Description

A method to improve the radio cell coverage in a cellular mobile radio system and a device to carry out the method

Technical Field

The invention relates to a method to improve the radio cell coverage in a mobile radio system in accordance with the introductory clause of Claim 1. Such a method is known from the WO-A-9107043.

Prior Art

Cellular mobile radio networks are characterised in that the area which is to be supplied is divided into a number of cells, each of which is supplied by a fixed station. There is associated with each cell a channel group which consists of several channels. Channels are understood hereinbelow to mean speech channels, also known as traffic channels (TCH), via which speech- or data connections are effected with mobile stations. Accordingly, the concern here is with duplex radio channels for the two transmission directions, i.e. for example a pair of frequencies with a fixed duplex interval. Channels, and likewise channel groups, can be separated by the criteria of frequency, time, or signal form (code), or by a combination of these criteria. For the description of the method according to the invention it is assumed hereinbelow, without restriction of the generality, that a channel group consists of one or more (duplex-) frequencies, whilst the individual channels are operated on such a frequency in time multiplex. The term "mobile station" comprises all types of apparatus, i.e. also portable and hand-portable subscriber apparatus.

To achieve as high a subscriber capacity as possible, the channel groups are to be able to be re-used as frequently as

possible in the area for different connections, i.e. are to be repeated in cells which are spatially as closely adjacent to each other as possible (frequency repetitions or channel repetitions, also known as channel reuse). Here, on the other hand, it must be ensured that same-channel interferences and hence reciprocal disturbances of conversations do not occur. An arrangement of cells, within which the channel groups associated with the cells are all different with respect to each other, and which can be repeated spatially with the same association of channel groups to cells without gaps in the area, is termed a cluster.

In Figure A, a 7 cluster arrangement is shown, consisting of hexagonal omni-cells. With such an omni-cell arrangement, the omnidirectional transmitters are arranged in each case in the cell centre of the respective cell.

If a mobile station (MS) changes during a connection from one cell into an adjacent cell, then a handover procedure must be carried out by the system. It is termed "passing on" or, more frequently "handover" (also "handoff" in the USA). In conventional networks according to Figure A, such a handover procedure requires simultaneously both the switching over of the connection from one fixed station to another fixed station and also the change from one radio channel of the previous cell to a radio channel of the next call. In so doing, undesired multiple switchovers frequently occur at the cell boundaries, connected with the risk of losing the connection.

It is known that through sectorising of cells, abbreviated to sector cells, with corresponding sector antennae an improvement of the signal-interference relationship can be achieved with the same cluster size, or else a reduction of the cluster size with the same signal-interference relationship. Fig. B and C show examples of clusters with

sector cells.

Fig. C shows a network with 60-degree sector cells. Each hexagonal cell of Fig.A is subdivided by 60-degree directional antennae into 6 triangular sectors, which function as independent cells, and to which in each case their own channel groups are associated. In the illustrated hexagonal 3-cluster, therefore, 18 different channel groups are given. The advantage compared with Fig. A lies in the improved repeatability of the channels through the smaller cluster size of 3 instead of 7, with approximately the same signal-interference relationship. This advantage is, however, partially counteracted again by the poorer beam gain owing to the 18 instead of 7 channel groups. A supply redundancy is not present, i.e. each point of the area is clearly only supplied from one channel group.

Fig. B shows a hexagonal 3-cluster with 9 rhomboid sector cells with 120-degree directional antennae. Each sector cell, as in Fig. C, has its own channel group allocated to it, so that here in the 3-cluster 9 channel groups are required. However, the signal-interference relationship which can be achieved is poorer than in Fig.C, because the main beam direction of identical channel cells lies in a line, whereas in Fig. C they are staggered with respect to each other. In this network, also, there is no supply redundancy.

The arrangement of Fig. A, B and C belongs to the prior art. The corresponding clusters are therefore known.

