

Cellular mobile station system

Field of the invention

5 The invention relates to a cellular mobile station system wherein a handover decision is based on measuring downlink transmissions of a serving cell and neighbouring cells by a mobile station. Adjacent cells are typically arranged to be in a partially overlapping configuration so as to ensure there is a sufficient
10 period of time for the reception and decoding of the downlink transmissions of the neighbouring cells for a handover decision.

Background of the invention

15 In cellular mobile station systems a mobile station, in which a call is established, that is, which is using a traffic channel, measures constantly the quality and/or the strength of the downlink signal from a serving base station. The serving base station also
20 informs the mobile station of the neighbouring cells/base stations and of their control channel frequencies. On the basis of this information, the mobile station is able to measure also the control channel frequencies of the neighbouring base stations
25 during a call. The measuring results are stored into the mobile station and/or are transmitted to the mobile station network for the handover decision depending on whether the handover decision is made by the mobile station or by the mobile station network. A handover
30 refers to a switching of a call from one new traffic channel to another during a call.

 The base stations of the cellular network constantly broadcast information about themselves and their surroundings. This information includes a cell or
35 base station identifier based on which the mobile

station is able to identify the neighbouring cell to be measured. The cell or base station identifier is also transmitted to the cellular network in possible measuring reports. The mobile station has to decode the cell or base station identifier of a neighbouring cell before this cell can be used as a potential target cell for a handover. In order that the mobile station would have a sufficient period of time to decode the cell or base station identifier and that way allow the handover, the adjacent cells of the cellular mobile station system must have overlapping areas. Besides the acceptable decoding time of the cell or base station identifier, the size required of the overlapping area of two adjacent cells depends, e.g. on the speed of the mobile station and the parameters of handover algorithm, such as, the size of the time window used for averaging the measured signal levels of the neighbouring cell, for example.

If the overlapping area of two adjacent cells is so small that the handover cannot be made, the call is lost. One reason for a lost call is an undecoded cell or base station identifier of the neighbouring cell. The overlapping requirement of cells is significant especially in microcells in which the diameter is some hundreds of metres. It is, however, difficult to arrange a sufficiently large overlapping area in places where terrain obstacles, buildings or the like obstacles obstructing the propagation of radio signals are shadowing the transmission of the neighbouring cell. Such problematic places are found for example in tunnels, at street corners and inside buildings. For example, when a mobile station comes fast out of a tunnel, the neighbouring cell outside the tunnel may develop an immediate need for a handover but the cell or base station identifier of the neighbouring

cell outside the tunnel is undecoded and the call is lost because a handover to the neighbouring cell cannot be made. This situation is illustrated in more detail by means of an example with reference to Figure 1.

5 In Figure 1 the serving cell is indicated with a reference S and the neighbouring cell with a reference A. The serving cell is for example obstructed by a tunnel 3 so that cell S extends somewhat outside the tunnel at the opening of the tunnel. The
10 neighbouring cell A is a cell outside the tunnel and the radio coverage of cell A does not extend essentially inside the tunnel. Thus, cells S and A have a very small overlapping area OA. A mobile station MS measures all the neighbouring cells specified for the
15 serving cell S and transmits the measuring results to the cellular network. The measuring result includes, e.g. the field strength of the downlink signal of the neighbouring cell and the cell or base station identifier of the neighbouring cell. This information
20 on the neighbouring cell is transmitted to the cellular network if the mobile station is able to receive the downlink signal of said cell. When the MS reaches the radio coverage of cell A in position (1), it can receive the downlink signal of cell A and start
25 decoding the cell or base station identifier of cell A. As it has not yet been possible for the mobile station MS to decode the cell or base station identifier, the information on the neighbouring cell is insignificant in the measuring result as it cannot be made certain
30 that the measurements concern the correct cell, for which reason the neighbouring cell cannot be used as a target cell in a case of a handover. In position (2) the cellular network detects the need for a handover for example due to the low reception level of the serving
35 cell S. If the overlapping area OA of cells S and A is

so small that the mobile station MS reaches the coverage area of cell S at position (2) before the base station identifier of the neighbouring cell A is decoded, a handover to cell A cannot be made and the call will be lost.

