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# United States Patent [19]

Marko et al.

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[54] **METHOD FOR MOBILE STATION LOCATION REGISTRATION WITH DYNAMIC CELL GROUPING FOR RADIOTELEPHONE SYSTEMS**

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[21] Appl. No.: **568,094**

[22] Filed: **Dec. 6, 1995**

[51] **Int. Cl.**[6] ..... **H04B 7/00**

[52] **U.S. Cl.** ..... **455/435**; 455/432; 455/433

[58] **Field of Search** ..... 455/33.1, 33.2, 455/33.4, 134, 435–439, 432–433, 442–444; H04B 7/00

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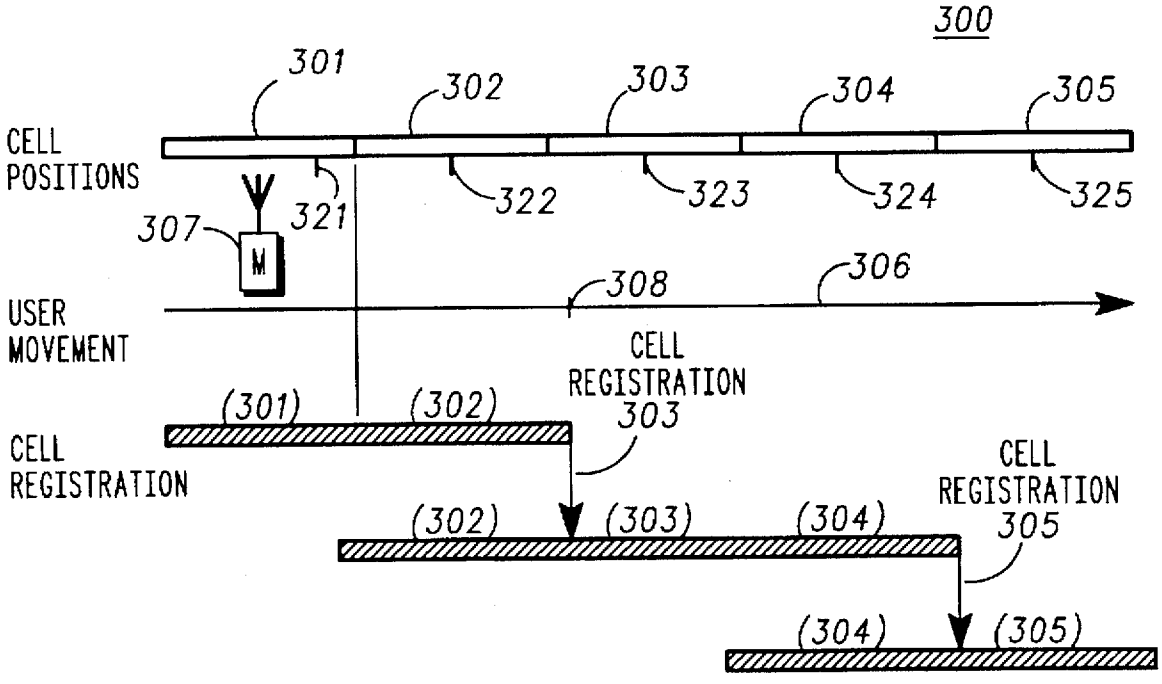
*Assistant Examiner*—Vu Le
*Attorney, Agent, or Firm*—John G. Rauch

[57] **ABSTRACT**

A method for registering a mobile station (**307**) in a radiotelephone communication system (**300**). The mobile station (**307**) receives system information from a base station (**321**), including a cell grouping level. The mobile station (**307**) determines if it is registered with the base station (**321**). If not, the mobile station (**307**) registers. The network controller of the radiotelephone communication system (**300**) automatically registers the mobile stations with all base stations defined by the cell grouping level. The mobile station (**307**), using the same algorithm, maintains a record of the base stations with which it is automatically registered.

**12 Claims, 5 Drawing Sheets**



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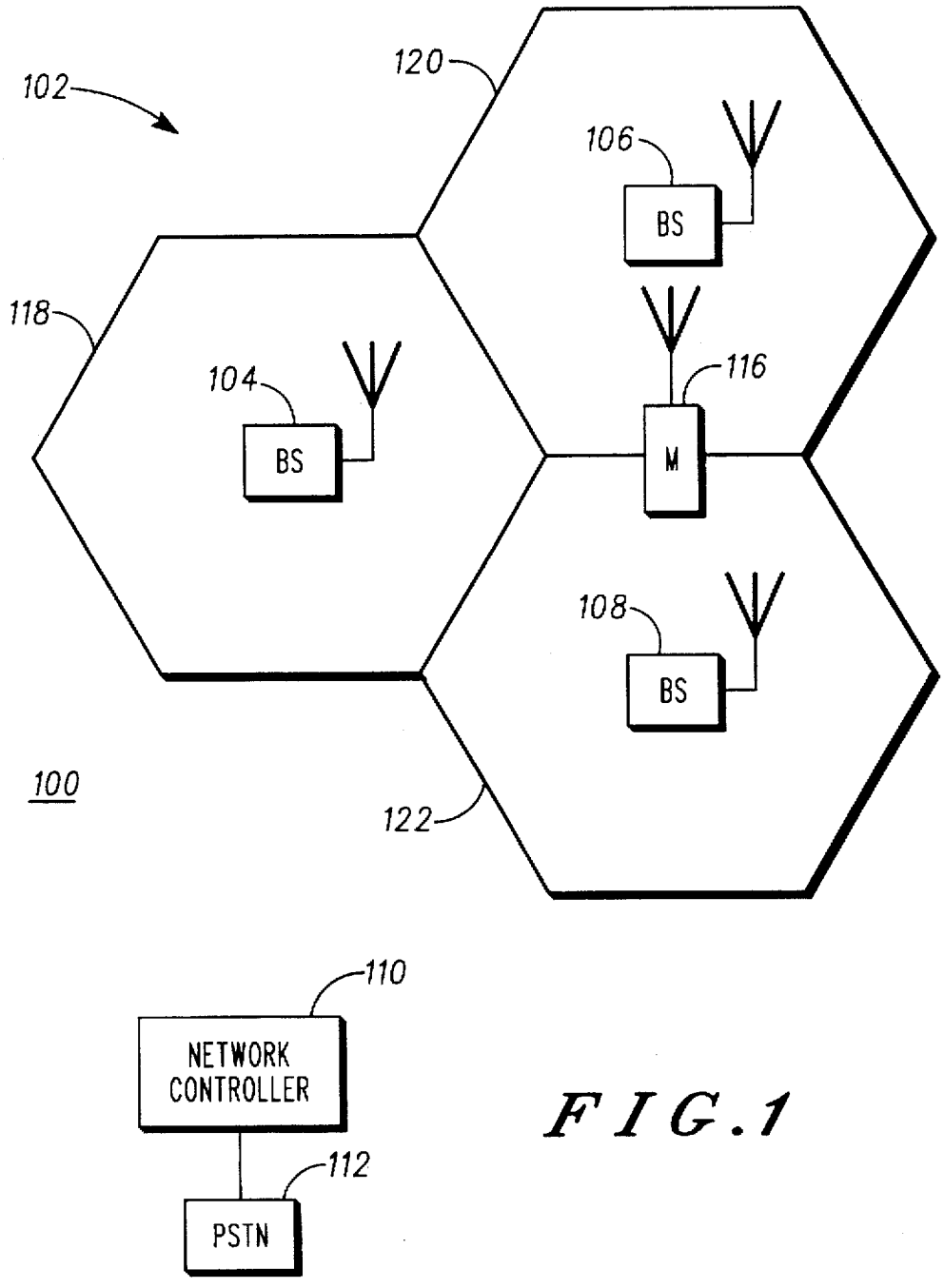