Outside the clusters 10,13 the same arrangements repeat themselves with homogeneous field intensity distributions, in which the fixed stations 1-9 transmit so that interference disturbances (increasing and interrupting of amplitudes of the same wave length) are avoided.

The arrangement of such clusters 10,13, however, entails the disadvantage that only a small number of channel groups can be made available, which restricts the controllability of a plurality of mobile stations situated in the respective sector cells.

A further disadvantage of the known cluster concept with sector cells and sector antennae arranged in the marginal region of the sector cells is that only an insufficient coverage of the respective sector cell exists from the fixed station arranged in the marginal region. The further the mobile station moves from the fixed station, the poorer does the reception quality become, which, in addition, is impaired by interferences from fixed stations of adjacent cells.

Furthermore, the so-called handover procedure in the known sector cells according to Figure B is made difficult, because with the only insufficient coverage of the sector cells by fixed stations arranged in the marginal region, intensive fluctuations of the receiving field intensity can occur in the mobile station, without this already being handed over to the fixed station of the adjacent sector cell. Therefore, the known handover procedure is relatively uncertain and critical with respect to time.

Representation of the Invention

The invention is therefore based on the problem of further developing a method of the type indicated in the introduction, so that an improved radio cell coverage can be achieved with a simplified and interference-free handover procedure.

To solve the problem which is posed, the invention is characterised by the technical teaching of Claim 1.

It is a feature of the invention that no longer is a single fixed station associated with one cell, but rather that the fixed stations of adjacent cells, which adjoin the first-mentioned cell, likewise transmit into the field of the first-mentioned cell with the same channel group.

Thereby, it is ensured that each mobile station which is situated in a cell is supplied not only from the one fixed station situated in the sector cell itself, but also by the fixed stations of adjacent cells.

No longer is one 120° sector antenna associated with each fixed station, but now 6, which overlap each other in their radiation range by 60° in each case. Each of the 6 sectors of a fixed station has its own channel group associated with it. Sectors facing each other, of adjacent fixed stations, have the same channel group and are synchronised with each other. Each MS is basically always supplied anew by the three fixed stations lying closest. Each channel in each fixed station is provided with an individual output association, in which the respective output of a fixed station is adjusted on this channel in proportion to its contribution at the receiver input of the MS, with the additional limiting condition that the total output at the receiver input lies just above the minimum tolerable signal-interference interval for a defined transmission quality under fading conditions (adaptive output association). The transmissions of each fixed station on each channel are pre-distorted in accordance with a separate subject of the invention so that the transmission path to the MS acts as an antidistortion device. Hence the share of each fixed station at the receiver site is optimally corrected of distortion and the individual shares overlie each other at the same time. The transmissions of each mobile station are basically received in the three fixed stations lying closest and are then supplied to a diversity combining.

This means that a differentiation is made between the fixed stations transmitting on the same channel group as to which fixed station is allowed to transmit with which transmission output into the cell which is to be covered.

If the vehicle is now, for example, in the central region between two fixed stations, but away from the third fixed station, then the output of the individual fixed stations is regulated so that the two fixed stations lying closest to the vehicle transmit with in each case a portion of their output, whilst the third fixed station is switched off.

Hence, the essential advantage exists that an optimum radio cell coverage of the respective cell takes place, because the cell is covered from several sides, which hitherto was not possible.

Also the mobile stations are regulated with regard to output with control from the fixed side, in order to also here maintain the condition regarding the minimum tolerable signal-interference relationship. The parameters for regulating the output can be calculated sufficiently accurately from the respective reception output.

In total with this network configuration a cell pattern results again with abstracted hexagonal cells, which are nested one into another and each of which has its own channel group associated with it.

The cells are covered by in each case three of the six corners by fixed stations and overlap each other reciprocally in each case by one third. Thereby, finally, each such cell is covered by two channel groups.

In such a network there are two forms of handover. Firstly, an implied or "soft" handover, which arises through the

adaptive output assignment on the fixed side, and which the MS does not recognise. It takes place through the flowing transition between the 3 fixed stations which serve one cell with the same channel group. Here at least one or two of the fixed stations, as before, remain taking part in the connection. A channel change does not take place.