At present in cellular systems there are some solutions for eliminating this problem. The size of the cell can be enlarged and antennas can be directed so that required cell overlapping is achieved. These solutions cause some other problems, especially in network planning. The enlargement in the coverage area of cell S can cause co-channel interference in some parts of the network. In a case in which the coverage area of cell A is enlarged, the advantage gained by microcells is lost besides which co-channel interference may occur. The openings produced by directing the antenna of cell A towards cell S have to be filled from other cells.

Disclosure of the invention

The object of the present invention is a new method for relieving or eliminating the problem mentioned above.

This is achieved with a cellular mobile station system disclosed in the preamble which is according to the invention characterized in that a first cell, in which terrain obstacles, buildings, tunnels or the like obstacles obstructing the propagation of radio signals are shadowing the downlink transmission of one of the neighbouring cells so that overlapping is not sufficient between said first cell and said one of the neighbouring cells, is provided with a repeater or an antenna of said one of the neighbouring cells which extends in said first cell the coverage area of the downlink transmission of said one

of the neighbouring cells for an advanced transmission and decoding of the downlink transmission of said one of the neighbouring cells.

The basic idea of the present invention is to
5 render it possible for a mobile station to detect a neighbouring cell and decode a cell identifier, such as a base station identifier before the mobile station can listen to the actual downlink transmission of the neighbouring cell. Because of this, the size
10 requirements of the overlapping areas of cells are not as great in relation to the actual coverage areas as especially in the microcell areas of the prior art solutions. The advanced detection and decoding of a neighbouring cell according to the invention is brought
15 about by extending the coverage area of the neighbouring cell to the area of the cell serving only in the downlink direction in which the obstacles obstructing the propagation of radio signals are shadowing the downlink transmission of the neighbouring
20 cell. As the object of the extension of the neighbouring cell is only to prepare for a fast handover, an equivalent extension need not be made in the uplink direction. The advanced detection of a neighbouring cell and the decoding of the base station
25 identifier according to the invention allow the neighbouring cell to be selected as a potential target cell of a handover even before arriving in the actual coverage area of the neighbouring cell and thereby ensuring a fast handover and maintaining the call even
30 if there would not be enough time to decode the base station identifier from the actual downlink transmission of the neighbouring cell. The invention can be implemented over existing network planning without having to change the cells of the existing
35 network planning in any way. This is a significant

advantage, because especially in a microcell environment, it is difficult to redo network planning, for example, the extension of cells may disturb other microcells.

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Brief description of the drawings

The invention is described in more detail by means of preferred embodiments with reference to the accompanying drawings, in which

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Figure 1 illustrates a handover situation in a mobile station system of the prior art when moving from a cell inside the tunnel to a cell outside the tunnel,

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Figure 2 illustrates a cellular mobile station system in which the extension of the downlink direction of the neighbouring cell according to the invention is accomplished in the tunnel cell.

Preferred embodiments of the invention

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The present invention is applicable to any cellular mobile station network in which the mobile station performs the measuring of neighbouring cells for handover and requires sufficient overlapping of the coverage area of the cells so as to ensure there is a sufficient period of time for the reception and decoding of the downlink signal of the neighbouring cell. In the following, the invention will be described by using the GSM mobile station system as an example without restricting the invention thereto.

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GSM (Global System for Mobile Communications) is a pan-European digital mobile station system. Figure 2 discloses only some basic structures of the GSM system, without further specifying the properties and other parts of the system. With regard to a more detailed description of the GSM system, a reference is

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made to the GSM Specifications and to *The GSM System for Mobile Communications*, by M. Mouly & M. Pautet, Palaiseau, France, 1992, ISBN:2-9507190-0-0-7.

