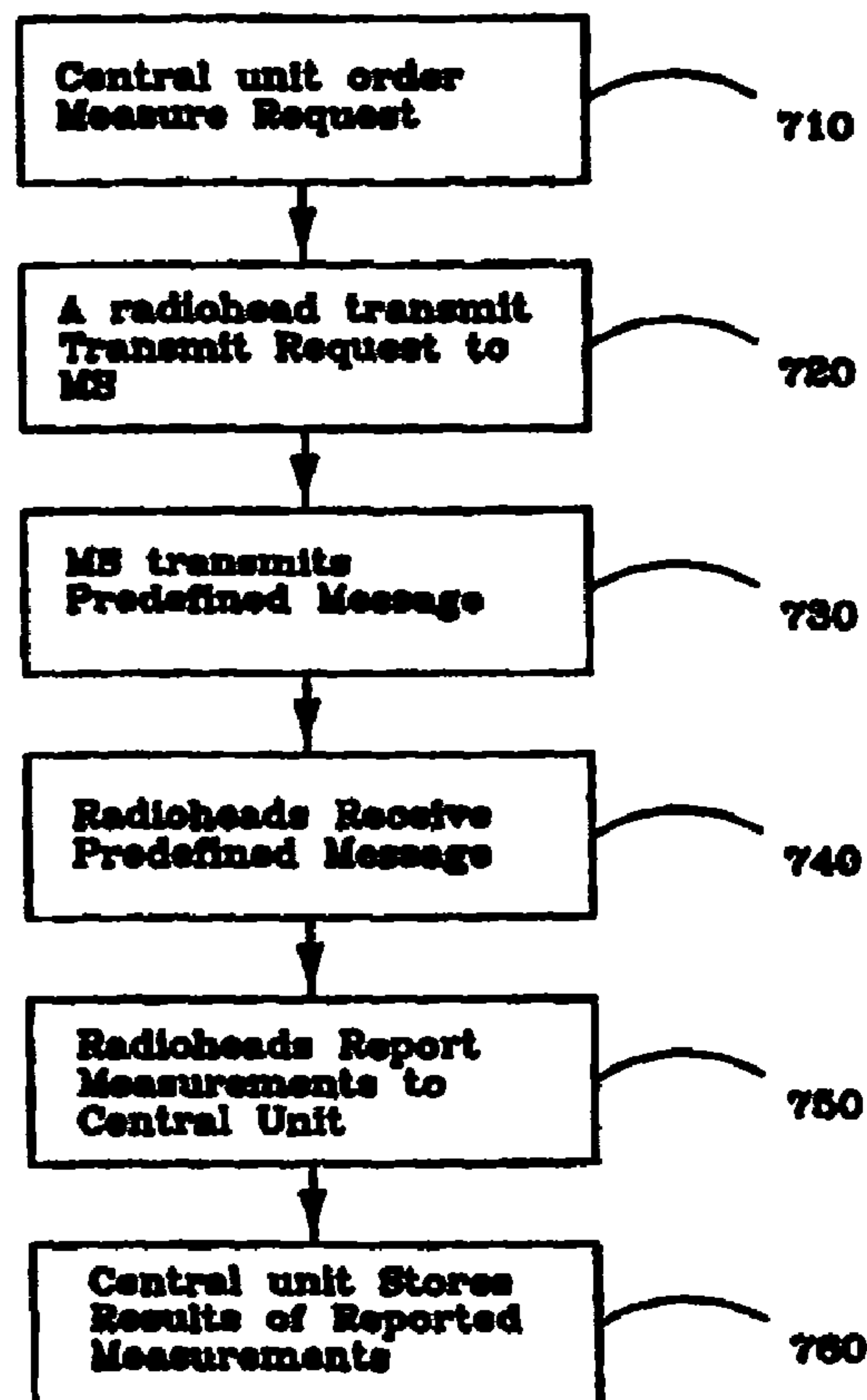




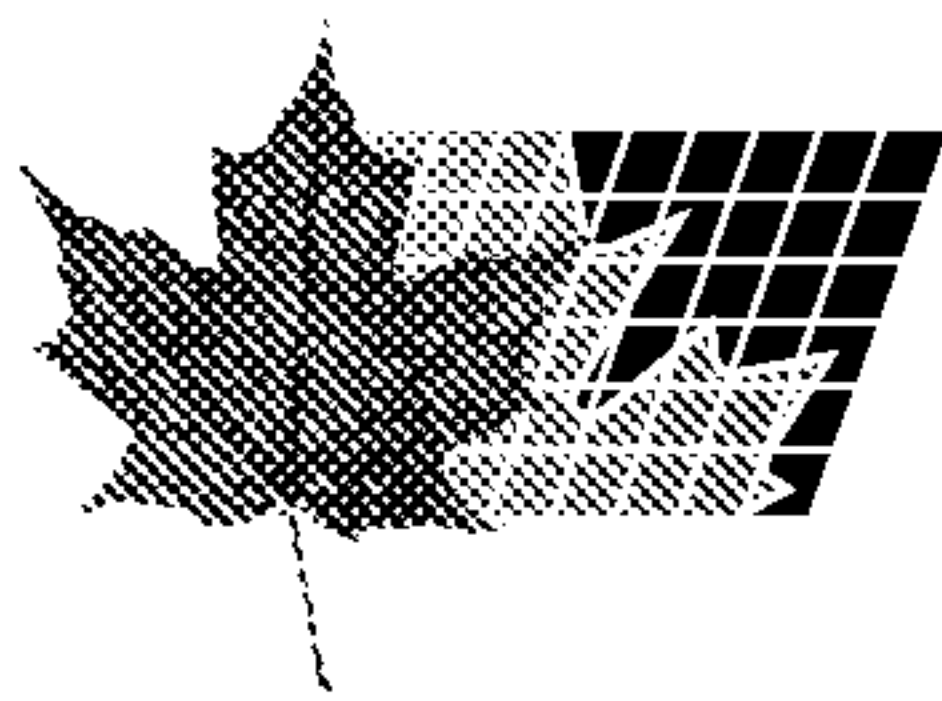
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(54) **PROCEDE ET DISPOSITIF POUR CREER DES RELATIONS
CELLULAIRES DANS UN SYSTEME DE COMMUNICATIONS
MOBILES**
(54) **A METHOD AND ARRANGEMENT FOR GENERATION OF
CELL RELATIONS IN A MOBILE COMMUNICATIONS
SYSTEM**



(57) La présente invention concerne un système et un procédé de communications mobiles permettant de

(57) A mobile communication system and method for determining cell relations between cells is





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déterminer les relations entre les cellules. Cette invention utilise des messages prédéfinis fortement codés émis par des MS (ou BS), et reçus au niveau d'une pluralité de points d'accès radio. Les mesures de ces messages sont communiqués à une unité centrale pour traitement et/ou mémorisation. La transmission et la réception des messages prédéfinis est classée par l'unité centrale. Cette dernière peut également éliminer l'interférence sur une certaine fréquence pour permettre la réception fiable par les récepteurs distants.

disclosed. The invention makes use of strongly coded predefined messages sent from MSs (or BSs) and received in a plurality of radio ports. Measurements of the received messages are reported to a central unit for processing and/or storage. The transmission and reception of the predefined messages is ordered from the central unit. The central unit can also clear interference on a certain frequency to allow for reliable reception in remote receivers.



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(54) Title: A METHOD AND ARRANGEMENT FOR GENERATION OF CELL RELATIONS IN A MOBILE COMMUNICATIONS SYSTEM

(57) Abstract

A mobile communication system and method for determining cell relations between cells is disclosed. The invention makes use of strongly coded predefined messages sent from MSs (or BSs) and received in a plurality of radio ports. Measurements of the received messages are reported to a central unit for processing and/or storage. The transmission and reception of the predefined messages is ordered from the central unit. The central unit can also clear interference on a certain frequency to allow for reliable reception in remote receivers.

```

graph TD
    710[Central unit order Measure Request] --> 720[A radiohead transmit Transmit Request to MS]
    720 --> 730[MS transmits Predefined Message]
    730 --> 740[Radioheads Receive Predefined Message]
    740 --> 750[Radioheads Report Measurements to Central Unit]
    750 --> 760[Central unit Stores Results of Reported Measurements]
      
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A METHOD AND ARRANGEMENT FOR GENERATION OF CELL RELATIONS IN A MOBILE COMMUNICATIONS SYSTEM

Field of the Invention

5 The present invention generally relates to radiocommunication systems, and more particularly to a method and system for measuring cell relations in a cellular communication system.