Secondly, there is a conventional handover with channel change in the overlapping region between two cells, which therefore always takes place in the fields which as a rule are supplied equally well by two fixed stations on both the old and the new channel and which do not coincide with sector boundaries or conventional radio zone boundaries. Therefore, this handover is neither uncertain nor critical with regard to time.

The output regulation of the fixed stations is determined by means of a mathematical algorithm.

Advantages:

- 3-clusters are produced with a considerable gain in terms of frequency economy.

- The handover procedures run "unnoticed" and completely free of problems.

- The quality of service in accordance with the proposal is substantially higher than in the networks known hitherto.

The subject matter of the present invention can be seen not only from the subject matter of the individual claims, but also from the combination of the individual claims with each other.

Brief Description of the Drawings

The invention is explained hereinbelow with the aid of drawings illustrating merely one form of embodiment. Further features essential to the invention, and advantages of the invention, will emerge here from the drawings and the description thereof.

Figure A: shows omni-cells according to the prior art,

Figure B: shows a sector cell with 120-degree sectors according to the prior art

Figure C: shows triangular cells with 60-degree sectors according to the prior art

Figure 1: shows a hexagonal cell pattern with marginal coverage according to the invention

Figure 2: shows the central cell according to Figure 1 in enlarged representation with further details

Figure 3: shows a network according to the invention with 120-degree sector antennae and hexagonal cells with marginal coverage and multiple overlap according to the invention

Figure 4: shows handover with channel change in the overlapping region of two cells according to the invention

Figure 5: shows occupation of the antennae with six channel groups with a 3-cluster according to the invention.

Figures A, B and C were already described in the introduction to the description as cluster concepts belonging to the prior art. According to Figure B it is known, for example, that the fixed stations 1,2,3,4 shown there emit to the sector cells 20 to 33 with a single sector antenna and at an angle of 120 $^{\circ}$, which involves the

disadvantage that - the further the vehicle moves in the respective sector cell 20-23 away from the associated fixed station 1-4 - the poorer the reception quality becomes.

The more the vehicle draws close to another fixed station in an adjacent sector cell, the greater is the danger, then, that interferences will arise between the channel group in the one sector cell (e.g. the sector cell 20) and the same channel group in a sector cell of an adjacent cluster (e.g. sector cell 20a).

According to the invention, in accordance with Figure 1 a novel cell concept is proposed, which operates for example with six antennae overlapping in each case by 60 , in which the antennae associated with antenna beams of each fixed station 1,2,3 are only illustrated diagrammatically in Figure 1.

Figure 1 is intended to show that - when a mobile station is situated for example in the cell 20 - this mobile station (vehicle 34 - figure 3) is not only supplied from the fixed station 1 associated directly with the cell 20, but in addition also from the fixed station 2 and thirdly also from the fixed station 3.

In an analogous manner, this concept applies to all the other adjacent cells 22,24,25,26.

Way to Carry Out the Invention

With the aid of an example embodiment with sector antennae, which emit with a sector angle 2 of 120° , the example illustrated diagrammatically in Figure 1 is to be explained in further detail with the aid of Figure 2 and 3.

Here it is assumed, for the sake of simplification in the drawing, that six antennae A,B,C,D,E,F are present and each

of the antennae A-F sweeps over a sector angle a-a or b-b or c-c and so on up to f-f.

The fixed station 1 associated with the cell 20 consequently has six antennae, which transmit, uniformly distributed on the circumference of a full circle, and consequently not only transmit into the cell 20, but likewise into the adjacent cells 25 and 26. It additionaly supplies three further cells, the hexagonal delimitation of which is illustrated in Figure 3 with broken lines, and two of which overlap the central cell 20 in each case by one third.