5 A mobile services switching centre MSC attends to the switching of incoming and outgoing calls. It performs similar tasks to a public switched telephone network centre. In addition to the above, it performs functions characteristic of only mobile telephone traffic, such as subscriber location management. Mobile
10 radio stations or mobile stations MS are connected to the centre MSC by means of base station systems BSS. The base station system BSS comprises a base station controller BSC and base stations BTS. One base station controller BSC is used for controlling several base
15 stations BTS. A function of the BSC is e.g. handovers in cases in which a handover is made inside the base station or between two base stations that are both under the control of the same BSC. For the sake of clarity, only one base station system BSS is shown in
20 Figure 2 in which two base stations BTS1 and BTS2 are connected to the base station controller BSC. The radio coverage areas of the base stations comprise corresponding radio cells S and A.

The mobile station MS with an ongoing call
25 constantly measures the quality or level of the signal received from the serving cell and the reception level of the control channel frequencies of neighbouring cells in order to prepare for handovers. The serving cell notifies the mobile station which neighbouring
30 cells it should measure. In the GSM system, the control channel carrier waves the mobile stations listen to and measure are called broadcast control channels BCCH. In order that the mobile station MS could distinguish the cell with the same BCCH carrier wave, a base station
35 identity code BSIC is included in the BCCH

transmission. It is possible that the MS receives in some cases two BCCH transmissions from different cells on the same carrier wave frequency. As was mentioned earlier, the mobile station MS is provided with a list of the carrier wave frequencies it should observe for measuring neighbouring cells. In a report message, which the mobile station regularly transmits to the serving base station BTS and which contains at most the measuring results of six neighbouring cells, the mobile station has to inform the BSIC of every measured BCCH carrier wave on which it reports measuring results. This means that the mobile station has to decode a synchronization channel SCH on the BCCH carrier wave to find out the BSIC of the neighbouring cell. The base station controller BSC, to which the base station BTS transmits the measuring reports from the mobile station MS, is able to check in uncertain cases which cell has actually been measured. If the BSIC of the BCCH carrier wave has not been decoded, the measuring results of said BCCH carrier wave will not be reported further and the neighbouring cell related thereto cannot be selected as a potential target cell of handover.

In the cellular system of Figure 2, cell S of the base station BTS1 is a cell obstructed inside a tunnel 23 the coverage area of which extends only a little outside the opening of the tunnel. Correspondingly, cell A of the base station BTS2 is a cell outside the tunnel 23 the coverage area of which does not at all extend inside the tunnel 23. Thus the overlapping area OA of cells S and A is very small and it does not provide the mobile station MS with enough time in all situations to measure and decode the BCCH carrier wave of the base station BTS2 when the mobile station MS is moving from the tunnel to the overlapping area OA. This may be followed by a handover failure and

a loss of the call, as was explained in connection with Figure 1.

In accordance with the invention, an extended coverage area A' is formed for the downlink BCCH signal inside cell S in the area in which the tunnel 23 obstructs the extent of the actual coverage area A of the base station BTS2. This extension area A' is achieved with a repeater and a directional antenna 22 which are positioned inside the tunnel 23 and cell S outside cell A. The repeater and antenna 22 are connected to the base station BTS2 by means of a cabling 21. The downlink BCCH signal of cell A is transmitted in the extension area A' at such a level that the mobile station in this area can decode the identifier BSIC of cell A. Further, the repeater and antenna 22 are positioned so that cell A and the extension A' do not significantly cause any disturbance to one another. The position of the repeater and antenna 22 in the extension area A' can be found by measuring the signal level of cell A, for example.

In the following, the effect of the extension area A' on handover is examined by means of an example. It is first assumed that the mobile station MS is connected to the serving cell S. When the mobile station MS moves towards the neighbouring cell A, it will reach the extension area A' of the neighbouring cell at position (3). At this position the mobile station MS is able to receive the BCCH carrier wave of cell A which is transmitted through the repeater and antenna 22 and thus is ready to start decoding the BSIC. When the BSIC is decoded, the MS will store the BSIC. When this BCCH carrier wave is no longer among the six strongest carrier waves, the BSIC should be retained for at least 10 seconds in compliance with the GSM Specification 0508. This time is equivalent to a