102
120
106
BS
118
104
BS
116
M
108
BS
100
122
110
NETWORK CONTROLLER
112
PSTN

FIG.1

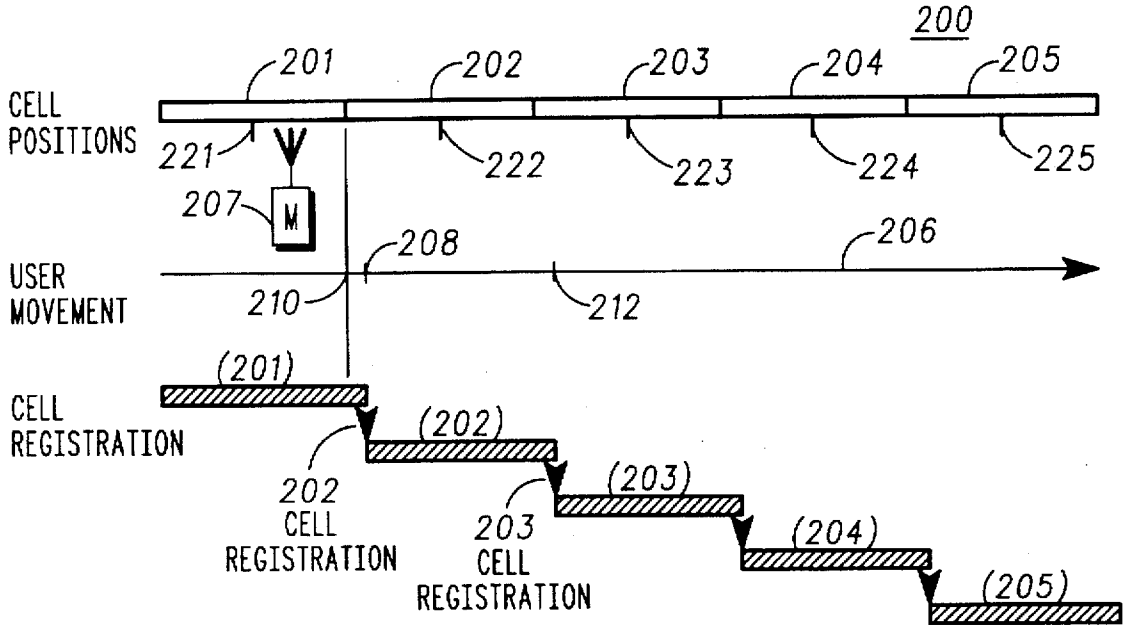



FIG. 2
— PRIOR ART —

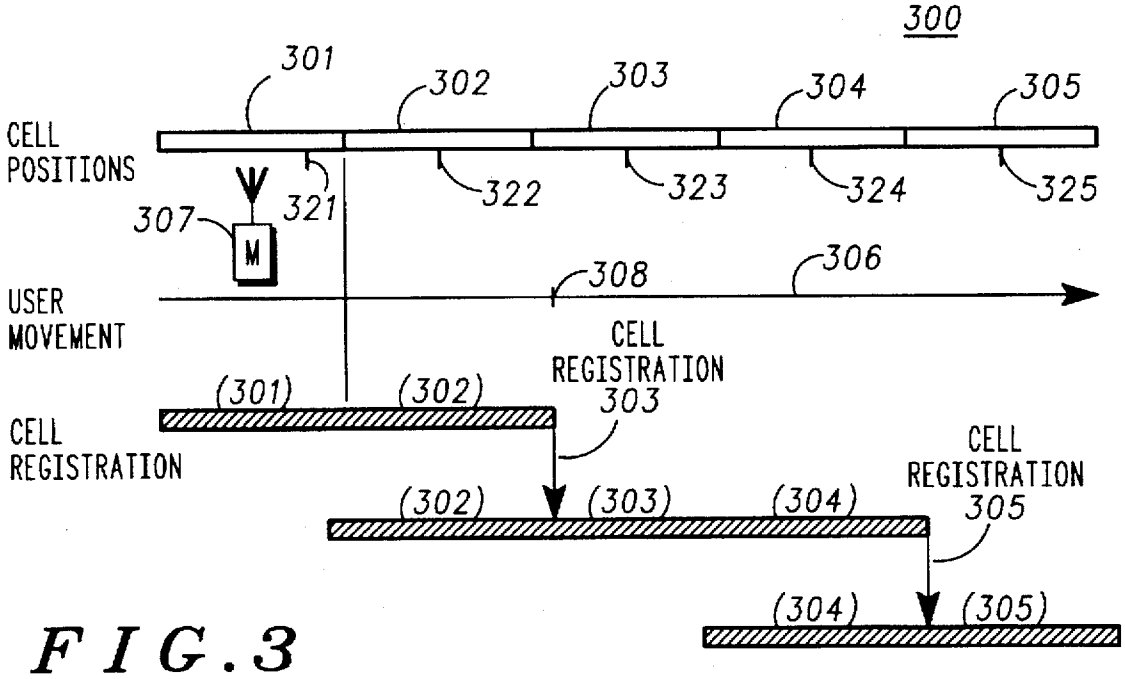



FIG. 3

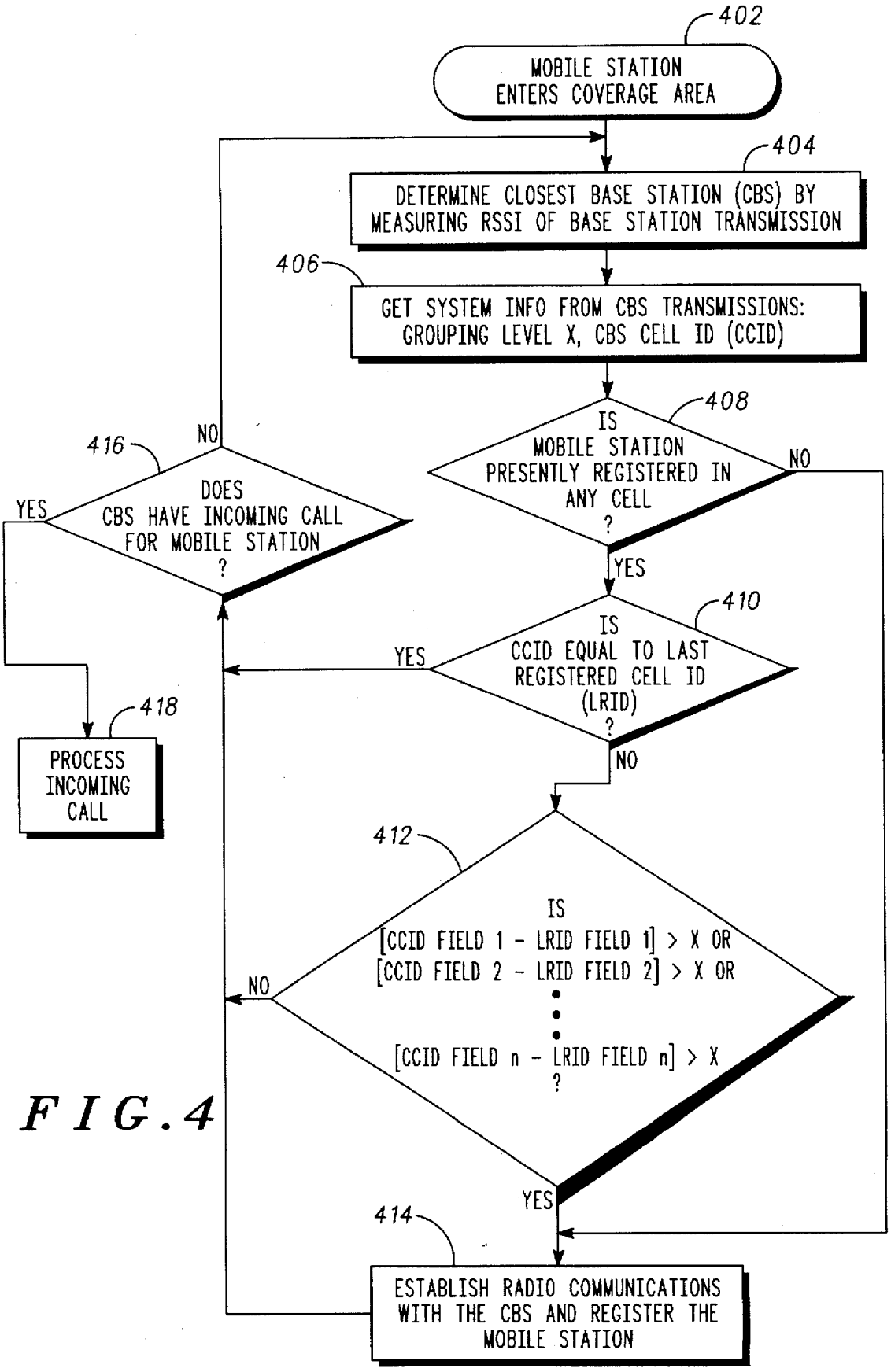

402
MOBILE STATION ENTERS COVERAGE AREA
404
DETERMINE CLOSEST BASE STATION (CBS) BY MEASURING RSSI OF BASE STATION TRANSMISSION
406
GET SYSTEM INFO FROM CBS TRANSMISSIONS: GROUPING LEVEL X, CBS CELL ID (CCID)
408