The same applies to the fixed stations 2 with their sector antennae, which likewise not only emit into their own cell 21 but also into the cell 20 and into the adjacent cell 22. This fixed station 2 also additionally supplies three further overlapping cells.

This also applies to the fixed station 3 in an analogous manner.

It can be seen from this - in relation to the cell 20 which is to be observed - that a vehicle 34 situated in the cell 20 is supplied with transmission energy from three different fixed stations 1 - 3.

In total thereby using six channel groups two 3-clusters are formed inserted one into another and overlapping each other reciprocally, which are displaced against each other about a cell radius, as illustrated in Figure 3. Here, it is to be pointed out that the network according to the invention has the same number of fixed stations as the known arrangements of Figures A, B and C, i.e. manages without an increase in the number of positions.

The number of possible frequencies is now achieved through the described overlapping of the antennae A-F. Each antenna

A-F transmits with a sector angle 27-32, which is indicated in the example embodiment with 120° . In another form of embodiment, this sector angle can also amount to 90° (with a reciprocal overlapping of 45°) or 60° (with a reciprocal overlapping of 30°).

In the example of Figure 2, it is set forth with regard to the fixed station 1 that for example the antenna A overlaps with the antenna B in the overlapping region 38. Likewise the antenna A overlaps with the antenna F in the overlapping region 37.

An overlapping is therefore possible because the antenna A transmits with a different frequency from for example the antenna B or the antenna F. Thereby, the number of possible calls in the field of the cell 20 is greatly increased, because both with the one channel group one has for example 16 speech channels available, and also with the other channel group, which likewise transmits into the cell 20.

It goes without saying that the same conditions must also exist for the other sector antennae of the fixed stations 2,3. This means, in relation to the fixed stations 2, the antennae C with B and C with D overlap each other with respect to the cell 20 and it goes without saying that these antennae transmit in each case on the same channel group as the antennae previously described with the example of the fixed station 1, in order to supply a vehicle situated in the field of the cell 20 uniformly with the respectively produced transmission frequencies.

The same statements additionally apply to the sector antennae of the fixed station 3.

With the aid of Figure 4, a so-called handover procedure is to be explained on transition from one cell 20 into an adjacent overlapping cell.

Here it is assumed that the vehicle 34 is situated approximately in the central region between the two fixed stations 1,2 and is furthest away from the fixed station 3. Between the said fixed stations 1,2,3 an arrangement takes place with the aim of establishing which of the fixed stations is authorized with which output, to communicate with the mobile station (vehicle 34). Since the vehicle 34 receives the strongest the transmission beams 18,19 from the fixed stations 1,2 and only receives the transmision beam 36 from the fixed station 3 weakly, the fixed station 3 is switched off, whilst the other two fixed stations 1,2 in each case transmit with approximately 1/3 of their available output. "Available output" is defined here as an output which would be sufficient to supply with a single fixed station the entire range of the cell 20, for instance with a central arrangement according to Figure A.

According to the method in accordance with the invention, within a hexagonal cell the passing on of a connection from one fixed station to another is brought about on the radio path through the adaptive ouput association set forth above, without a change of the radio channel having to be undertaken.

The output association is determined by means of a mathematical algorithm.

If the mobile station (vehicle 34) moves from one cell into an adjacent overlapping cell, a handover is carried out with a channel change. In Figure 4, the cell 20 supplied by the fixed stations 1,2,3 is laterally delimited by the two edges 16 and 17, whilst the adjacent overlapping cell, which is supplied by the fixed stations 1, 2 and 4 extends with the edges 14 and 15 into the cell 20.

In the transition region between these two cells, a handover

zone 33 is therefore produced, which owing to the transmission beams 18,19 of the fixed stations 1,2 is constructed approximately in the shape of an ellipse. The vehicle 34 moves here in arrow direction 35 out of the cell 20 in the direction of the fixed station 4.

This movement is established by the monitoring between the individual fixed stations 1,2,3 and the transmission beam 36 of the fixed station 3 is interrupted, whereby the mobile station 34 is only then still supplied by the fixed stations 1,2 in approximately identical proportions.

