

MOBILE STATION LOCATING AND HANDOVER ARRANGEMENT FOR A DIGITAL CELLULAR TELEPHONE.

The invention relates to digital cellular telephone networks.

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 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 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 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 billing.

Normally, the base stations are arranged so as to provide areas of suitable transmission and reception over a number of hexagonal side by side areas or so-called "cells". The

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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.

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 invention there is provided a mobile telephone locating arrangement for a digital cellular telephone network having a central controller and a number of mobile telephones in which a 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 to identify that a mobile telephone is 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.

A handover arrangement may be provided 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.

5 The handover arrangement may additionally be determined on the basis of a C/I ratio where C is the downlink strength of signals of a potential handover target base station and in particular chosen for handover only provided that that C/I ratio is above a predetermined value.

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

The selected base stations used for determining the handover arrangement 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 used for the handover arrangement may be preselected other base stations geographically associated with the potential handover target base station. The downlink strengths of these selected base stations may be modified before being
20 summated by selected quotients or scaling factors relating to previous calculations or measurements of the network.

According to another aspect of the invention there is provided a mobile telephone for the digital cellular



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telephone network having a central controller including means for continuously periodically measuring the strength of downlink signals received from a first base station when the mobile telephone is located in a special area
5 which the first station serves and the downlink strengths of two or more other base stations remotely located from the special area, and means for transmitting these signal strengths via the first base station to the central controller.

10 To provide alternative or additional information for use in a handover arrangement, the mobile telephone may include means for continuously periodically measuring the strength of downlink signals received from a first base station and the strengths of downlink signals received
15 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
20 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.

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Handover arrangements incorporating a special locating
facility 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
5 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
10 network;

Figure 4 is a schematic side view of another cellular
network showing a mobile telephone located in a special
area; and

Figure 5 is an idealised plan view of a cellular network
15 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
20 channels of one of the carrier frequencies is used for
control signals and the rest of the one carrier frequency
and all the channels of the other two carrier frequencies

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are used for voice or data transmission, so-called "traffic". The channels are arranged in pairs and one 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 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 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 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 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 localised reception area of the cell presently in communication with the mobile telephone.

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In Figure 1, in the cellular network the control channel frequencies are re-used every seven cells (C1 to C7). The 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 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 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. 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

L_{is1} = downlink signal strength of the 1st potential 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

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

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

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
10 referred to as "direct C/I ratio measurement".

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
15 seven cells.

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
20 stations is used to identify a set of neighbouring base
stations on different control-channel frequencies and are
specially selected for estimating the signal level of
likely interferers. All these measurement results are
reported to the central controller which calculates the

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approximate C/I ratio of the in-use radio link according to the following method:

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

- 15 The interference level of the k th potential interferer is approximated as :

$$L_{isk} = \text{MAX} [(L_{rk1} * a_1), (L_{rk2} * a_2), \dots, (L_{rkx} * a_x)]$$

- where $a_1, a_2, \dots, a_x$ are fixed quotients or scaling factors. The scaling factors are pre-set by prior
- 20 measurements taken for network and provide necessary adjustment so that the composite signal contour of reference base stations after scaling is approximately equal to that of the k th potential interferer within the service area of the serving base station. This is
- 25 illustrated in Figure 3.

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

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

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

Some special circumstances arise for particular locations
or terrain as illustrated in Figure 4. Thus, across a
10 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
situation is depicted in Figure 4 where there is a
requirement to establish that the mobile telephone is in
15 a particular or special area.

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
25 from, the signals from selected remotely located base

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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
relative to that of the serving base station is high. On
5 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
the central controller which will determine the relative
10 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:-

L_s = downlink signal strength of the serving base
15 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

The mobile telephone is in the planned service area if and

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only if:

Positive Logic

5 $L_{cs1} - L_s > d_1$
 or $L_{cs2} - L_s > d_2$

 or $L_{csx} - L_s > d_x$

Negative Logic

$L_{cs1} - L_s < d_1$
 and $L_{cs2} - L_s < d_2$

 and $L_{csx} - L_s < d_x$

where $d_1, d_2, \dots d_x$ are constants, the values of which are
 determined from the predicted or measured signal strength
 10 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".

A typical logic programme for determining handovers
 15 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.
- (b) The mobile telephone periodically measures the
 20 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
 controller via the serving base station. Measurement
 25 results include:

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For the serving base station:

- 5 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:

- 10 $C_{n1}, C_{n2}, \dots, C_{nk}$ - 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.

- (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 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

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

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

The triggering function T is defined as:

$$T = ci_threshold - CI_s$$

where ci_threshold is a predetermined minimum acceptable
10 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.

For the potential handover target identified by C_{nj} , the
15 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} .

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

... ..

... ..

L_{injm} = downlink signal strength of the mth potential

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interferer of base station identified by C_{nj} .

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

$$CI_{nj} = L_{nj} / (L_{inj1} + L_{inj2} + \dots + L_{injM})$$

- 5 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 handover target.

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

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

- 15 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.