distance of about 140 metres at a speed of 50 km/h. When the mobile station MS reaches the actual coverage area of the neighbouring cell A at position (1), the identifier BSIC of the neighbouring cell A is already
5 decoded because of the extension area A'. Therefore in the case of a handover, cell A can be regarded as a possible target cell. If the mobile station MS moves fast in the area of cells S and A, it is possible to maintain the BSIC stored in the memory as long as is
10 needed for moving from the area A' to the area A. If the mobile station MS moves slowly, it can lose the BSIC information between the areas A' and A but decode it again in the overlapping area OA of cells S and A. The mobile station transmits measuring reports via the
15 base station BTS1 to the base station controller BSC.

The base station controller BSC detects a need for a handover at position (2). This need can be detected for example on the basis of the low reception level of the serving cell S. When the need for a
20 handover is detected, the call is transferred to a suitable neighbouring cell. In this case, the target cell is cell A which has been found to be a suitable neighbouring cell for a handover. This means that cell A has been identified by means of BSIC decoding and the
25 reception level of cell A is sufficient for maintaining the call.

The invention is above described by using as an example cell S positioned in the tunnel. The invention is not in any way restricted to this example,
30 but it can be applied in any shadow area of the network to eliminate the same problem. Cell S can for example be a cell inside a building and cell A a cell outside the building at the entrance. In that case, the extension area A' can be situated inside the building
35 in the lobby before the entrance, for example. Further,

cell S can be a cell inside a multi-storey car park and cell A a cell inside the car park at the entrance. In that case, the extension area A' can be situated inside the car park before the exit, for example. Further,
5 cell S can be a cell between tall buildings covering the street between them and cell A a cell covering an intersecting street.

When needed, the extension area can be formed by using one antenna, several antennas, a combination
10 of an antenna and a repeater, a leaking (radiating) cable or any equipment with which a suitable type of downlink extension area is achieved in each special case.

The figures and the explanation related thereto are only meant to illustrate the present
15 invention. It is to be understood that changes can be made to the disclosed cellular system without deviating from the spirit and scope of the accompanying claims.



Claims

1. A cellular mobile station system wherein a handover decision is based on measuring downlink transmissions of a serving cell (S) and neighbouring cells (A) by a mobile station and wherein cells are typically arranged to be in a partially overlapping configuration (OA) so as to ensure there is a sufficient period of time for the reception and decoding of the downlink transmissions of the neighbouring cells and for a handover decision, characterized in that a first cell (S), in which terrain obstacles, buildings, tunnels or the like obstacles (3,23) obstructing the propagation of radio signals are shadowing the downlink transmission of one of the neighbouring cells (A) so that overlapping (OA) is not sufficient between said first cell and said one of the neighbouring cells, is provided with a repeater or an antenna (22) of said one of the neighbouring cells which extends in said first cell (S) the coverage area (A') of the downlink transmission of said one of the neighbouring cells (A) for an advanced transmission and decoding of the downlink transmission of said one of the neighbouring cells.

2. A cellular mobile station system according to claim 1, characterized in that the extended downlink coverage area (A') of said one of the neighbouring cells allows an advanced decoding of the downlink signal of said one of the neighbouring cells and thereby an advanced recognition of said one of the neighbouring cells as a potential target cell for a handover before arriving in the actual coverage area (A) of the neighbouring cell.

3. A cellular mobile station system according to claim 1 or 2, characterized in that the



extended downlink coverage area (A') and the actual coverage area (A) are separate from one another.

5 4. A cellular mobile station system according to claim 1, 2 or 3, c h a r a c t e r i z e d in that said first cell (S) is a cell inside a building and said one of the neighbouring cells (A) is a cell outside the building.

10 5. A cellular mobile station system according to claim 1, 2 or 3, c h a r a c t e r i z e d in that said first cell (S) is a cell inside a tunnel and said one of the neighbouring cells (A) is a cell outside the tunnel.

15 6. A cellular mobile station system according to any of the preceding claims, c h a r a c t e r i z e d in that the antenna (22) is a leaking cable.