.2004
		ES 2194875 T3	01.12.2003
		AT237912 T	15.05.2003
		PT724817 E	29.08.2003
		HK1011497 B	21.11.2003
WO 0028771 A1	18.05.2000	AU 1591200 A	29.05.2000
		US 6275706 B1	14.08.2001
CN 101588545 A	25.11.2009	WO 2009140924 A1	26.11.2009
		US 2011072068 A1	24.03.2011
CN 101409898 A	15.04.2009	None	