

Mobile Assisted Handover Arrangements for Digital Cellular Telephone Networks

The invention relates to handover arrangements for digital cellular telephone networks.

5 Mobile telephone networks are already well established in many geographical regions enabling relatively small and light telephones to be in general use. The smallness and lightness is due in the main part to using relatively low powered transmission between the telephones and
10 fixed communications transmitters and receivers. The communications transmitters and receivers are generally evenly dispersed geographically around the region of the network in an array at base stations and connected to a central network control station which serves to control
15 the communications between all the base stations and the mobile telephones. The central control station allocates frequencies and channels and selects appropriate base stations at the beginning of each telephone call for individual communications. Handover arrangements are
20 provided by the central controller to vary or alter the channels and frequencies to connect the telephones to communicate with different base stations during each call according to prevailing circumstances. The central controller also monitors and records the calls for user
25 billing.

Normally, the base stations are arranged so as to provide areas of suitable transmission and reception over a number

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of hexagonal side by side areas or so-called "cells". The carrier frequencies used by one cell is different to any carrier frequencies in an immediately adjacent cell but are the same as the frequencies used in another cell in the network somewhat remote and usually separated by a further two cells of the network. Thus a honeycomb type pattern of communication cells can be conveniently formed using say seven different sets of carrier frequencies. Of course, as is already known, if the mobile telephone moves from one cell to another during a call, the control station is capable and designed to transfer or handover the mobile telephone to communicate at appropriate different frequencies.

At present this is determined simply by signal strength comparisons as reported between the cell with which the telephone is communicating with at any time and adjacent cells. If the signal strength of an adjacent cell increases more than a predetermined amount above the signal strength of the communicating cell, the central controller will handover the mobile telephone to the adjacent cell.

Such arrangements are not sufficiently reliable in practice especially for networks required to operate in difficult terrains adjacent coastal areas of totally open spaces, adjacent mountains and/or in densely populated areas with high rise buildings.

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It is an object of the invention to provide a network and a mobile telephone that can more satisfactorily operate in difficult terrains and also in less difficult terrains provide even better service even when the density of use is high.

According to one aspect of the present invention there is provided a handover arrangement for a digital cellular telephone network having a central controller and a number of mobile telephones, in which each telephone is arranged to continually measure and transmit downlink signal strength of a first base station and downlink signal strength measurements of a number of other selected base stations, and in which these signals are passed to the central controller which determines a C/I ratio and controls a handover of the mobile telephone from the first base station to another base station if this ratio falls below a predetermined value, where C equals the downlink signal strength of the first base station and I is a summation of the downlink signal strengths of other selected base stations.

According to another aspect of the present invention there is provided a handover arrangement for a digital cellular telephone network having a central controller and a number of mobile telephones, in which each telephone is arranged to continually measure and transmit downlink signal strength of a first base station and downlink signal



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strength measurements of a number of other selected base stations, and in which these signals are passed to the central controller which determines a C/I ratio and controls a handover of the mobile telephone from the first
5 base station to another base station provided this ratio is above a predetermined value, where C equals the downlink signal strength of potential handover target base station and I is a summation of the downlink strengths of the other selected base stations.

10 The downlink strengths may be measured on control channels of the network.

The selected base stations may comprise the base stations which are the nearest other base stations in the network having the same carrier frequency.

15 The selected base stations may be preselected other base stations geographically associated with the potential handover target base stations.

The downlink strengths of the selected base stations may be modified before being summated by selected quotients or
20 scaling factors relating to previous calculations or measurements of the network.

Where the first base station is arranged to serve a special area of the network, two or more other remotely



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located base stations in the system may be selected to identify that a mobile telephone is in that special area, and the mobile telephone arranged to measure the downlink strength of signals from the two or more selected base stations and communicate the signal strengths to the first base station for onward transmission to the central controller.

According to a further aspect of the invention there is provided a mobile telephone for the digital cellular telephone network, including means for continuously periodically measuring the strength of downlink signals received from a first base station and the strengths of downlink signals received from a number of selected other base stations, and means for transmitting these measurements to the first base station.

The measuring means may be arranged to measure the strength of downlink signals from the surrounding base stations operating at the same carrier frequency.

The measuring means may be alternatively or additionally arranged to measure the strength of downlink signals from base stations that are preselected geographically associated with a potential handover target base station.

The measuring means may also be arranged to measure the strength of downlink signals from selected two or more



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geographically positioned relative to the potential handover target station.

Handover arrangements for digital cellular telephone networks and telephones for such networks according to the invention will now be described by way of example with reference to the accompanying diagrammatic drawings in which :-

Figure 1 is an idealised plan view of a cellular network;

Figure 2 is another idealised plan view of a cellular network;

Figure 3 is a plan view of part of a typical cellular network;

Figure 4 is a schematic side view of another cellular network; and

Figure 5 is an idealised plan view of a cellular network having some cells with super re-use carrier frequencies.

Digital cellular mobile telephone networks are already known and typically each cell is arranged to transmit at three different carrier frequencies providing eight (time division multiplexed) channels per carrier frequency. Two channels of one of the carrier frequencies is used for



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control signals and the rest of the one carrier frequency and all the channels of the other two carrier frequencies are used for voice or data transmission, so-called "traffic". The channels are arranged in pairs and one
5 channel of each pair is used for transmission to a mobile telephone (downlink signals) and the other channel of the pair is used for transmission from the mobile telephone (uplink signals).

The mobile telephone is normally connected for
10 communications at first to its nearest cell and allotted a pair of channels by the central network controller for communication of traffic. This is done by exchanges of messages on the control channels in accordance with well-practised procedures already known. In embodiments of the
15 present invention each mobile telephone is arranged to periodically respond to signals from other cells and relay to the central controller via the cell radio links the signal strengths of signal received from the other cells (downlink signals) in a manner to be described below. The
20 purpose of receiving and measuring the strength of various downlink signals, including its own downlink signal, is to provide information that the central controller can use to "handover" the particular mobile telephone to another cell. This is to ensure that the quality of the
25 communications remains satisfactory as conditions change which will usually be due to the mobile telephone moving closer to a neighbouring cell or possibly into a poor

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localised reception area of the cell presently in communication with the mobile telephone.

In Figure 1, in the cellular network the control channel frequencies are re-used every seven cells (C1 to C7). The
5 normal traffic channels frequencies are re-used every four cells (V1 to V4). In Figure 1, level of re-use for the traffic channels is significantly higher than the level of re-use of the control channels but it will be noted that the "potential interferers" have control channels using
10 different frequencies. "Potential interferers" is used to identify the cells or base stations in the system using the same set of traffic channel frequencies, so that the signals from potential interferers are potentially strong enough to cause interference within the cell or base
15 station area presently communicating with the mobile telephone.