Background of the Invention

10 Generally for a cellular radiocommunications system, the radio resources are divided throughout a systems coverage area. The principles of a cellular system is to have a coverage area divided in sub-areas, i.e., cells, where each cell have a set of radio resources available, to serve subscribers. There are many well known techniques for a division of available radio resources between cells. In a TDMA system (Time Division Multiple Access), the users are allowed to transmit information in timeslots on radio frequency carriers such that single users on the same frequency are assigned different timeslots. In such systems, for example, the division of channels between cells can be such that adjacent cells utilize different frequencies. There are two types of interference, that can be limited by intelligently dividing radio resources between coverage areas, i.e., cells; co-channel interference, and adjacent channel interference. Co-channel interference appears if two separate signals are sent on the same frequency simultaneously. The signals will interfere with each other and a receiver receiving both signals may not be able to separate one signal from the other or detect any of them. Adjacent channel interference appears if channels that are adjacent to each other in the frequency spectrum are used in the same geographical area. Transmissions on a certain frequency tend to leak to adjacent frequencies and cause interference. By intelligently allocating frequencies to different coverage areas these problems can be limited. There will however still be some (co-channel) interference between different cells, mainly because the

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frequencies must be reused. Improved frequency planning can however be performed if the cell relations are known, and such inevitable interference may be further limited.

5 Additionally, if it is known how much interference certain channels are susceptible to and where (in what cell) that interference is generated, improved channel allocation algorithms can be implemented. Thus both slow and fast information of how a new connection would affect already existing connections could further improve such allocation algorithms. Known methods to estimate cell relations have focused on measuring overall interference in a certain cell. Measurements are
10 usually done on ordinary traffic in the system and thus, measurements of cell relations cannot be controlled in an efficient manner. Rather, the measurements are limited to estimates of interference and signal strengths of ongoing traffic and signaling, usually in itself susceptible to interference. This will not allow for radio heads to receive signals from cells far away, since the carrier to interference (C/I)
15 ratio will not be sufficiently high for reliable detection. Furthermore, earlier methods based on statistical measurements for estimating path gain in cellular systems generates a lot of signaling from the mobile station, which further introduces unnecessary traffic in the system.

In the US patent US 5,157,709 an adaptive radio communication system is
20 shown. The system comprises a control station in which an interference matrix is upheld. The matrix represents path gain values for signals received on radio channels. The information is used for adaptive channel allocation. In the US patent US 5,603,092, another method to estimate interference is shown. In both the two US patents measurements are made during ongoing traffic. Simultaneous measuring of
25 signals from several transmitters, normally results in that only the strongest signal can be identified. It is interesting to find the cell relations between all pairs of cells that could interfere with each other if they were on the same channel. From some of

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these cells, the signals are very weak, and it is difficult to decode the origin of the signals.

Thus, it would be advantageous with a method for reliably estimating cell relations even from distant (non-neighboring) cells, without disturbing or being
5 disturbed by ongoing traffic and without generating a large amount of signaling between the Mobile Stations and the system.

Summary of the Invention

When measuring cell relations between cells being located far away from each other problem often arises due to insufficient carrier to interference ratio (C/I).

10 This and other problems is solved in accordance with the invention by ordering a transmitter to transmit a specific, predefined message intended mainly for measurement purposes and to order one or several receivers to measure the received signal strength thereof.

More in detail, the problem is solved by ordering a transmitter to transmit the
15 message on a certain frequency at a certain time and by ordering at least one receiver to measure the signal strength of the message and to report said measured signal strength to a central unit. In the central unit a statistical cell relation value is generated representing the path gain from transmitter to receiver.

The specific, predefined message may be strongly coded to allow for detection
20 thereof in poor radio environments and in remote receivers. Furthermore, in one embodiment of the invention, a central unit may transmit a silence request, i.e., to order other transmitters not to transmit on a certain frequency during a certain period. This will further decrease the interference on the frequency and allow for detection of the specific, predefined message in even further remote receivers.

25 In an alternate embodiment, prior to channel allocation, a mobile station may transmit a specific, predefined message on the frequency intended for allocation, and transceiver stations, e.g., radio heads, may then estimate the additional interference a

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certain channel allocation of a new connection would add to already existing connections in the system. This information may be quickly achieved and possibly combined with the acquired statistical information to be utilized for example in Adaptive Channel Allocation-(ACA-) algorithms, Admission Control or Handover Algorithms.

In another embodiment of the present invention a specific frequency is used to send a predefined message from a single radio head and signal strength measurements in mobile stations in cells not served by the transmitting radio head are made. For a given limited geographical area, the specific frequency is only used for the predefined message. These measurements are combined with mobile measurements of signal strength on the serving frequency in the own cell and an alternate cell relation measure, i.e., C/I may be calculated. The single radio head is the sole transmitter on the specific frequency during a limited time, and then another radio head becomes sole transmitter on the specific frequency, while mobiles are making measurements. Repetitive measurements provide cell relations in terms of C/I for all pairs of cells.

One object of the present invention is to derive reliable cell relations also between cells being located far from each other.

Another object of the present invention is to obtain short-term information about the current interference situation.

Yet another object of the invention is to obtain frequent measurements and gather measured information for statistical use.

One advantage of the present invention is that cell relations can be obtained not only between cells being located close to each other.

Another advantage is that a current situation may be analyzed before e.g., a mobile start to transmit.

Yet another advantage is that statistical measurement may be obtained for cell relations in a large area.

Brief Description of the Drawings

The present invention can be more fully understood upon reading the Detailed Description in conjunction with the accompanying drawings, in which like reference indicia are used to designate like elements, and in which;

5 FIG 1 represents signaling between a central unit, radio heads and mobile stations according to one embodiment of the present invention.

FIG 2 depicts a representation of an indoor system in which the present invention could be implemented

10 FIG 3 depicts a representation of a (macro-)cellular system in which the present invention could be implemented

FIG 4 represents a path gain matrix wherein measurements performed according to the present invention can be stored.

FIG 5 is a flow chart diagram describing an exemplary embodiment of the present invention

15 FIG 6 is a flow chart diagram describing another exemplary embodiment of the present invention

FIG 7 illustrates an exemplary embodiment of the present invention where measurements are performed in the mobiles

Detailed Description

20 The present invention will be described with respect to a centralized and synchronized cellular mobile communication system employing a Time Division Multiple Access Scheme (TDMA). It should be understood, however, that the invention could be considered for other types of synchronized as well as non-synchronized systems of the same or other access types. Both packet switched
25 systems as well as circuit switched systems could make use of the invention.

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According to one aspect of the present invention, a transmitting station, e.g., a mobile station, transmits a predefined message on a traffic channel that could be received by a plurality of radio heads. The predefined message will be further explained below in the text. A radio head is herein defined as a base station or other type of transceiver station with direct or indirect connection to a Mobile Switching Centre or thereto corresponding device. A radio head is typically a base station serving a particular cell in a cellular communication system. In a distributed indoor system, a radio head is the transceiver station serving part of a cell, i.e., subcell, where a plurality of subcells forms a cell. The radio head can measure a plurality of parameters for the specific predefined message, like for example received signal strength, delay spread, mobile identity (if included in the predefined message) and signal to interference ratio (carrier to interference ratio, C/I). In one embodiment the radio heads receiving the predefined messages measure signal strength and report the measurements to a central unit. In the central unit the signal strength measurements are used for calculating path gain between a cell in which the message was transmitted and a cell in which the message was received. This is possible if the predefined messages are transmitted at a certain transmitting power. Either the central unit (or radio head) can order the MS to transmit the predefined message at a certain transmitting power or the MS could include information about the used power level in the predefined message. The measurements could of course alternately be used for calculating other types of cell relations and path gain is to be considered exemplary. The path gain would then simply be the relation between the transmitted power and the received power. The processing of path gain could alternatively be performed in each radio head, in which case the results thereof are reported to the central unit. This is an ongoing procedure. Statistical representations of acquired measurements may be formulated, e.g., in terms of distribution functions.