In this expanded ellipsoid field, a handover can now be undertaken with a change of the radio channel. It therefore always takes place in fields which as a rule are supplied equally well from two fixed stations on both the old and the new channel and which do not coincide with sector boundaries or conventional cell boundaries. Therefore, this handover procedure according to the method in accordance with the invention, in contrast to previous networks, is reliable and non-critical with regard to time, and is not bound to exact locations. In this way, the undesired multiple switchovers can also be avoided. Of course, the described sequence applies in the same manner for any desired directions of movement of a mobile station and its transition into any other adjacent overlapping cell.

In addition to the reliability of this procedure, it is to be mentioned as a further advantage that the boundaries within which the channel group of one cell is actually used, are reduced to the - by sectors - approximately ellipsoid outer handover boundaries between two fixed stations in each case, as they are drawn in Figure 4 between the fixed stations 1 and 2. Thereby the signal-interference relationships in the network are additionally improved.

Figure 5, finally, shows the allocation of the six channel

groups 1 to 6 necessary for a 3-cluster, to the 120-degree sector antennae of the fixed stations FS1 to FS3 in such a 3-cluster which is able to be continued with respect to area. Here, the FS 1' have the same antenna occupancy as FS 1. This applies accordingly to the FS 2' and FS 3'.

Commercial Applicability

Finally, the following are mentioned as essential advantages of a network according to individual or several claims in accordance with the invention:

- improvement to the reliability of supply through multiple overlapping

- reducing the transmission outputs of fixed stations and mobile stations through transmitter- and receiver diversity on the fixed side

- improvement to the signal-interference relationships in the network, which can be converted into a reduction of the same channel repetition interval

- reliable handover procedure which is uncritical with regard to time and location, without the risk of loss of existing connections

- better employment of the channels (beam gain) through smaller number of channel groups, i.e. more channels per channel group, and through supply redundancy.

These features lead to a substantial increase in the frequency economy, i.e. the number of subscribers able to be dealt with in a limited available frequency band, and an improvement to the quality of service offered to the subscribers through improved supply and reliable handover sequences, without resulting in an increase in the number of

fixed stations.

Legend to the Drawing

1 fixed station
2 "
3 "
4 "
5 "
6 "
7 "
8 "
9 "
10 cluster
12 sector angle
13 cluster
14 edge
15 edge
16 edge
17 edge
18 transmission beam
19 transmission beam
20 cell
20a same channel cell
21 cell
22 cell
23 cell
24 cell
25 cell
26 cell
27 sector angle antenna A
28 sector angle antenna B
29 sector angle antenna C
30 sector angle antenna D
31 sector angle antenna E
32 sector angle antenna F
33 handover zone
34 vehicle (mobile station)
35 arrow direction

36 transmission beam
37 overlapping region
38 overlapping region

Claims

1. A method to improve the radio cell coverage in a cellular mobile radio system, in which a number of adjacent and adjoining cells (20-26) form a cluster (10,13), in which in the marginal region of each cell (20) at least one fixed transmitter (1) is arranged with at least one sector antenna, which sweeps over at least the region of this cell (20) with radio frequencies of a channel group, characterised in that the fixed transmitters (2,3) of adjacent cells (21,23) immediately adjoining a cell (20), with the same channel group, like the fixed transmitter (1) of the cell (20) itself which is to be supplied, transmit into this cell (20).

2. A method according to Claim 1, characterised in that the fixed transmitters (1,2,3) are synchronised with each other.

3. A method according to one of Claims 1or 2, characterised in that each mobile station (vehicle 34) which is situated in one of the cells (20-26), is supplied by at the most three different fixed stations (1,2,3) simultaneously.

4. A method according to one of Claims 1 to 3, characterised in that each channel transmits in each fixed station (1,2,3) with an individual, adjustable output, in which the respective output of a fixed station (1,2,3) on this channel is adjusted in proportion to the share of the transmission output of this fixed station (1,2,3) at the receiver input of the mobile station (vehicle 34).