During the progress of a call, the mobile telephone periodically measures the downlink signal strength of the serving base station and those of potential interferers.
20 All measurement results are reported to the central controller which calculates the C/I ratio of the in-use radio link according to the following method :

L_s = downlink signal strength of the serving base station
25 L_{is1} = downlink signal strength of the 1st potential

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interferer

L_{is2} = downlink signal strength of the 2nd potential
interferer

..... ..

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L_{ism} = downlink signal strength of the mth potential
interferer

The C/I ratio of the in-use radio link is calculated as :

$$C/I = L_s / (L_{is1} + L_{is2} + \dots + L_{ism})$$

- 10 When the C/I ratio falls below a predetermined level, the
central controller will handover the mobile telephone to
another cell. This type of measurement is sometimes
referred to as "direct C/I ratio measurement".

- 15 In Figure 2, the level of re-use of the traffic channel
frequencies is the same as that of the level of re-use of
the control channel frequencies. In the Figure the same
traffic channels and the control channel are re-used every
seven cells.

- 20 When using the network in Figure 2, during the progress of
a call the mobile telephone periodically measures the
downlink signal strength of the serving base station and
those of "reference" base stations. "Reference" base
stations is used to identify a set of neighbouring base
stations on different control-channel frequencies and are

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specially selected for estimating the signal level of likely interferers. All these measurement results are reported to the central controller which calculates the approximate C/I ratio of the in-use radio link according to the following method:

- L_{isk} = downlink signal strength of the kth potential interferer (to be estimated)
 L_s = downlink signal strength of the serving base station.
 10 L_{rk1} = downlink signal strength of the 1st reference base station for the kth potential interferer.
 L_{rk2} = downlink signal strength of the 2nd reference base station for the kth potential interferer.

 15
 L_{rkx} = downlink signal strength of the xth reference base station for the kth potential interferer.

The interference level of the kth potential interferer is approximated as :

- 20 $L_{isk} = \text{MAX} [(L_{rk1} * a_1), (L_{rk2} * a_2), \dots, (L_{rkx} * a_x)]$
 where $a_1, a_2, \dots, a_x$ are fixed quotients or scaling factors. The scaling factors are pre-set by prior measurements taken for network and provide necessary adjustment so that the composite signal contour of reference base stations after scaling is approximately
 25 equal to that of the kth potential interferer within the

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service area of the serving base station. This is illustrated in Figure 3.

The C/I ratio of the in-use radio link is therefore calculated as :

$$5 \quad C/I = L_s / (L_{is1} + L_{is2} + \dots + L_{ism})$$

When the C/I ratio falls below a predetermined level, a handover is arranged by the central controller. Such type of criteria is sometimes referred to as based on the "approximated C/I ratio".

10 Some special circumstances arise for particular locations or terrain as illustrated in Figure 4. Thus, across a planned service area boundary, there can exist a number of neighbouring base stations that exhibit a change in signal strength relative to the serving cell. A typical
15 situation is depicted in Figure 4.

Base station A is planned to illuminate or serve a part of a road on a mountain road but due to the position of antennas, the base station also covers part of the ground areas. The road is exposed to radio signals from many
20 other base stations so only very few frequencies are clean enough to be assigned to the base station A. It is necessary to prevent traffic from ground level being captured by the base station A otherwise it will run into congestion. To determine where the traffic is coming

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from, the signals from selected remotely located base stations B and C are used as references. On the mountain, the mobile telephone is in line of sight with base stations B and C so their downlink signal strengths
 5 relative to that of the serving base station is high. On ground area, the situation is reversed as signals from base stations B and C are blocked off by buildings.

Thus, in operation the mobile telephone is arranged to monitor the signal strength and pass the information to
 10 the central controller which will determine the relative location of the mobile telephone and decide in this embodiment whether a handover is actually necessary or not.

The signal strength information is dealt with as follows:-

15	L_s	=	downlink signal strength of the serving base station
	L_{cs1}	=	downlink signal strength of the 1st selected base station
	L_{cs2}	=	downlink signal strength of the 2nd selected base station
20			
			
			
	L_{csx}	=	downlink signal strength of the xth selected base station

Positive Logic

Negative Logic

$$\begin{aligned} & L_{cs_1} - L_s < d_1 \\ \text{and } & L_{cs_2} - L_s < d_2 \\ & \dots\dots\dots \\ & \dots\dots\dots \\ \text{and } & L_{cs_v} - L_s < d_v \end{aligned}$$

10 determined from the predicted or measured signal strength of the serving base station and those of selected base stations inside and outside the planned service area. Thus the handover is subject to what can be referred to as "service area control".

15 A typical logic programme for determining handovers generally is automatically carried out by the central controller as follows:-

(a) A radio traffic channel is set up between a mobile telephone and a serving base station.

20 (b) The mobile telephone periodically measures the
downlink signal strength of the serving base station
and those of other base stations in accordance with
the information received from the network. All
measurement results are reported to the central
25 controller via the serving base station. Measurement
results include:

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For the serving base station:

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|-------|---|--|
| L_u | - | uplink signal strength |
| L_d | - | downlink signal strength |
| Q_u | - | uplink quality |
| Q_d | - | downlink quality |
| D | - | distance between the mobile and the serving base station |

For other base stations:

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- | | | |
|---------------------------------|---|--------------------------|
| $C_{n1}, C_{n2}, \dots, C_{nk}$ | - | base station identity |
| $L_{n1}, L_{n2}, \dots, L_{nk}$ | - | downlink signal strength |

- (c) As new measurement results are received, the central controller checks whether handover is necessary by looking at the triggering function:

$$T (L_u, L_d, Q_u, Q_d, D, C_{n1}, C_{n2}, \dots, C_{nk}, L_{n1}, L_{n2}, \dots, L_{nk})$$

- 15 If $T > 0$, handover is necessary, proceed to step (d).
Go back to step (b) otherwise.

- (d) As handover is determined to be necessary, from the k non-serving base stations in the measurement reports, the central controller selects a number of
20 base stations as potential handover targets by using the respective qualifying function:

$$Q_{ni} (L_u, L_d, Q_u, Q_d, D, C_{n1}, C_{n2}, \dots, C_{nk}, L_{n1}, L_{n2}, \dots, L_{nk})$$

- Q_{ni} is a function parameterized to determine whether the base station identified by C_{ni} is qualified as a
25 handover target. If $Q_{ni} > 0$, the base station is qualified.

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- (e) The central controller determines the priority of qualified handover targets by using the priority function:

$$P_{ni} (L_u, L_d, Q_u, Q_d, D, C_{n1}, C_{n2}, \dots, C_{nk}, L_{n1}, L_{n2}, \dots, L_{nk})$$

- 5 P_{ni} is a function parameterized to determine the relative priority of the handover target identified by C_{ni} .

- (f) The central controller commands the mobile to handover to the target base station having the
10 highest priority.