- 20 It is also possible to determine handover on the basis of approximate C/I ratios as explained earlier with reference 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 the serving base station.

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- L_{rs1} = downlink signal strength of the 1st reference
 base station for estimating the C/I ratio of the
 serving base station

 L_{rs2} = downlink signal strength of the 2nd reference
 base station for estimating the C/I ratio of the
 serving base station

 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.

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

- 15 The triggering function T for handover is defined as:

$$T = ci_threshold - CIs$$

where ci_threshold is pre-defined 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.

The potential handover target is identified by C_{nj} . This
 is picked out from the associated reference base stations
 from the k non-serving base stations in the measurement

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reports.

- 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} .
- 5 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 xth reference base station for estimating the C/I ratio of the base station identified by C_{nj} .

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

$$15 \quad CI_{nj} = L_{nj} / \text{MAX} [(L_{rnj1} * a_{nj1}), (L_{rnj2} * a_{nj2}), \dots, (L_{rnjx} * a_{njx})]$$

The associated qualifying function is defined as:

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

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

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

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

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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.

- 5 It was earlier mentioned with reference to Figure 4 that certain special arrangement may be required in difficult terrains or locations. Normally locating a mobile telephone in special area is to do with deciding handover occurrences but it may be useful or required for other
- 10 reasons, such as deciding whether super re-use frequencies, mentioned later, can be used or whether a different C/I ratio should be employed to determine handover decisions. Where handover decisions are made in accordance with location the following programme is
- 15 provided:-

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
- 25 base station for estimating whether the mobile

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is within the planned service area of the in-use base station.

.....

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

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

Positive Logic

15 $L_{cs1} - L_d > d_{s1}$
 or $L_{cs2} - L_d > d_{s2}$
 ..
 ..
 or $L_{csx} - L_d > d_{sx}$

Negative Logic

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

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

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

25 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

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station identified by C_{nj} .

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

.....
.....

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} .

The qualifying function Q is greater than 0 if:

Positive Logic

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

Negative Logic

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

20 $Q > 0$ 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.

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

25 The described handover arrangements can be applied to
underlay-overlay cellular networks. Referring to Figure

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5, the cellular network has an underlay-overlay configuration where some of the cells have super re-used 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 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.

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 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 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

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"parent base stations" and the micro cell is referred to as "child base stations".

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

- 25 -

controller checks if sufficiently clean super-reuse frequencies are available (including those in associated child base stations) by using qualifying functions based on:

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

10 (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.

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

20 (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
- service area control

(f) If returning to regular-reuse frequencies is

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necessary as indicated by the handover triggering function, the central controller evaluates every regular-reuse frequency of the serving base stations 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

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

(h) Go back to step (b).

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 employed additionally or alternatively.

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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

SUBSTITUTE SHEET (RULE 26)



THIS SHEET HAS BEEN REPLACED

CLAIMS

1. A mobile telephone locating arrangement for a digital cellular telephone network having a central controller and a number of mobile telephones in which a first base station is arranged to serve over a special area of the network and two or more other remotely located base stations in the system are selected to identify that a mobile telephone is 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.
2. A handover arrangement incorporating the locating arrangement of claim 1, in which each telephone is arranged to continually measure and transmit downlink signal strength of the 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.





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3. A handover arrangement according to claim 1 in which handover is also determined on the basis of a C/I ratios being above a predetermined level, in which C is the downlink signal strength of the one or more potential
- 5 handover target base stations.
4. A handover arrangement according to claim 2 or 3, in which the downlink strengths are measured on control channels of the network.
5. A handover arrangement according to any one of claims
- 10 2 to 4, in which the selected base stations for the handover arrangement comprise the base stations which are the nearest other base stations in the network having the same carrier frequency.
6. A handover arrangement according to any one of claims
- 15 3 to 5, in which selected base stations for the handover arrangement are preselected other base stations geographically associated with the potential handover target base station.
7. A handover arrangement according to any one of claims
- 20 2 to 6, in which the downlink strengths of these selected base stations are modified before being summated by selected quotients or scaling factors relating to previous calculations or measurements of the network.



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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
5 when the mobile telephone is located in a special area over which the first station serves and the downlink strengths of two or more other base stations remotely located from the special area, and means for transmitting these signal strengths via the first base station to the
10 central controller.

9. A mobile telephone according to claim 8, for use in association with handover arrangements, including means for continuously periodically measuring the strength of downlink signals received from one base station and the
15 strengths of downlink signals received from a number of selected other base stations, and means for transmitting these measurements to the one base station, in which the measuring means is arranged to measure the strength of downlink signals from the surrounding base stations
20 operating at the same carrier frequency as the one base station.

10. A mobile telephone locating arrangement for a digital cellular telephone network substantially as herein described with reference to Figure 4 of the accompanying
25 drawings.



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11. A mobile telephone for a digital cellular telephone network incorporating a telephone locating arrangement substantially as herein described with reference to Figure 4 of the accompanying drawings.



* C L M S *