These measurements can be stored in a path gain matrix, and later on used in several applications when relations between cells are requested. This could for

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example be in adaptive channel allocation algorithms, for cell planning purposes, in handover algorithms or for Admission Control.

One embodiment of the present invention is shown in figure 1. A mobile telecommunication system is shown in the figure. Numerous units included in a complete telecommunication system have been excluded from figure 1 in an attempt to make the figure more clear. Figure 1 illustrates solely those units in a public land mobile network that are necessary to obtain an understanding of the invention. A central unit CU is connected to a number of radio heads, or base stations. A connection from the central unit to a radio head BS1 is indicated with a broken line. The radio heads BS1 is arranged to establish radio connections to mobile stations located within the radio coverage area of the station. A radio connection is shown in the figure as a zig-zag symbol between the radio head BS1 and the mobile subscriber MS.

The method in accordance with the invention comprises the following step:

- The central unit CU instructs measurement devices in each base station, i.e., each radio head, to be prepared to measure on a certain frequency and time slot. An instruction message I1 representing this order is illustrated in the figure with an arrow symbol between the central unit CU and one of the radio heads. Instruction messages are sent from the central unit to all radio heads, even though only one arrow symbol is shown in figure 1. The instruction I1 is of course preferably limited to the radio heads for which measurements may be of interest, e.g., within a limited geographical area or even a single radio head

- The central unit CU transmits an order 12 addressed to the mobile station MS to send a specific predefined message on the specific channel (frequency) at the specific time (slot) as previously indicated to the radio heads.

- An order message 13 to the mobile station MS to transmit a predefined message is transmitted via the radio head BS1 and forwarded to the specific mobile station MS. The central unit can transmit, to the plurality of radio heads, an order

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not to schedule any traffic on the certain channel at the certain time. This is indicated in figure 1 with an arrow I4 between the control unit CU and the radio head BS1. The reason for this is that it is desired that the predefined message transmitted by the MS is heard by as many radio heads as possible, to obtain cell relations not only to the closest radio heads but also to radio heads further away. Low C/I (carrier to interference ratio) and C/N (carrier to noise ratio) conditions on these links may complicate this. Therefore, the central unit is also able to limit the interference on the relevant frequency and time slot and listen to the predefined message on that channel. This "Silence Request" could be implemented as an optional feature or not at all. It may also be extended to include adjacent channel or frequencies to limit the adjacent channel interference during measurements. For example, in a packet switched GPRS-like system, the uplink transmissions are controlled by an uplink state flag, (USF) which must have a certain value for a mobile to be allowed to transmit. The Silence Request can thus, easily be implemented in such systems, by not setting the uplink state flag, except for the mobile station ordered to transmit the predefined message.

- The MS transmits the predefined message at the defined frequency and time slot. This is shown in the figure with an arrow I5 between the mobile station and the radio head BS 1.

- A plurality of radio heads receive the predefined message I5. The radio heads perform the measurements, (e.g., signal strength measurements) requested by the central unit CU, and forwards the result to the CU. For establishing cell relations, the above procedure is repeated until sufficient knowledge of the relations is obtained. One may want to perform such measurements intermittently, filtering the results, to update cell relations as the cellular system develops. The predefined message could include the identity of the transmitting mobile station, the identity of the radio head connected to, the transmit power at which the mobile transmitted the message or any other suitable information. However, in the case when the central

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unit orders only one specific mobile to send a predefined message, then the system already knows the mobile identity, and the inclusion of such in the predefined message is redundant.

5 Since the predefined message should be heard even in bad radio environments, it should be protected by a low rate code, e.g., Rate = $\frac{1}{2}$ or lower. If decoding still is unsuccessfully performed, an additional, identical predefined message may be transmitted and the two decoded messages may be softly combined. This procedure is however likely to occur only if a plurality of radio heads or a specific radio head cannot decode the first transmission of the predefined message, since the order of
10 such second transmission must come from the central unit. It should also be noted that in an alternative embodiment of the present invention, where all the necessary information already is available in both the mobile station as well as on the network side, the predefined message does not have to carry any information at all and coding is thus not important.

15 It is possible to also use idle MSs for the transmission of the predefined messages, however, active MSs could be used as well. In this case, limitations might be necessary as to what information to be included in the predefined message. If the above mentioned "Silence Request" is not transmitted from the central unit (CU), the described method for cell relation measurements is preferably performed during low
20 traffic conditions when the number of undisturbed channels (frequencies) is high.

Referring now to Figure 2, illustrating an exemplary distributed indoor system wherein the present invention could be implemented. This type of system typically transmits signals with low power and the cells are typically very small. The system herein referred to as indoor system, can of course be a system serving outdoor
25 environment also. The radio heads RADs (Radio Antenna Devices) provide radio coverage to the cells 1-3. The coverage area of a RAD is called a subcell, and a number of subcells define a cell 1-3. Each RAD is controlled by a Central control unit CU, responsible for a number of cells. In the figure is illustrated that radio

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heads covering three cells are connected to the same central unit, however it could be any number of cells, as could the number of RADs serving each cell. In this type of system the cells are typically assigned a set of frequencies, and the RADs in each cell can transmit on all of these, although not at the same time. The invention is readily
5 applicable to this system, wherein the Central unit can order each RAD to measure on a mobile transmitting a predefined message in a cell and subcell relations can be achieved in the same manner as for between cells. It will be appreciated that relations between cells still are important and that such measurements also are performed, even in these types of systems.

10 In Figure 3, a macrocellular system is illustrated, wherein the present invention could be implemented. In a manner similar to that described above, a central unit, e.g., an MSC (Mobile Service Switching Centre) or a BSC (Base Station Controller) in the case of a GSM-like system, can instruct any terminal in an area served by any of its connected radio heads, to transmit a predefined message. The
15 MSC could similarly order a plurality of radio heads to listen to that message and report measurements back to the MSC. The MSC may itself store the results of the measurements, or it may forward it to any other node for processing and storage.

Referring now to Figure 4, wherein an exemplary path gain matrix is depicted. This is a manner in which to store the measurements performed in radio
20 heads on the predefined messages. The vertical axis corresponds to different radio heads and the horizontal axis corresponds to area of origin for the transmitted predefined message. The relation for example, between a cell, here denoted 2, and a radio head, here denoted 1, could be stored as matrix element g₁₂. The measurements performed in radio head 1, serving cell 1, on signals transmitted from
25 cell 2 are thus suitably stored in matrix element g₁₂. The matrix elements could represent, e.g., a distribution function of path gain versus number of observations. Other representations are of course also possible.

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In figure 5 is shown a flow chart of one embodiment of the present invention. A Measure Request order from a central unit is transmitted to a plurality of radio heads to start a measurement procedure, 710. This order include at least that one radio head instructs a mobile station (MS) or any other type of terminal, to transmit a predefined message, and that at least one radio head listens to a certain frequency to receive the predefined message. One radio head, according to the Measure Request order, then transmits a Transmit Request to a mobile station MS, 720. The mobile station receives in the Transmit Request the type of message to transmit, tunes to the right frequency and transmits the predefined message, 730. At least one radio head, according to the Measure Request, performs measurements on the predefined message and report those measurements back to the central unit. In the central unit, these measurements are received and processed in manners suitable for further usage thereof.

In figure 6 is shown an alternate embodiment of the present invention, the difference being that the Measure Request is sent along with a Silence Request. This Silence Request instructs a plurality of radio heads to order mobile stations they are serving not to transmit on a certain frequency at a certain time. Aborting transmission on a certain frequency may be realized by reallocating users to other frequencies, or, by simply wait until the transmission has been terminated and not allocate more calls on the specific frequency.

This silence request is of course later on ignored by the mobile station ordered to transmit the predefined message. By this, the interference is cleared on a certain frequency at a certain time, and radio heads may easier be able to receive a predefined message sent at that time and on that frequency. Thus cell relations between remotely located cells may be achieved and reliability of such measured relations is greatly improved over state of the art methods.

In yet another embodiment it is possible to instruct a mobile terminal to measure on a predefined message transmitted by the radio ports and report that

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measurement to the central unit. In such a case, the order to transmit a predefined message would be sent to at least one radio port, and an order to listen to a certain frequency at a certain time may be sent, via radio ports to the mobile stations. The measurements performed in the mobiles are then forwarded, via the radio heads to the central unit. In this embodiment, the processing on the measurements are preferably done in the central unit for at least battery saving reasons.