For handover programmes in accordance with embodiments of the invention and using the system described with reference to Figure 1, the central controller is programmed to operate as follows:-

- 15 When a radio traffic channel has been set up between a mobile telephone and a serving base station, all potential interferers of the serving base station are picked out from the k non-serving base stations in the signal strength measurement reports.

- 20 L_{is1} = downlink signal strength of the 1st potential interferer of the serving base station.
 L_{is2} = downlink signal strength of the 2nd potential interferer of the serving base station.

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 L_{ism} = downlink signal strength of the mth potential
 interferer of the serving base station

- 5 The C/I ratio for the serving base station can then be
 calculated:

$$CI_s = L_d / (L_{is1} + L_{is2} + \dots + L_{ism})$$

The triggering function T is defined as:

$$T = ci_threshold - CI_s$$

- 10 where ci_threshold is a predetermined minimum acceptable
 c/I ratio.

T > 0 means that the C/I ratio is worse than the minimum
 acceptable level so handover to another better base
 station is necessary.

- 15 For the potential handover target identified by C_{nj} , the
 associated potential interferers are picked out from the
 k non-serving base stations in the measurement reports.

L_{inj1} = downlink signal strength of the 1st potential
 interferer of base station identified by C_{nj} .

- 20 L_{inj2} = downlink signal strength of the 2nd potential
 interferer of base station identified by C_{nj} .

... ..

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L_{injm} = downlink signal strength of the m th potential interferer of base station identified by C_{nj} .

The C/I ratio for the base station identified by C_{nj} can then be calculated:

$$5 \quad CI_{nj} = L_{nj} / (L_{inj1} + L_{inj2} + \dots + L_{inj_m})$$

The associated qualifying function is defined as:

$$Q = CI_{nj} - ci_threshold$$

$Q > 0$ means the C/I ratio is better than the minimum acceptable level so the base station is qualified to be a
10 handover target.

In practice, a priority function of the base station identified by C_{nj} is defined as :

$$P_{nj} = CI_{nj}$$

The priority of potential handover targets is determined
15 solely on the corresponding C/I ratio. The better the C/I ratio and hence the signal quality, the higher the priority.

It is also possible to determine handover on the basis of approximate C/I ratios as explained earlier with reference
20 to Figure 2. This is carried out by picking out from the k non-serving base stations in the measurement report, all reference base stations for estimating the C/I ratio of

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the serving base station.

- L_{rs1} = downlink signal strength of the 1st reference base station for estimating the C/I ratio of the serving base station
- 5 L_{rs2} = downlink signal strength of the 2nd reference base station for estimating the C/I ratio of the serving base station
-
-
- 10 L_{rsx} = downlink signal strength of the xth reference base station for estimating the C/I ratio of the serving base station

The C/I ratio for the serving base station is then calculated in the central controller programme.

$$15 \quad CI_s = L_d / \text{MAX} [(L_{rs1} * a_{s1}), (L_{rs2} * a_{s2}), \dots, (L_{rsx} * a_{sx})]$$

The triggering function T for handover is defined as:

$$T = ci_threshold - CI_s$$

where ci_threshold is pre-defined minimum acceptable C/I ratio.

- 20 $T > 0$ means that the C/I ratio is worse than the minimum acceptable level so handover to another better base station is necessary.

The potential handover target is identified by C_{nj} . This

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is picked out from the associated reference base stations from the k non-serving base stations in the measurement reports.

5 L_{rnj1} = downlink signal strength of the 1st reference base station for estimating the C/I ratio of the base station identified by C_{nj} .

L_{rnj2} = downlink signal strength of the 2nd reference base station for estimating the C/I ratio of the base station identified by C_{nj} .

10

L_{rnjx} = downlink signal strength of the x th reference base station for estimating the C/I ratio of the base station identified by C_{nj} .

15 The C/I ratio for the base station identified by C_{nj} can then be calculated:

$$CI_{nj} = L_{nj} / \text{MAX} [(L_{rnj1} * a_{nj1}), (L_{rnj2} * a_{nj2}), \dots, (L_{rnjx} * a_{njx})]$$

The associated qualifying function is defined as:

$$Q = CI_{nj} - ci_threshold$$

20 $Q > 0$ means that the C/I ratio is better than the minimum acceptable level so the base station is qualified to be an handover target. In other words, provided the C/I ratio for the potential handover target station is above a predetermined value a handover can be carried out.

- 20 -

The priority function of the target base station is identified by C_{nj} and defined as:

$$P_{nj} = CI_{nj}$$

5 The priority of potential handover targets is determined solely on the corresponding C/I ratio. The better the C/I ratio and hence the signal quality, the higher the priority.

10 It was earlier mentioned with reference to Figure 4 that certain special arrangement may be required in difficult terrains or locations. Where handover decisions are made in accordance with location the following programme is provided:-

15 From the k non-serving base stations in the measurement reports, all selected remotely located base stations for estimating whether the mobile is within the planned service area of the in-use base station are picked out.

20 L_{cs1} = downlink signal strength of the 1st selected base station for estimating whether the mobile is within the planned service area of the in-use base station.

L_{cs2} = downlink signal strength of the 2nd selected base station for estimating whether the mobile is within the planned service area of the in-use base station.

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 L_{csx} = downlink signal strength of the xth selected
 base station for estimating whether the mobile
 5 is within the planned service area of the in-use
 base station.

The triggering function $T > 0$ or handover function is
 provided if:

Positive LogicNegative Logic

10 $L_{cs1} - L_d > d_{s1}$
 or $L_{cs2} - L_d > d_{s2}$
 ..
 ..
 or $L_{csx} - L_d > d_{sx}$

$L_{cs1} - L_d < d_{s1}$
 and $L_{cs2} - L_d < d_{s2}$
 ..
 ..
 and $L_{csx} - L_d < d_{sx}$

15 $T > 0$ means that the mobile is outside the planned service
 area of the in-use base station so handover to another
 base station is necessary.

The potential handover target is identified by C_{nj} , the
 associated reference base stations are chosen from the k
 20 non-serving base stations in the measurement reports.

L_{cnj1} = downlink signal strength of the 1st selected
 base station for estimating if the mobile is
 within the planned service area of the base
 station identified by C_{nj} .
 25 L_{cnj2} = downlink signal strength of the 2nd selected

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base station for estimating if the mobile is within the planned service area of the base station identified by C_{nj} .

..... ..
 5
 L_{cnjx} = downlink signal strength of the xth selected base station for estimating if the mobile is within the planned service area of the base station identified by C_{nj} .

10 The qualifying function Q is greater than 0 if:

Positive Logic

..... ..
 15
 or $L_{cnj1} - L_{nj} > d_{nj1}$
 or $L_{cnj2} - L_{nj} > d_{nj2}$
 or $L_{cnjx} - L_{nj} > d_{njx}$

Negative Logic

..... ..
 and $L_{cnj1} - L_{nj} < d_{nj1}$
 and $L_{cnj2} - L_{nj} < d_{nj2}$
 and $L_{cnjx} - L_{nj} < d_{njx}$

$Q > 0$ means that the mobile is with the planned service area of the base station identified by C_{nj} so it is qualified as an handover target.