IS MOBILE STATION PRESENTLY REGISTERED IN ANY CELL ?
NO
YES
410
IS CCID EQUAL TO LAST REGISTERED CELL ID (LRID) ?
YES
NO
412
IS [CCID FIELD 1 - LRID FIELD 1] > X OR [CCID FIELD 2 - LRID FIELD 2] > X OR • • • [CCID FIELD n - LRID FIELD n] > X ?
NO
YES
414
ESTABLISH RADIO COMMUNICATIONS WITH THE CBS AND REGISTER THE MOBILE STATION
416
DOES CBS HAVE INCOMING CALL FOR MOBILE STATION ?
NO
YES
418
PROCESS INCOMING CALL

FIG. 4

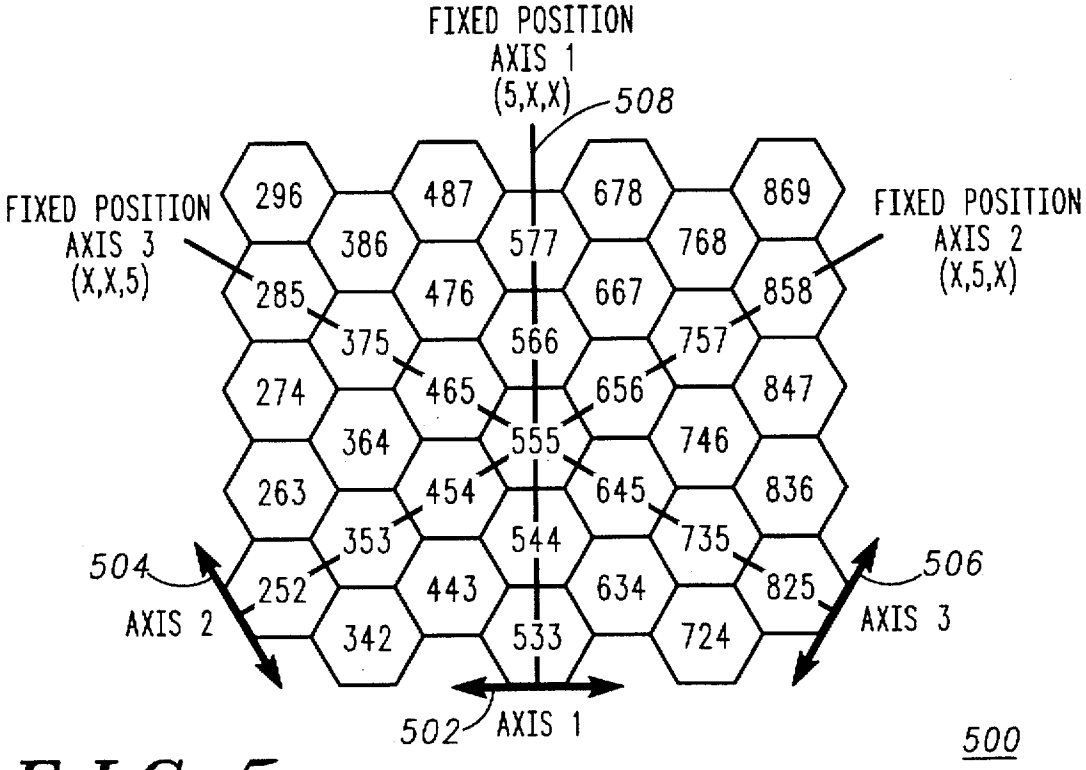
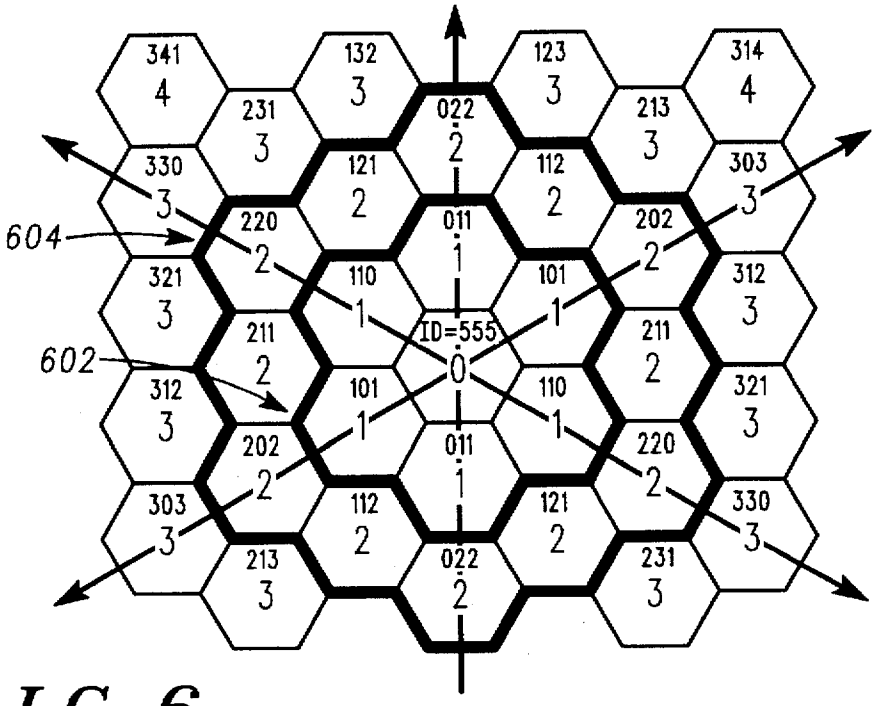