Referring now to figure 7 to further describe the embodiment of making the measurements in the mobile stations instead of in the radio heads. Therein is depicted a number of cells C1..Cn, served by radio heads BS1..BSN and a number of mobile stations M1..Mm. As described above the central unit can transmit a silence request for a certain frequency and allow only one radio head within a certain area, e.g., BS1 to transmit on a certain frequency, f1 with a certain output power. Again, aborting traffic on a frequency in this way may be realized by reallocating users to other frequencies, or, by simply wait until the transmission has been terminated and not allocate more calls on the specific frequency. Then, the central unit orders mobiles M1..Mm to measure received signal strength on the frequency f1. This order may for example be realized by including f1 in a MAHO-list (Mobile Assisted handover). The MAHO list is a list of frequencies a mobile makes regular measurements on to be able to perform handover to a frequency with sufficient quality once their signal quality on the present frequency becomes to low. This list could also be used to force a mobile to measure on a certain frequency for cell relation purposes. These features of the invention are further described below.

The mobiles M1..Mm located in different cells, then report the signal strength measured on f1 to the central unit where the path gain between the cell C1 served by BS1 and the cells where M1..Mm are camping can be calculated. After sufficient measurements have been gathered for cell C1 when BS1 is transmitting on f1, then BS1 may be ordered to be silent on f1 and e.g., instead BS3 is ordered to transmit on

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f1 and cell relations between cell C3 and cells serving M1..Mm may be obtained in a similar manner.

A particular base station should only transmit long enough for mobile stations to get good measurements. Repeated measurements within a very short time interval are of limited use since the traffic situation will have changed very little. Thus it is advantageous to utilize f1 for some other cell relation measurements after a while, e.g., from BS3. By repeating this strategy, allowing different BSs to transmit on f1 while other BSs are silent on f1 it is possible to obtain cell relations for large areas in an efficient way. Several frequencies like f1 may of course also be used. This may be a tradeoff against the amount of resources that may be blocked for traffic in different situations.

As mentioned earlier, it may be important to not only to measure the signal strength and calculate the path gain between different cells. Another quality measure that is interesting e.g., for frequency planning purposes is C/I, carrier to interference ratio. The present invention may easily be modified to calculate C/I values instead of merely path gain values. For example in the above described embodiment, the mobiles M1..Mm collect and report measurements of signal strength both from the frequency f1, but also from their own traffic in the serving cell, e.g., M4 measures signal strength on f4. The signal strength on f1 will correspond to the I from a particular cell and the signal strength on f4 will correspond to C at a certain location and time, and C/I is immediately given. Note that this is the C/I that would have been experienced if M4 in C4 had received on frequency f1 interfered by transmissions from BS1 in cell C1.

As described in more detail below, it is even possible to make estimates of the *uplink* C/I by using results from the same downlink measurements as described above. In addition to the above, a radio head merely need to collect signal strength measurements from mobiles in the cell its serving. The path gain from BS1 to a mobile e.g., M4 in C4 is known. As the output power of the mobile station is

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known, it is possible to estimate the uplink interference at cell C1 caused by the mobile station M4 in cell C4. Repeated measurements may provide the desired uplink interference distribution from mobile stations in C4 to the uplink in C1. Meanwhile, measurements of the uplink in C1 from mobiles camping in C1 may be gathered. It is a fair approximation for the uplink that the interference and the own signal strength are independent and we can arrive to estimates of the uplink C/I distribution for cell C1 by convoluting the C and the I distributions. This approximation is not possible for the downlink measurements since then C and I are correlated.

10 It should be noted that there are a variety of embodiments to which the present invention can be advantageously implemented. For example, the invention can be used for obtaining short-term information about the current interference situation. When an idle MS wants to start transmitting, it may be desired to know how this would influence the rest of the network. Then, the invention provides the means to send a "trial" burst from the MS to determine how much interference the MS would generate if it started to transmit. This could also be useful during handover.

Another advantage of the invention is that if the measurements can be performed frequently, it is possible to obtain a "snapshot path gain matrix", describing the instantaneous path gain values between all MSs and BSs (radio heads). This matrix would be very useful for algorithms such as fast ACA (Adaptive Channel Allocation). The path gain matrix estimate could be updated with regular intervals, by letting all MSs send an uplink message while the rest of the user traffic is waiting. This "fast" method is especially suitable for packet switched communication, wherein delays in traffic usually is allowed. It is also possible to have a special channel in the system reserved for this purpose.

As it may be appreciated, the above described embodiment uses the received signal measurements for determining attenuation cell relations in terms of amplification values. Sometimes, however, it is desirable to express the cell relations in terms of

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carrier to interference (C/I) ratios. It is, of course, possible to use the amplification values to calculate other cell relation measures. According to one aspect of the present invention, the downlink cell relations are expressed in terms of C/I ratios using the amplification values derived by uplink signal strength measurements, without actual
5 downlink signal strength measurements. Because of relatively narrow frequency spread of the uplink and downlink spectrum, it is assumed that the uplink amplification values also correspond to the downlink amplification values. That is, the amplification values, which are derived in the uplink direction, also represent the downlink amplification values in the downlink direction. Under this assumption, the down link cell relations
10 are estimated in terms of C/I ratios based on the uplink amplification values and known power outputs of the base stations. Then, signal strength C can be measured by the base station for the traffic. The signal strength C can then be combined with the interference from transmissions in surrounding cells to achieve a carrier to interference ratio (C/I). This C/I ratio may be stored in a matrix in lieu of, or in addition to, the
15 amplification values. Thus, for all pairs of cells, we have distributions describing the C/I situation in the downlink and/or uplink in one of the cells given that the other is using the same frequency, and vice versa.

Downlink I may be estimated by multiplying a corresponding uplink amplification value by the known base station power output. Downlink C may be
20 estimated by multiplying a corresponding uplink amplification value by the known base station power output at a cell. Alternatively, downlink C may be a reported measure of signal strength at the mobile stations. The necessity of measuring C and I simultaneously to obtain a correct downlink distribution, due to the correlation between C and I in the downlink, should also be noted. For the uplink, however, C and I
25 distributions can, for example, be collected separately and subsequently convoluted. This is because the distributions of uplink carrier strength and interference are uncorrelated. Transforming the collected information on co-channel C/I into

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information on adjacent channel C/I can be accomplished easily by decreasing the interference by an appropriate factor.

Often, expansion of a cellular phone network results in the creation of new cells on a gradual basis through installation of new base stations. Consequently, it is desirable to estimate cell relations for the new cells, with respect to existing cells, before the new cells become active. The method described above can, of course, be modified to handle this situation. The crucial point is to determine which mobile stations would be in the "virtual" cell (i.e., non-active, new cell) if it were active. Once these mobile stations have been identified, base stations in the actual cells can measure the signal strength of the random access bursts associated with these mobile stations. The signal strength measurements can then be used to compute attenuation or C/I distributions which, in turn, can be attributed to the virtual cell.

To determine which of the mobile stations will belong to the virtual cell once it becomes active, we can use the Mobile Assisted HandOver (MAHO) measurements performed by the mobile stations. An antenna at the place of a virtual base station transmits on a frequency included in the MAHO-lists of all mobile stations in the area, and subsequently the MAHO-measurements are reported to a central unit. Although no mobile stations will actually connect to the virtual base station, the central unit can determine which mobile stations would connect if the virtual cell were active, simply by considering standard cell selection criteria. One should note, of course, that mobile stations that are currently located in areas not covered by existing cells will not be used in the measuring process.

It is of course possible to perform measurements from mobile stations in other cells with a device (e.g., the virtual base station) located in the place of a would be base station. If we are interested in C/I relationships, C can be estimated by the MAHO measurements or by signal strength measurements and possibly decoding by the virtual base station. By transmitting signals from the virtual cell, interference may be generated by the virtual base station to be measured in other cells.

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Conversely, the virtual base station may measure interference generated in other cells. However, the interference from another cell must be distinguished from carrier signal that would be generated if a mobile station was connected to the virtual base station. The distinction between the carrier signal strength (C) and interference (I) may be made based on the timing of reported MAHO measurements as described above.