20

For prioritizing functions such factors as signal strength, traffic loading and C/I ratio are applied.

The described handover arrangements can be applied to underlay-overlay cellular networks. Referring to Figure
 25 5, the cellular network has an underlay-overlay configuration where some of the cells have super re-used

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carrier frequencies. The operating spectrum of the network is divided into two groups, namely a regular-reuse group and a super-reuse group. The regular-reuse frequencies are reused over safe distance such as that in
5 7-cell reuse pattern and are intended to serve mobile telephones near the cell boundary where the C/I ratio is usually the worst. As the name implies, the super-reuse frequencies are reused very intensively to produce a required increased capacity.

10 Some of the ordinary base stations are equipped with both types of frequencies. Super-reuse frequencies allocated to a base station are divided into several groups with each group having different sources of interference. Based on the profile of interference to which each mobile
15 telephone is exposed to, the central controller determines the most appropriate frequency group to be assigned for carrying traffic.

Stand-alone micro cells with antenna height well below the roof level may be equipped solely with super-reuse
20 frequencies. By establishing appropriate handover connections, a micro cell at good location can effectively absorb the traffic of more than one ordinary base stations in its vicinity. With such an arrangement, the surrounding base stations are usually referred to as
25 "parent base stations" and the micro cell is referred to as "child base stations".

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The conventional frequency selection mechanism used with underlay-overlay configuration is only based on the signal strength of the serving base station. A strong signal means that the mobile is close to the base station and the system will assign a super-reuse frequency for a call. Otherwise, a regular-reuse frequency will be used. The arrangement works well over flat, homogeneous terrains but in interference limited environment, signal strength alone is no indication in practice of the susceptibility to interference. In open areas, the signal level is usually high but so is the chance of interference. When the signal is weak, the mobile telephone may be inside buildings and well shielded from interference.

A frequency selection mechanism using embodiments of the invention is therefore more effective. The improved handover arrangements of the present invention may be applied to selection of frequencies. The procedures are as follows:

- (a) At call set up, the central controller assigns a regular-reuse frequency.
- (b) As signal strength measurements become available during the progress of the call, the central controller checks if sufficiently clean super-reuse frequencies are available (including those in associated child base stations) by using qualifying

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functions based on:

- direct C/I ratio measurement (Figure 1)
- approximated C/I ratio (Figure 2)
- service area control (Figure 4)

5 (c) If clean super-reuse frequencies are found, the central controller prioritizes the usable super-reuse frequencies according to the respective number of idle traffic channels. The more the number of idle traffic channels, the higher the priority.

10 (d) The central controller hands over the mobile telephone to the super-reuse frequency with the highest priority.

15 (e) On super-reuse frequencies, the central controller constantly monitors the in-use radio links to see if it is necessary to return to regular-reuse frequencies. Handover triggering functions based on the following criteria can be used:

- direct C/I ratio measurement
- approximated C/I ratio
- 20 - service area control

(f) If returning to regular-reuse frequencies is necessary as indicated by the handover triggering function, the central controller evaluates every regular-reuse frequency of the serving base stations

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and those in its neighbourhood by using qualifying functions and prioritizing functions based on :

- direct C/I ratio measurement
- approximated C/I ratio
- service area control

5

(g) The central controller hands over the mobile telephone to the regular frequency with the highest priority.

(h) Go back to step (b).

10 In the described arrangements, downlink signal strengths of control signals are measured and used to determine the handover criteria and in Figure 4 the location of the mobile telephone. It will be appreciated that downlink signal strengths of the traffic channels might also be
15 employed additionally or alternatively.

It will be appreciated that in embodiments of the invention the handover criteria is determined on the basis of C/I ratios and when this ratio falls below a predetermined value for a serving base station, or
20 otherwise, C/I ratios of potential handover target base stations are monitored to identify and choose an appropriate of those stations for handover.

26a

Drawing Legend

- A - 1st tier of co-control channel base stations
- B - 1st tier of co-traffic channel base stations
- C - 1st tier of co-control channel and co-traffic channel base stations
- D - potential handover target station
- E - reference base station A
- F - interfering base station
- G - service area boundary
- H - reference base station B
- I - signal level contour of the interfering base station
- J - zone of interference within the service area
- K - scaled signal level contour of reference base stations A and B
- L - unintended (-ve logic)/intended (+ve logic) service area of base station A

$$\text{or } \begin{cases} (L_{B1} - L_{A1}) > d_B \\ (L_{C1} - L_{A1}) > d_C \end{cases}$$

- M - unintended (+ve logic)/intended (-ve logic) service area of base station A

$$\text{and } \begin{cases} (L_{B2} - L_{A2}) > d_B \\ (L_{C2} - L_{A2}) > d_C \end{cases}$$

- N - base station A
- O - reference base station B
- P - reference base station C
- Q - 1st co-channel cell tier for regular-reuse freq.
- R - 1st co-channel cell tier for super-reuse freq. in parent base station
- S - 1st co-channel cell tier for child base station



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CLAIMS

1. A handover arrangement for a digital cellular telephone network having a central controller and a number of mobile telephones, in which each telephone is arranged to continually measure and transmit downlink signal strength of a first base station and downlink signal strength measurements of a number of other selected base stations, and in which these signals are passed to the central controller which determines a C/I ratio and controls a handover of the mobile telephone from the first base station to another base station if this ratio falls below a predetermined value, where C equals the downlink signal strength of the first base station and I is a summation of the downlink signal strengths of the other selected base stations.

2. A handover arrangement for a digital cellular telephone network having a central controller and a number of mobile telephones, in which each telephone is arranged to continually measure and transmit downlink signal strength of a first base station and downlink signal strength measurements of a number of other selected base stations, and in which these signals are passed to the central controller which determines a C/I ratio and controls a handover of the mobile telephone from the first base station to another base station provided this ratio is above a predetermined value, where C equals the





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downlink signal strength of potential handover target base station and I is a summation of the downlink strengths of the other selected base stations.

3. A handover arrangement according to claim 2, in which
5 the downlink strengths are measured on control channels of the network.

4. A handover arrangement according to claim 2 or 3, in which the selected base stations comprise the base stations which are the nearest other base stations in the
10 network having the same traffic channel frequency.

5. A handover arrangement according to claim 1 or 2, in which the selected base stations are preselected other base stations geographically associated with the potential handover target base station.

15 6. A handover arrangement according to any one of claims 1 to 5, in which the downlink strengths of the selected base stations are modified before being summated by selected quotients or scaling factors relating to previous calculations or measurements of the network.