FIXED POSITION
AXIS 1
(5,X,X)
508
FIXED POSITION
AXIS 3
(X,X,5)
FIXED POSITION
AXIS 2
(X,5,X)
296
487
678
869
386
577
768
285
476
667
858
375
566
757
274
465
656
847
364
555
746
263
454
645
836
353
544
735
252
443
634
825
342
533
724
504
506
AXIS 2
AXIS 3
502
AXIS 1
500

FIG.5


341
4
132
3
123
3
314
4
231
3
022
2
213
3
330
3
121
2
112
2
303
3
604
220
2
011
1
202
2
321
3
110
1
101
1
312
3
211
2
ID=555
0
211
2
602
312
3
101
1
110
1
321
3
202
2
011
1
220
2
303
3
112
2
121
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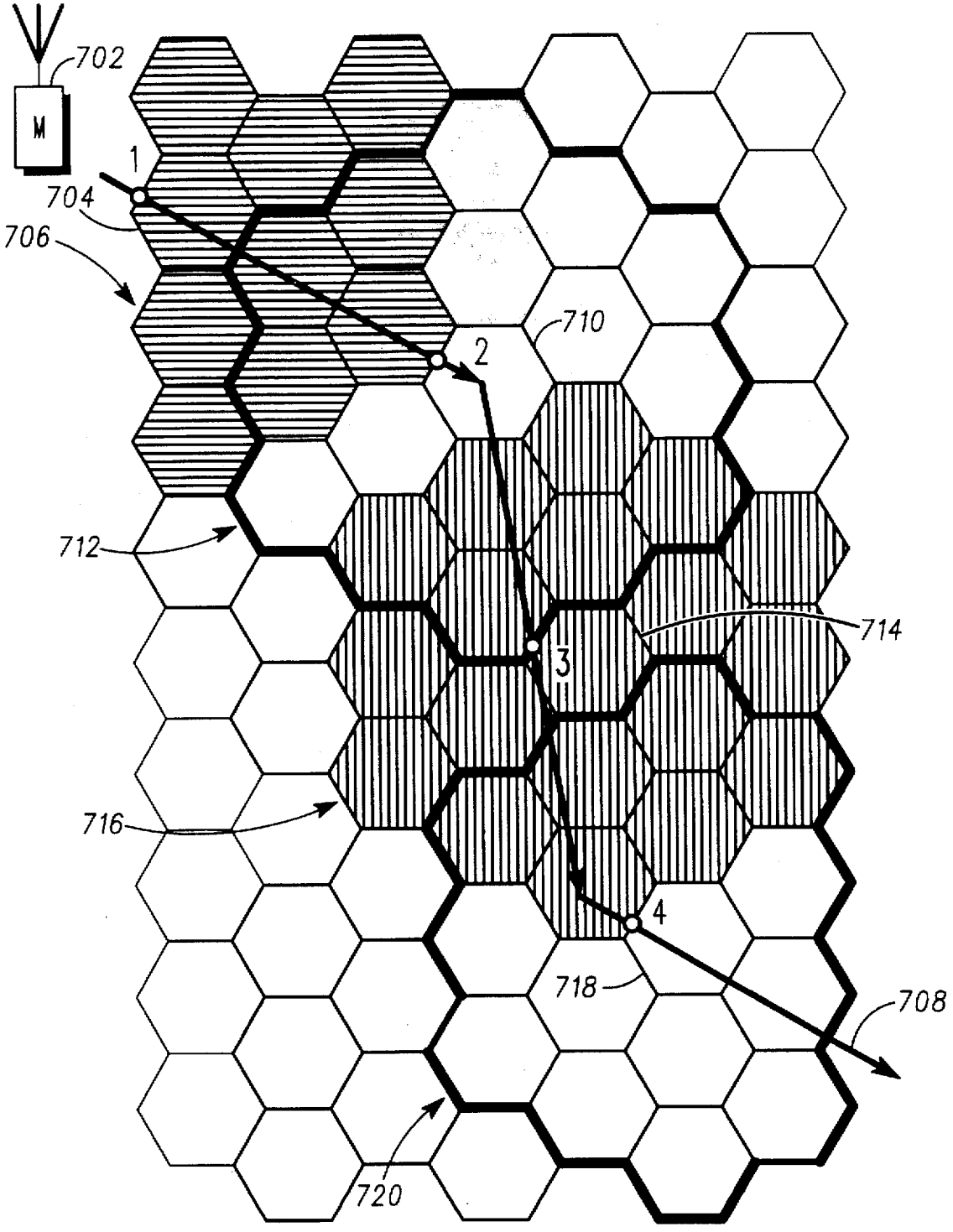
330
3
213
3
022
2
231
3

FIG.6




O = POSITION OF LOCATION REGISTRATION

FIG.7

700

# METHOD FOR MOBILE STATION LOCATION REGISTRATION WITH DYNAMIC CELL GROUPING FOR RADIOTELEPHONE SYSTEMS

## FIELD OF THE INVENTION

The present invention generally relates to radiotelephone systems. The present invention more particularly relates to location registration of a mobile station in a cordless or cellular radiotelephone system.

## BACKGROUND OF THE INVENTION

Radiotelephone systems generally include a plurality of base stations configured to communicate with one or more mobile stations. Each base station provides transmission and reception of radiotelephone signals in a respective service area. Mobile stations in a given service area communicate with the base station associated with that area. The base station provides communication between the mobile stations and the public switched telephone network. The radiotelephone system is controlled by a network controller.

Mobile stations may move among service areas. The mobile stations may be mounted in automobiles or hand-carried by the user. The mobile station monitors aspects of the communication channel between the mobile station and surrounding base stations, such as received signal strength (RSS). As mobile stations are moved from a first service area to a second service area, the mobile stations establish communication with the base station servicing the second service area and discontinue communication with the base station serving the first service area. This process is known as hand-off and is generally automatically accomplished.