Similarly, the mobile station that would belong to the virtual cell can be used to generate or measure interference. Based on the knowledge of which mobile station would belong to the virtual cell, we can measure interference at the base stations of other cells. Carrier signal strength from a mobile station that would belong to the virtual cell can also be measured by a receiver included in the virtual base station. Under the assumption that uplink and downlink amplification values are the same, carrier signal strength at the mobile station that would belong to the virtual cell can be derived based on uplink amplification values and transmit power output of the virtual base station. The so derived carrier signal strength and measured interferences at the mobile station can be time correlated in the CU. Moreover, carrier signal strength from the virtual base station at the mobile station that would belong to the virtual cell can be measured using the MAHO measurements by including a list of frequencies that are used by the virtual base station for communication within the virtual cell.

Accordingly, it is to be understood that the description provides exemplary embodiments of the invention and that it can undergo many modifications without departing from the spirit and scope of the invention, as defined by the following claims.

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What is Claimed is:

1. A method for determining cell relations between a plurality of cells in a cellular communication system, each cell being served by at least one radio head, the method comprising the steps of:
 - 5 -from a transmitter, transmitting a predefined message on a certain frequency at a certain time;
 - receiving in at least one receiver, the predefined message on said certain frequency;
 - measure in the at least one receiver, received signal strength of said predefined message;
 - 10 -in the at least one receiver, identify the transmitter transmitting the predefined message;
 - report said measured received signal strength to a central unit;
 - in the central unit, generate a cell relation value, representative of the path gain from said transmitter to said at least one receiver for said predefined message.
 - 15
2. The method of claim 1 wherein the transmitted signal output power for the predefined message from the transmitter is predetermined by the central unit.
3. The method of claim 1, wherein the transmitted signal output power for the predefined message from the transmitter is reported to the central unit.
- 20 4. The method of claim 1, wherein the transmitter is a mobile station.
5. The method of claim 1, wherein the at least one receiver is a radio head.

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6. The method of claim 5, wherein the radio head is a radio head not serving a cell in which the transmitter is located.

7. The method of claim 1 wherein the transmission of the predefined message is initiated by an order from the central unit.

5 8. The method of claim 1, further comprising, prior to the step of transmitting a predefined message,

-from the central unit in the system, transmit a silence request, wherein said silence request is an order to other transmitting units, not to transmit on said certain frequency at said certain time.

10 9. The method of claim 1 wherein said predefined message is a coded message.

10. The method of claim 7, wherein the code rate is equal to or lower than $1/2$.

11. A method for determining instantaneous interference information
15 between a plurality of cells in a cellular communication system each cell being served by at least one radio head, the method comprising the steps of:

-from a mobile station, transmitting a predefined message on a certain frequency at a certain time;

-receiving in a plurality of radio heads, the predefined message on said certain
20 frequency,

-measure in the radio head, received signal strength of said predefined message;

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-in the radio heads, identify the transmitter transmitting the predefined message;

5 -in each radio head serving cells wherein said certain frequency is utilized for communication, estimate a value of interference introduced by said predefined message in ongoing connections on said certain frequency.

12. A method for determining cell relations between a plurality of cells in a cellular communication system, each cell being served by at least one radio head, the method comprising the steps of:

10 -transmitting a measurement order from a central unit to at least one radio head;

 -transmitting a transmit order to at least one mobile station;

 -from the at least one mobile station, transmit a predefined message on a traffic channel, wherein the message transmitted is determined by said transmit order;

15 -receive in the at least one radio head said predefined message and perform measurements according to said measurement order;

 -report said measurements to the central unit.

13. The method of claim 12 further comprising the step of

 -clear the traffic channel from interference during the measurement period.

14. The method of claim 12 wherein the measurement order includes at

20 least one of, measurement period, traffic channel, predefined message.

15. The method of claim 12 wherein the transmit order is sent to the at least one mobile station by at least one radio head.

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16. The method of claim 12 where the transmit order includes at least one of, transmit period, traffic channel, predefined message.

17. The method of claim 12 wherein the step of measuring on said predefined message includes determining at least one of signal strength, identity of
5 signal, delay spread, signal to interference ratio.

18. A method for determining cell relations between a plurality of cells in a cellular communication system, each cell being served by at least one radio head, the method comprising the steps of:

-from a transmitter, transmitting a predefined message on a certain frequency
10 at a certain time;

-receiving in a at least one receiver, the predefined message on said certain frequency;

-measure in the at least one receiver, received signal strength of said predefined message;

15 -in the at least one receiver, identify a radio head serving the transmitting station at the time when the predefined message was transmitted;

-report said measured received signal strength to the central unit;

-in the central unit, generate a path gain value, representative of the path gain from said transmitter to said receiver for said predefined message.

20 19. A cellular communication system comprising:

-a plurality of cells, wherein for each cell, radio coverage is provided by at least one radio head;

-a central unit, connected to a plurality of radio heads;

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-means for transmitting from said central unit, an order to a plurality of radio heads connected thereto, wherein said order includes at least an order to the radio heads to measure on a certain frequency at a certain time;

5 -means for transmitting from said central unit to a mobile station, an order to transmit a predefined message on a certain frequency at a predetermined time;

-means for measuring in a plurality of radio heads, received signal strength at least of said predetermined message;

-means for storing in said central unit, at least indications of measurements performed in the plurality of radio heads.

10 20. A method for determining cell relations between a plurality of cells in a cellular communication system, each cell being served by at least one radio head, the method comprising the steps of:

15 -from the at least one radio head serving a certain first cell, transmit a predefined message on a certain frequency at a certain time, wherein the transmission is ordered by a central unit and where said central unit orders radio heads serving other cells within a specified area to abort all transmission on said specific frequency;

-receiving in at least one mobile station the predefined message on said certain frequency, wherein the at least one mobile station is located in a cell within said specified area, different from said certain first cell;

20 -measure in the at least one mobile station, received signal strength of said predefined message on said specific frequency;

-report said measured received signal strength to a central unit;

25 -in the central unit, generate a cell relation measure, between the certain first cell and the cell wherein said at least one mobile station is located, wherein said cell relation measure is at least partially based on said reported signal strength measurement.

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21. The method of claim 20, wherein said aborting of transmission on said specific frequency is realized at least by reallocating users from said specific frequency to other frequencies.

22. The method of claim 20 further comprising the step of
5 -measure in the at least one mobile station received signal strength of signals transmitted from a radio head serving the cell wherein the at least one mobile station is located, and report these measurements to the central unit.

23. The method of claim 20, wherein transmission of said predefined
10 message on a certain frequency is terminated from the at least one radio head serving said certain first cell and where transmission of a second predefined message on said certain frequency is initiated from at least one radio head serving a certain second cell, that is different from said first certain cell and where the steps of measuring, reporting and generating cell relation measures are repeated for transmissions originating from said certain second cell.

24. The method of claim 22, wherein the cell relation measure generated
15 in the central unit is at least partially based on said reported measurements of signal strength of signals transmitted from a radio head serving the cell wherein the at least one mobile station is located.

25. The method of claim 20, wherein an indication to said mobile stations
20 to listen to said specific frequency is indicated in a Mobile Assisted Handover list of frequencies.

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26. The method of claim 22, wherein the signals transmitted from a radio head serving the cell wherein the at least one mobile station is located, are transmitted on a frequency different from said specific frequency.

27. The method of claim 24, wherein the cell relation measure is channel
5 to interference ratio, C/I.

28. The method of claim 23, wherein said cell relation measures are gathered for all possible pairs of cells within a specified area and arranged in a cell relation matrix.

29. The method of claim 20, wherein said predefined message carries no
10 information.

30. A cellular communication system comprising:
-a plurality of cells, wherein for each cell, radio coverage is provided by at least one radio head;
-a central unit, connected to a plurality of radio heads;
15 -means for transmitting from said central unit, an order to a plurality of radio heads connected thereto, wherein said order includes at least an order to the radio heads to transmit a predefined message on a certain frequency at a certain time;
-means for transmitting from said central unit to a mobile station, an order to measure and report to the central unit, signal strength on a certain frequency at a
20 certain time
-means for storing in said central unit, at least indications of measurements performed in the plurality of mobile stations.