20 7. A handover arrangement according to any one of claims 1 to 6, in which the first base station is arranged to serve a special area of the network and two or more other remotely located base stations in the system are selected

This Sheet Has Been Replaced





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to identify a mobile telephone in that special area, in which the mobile telephone is arranged to measure the downlink strength of signals from the two or more selected base stations and communicate the signal strengths to the first base station for onward transmission to the central controller.

8. A mobile telephone for a digital cellular telephone network according to any one of claims 1 to 7, including means for continuously periodically measuring the strength of downlink signals received from a first base station and the strengths of downlink signals received from a number of selected other base stations, and means for transmitting these measurements to the first base station.

9. A mobile telephone according to claim 8, in which the measuring means is arranged to measure the strength of downlink signals from the surrounding base stations operating at the same carrier frequency.

10. A mobile telephone according to claim 8 or 9, in which the measuring means is arranged to measure the strength of downlink signals from the immediately surrounding base stations operating at different carrier frequencies.

11. A mobile telephone according to any one of claims 8 to 10, in which the measuring means is arranged to measure





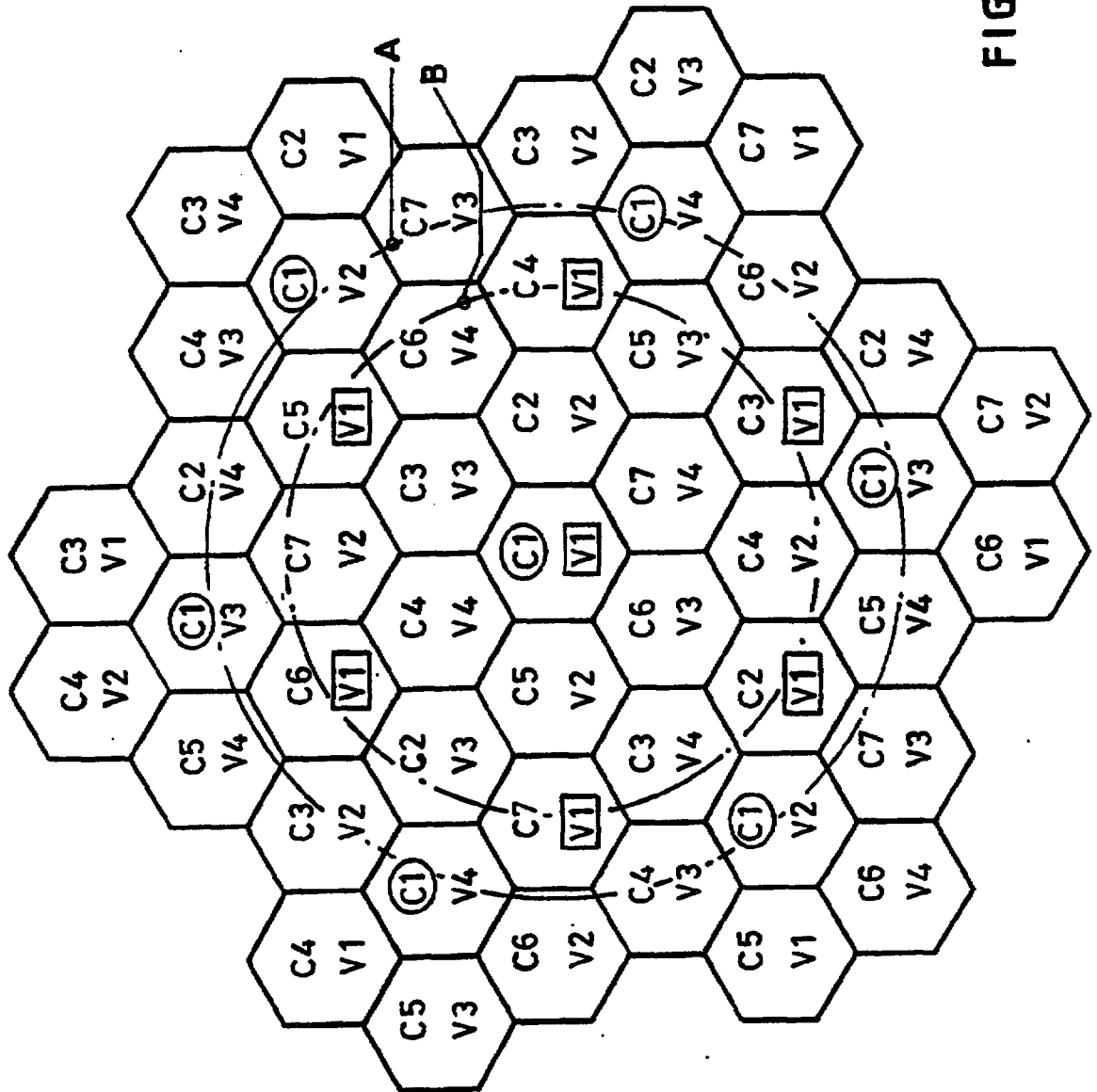
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the strength of downlink signals from selected two or more geographically remotely positioned base stations.

12. Handover arrangements for a digital cellular telephone network substantially as herein described with
5 reference to the accompanying drawings.

13. A mobile telephone for a digital cellular telephone network substantially as herein described with reference to the accompanying drawings.