In order that calls may be efficiently routed to a particular mobile station, each mobile station generally registers its location with the nearest base station. An incoming call is then routed by the network controller to that base station which then establishes radio communication with the mobile station to complete the call. If the mobile station is not registered, the radiotelephone system will send a broadcast message generally known as a page to alert the mobile station to register its location. When a mobile station moves into a new service area, it will automatically register with the base station associated with the new service area. The registration process occurs independently of hand-off.

The number of radio channels available for call traffic, paging, registration and other purposes is limited for each base station. In densely populated areas at times of heavy system usage, there may be times when no radio channels are available. One solution to provide additional channels is to provide more base stations serving smaller service areas. In extreme situations, such as in urban areas which may have many, densely located mobile stations, service areas may be as small as one city block or a single floor of a high rise building to provide a sufficient number of channels to carry communication and control channel traffic. Such service areas are referred to as microcells.

A limitation to the microcell strategy for providing additional communication and control channels is the channel traffic required for registration of the many mobile stations moving among service areas. As the number of base stations and cells in a system increases, the number of user registrations must also increase. Each mobile station carried down the street must register with the base station serving each newly-entered service area.

Another source of additional registration traffic is signal shadowing. Shadowing occurs when a signal is partially blocked by an object in the path between the mobile station and the base station. Shadowing may cause extreme, rapid variation in received signal quality, including received signal strength. For example, when a mobile station is located near a boundary between cells, the mobile station's determination of the appropriate base station for registration may change frequently in a short period of time due to signal shadowing. The mobile station attempts to register with the base station which provides the greatest received signal strength. RSS levels may change as the user turns his head, shadowing the mobile station's antenna from the received signals. In such a case, the mobile station may repeatedly register and re-register with two or more adjacent base stations, increasing registration traffic.

One solution proposed for location registration in microcell systems handling large numbers of subscribers involves a multi-layer location updating method. The coverage area of the system using this method has multiple location registration area layers. There are a fixed number of layers which are staggered and overlay each other. Mobile stations are divided into groups and each group is assigned to one or more layers. Mobile stations of each group have several location registration area layers. When a mobile station updates its registration, the mobile station switches layers or it updates to a different layer.

This proposal is very complicated and inefficient to implement, however. In a system using a hexagonal cell structure, where cells are grouped in groups of 19 cells, 19 layers are required to implement this scheme. The large number of layers requires substantial coordination and system overhead to operate smoothly. There is substantial broadcast overhead required, as each base station in each cell must transmit layer information so mobile stations can determine when to re-register. Dividing location registration areas into more layers requires more broadcast information, as the same information must be sent per layer, per cell.

Accordingly, there is a need for an improved method for registering a mobile station in a radiotelephone system which reduces registration traffic on radio channels, particularly in microcellular applications.

## BRIEF DESCRIPTION OF THE DRAWINGS

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The invention, together with further objects and advantages thereof, may best be understood by making reference to the following description, taken in conjunction with the accompanying drawings, in the several figures of which like reference numerals identify identical elements, and wherein:

FIG. 1 generally depicts an idealized geographic layout of radiotelephone system with which the present invention may be used;

FIG. 2 illustrates cell registration as a function of user position in a prior art radiotelephone system;

FIG. 3 illustrates cell registration as a function of user position in a radiotelephone system according to the present invention;

FIG. 4 is a flow diagram illustrating the method according to the present invention;

FIG. 5 depicts a cell identification system for a hexagonal cell pattern with which the present invention may be used;

FIG. 6 depicts levels of cell grouping for a hexagonal cell pattern for use with the present invention; and

FIG. 7 depicts location registration by a mobile station in the radiotelephone system of FIG. 1 according to the present invention.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 generally depicts an idealized geographic layout of a radiotelephone system **100** with which the present invention may be used. The radiotelephone system **100** generally includes a plurality **102** of base stations, including base station **104**, base station **106**, and base station **108**, and network controller **110**. The network controller **110** is coupled to the public switched telephone network **112**. The network controller **110** further is in wireline communication with each base station of the plurality **102** of base stations. The individual connections between the network controller **110** and the plurality **102** of base stations are not illustrated in FIG. **1** so as not to unduly complicate the figure.

Each of the plurality **102** of base stations is configured to be in radio communication with one or more mobile stations such as mobile station **116**. Such radio communication is conducted according to a standardized protocol, as is well known in the art. The terms "mobile station" or "mobile" as used herein, refer to mobile radiotelephones such as may be mounted in a car or other vehicle or portable radiotelephone handsets which are self-contained and may be carried by the user. Through radio communication with one or more of the base stations **104**, **106**, **108**, the mobile station **116** may complete a call with another mobile station (not shown) in the system **100** or with another subscriber coupled to the public switched telephone network **112**.

To provide effective radiotelephone communication, each base station of the plurality **102** of base stations serves a respective service area. Thus, base station **104** serves service area **118**, base station **106** serves service area **120**, and base station **108** serves service area **122**. In FIG. **1**, the service areas are illustrated as being hexagonal in shape. However, it will be recognized by those ordinarily skilled in the art that the service areas **118**, **120**, **122** may have any shape, such as triangular, square, or otherwise. Moreover, it will also be recognized by those ordinarily skilled in the art that the system **100** may include any number of base stations and any number of mobile stations such as mobile station **116** may be operated in conjunction with the system **100**.

Referring now to FIG. **2**, it illustrates cell registration as a function of user positioning in a prior art radiotelephone system **200**. For simplicity, FIG. **2** illustrates user movement along a single axis **206**. FIG. **2** thus models cell registration in the case of a user carrying a mobile station along a generally straight path through a series of service areas, such as along a street, highway or other road, while traveling on a train, or while riding an elevator in a high rise building.

The prior art radiotelephone system **200** includes cells **201**, **202**, **203**, **204**, **205**, as illustrated in FIG. **2**. The cells **201**, **202**, **203**, **204**, **205** are linearly arranged along the axis **206**. Each of the cells **201**, **202**, **203**, **204**, **205** includes a base station for establishing radio communication with one or more mobile stations located within each respective cell **201**, **202**, **203**, **204**, **205**. Cell **201** includes base station **221**. Cell **202** includes base station **222**. Cell **203** includes base station **223**. Cell **204** includes base station **224**. Cell **205** includes base station **225**.

FIG. **2** further indicates the location at which cell registration occurs as a user carrying a mobile station **207** travels along the axis **206**. This is indicated in the lower half of FIG. **2**, with the number in parentheses indicating the cell with which the mobile station **207** is registered as the mobile station **207** moves along the axis **206**. Thus, beginning at the left hand side of FIG. **2**, the mobile station registers with cell **201**. That is, the mobile station **207** registers with base station **221** which serves the service area defined by cell **201**. As the mobile station moves along the axis **206**, the mobile station **207** monitors the quality of signals received from base stations including base station **221** located in cell **201** and base station **222** located in cell **202**. When the signal quality, such as the received signal strength (RSS), of the signal received from base station **222** exceeds the quality of the signal received from base station **221**, at a point designated point **208** on the axis **206**, the handset registers with base station **222** in cell **202** and discontinues its registration with base station **221** in cell **201**.