31. A mobile station connected to a cellular system comprising;

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-means for receiving from a central unit, an indication to measure signal strength on a specific frequency at a certain time

-means for receiving from a central unit, an indication to measure signal strength at a certain time, on a frequency different from said specific frequency

5 -means for measuring signal strength on a specific frequency at a certain time

-means for measuring signal strength on signals transmitted from a radio head serving the cell said mobile station is located in, and where said signals are transmitted on a frequency different said specific frequency

10 -means for calculating a cell relation measure and report said cell relation measure to said central unit.

32. In a communication system divided into a plurality of cells, a method for determining cell relations comprising the steps of:

transmitting to mobile stations within the plurality of cells a list of at least one radio frequency channel assigned to a virtual cell;

15 measuring signal strength over the at least one radio frequency channel;

processing signal strength measurements over the at least one radio frequency channel to determine cell relations of the virtual cell with each one of the plurality of cells.

33. The method of claim 32 , wherein the signal strength is measured at the
20 virtual cell.

34. The method of claim 32, wherein the signal strength is measured at the mobile station.

35. The method of claim 32, wherein the mobile station transmits signals over the at least one radio frequency channel.

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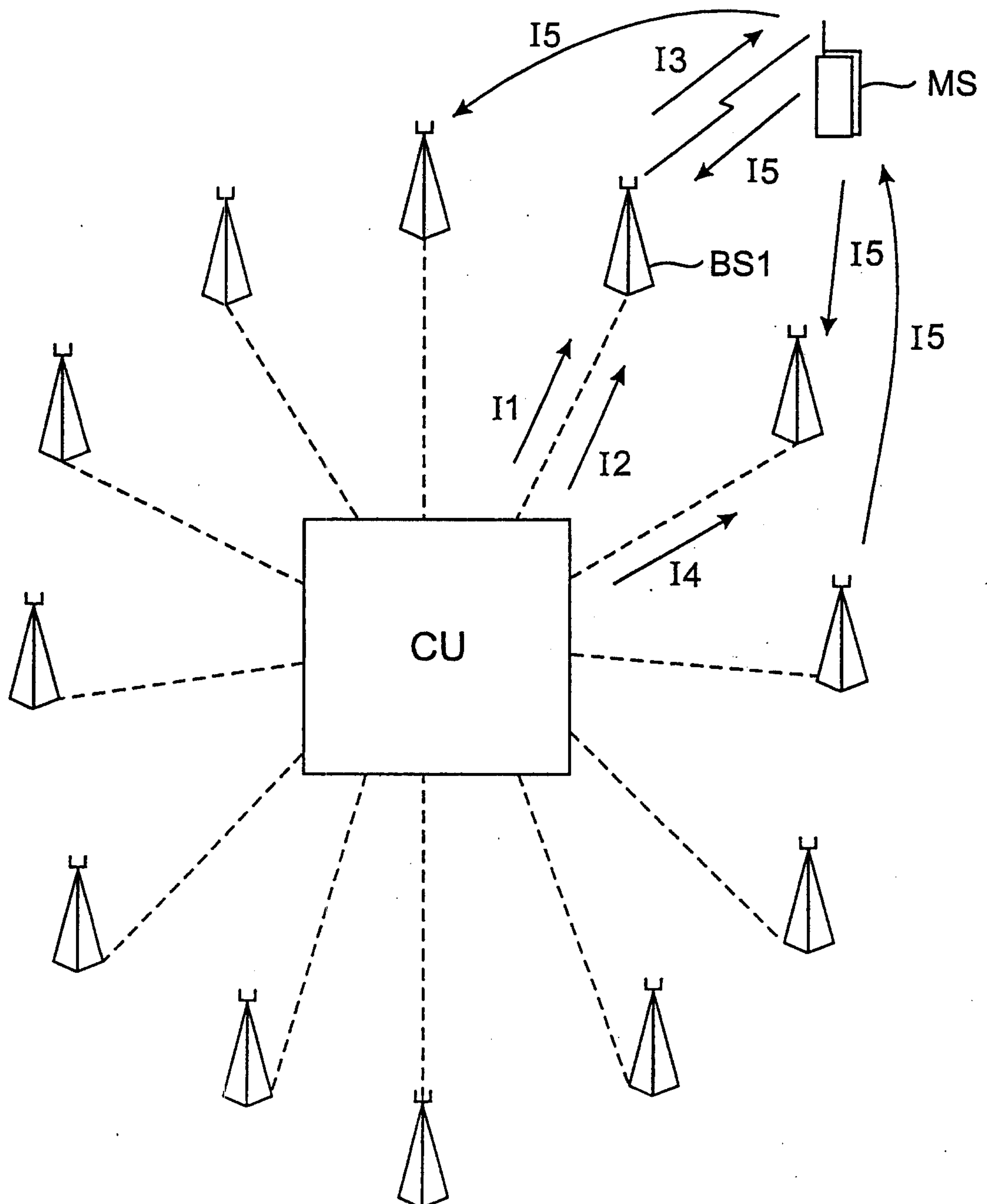
PCT/US98/20617

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36. The method of claim 32, wherein the mobile station receives signals over the at least one radio frequency channel.

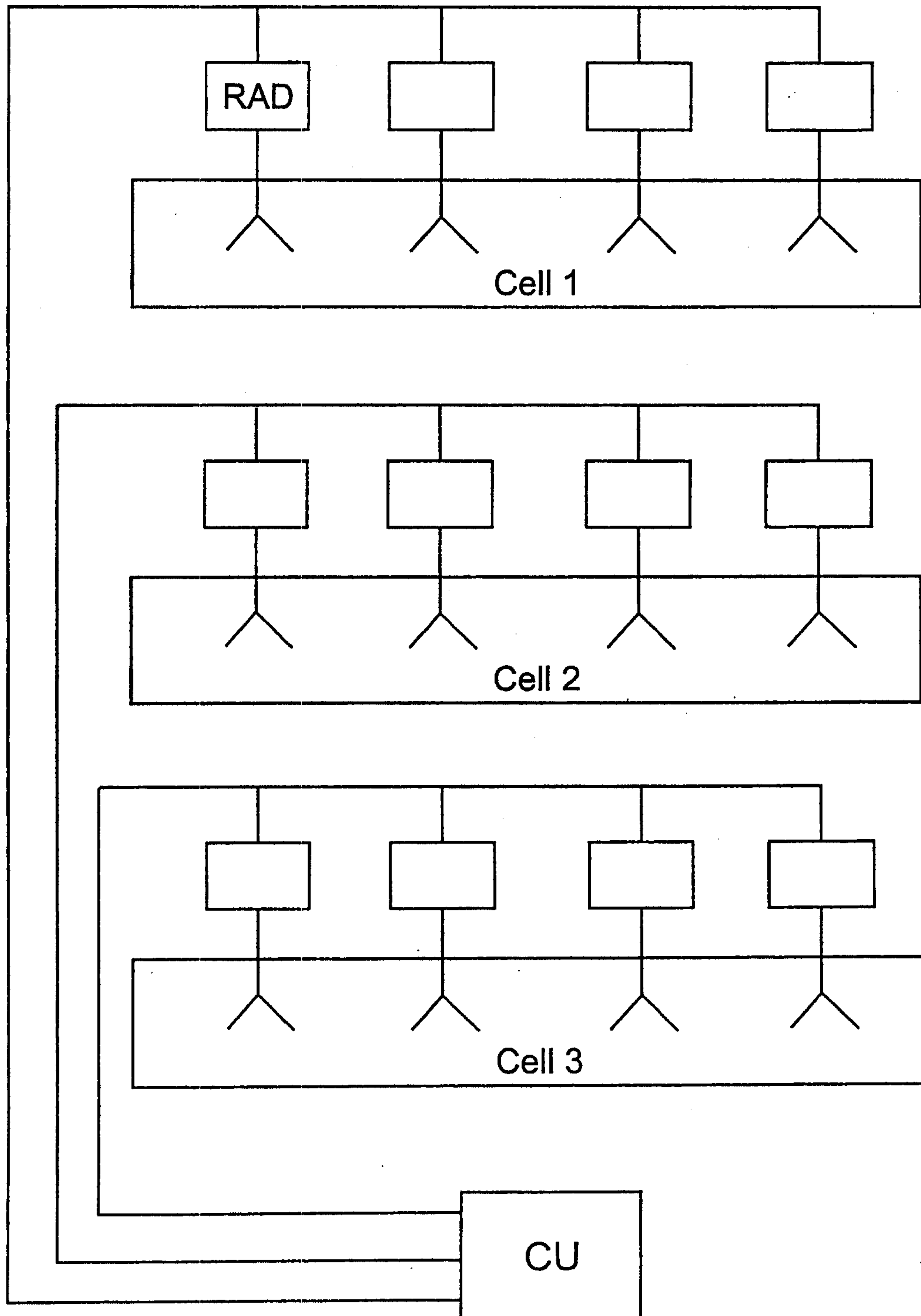
37. The method of claim 32, wherein the mobile stations perform mobile assisted hand offs (MAHO), and wherein the list is transmitted to the mobile stations
5 using a MAHO-list.