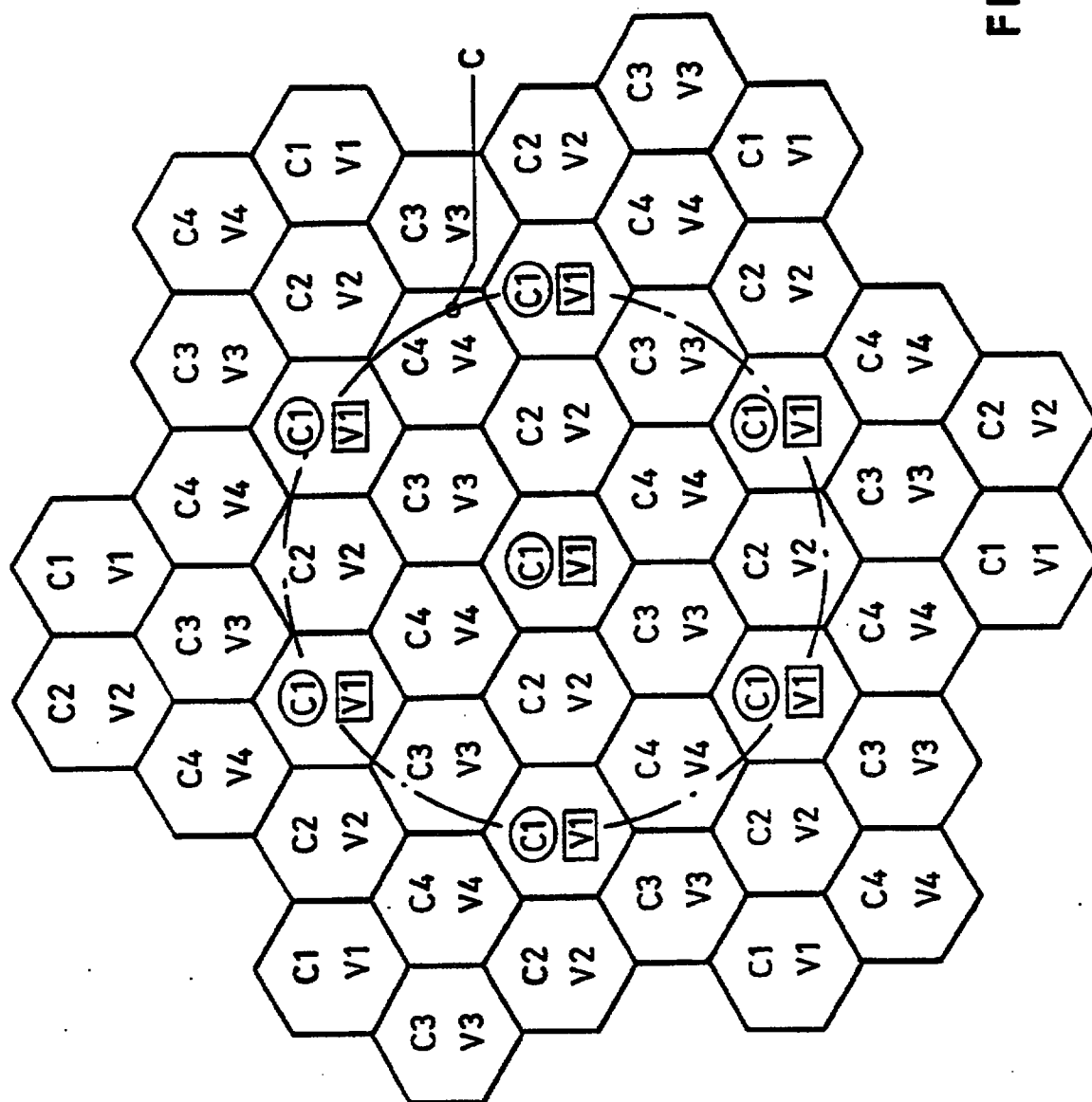


FIG. 2

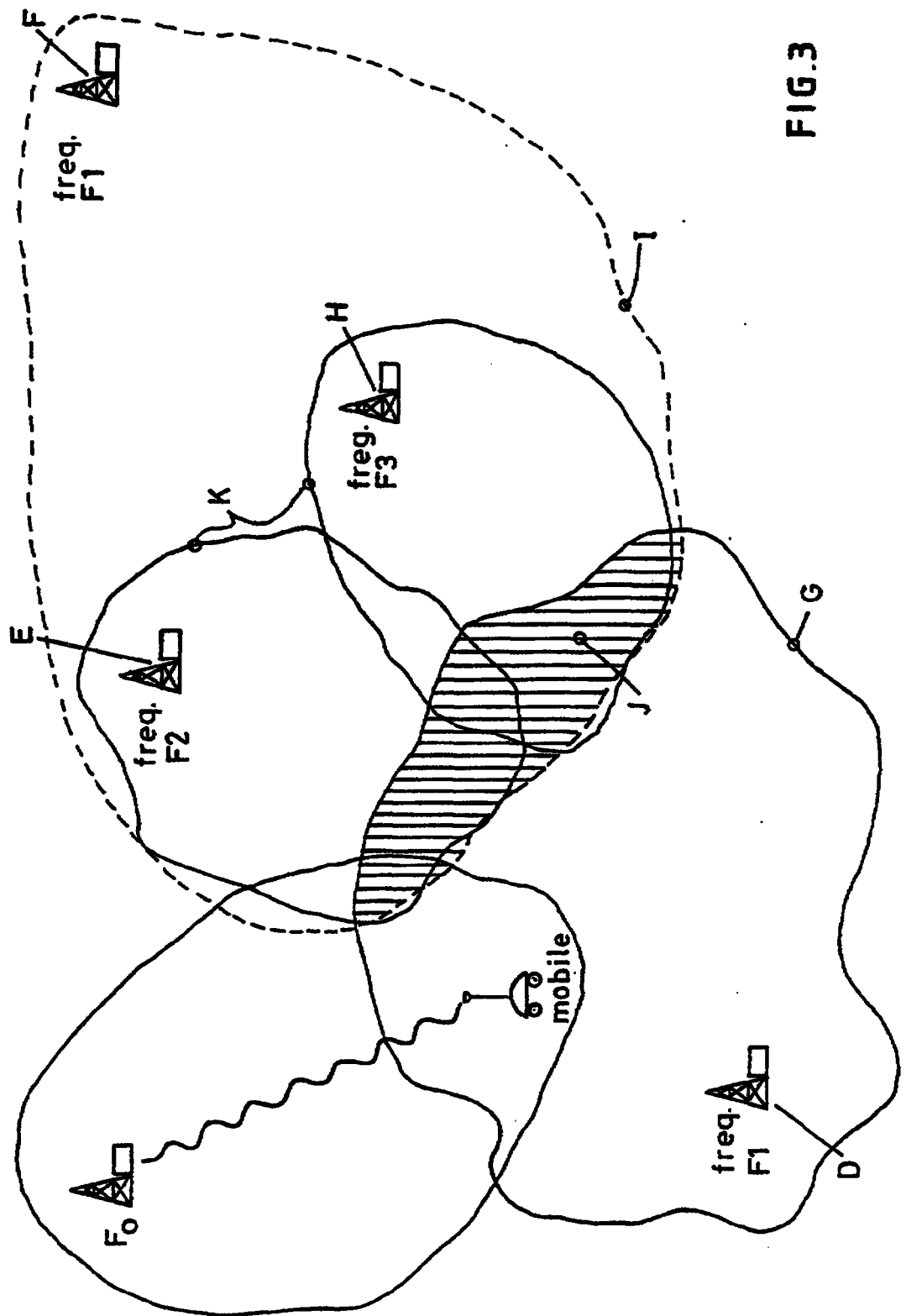


FIG. 3

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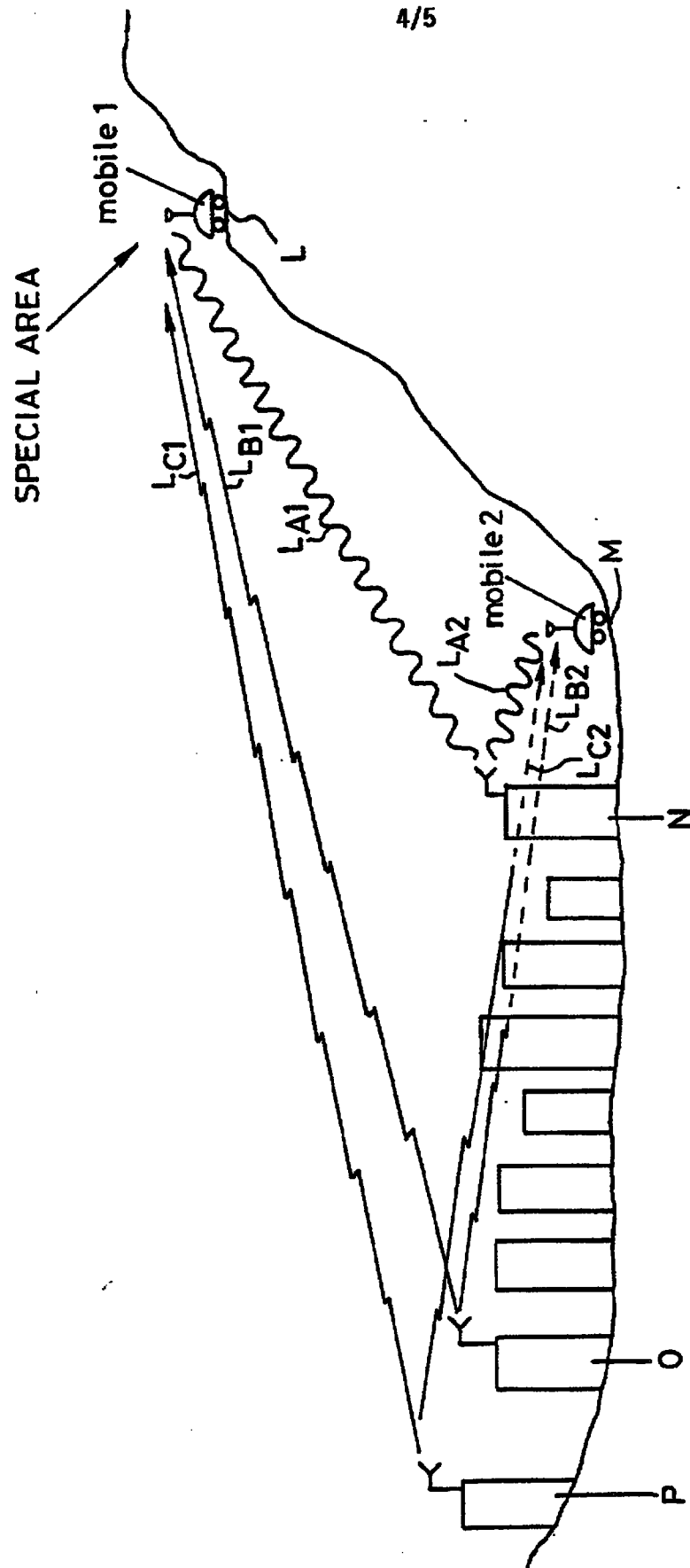


FIG.4

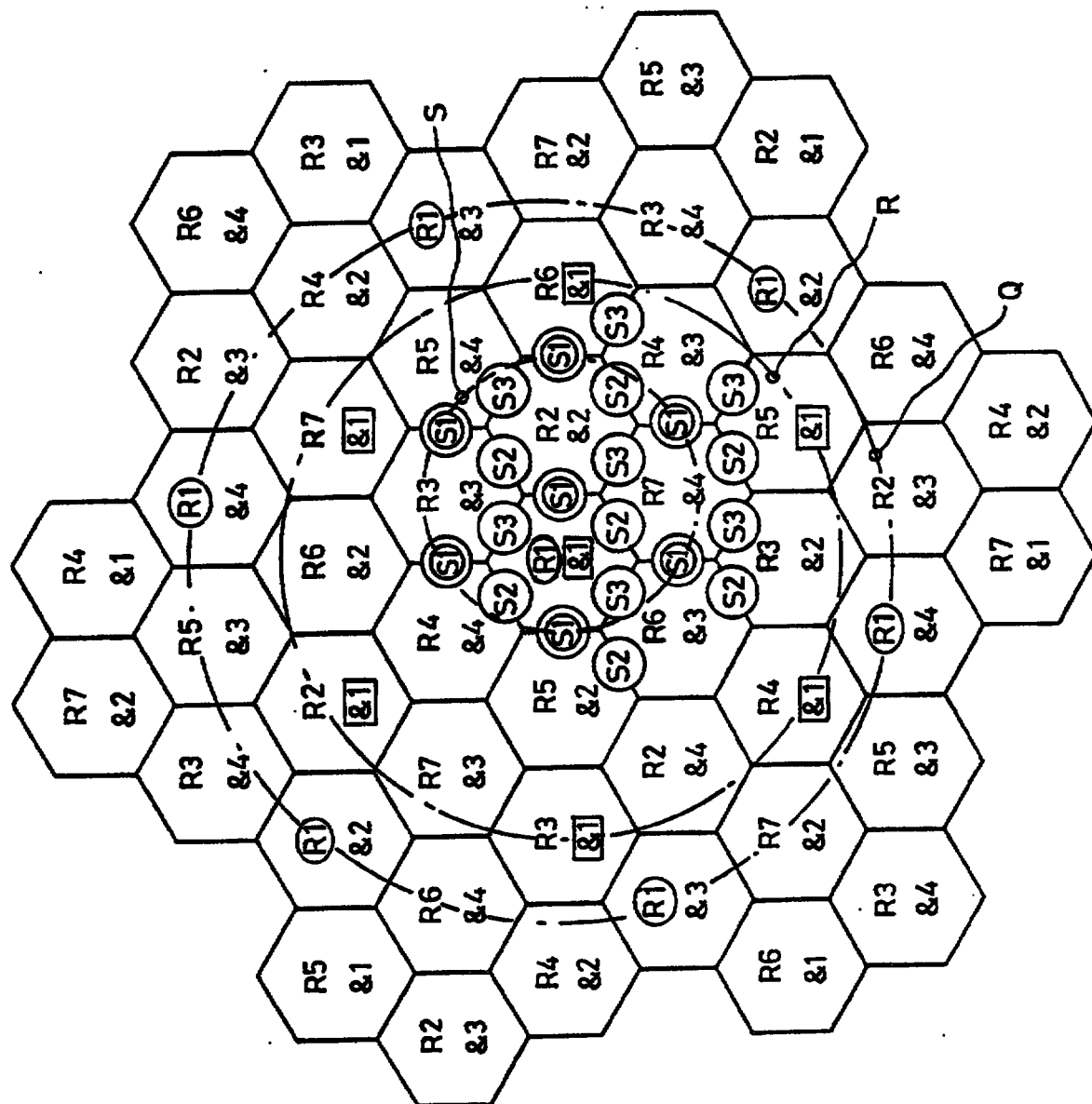


FIG.5



AMENDED CLAIMS

[received by the International Bureau on 6 December 1996 (06.12.96);
original claims 1-13 replaced by amended claims 1-11 (4 pages)]

1. A handover arrangement for a digital cellular telephone network having a central controller and a number of mobile telephones, in which each telephone is arranged
5 to continually measure and transmit downlink signal strength of a first base station and downlink signal strength measurements of a number of other selected base stations, and in which these signals are passed to the central controller which determines a C/I ratio and
10 initiates a handover of the mobile telephone from the first base station to another base station whenever this ratio falls below a predetermined value, where C equals the downlink signal strength of the first base station and I is a summation of the downlink signal strengths of the
15 other base stations.