5. A method according to one of Claims 1 to 3, characterised in that each channel in each fixed station (1,2,3) transmits with an individual, adjustable output, in which the respective output of a fixed station (1,2,3) on this channel is adjusted in proportion to the received output from the mobile station (vehicle 34) at the receiver

input of this fixed station (1,2,3).

6. A method according to one of Claims 4 or 5, characterised in that the transmission output of the fixed stations (1,2,3) is adjusted so that their total output at the receiver input of the mobile station (vehicle 34) lies just above the minimum tolerable signal-interference interval for a defined transmission quality with fading.

7. A method according to one of Claims 1 to 6, characterised in that the transmissions of a mobile station (vehicle 34) are received by the fixed station (1) of the cell (20) in which the mobile station (vehicle 34) is situated and by the fixed stations (2,3) of the adjoining cells and that between these fixed stations (1,2,3) a balancing of the transmission outputs takes place such that the fixed stations which lie closest to the vehicle (34) transmit with a portion of their outputs, whilst the fixed stations which are at a distance from the mobile station (vehicle 34) transmit with a smaller portion of their output or are completely switched off.

8. A method according to one of Claims 1 to 7, characterised in that the transmissions of a mobile station (vehicle 34) are received by the fixed station (1) of the cell, in which the mobile station (vehicle 34) is situated, and by the fixed stations (2,3) of the adjoining cells (21,23) and that these received signals are subjected to a diversity combining to improve the quality.

9. A method according to one of Claims 1 to 8, characterised in that the handover procedure of a mobile station (vehicle 34) takes place in the connection state from one sector of a cell (20) to an adjacent sector of this cell through an adaptive output assignment of the fixed station (1,2,3) which covers the cell.

10. A method according to one of Claims 1 to 9, characterised in that the handover procedure of a mobile station (vehicle 34) takes place in the connection state from one cell to an adjacent cell through a channel change, such that at least one of the fixed stations (1, or 2, or 3, or 1 and 2, or 1 and 3, or 2 and 3) takes part in the connection both before and after the handover procedure.

11. A device for radio cell coverage in a cellular mobile radio system, consisting of one or more cells, in each case forming a cluster, where in the marginal region of each cell in each case at least one fixed station is arranged, which has at least one sector antenna which sweeps over at least the region of this cell (20) with a channel group, characterised in that there are associated with each fixed station (1 to 9) several sector antennae (A to F), which at least partially overlap each other in their transmission range, which is delimited by sectors, and which together sweep over at least a range of 360 ,in which there is associated with each of the sectors of a fixed station its own channel group and sectors of adjacent fixed stations which face each other have the same channel group and are synchronised with each other.

12. A device according to Claim 11, characterised in that there are associated with the fixed station (1 to 9) in total six sector antennae (A to F) with in each case a sector angle (27 - 32) of 120° and that the transmission ranges of the sector antennae (A t F) overlap each other by 60° in each case.

13. A device according to Claim 11, characterised in that there are associated with the fixed station (1 to 9) in total eight sector antennae with in each case a sector angle of 90° and that the transmission ranges of the sector antennae overlap each other in each case by 45° .

14. A device according to Claim 11, characterised in that there are associated with the fixed station (1 to 9) in total twelve sector antennae with in each case a sector angle of 60° , and that the transmission ranges of the sector antennae overlap each other in each case by 30° .

15. A device according to one of Claims 11 to 14, characterised in that the transmission output of each channel is able to be adjusted in each fixed station (1,2,3) as a function of the received output from the mobile station (vehicle 34) at the receiver input of this fixed station (1,2,3), and is adjusted in relation to the respective transmission output of this mobile station.

16. A device according to one of Claims 11 to 15, characterised in that each fixed station (1 to 3) only transmits with a fraction of the output which would be necessary to supply the entire cell (20) with transmission output.