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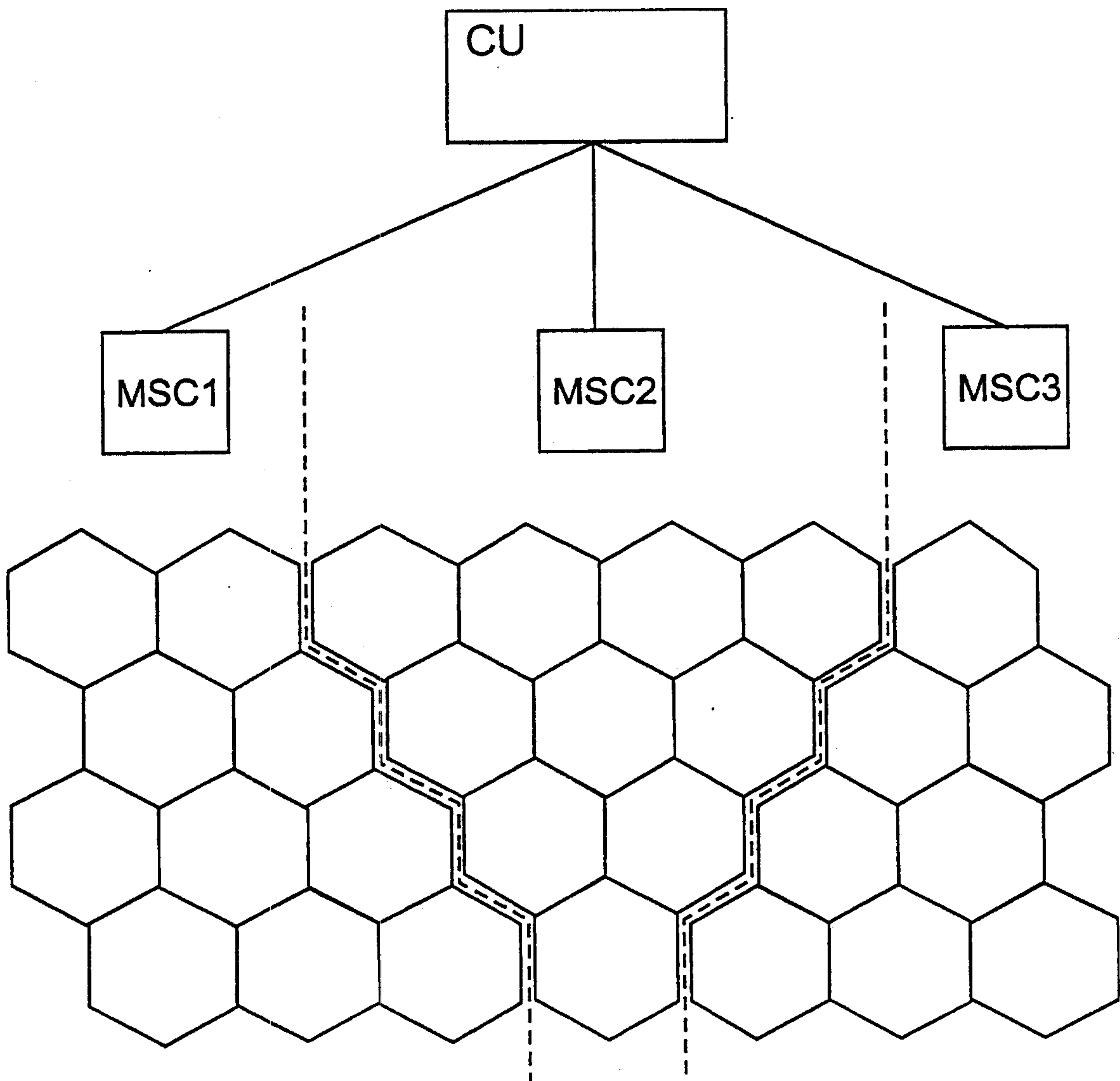
Fig. 1

Marks + Clerk

2/7

Fig. 2*Markus Clerk*

3/7

Fig. 3*Marko Clerk*

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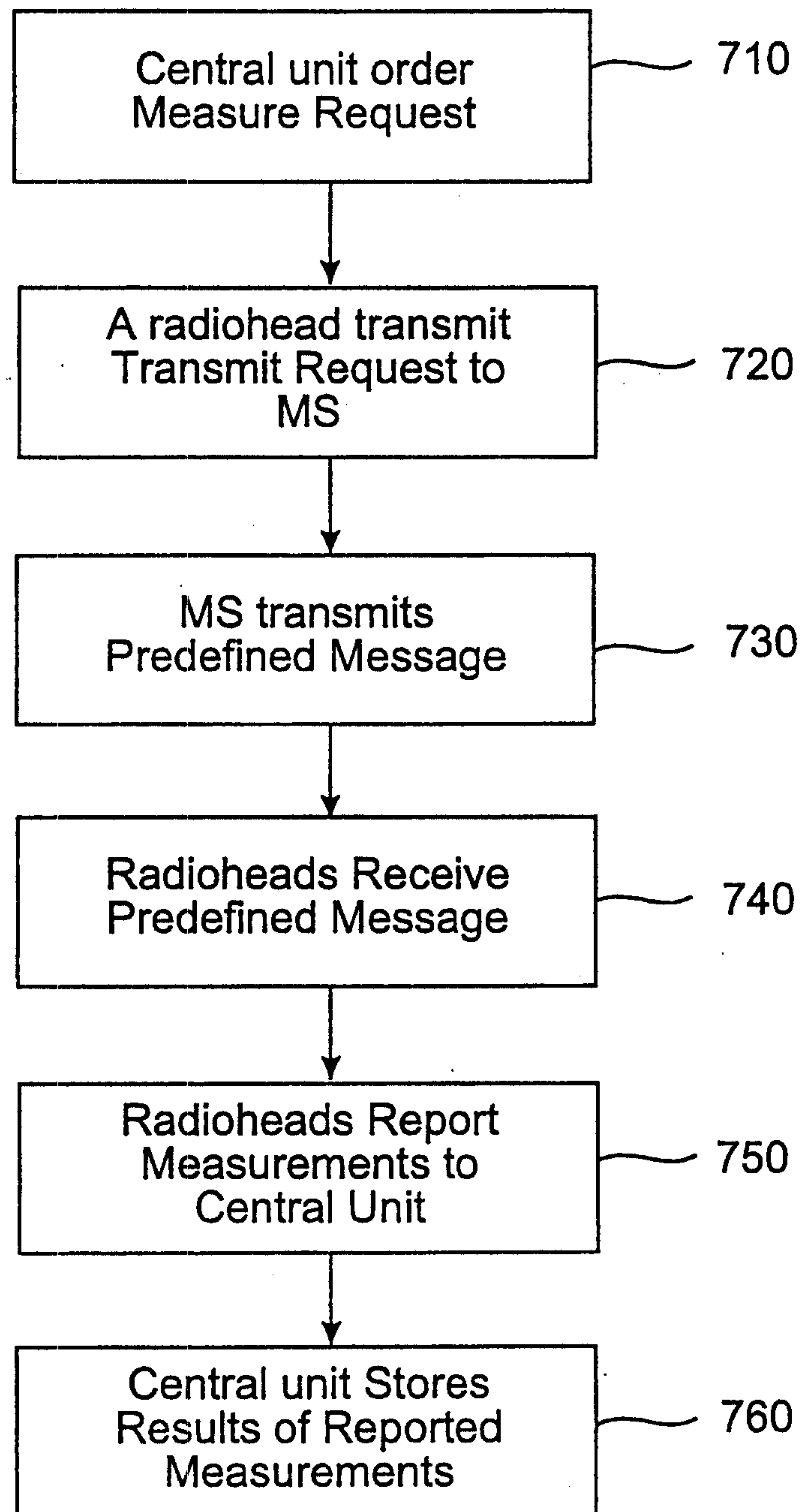
Fig. 4

Cells/Geographical Position

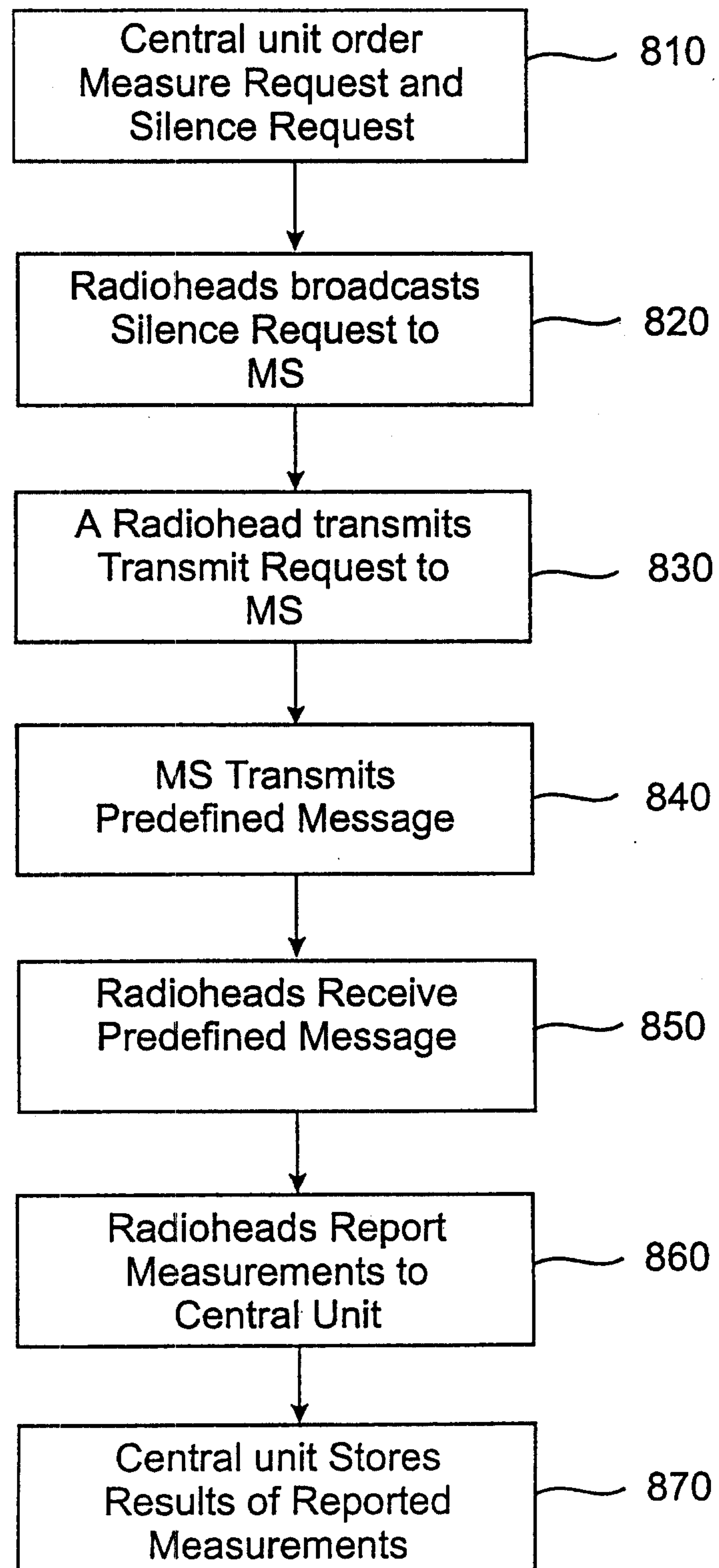