2. A handover arrangement for a digital cellular telephone network having a central controller and a number of mobile telephones, in which each telephone is arranged to continually measure and transmit downlink signal
20 strength of a first base station and downlink signal strength measurements of a number of other selected base stations, and in which these signals are passed to the central controller which determines a C/I ratio and initiates a handover of the mobile telephone from the
25 first base station to another base station whenever this ratio falls below a predetermined value provided the C/I



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ratio for the other base station is above the predetermined value, where C equals the downlink signal strength of potential handover target base station and I is a summation of the downlink strengths of the other
5 selected base stations.

3. A handover arrangement according to claim 1 or 2, in which the downlink strengths are measured on control channels of the network.

4. A handover arrangement according to claim 2 or 3, in
10 which the selected base stations comprise the base stations which are the nearest other base stations in the network having the same traffic channel frequency.

5. A handover arrangement according to claim 2 or 3, in which the selected base stations are preselected other
15 base stations geographically associated with the potential handover target base station.

6. A handover arrangement according to any one of claims 1 to 5, in which the downlink strengths of the base stations are modified before being summated by selected
20 quotients or scaling factors relating to previous calculations or measurements of the network.

7. A handover arrangement according to any one of claims 1 to 6, in which the first base station is arranged to

REPLACEMENT SHEET

06 DEC 1996

AMENDED SHEET (ARTICLE 19)



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serve a special area of the network and two or more other remotely located base stations in the system are selected to identify a mobile telephone in that special area, in which the mobile telephone is arranged to measure the downlink strength of signals from the two or more selected base stations and communicate the signal strengths to the first base station for onward transmission to the central controller.

8. A mobile telephone for a digital cellular telephone network according to any one of claims 1 to 7, including means for continuously periodically measuring the strength of downlink signals received from a first base station and the strengths of downlink signals received from a number of other base stations, and means for transmitting these measurements to the first base station.

9. A mobile telephone according to claim 8, in which the measuring means is arranged to measure the strength of downlink signals from the surrounding base stations operating at the same carrier frequency.

10. A mobile telephone according to claim 8 or 9, in which the measuring means is arranged to measure the strength of downlink signals from the immediately surrounding base stations operating at different carrier frequencies.

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AMENDED SHEET (ARTICLE 19)

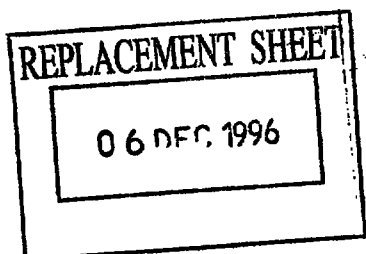


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11. A mobile telephone according to any one of claims 8 to 10, in which the measuring means is arranged to measure the strength of downlink signals from selected two or more geographically remotely positioned base stations.



AMENDED SHEET (ARTICLE 19)



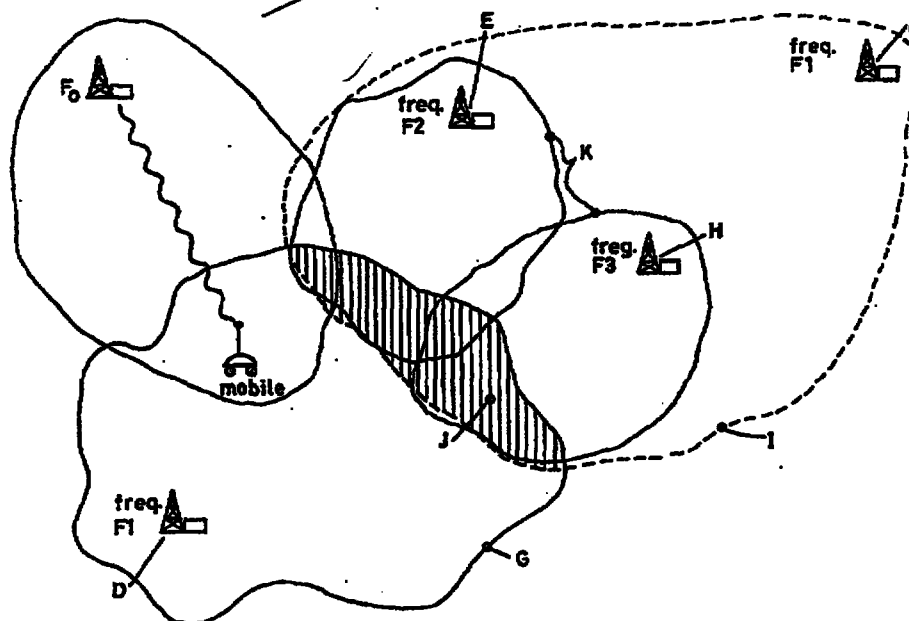
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WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : H04Q 7/38	A1	(11) International Publication Number: WO 96/38997 (43) International Publication Date: 5 December 1996 (05.12.96)
(21) International Application Number: PCT/GB96/01280 (22) International Filing Date: 30 May 1996 (30.05.96) (30) Priority Data: 9510861.9 30 May 1995 (30.05.95) GB (71) Applicant (for all designated States except US): HONG KONG TELECOM CSL LTD. [GB/GB]; Hongkong Telecom Tower, Taikoo Place, 979 King's Road, Quarry Bay (HK). (72) Inventor; and (75) Inventor/Applicant (for US only): LUI, Ying-chun [GB/GB]; Block F, 6th floor, 63 Lee Tung Street, Wanchai (HK). (74) Agent: LUCKHURST, Anthony, Henry, William; Marks & Clerk, 57-60 Lincoln's Inn Fields, London WC2A 3LS (GB).	(81) Designated States: AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, AR, RO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.	

(54) Title: MOBILE ASSISTED HANDOVER ARRANGEMENTS FOR DIGITAL CELLULAR TELEPHONE NETWORKS



(57) Abstract

A digital cellular telephone network is provided with mobile telephone handover arrangements in which a mobile telephone supplies signals relating to the strengths of downlink signals. The signals are the signals from a first base station, with which the telephone is communicating, as well as downlink signals from other selected base stations in the network. Based on this information a central controller calculates a carrier-to-interference ratio C/I and determines when and to which other base station the mobile telephone should be handed over to.