Depending on the quality of the various received signals and on the hysteresis of the signal strength averaging algorithm used by the mobile station **207**, the point at which registration with cell **202** occurs, point **208**, may be reached after the handset crosses the point **210** defining the geographical boundary between cell **201** and cell **202**. The mobile station **207** continues moving along the axis **206** and continues monitoring received signal quality. When the mobile station reaches point **212**, the mobile station registers with base station **223** in cell **203**.

Thus, as the user carrying the mobile station **207** enters the service area of the radiotelephone system **200**, the mobile station **207** first registers with cell **201** allowing the network controller (not shown) for the system **200** to route calls for that mobile station **207** to cell **201**. When the mobile station **207** passes through to cell **202**, a second registration automatically occurs to update the network controller with the new service area entered. The mobile station **207** initiates the registration process based on signal strength and quality received from the respective cells. To avoid multiple registrations between cells due to signal fluctuations at the midpoint, point **210**, the mobile station **207** executes an averaging algorithm with hysteresis. This typically delays the registration to the adjacent cell until the mobile station **207** is well within that cell, point **208**. Even with averaging algorithms, multiple registrations at the midpoint between cells still occur due to body shadowing and other small sector shadowing effects. These multiple registrations increase network traffic, reduce available capacity, and reduce battery life of the mobile station **207**.

Referring now to FIG. **3**, it illustrates cell registration as a function of user position in a radiotelephone communication system **300** according to the present invention. The system **300** is divided into a plurality of cells or service areas **301**, **302**, **303**, **304**, **305**. As was the case in FIG. **2**, FIG. **3** shows a one-dimensional system **300** in which a user carrying a mobile station **307** moves along a single axis **306**. FIG. **3** thus models cell registration in the case of a user carrying a mobile station along a generally straight path, such as a road, rail line or in an elevator.

The system **300** includes a plurality of base stations, each base station serving a respective service area **301**, **302**, **303**, **304**, **305** of a plurality of service areas. Service area **301** includes base station **321**. Service area **302** includes base station **322**. Service area **303** includes base station **323**. Service area **304** includes base station **324**. Service area **305** includes base station **325**. The base station serving each respective service area **301**, **302**, **303**, **304**, **305** establishes radio communication with mobile stations such as mobile station **307** located within the respective service area **301**, **302**, **303**, **304**, **305**. Further, the base station transmits system information on control channels for receipt by mobile stations such as mobile station **307**. The base station and the mobile station communicate using control channels and communication channels in accordance with a predetermined communications protocol.

FIG. 3 further indicates the location at which cell registration occurs as a user carrying a mobile station travels along axis **306**. In FIG. 3, a cell grouping level of 1 is assumed. This is indicated in the lower half of FIG. 3, with the number in parentheses indicating the cell or service area with which the mobile station **307** is registered as the mobile station moves along the axis **306**. Thus, beginning at the left hand side of FIG. 3, the mobile station **307** registers with cell **301**. That is, the mobile station **307** registers with the base station **321** which serves the service area defined by cell **301**. In addition, in accordance with the present invention, the mobile station **307** is also registered with all cells within the group of cells defined by the cell grouping level of 1. Thus, the mobile station is also registered with cell **302**, as is indicated in FIG. 3.

As the mobile station **307** moves along the axis **306**, the mobile station **307** monitors the quality of signals received from base stations including base station **321** located in cell **301**, base station **322** located in cell **302** and base station **323** located in cell **303**. When the signal quality, such as the received signal strength (RSS), of the signal received from base station **323** exceeds the quality of the signal received from base station **321** and base station **322**, the mobile station **307** registers with base station **323** in cell **303** at point **308**. Depending on the quality of the various received signals and on the hysteresis of the signal strength averaging algorithm used by the mobile station **307**, the point **308** at which registration with cell **202** occurs may be reached after the mobile station **307** crosses the point defining the geographical boundary between cell **302** and cell **303**.

When the mobile station **307** registers with base station **323**, in accordance with the present invention the mobile station is also registered with all base stations within the group of cells defined by the cell grouping level of 1. That is, the mobile station is also registered with base station **324** in cell **304** and base station **322** in cell **302**. At this point, the mobile station is free to move about in any of cells **302**, **303**, or **304** without the need to re-register. Further, movement of the mobile station **307** within, for example, cell **303** near the boundary of cell **303** and cell **302** or the boundary of cell **303** and cell **304** is not accompanied by repeated registering and re-registering with the two adjacent base stations. Thus, registration traffic in the radiotelephone system **300** is reduced.

The mobile station **307** continues moving along the axis **306** and continues monitoring received signal quality. When the signal quality from base station **325** in cell **305** exceeds the signal quality from base station **324** in cell **304**, the mobile station **307** registers with base station **325** in cell **305**. In accordance with the present invention and with a cell grouping level of 1, the mobile station **307** also registers or retains its registration with base station **324** in cell **304**.

FIG. 3 depicts Level 1 cell grouping, which refers to the threshold value and the number of cells adjacent to the registration cells which are included in the registration area. In Level 1 cell grouping, the mobile station **307** registers with all cells contiguous with the registration cell. However, the level of cell grouping provided by the algorithm may be varied. For example, Level 2 or Level 3 cell grouping are also available. Preferably, this level is programmable on a cell-by-cell basis and is downloaded to the mobile station **307** during the registration process. This allows the cell grouping to be dynamically adjusted with changing traffic and capacity demands on the system **300**.

FIG. 4 is a flow diagram illustrating a method for registering a mobile station in a radiotelephone system according to the present invention. The method begins at step **402** where a mobile station such as mobile station **307** (FIG. 3) enters the coverage area of a radiotelephone system such as radiotelephone system **300** (FIG. 3). At step **404**, the mobile station receives a first signal from a first base station serving a first service area. In addition, the mobile station may also receive a second signal from a second base station or other signals as well. Preferably, the first signal and the second signal comprise control channel signals broadcast by the first and second base station. The control channel signals include system information such as a base station identifier which uniquely identifies the first base station and the second base station in the radiotelephone system. In accordance with the present invention, the system information also includes a cell grouping level, the cell grouping level defining a group of one or more service areas including the first service area. As will be described further below, the cell grouping level defines the number of ranks of service areas, or cells, surrounding the first service area with which the mobile station will be automatically registered by the radiotelephone system.

Also at step **404**, the mobile station detects a received signal characteristic of the first signal, the second signal and any other received signals. Preferably, the signal characteristic is related to the quality of the received signal, such as a received signal strength indication (RSSI). Circuits for detecting received signal strength indication are well known in the art. In response to the received signal characteristic, the mobile station selects as the first base station the base station from which the mobile station receives the signal having the best signal quality. For example, the mobile station determines which base station has the greatest received signal strength, corresponding to the closest base station.

At step **406**, the mobile station receives the first signal broadcast by the first base station. The mobile station determines system information from the first signal. The system information preferably includes a cell grouping level and a first cell identifier or base station identifier which uniquely identifies the base station.