Radio heads/
Transceiver
Station

g11	g21	g31								
g12	g22	g32								
g13	g23	g33								

5/7

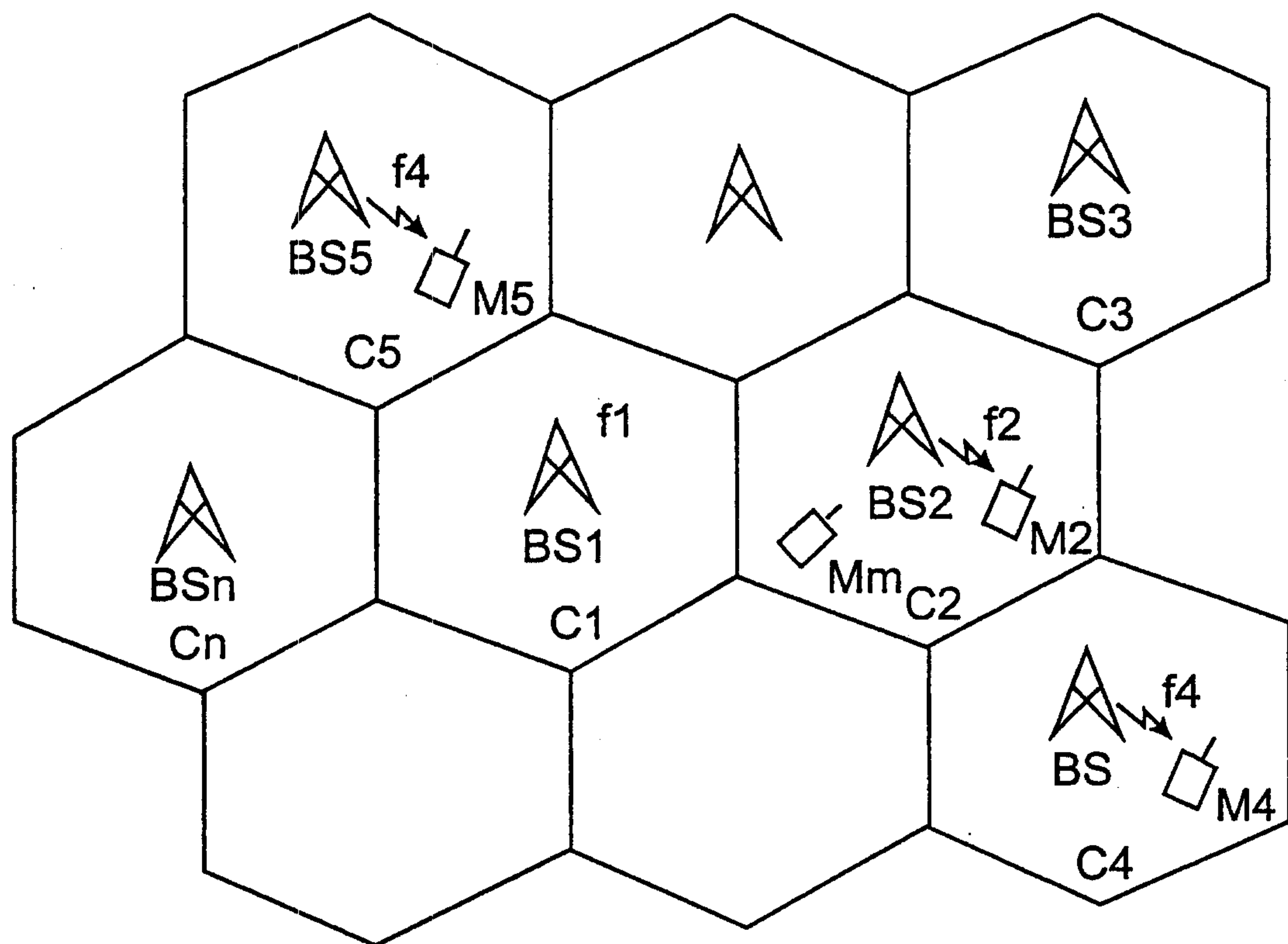
Fig. 5*Markos Alek*

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Fig. 6*Marks+Clark*

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Fig. 7



Marko Clerk