Preferably, service areas in the radiotelephone system are arranged along one or more axes. In a multi-dimensional system, the service areas are arranged along multiple axes. In accordance with the present invention, the base station identifier (or cell identifier) uniquely locates the base stations (and associated service areas) on each axis of the one or more axes. The base station identifier preferably contains one or more fields corresponding to one axis of the one or more axes. Using the base station identifiers, the cells or service areas may be considered to be in ranks of service areas surrounding a particular service area.

Continuing with the description of the method, at step **408**, the mobile station determines if the mobile station is presently registered in any cell of the radiotelephone system. Preferably, the mobile station includes a memory for storing an indication of previous cell registration, including a last registered cell identifier which indicates the base station identifier of the last cell, if any, with which the mobile station registered. If the mobile station has just entered the coverage area of the system or has just been powered up, the mobile station has not yet registered and execution continues at step **414**. If the mobile station has previously registered, the registration information including the last registered cell identifier is read by the mobile station and execution continues at step **410**.

At step **410**, the mobile station determines if the base station identifier of the first (closest) base station matches

the last registered cell identifier. If the two identifiers match, the mobile station has previously registered with the closest base station and execution continues with step **416**. If the two identifiers do not match, the mobile station must determine if registration with the closest base station is required and the method continues at step **412**.

At step **412**, the mobile station determines whether the closest base station determined in step **404** is included in the group of one or more service areas defined by the cell grouping level surrounding the last registered service area. Preferably, the mobile station relates the base station identifier for the closest base station and the last registered cell identifier in a manner to the described below.

The mobile station compares the base station identifier for the closest base station with the last registered base station identifier. If the absolute value of the difference between any one of the respective axes fields of the base station identifier for the closest base station and the last registered base station is greater than the cell grouping level, the mobile station will register with the closest base station. This calculation represents the basic algorithm for determining if a mobile station is within or outside the present registration cell group.

The method continues at step **414** where the mobile station is registered. To register, the mobile station establishes radio communication with the closest base station according to the radio communication protocol of the radiotelephone system. The mobile station then transmits a registration request to the closest base station and the base station registers the mobile station with the base station and conveys registration information to the network controller.

Under control of the network controller, the mobile station is registered with the first base station and with all base stations within the group defined by the cell grouping level. Thus, with a cell grouping level of 1, the mobile station is registered in a rank of service areas including the service area associated with the first base station and all immediately adjacent service areas. If the cell grouping level had been 2, the mobile station would additionally be registered with all service areas immediately adjacent to the grouping level 1 group of cells. This technique using a cell grouping level of 1 creates a one cell buffer around the cell (service area) served by the current, closest base station. This eliminates multiple registrations due to signal fluctuations or shadowing between cells. This technique also reduces cell registrations in the system because, once a mobile station is registered with a service area, a mobile station is also registered with adjacent service areas.

Registering with the adjacent cells is preferably provided by the network controller (not shown) for the system to further eliminate registration traffic. The network controller determines what service areas to register a mobile station in using the same algorithm as the mobile station. The network controller for the system routes calls to the mobile station based on knowledge of the mobile station's dynamic registration algorithm.

Referring now to FIG. **5**, a cell identification system for a two-dimensional, hexagonal cell pattern for use with the present invention is depicted. FIG. **5** illustrates assignment of location parameters, also referred to as cell identifiers, to cells in a hexagonal cell pattern **500**. Each of the cells is arranged along three axes, including a first axis **502**, a second axis **504**, and a third axis **506**. Each of the cells has a unique 3-field location parameter. Each field is associated with one axis and the number within the field specifies the cell position on the axis. Adjacent cells with the same axis field number have a fixed position along the respective axis and form a line perpendicular to the axis, as shown by line **508** and axis **502**. A similar location parameter assignment using multiple axes can be made for a cell pattern using cells of different shapes, such as triangular cells or square cells. Also, this same location parameter assignment technique can be extended to a three-dimensional cell pattern by using a fourth axis extending from the page containing FIG. **5**. Such a cell pattern might exist in a microcellular radiotelephone system installed in a multi-story office building.

FIG. **6** depicts different levels of cell grouping for the hexagonal cell pattern and identifiers **500** for use with the present invention. The large single digit in each cell represents the largest axis offset from the cell having the identifier **555** and the three smaller numbers represents the individual axis offsets. According to the overall group level calculation in the algorithm described above, a mobile unit registered to cell **555** will only register to a new cell if the magnitude of one of the new cell's axis fields exceeds the specified group level. Thus in FIG. **6**, if the mobile unit moves to a cell in which the large digit exceeds the group level, registration will take place. For Level 1 cell grouping, when a mobile station registers with the base station serving the service area associated with the cell identified as **555** in the center of FIG. **6**, the mobile station is also automatically registered with all cells in group **602** by the network controller (not shown). Incoming call notification for the mobile station will then be routed to all cells in group **602**. This is accomplished in the network by simply routing call notification to all cells with axis offsets from the last mobile station cell registration which do not exceed the group level. For Level 2 cell grouping, when the mobile station registers with the cell identified as **555**, the mobile station is also automatically registered with all cells within group **604**.

In FIG. **6**, it can be seen that each service area is surrounded by ranks of service areas and that the cell grouping level indicates a number of the ranks of service areas surrounding a given service area. For example, group **602** corresponds to a rank of service areas identifiable in that, as illustrated in FIG. **6**, the service areas all are indicated by a large number 1. A second rank of service areas includes the service areas indicated in FIG. **6** by a large number 2.

FIG. **7** depicts Level 2 location registration by a mobile station **702** in a radiotelephone system **700** according to the present invention. In the two-dimensional system **700** illustrated in FIG. **7**, the mobile station **702** is free to move along either of three cell axes contained in the plane of the page. FIG. **7** illustrates Level 2 grouping.

As the mobile station **702** enters the service area of the system **700**, the mobile station **702** registers with cell **704** at point **1** illustrated in FIG. **7**. That is, the mobile station **702** registers with the base station (not shown) which serves cell **704**. In addition, the mobile station **702** is automatically registered with all the cells contained in group **706** for Level 2 registration. These cells are illustrated with a horizontal cross-hatch in FIG. **7** for the purpose of clarify. Thus, the mobile station **702** has a two cell buffer around the cell where it is currently registered.

As the mobile station **702** moves along the path **708**, the mobile station **702** comes to cell **710** where the mobile station **702** is not yet registered, as indicated by the outcome of the level 2 algorithm calculation. The mobile station thus registers with cell **710** at point **2** in FIG. **6**. In addition to registering with cell **710**, the mobile station **702** is also automatically registered with all cells in group **712**, again

creating a two cell boundary around the registration cell **710**. The mobile station **702** may move anywhere within this two cell buffer region defined by group **712** without having to re-register.

As the mobile station **702** moves along the path **708** to point **3** in FIG. **6**, the mobile station comes to cell **714**, with which the mobile station **702** is not registered. Therefore, at point **3**, the mobile station **702** registers with cell **714**, and with all cells located in group **716**. The cells in group **716** are identified by vertical cross-hatching. Moving farther along the path **708**, when the mobile station **702** reaches cell **718**, with which the mobile station has not registered, the mobile station registers with cell **718** and automatically with all cells contained in the group **720**.

As is illustrated in FIG. **7**, once registration has occurred, the new cell grouping ensures that another registration will not be initiated due to large or small signal shadowing. This reduces the impact of the automatic location registration signal strength averaging algorithm used by the mobile station **702**. Also, dynamic cell grouping in accordance with the present invention randomizes location registrations throughout the service area. That is, registration is a function of the user's previous movement. This reduces location registration peaks which may occur if the cell groups were fixed. Because the boundaries of the cell groups according to the present invention vary dynamically, location registrations are dispersed throughout the service area rather being concentrated along the fixed cell boundaries.

From the foregoing, it can be seen that the present invention provides a system and method for registering a mobile station in a radiotelephone communication system. To reduce location registration traffic in a system, when a mobile station registers with a registration cell, the mobile station further registers with all cells located within a registration group. The group includes at least all cells contiguous with the registration cell and may additionally include other layers of surrounding cells. The level of registration is dynamically variable to accommodate radio channel traffic in the radiotelephone communication system.

While a particular embodiment of the present invention has been shown and described, modifications may be made and it is therefore intended in the appended claims to cover all such changes and modifications which fall within the true spirit and scope of the invention.

What is claimed is:

**1**. A method for registering a mobile station in a radiotelephone communication system, the radiotelephone communication system including a plurality of base stations and a network controller coupled to each base station of the plurality of base stations, each base station of the plurality of base stations serving a respective service area, the mobile station having previously registered in a last registered service area, the last registered service area being uniquely identified in the radiotelephone communication system by a last registered base station, the method comprising the steps of:

transmitting system information from a first base station to the mobile station, the first base station serving a first service area, the first service area being surrounded by one or more ranks of service areas, the system information including a cell grouping level and a first base station identifier, the cell grouping level defining a group of one or more service areas including the first service area and indicating a number of the one or more ranks of service areas surrounding the first service area, the first base station identifier uniquely identifying the first service area;

determining at the mobile station whether the group includes the last registered service area, including

relating the first base station identifier and the last registered base station identifier, and

in response thereto, determining whether the last registered service area is within one rank of the one or more ranks of service areas; and

when the group does not include the last registered service area, registering the mobile station.

**2**. A method for registering a mobile station in a radiotelephone communication system as recited in claim **1** wherein each service area is arranged along one or more axes and wherein each base station identifier uniquely locates each respective service area on each axis of the one or more axes, each base station identifier including one or more fields, each field corresponding to one axis of the one or more axes, and wherein the first base station identifier comprises a base station identifier for the first service area and the last registered base station identifier comprises a base station identifier for the last registered service area, and wherein the relating step includes the step of subtracting each respective field of the last registered base station identifier from each respective field of the first base station identifier.

**3**. A method for registering a mobile station in a radiotelephone communication system as recited in claim **1** wherein the method further comprises the steps of:

at the mobile station, receiving control signals from two or more base stations;

at the mobile station, determining signal quality of the control signals;

at the mobile station, selecting as the first base station a base station from which the mobile station receives a signal having best signal quality; and

if the first service area does not correspond to the last registered service area, proceeding with the determining step.

**4**. A method for registering a mobile station in a radiotelephone communication system as recited in claim **1** wherein the registering step comprises the steps of:

at the mobile station, establishing radio communication with the first base station;

transmitting a registration request;

at the first base station, conveying the registration request to the network controller; and

at the network controller, registering the mobile station with the first base station and with all base stations serving service areas in the group of one or more service areas.

**5**. A method for registering a mobile station in a radiotelephone communication system as recited in claim **4** wherein the method comprises the further step of, at the network controller, routing subsequently received telephone calls to the first base station and to all base stations serving service areas in the group of one or more service areas.

**6**. A method of registering a mobile station in a radiotelephone system, the radiotelephone system including a plurality of base stations coupled with a network controller and configured for radio communication with the mobile station, the method comprising the steps of:

registering the mobile station with a first base station;

at the mobile station:

storing a first base station identifier;

receiving a first signal from the first base station and a second signal from a second base station;

detecting a received signal characteristic of the first signal and the second signal;

when the received signal characteristic of the first signal is not acceptable and the received signal characteristic of the second signal is acceptable, receiving a control signal from the second base station, the control signal including a second base station identifier and a cell grouping level;

determining, from the cell grouping level, the first base station identifier and the second base station identifier, if the mobile station is registered with the second base station;

if the mobile station is not registered with the second base station, registering with the second base station; and

at the network controller:

in response to registration of the mobile station with the second base station, registering the mobile station with a group of base stations, the group of base stations defined by the cell grouping level and the second base station identifier.

**7**. A method of registering a mobile station in a radiotelephone system as recited in claim **6** wherein the cell grouping level and the first base station identifier define a last registered group of base stations with which the mobile station last registered, and wherein the step of determining comprises the step of determining if the last registered group includes the second base station.

**8**. A method of registering a mobile station in a radiotelephone system as recited in claim **6** wherein the plurality of base stations is arranged on one or more axes and wherein the first base station identifier and the second base station identifier locate the first base station and the second base station, respectively, on each axis of one or more axes, and wherein the determining step comprises the step of comparing a difference between a location of the first base station and a location of the second base station on each axis with the cell grouping level and concluding that the mobile station is not registered with the second base station when the difference exceeds the cell grouping level.

**9**. A method of registering a mobile station in a radiotelephone system as recited in claim **8** wherein the first base station identifier and the second base station identifier each includes one or more fields, each field of the one or more fields corresponding to one axis of the one or more axes and uniquely locating the first base station and the second base station, respectively, on each axis of the one or more axes, and wherein the comparing step comprises the step of subtracting each respective field of the first base station identifier from each respective field of the second base station identifier to produce one or more respective results, and comparing each respective result to the cell grouping level, and wherein the concluding step includes the step of concluding that the mobile station is not registered with the second base station if any result of the one or more respective results exceeds the cell grouping level.

**10**. A method of registering a mobile station in a radiotelephone system as recited in claim **6** wherein the detecting step includes the steps of measuring a first received signal strength of the first signal and measuring a second received signal strength of the second signal, and wherein the method further includes the step of determining a closest base station in response to the first received signal strength and the second received signal strength.

**11**. A method of registering a mobile station in a radiotelephone system as recited in claim **6** wherein the step of registering the mobile station with the second base station comprises the steps of establishing radio communication with the second base station and transmitting a registration request from the mobile station to the second base station.

**12**. A method of registering a mobile station in a radiotelephone system as recited in claim **11** wherein the plurality of base stations is arranged on one or more axes and wherein the first base station identifier and the second base station identifier each includes one or more fields, each field of the one or more fields corresponding to one axis of the one or more axes and uniquely locating the first base station and the second base station, respectively, on each axis of the one or more axes, and wherein the method further comprises the steps of:

at the mobile station:

subtracting each respective field of the first base station identifier from each respective field of the second base station identifier to produce one or more respective results;

comparing each respective result to the cell grouping level;

concluding that the mobile station is not registered with the second base station if any result of the one or more respective results exceeds the cell grouping level;

at the second base station:

receiving the registration request; and

registering the mobile station with the second base station.

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