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Contents

Foreword

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1 Scope

The present document gives examples for the Radio sub-system link control to be implemented in the Base Station System (BSS) and Mobile Switching Centre (MSC) of the GSM and DCS 1 800 systems in case hierarchical cell structures are employed.

Unless otherwise specified, references to GSM also include DCS 1 800, and multiband systems if operated by a single operator.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
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[1] 3GPP TS 03.22 (ETS 300 930): "Functions related to Mobile Station (MS) in idle mode and group receive mode".

[2] 3GPP TR 03.30 (ETR 364): "Radio network planning aspects".

[3] 3GPP TS 45.008: "Radio subsystem link control".

[4] 3GPP TR 01.04 (ETR 350): "Abbreviations and acronyms".

3 Abbreviations

Abbreviations used in the present document are listed in 3GPP TR 01.04 [4].

4 General

ETS 300 911 (GSM 05.08 [3]) specifies the radio sub system link control implemented in the Mobile Station (MS), Base Station System (BSS) and Mobile Switching Centre (MSC) of the GSM and DCS 1 800 systems of the European digital cellular telecommunications system (Phase 2).

The present document gives several examples of how the basic handover and RF power control algorithm as contained in (informative) annex A to ETS 300 911 [3] can be enhanced to cope with the requirements on the radio subsystem link control in hierarchical networks.

A hierarchical network is a network consisting of multiple layers of cells, allowing for an increased traffic capacity and performance compared to a single layer network.

The radio sub-system link control aspects that are addressed are as follows:

- Handover;
- RF Power control.

5 Hierarchical networks

5.1 General

In a hierarchical, or microcellular network, traffic is supported on multiple layers of cells. Typically, a network operator could implement a layer consisting of microcells as a second layer in his existing network consisting of large or small cells. The addition of this second layer would improve the capacity and coverage of his network.

In the present document the following naming convention is used for the different layers. For a network consisting of three layers the layer using the biggest cells is the "upper layer", followed by the "middle layer", and then the "lower layer" which has the smallest cells. For a network consisting of two layers, only "upper layer" and "lower layer" are used.

The intention in a hierarchical network is to use the radio link control procedures to handle the majority of the traffic in the lower layer, i.e. the smallest cells, as this will limit interference and therefore improve the frequency reuse.

However, a part of the traffic cannot always efficiently be handled in the lower layer. Examples are cases where the MS is moving fast (relative to the cell range), or where the coverage is insufficient, or where a cell to make a handover to on the same level may not be available fast enough (going around corners, entering/leaving buildings).

5.2 Cell types

GSM 03.30 [2] distinguishes between three kinds of cells: large cells, small cells and micro cells. The main difference between these kinds lies in the cell range, the antenna installation site, and the propagation model applying:

5.2.1 Large cells

In large cells the base station antenna is installed above the maximum height of the surrounding roof tops; the path loss is determined mainly by diffraction and scattering at roof tops in the vicinity of the mobile i.e. the main rays propagate above the roof tops; the cell radius is minimally 1 km and normally exceeds 3 km. Hata's model and its extension up to 2 000 MHz (COST 231-Hata model) can be used to calculate the path loss in such cells (GSM 03.30 [2] annex B).

5.2.2 Small cells

For small cell coverage the antenna is sited above the median but below the maximum height of the surrounding roof tops and so therefore the path loss is determined by the same mechanisms as stated in subclause 5.1.1. However large and small cells differ in terms of maximum range and for small cells the maximum range is typically less than 1-3 km. In the case of small cells with a radius of less than 1 km the Hata model cannot be used.

The COST 231-Walfish-Ikegami model (see GSM 03.30 [2] annex B) gives the best approximation to the path loss experienced when small cells with a radius of less than 5 km are implemented in urban environments. It can therefore be used to estimate the BTS ERP required in order to provide a particular cell radius (typically in the range 200 m - 3 km).

5.2.3 Microcells

COST 231 defines a microcell as being a cell in which the base station antenna is mounted generally below roof top level. Wave propagation is determined by diffraction and scattering around buildings i.e. the main rays propagate in street canyons. COST 231 proposes an experimental model for microcell propagation when a free line of sight exists in a street canyon (see GSM 03.30 [2]).

The propagation loss in microcells increases sharply as the receiver moves out of line of sight, for example, around a street corner. This can be taken into account by adding 20 dB to the propagation loss per corner, up to two or three corners (the propagation being more of a guided type in this case). Beyond, the complete COST231-Walfish-Ikegami model as presented in annex B of GSM 03.30 [2] should be used.

Microcells have a radius in the region of 200 to 300 metres and therefore exhibit different usage patterns from large and small cells.

6 Idle mode procedures

GSM 03.22 [1] outlines how idle mode operation shall be implemented. Further details are given in Technical Specifications GSM 04.08 and GSM 05.08 [3].

A useful feature for hierarchical networks is that cell prioritization, for Phase 2 MS, can be achieved during cell reselection by the use of the reselection parameters optionally broadcast on the BCCH. Cells are reselected on the basis of a parameter called C2 and the C2 value for each cell is given a positive or negative offset (CELL_RESELECT_OFFSET) to encourage or discourage MSs to reselect that cell. A full range of positive and negative offsets is provided to allow the incorporation of this feature into already operational networks.

The parameters used to calculate C2 are as follows:

a) CELL_RESELECT_OFFSET;

b) PENALTY_TIME;

When the MS places the cell on the list of the strongest carriers as specified in GSM 05.08 [3], it starts a timer which expires after the PENALTY_TIME. This timer will be reset when the cell is taken off the list. For the duration of this timer, C2 is given a negative offset. This will tend to prevent fast moving MSs from selecting the cell.

c) TEMPORARY_OFFSET;

This is the amount of the negative offset described in (ii) above. An infinite value can be applied, but a number of finite values are also possible.

The permitted values of these parameters and the way in which they are combined to calculate C2 are defined in GSM 05.08 [3].

7 Examples of handover and RF power control algorithms.

7.1 General

In the following annexes four examples of handover and power control algorithms are presented. All of these are considered sufficient to allow successful implementation in hierarchical or microcellular networks. None of these solutions is mandatory.

The "**Description of algorithm**" of each annex, contains a text as provided by the authors of the algorithm. Any discussion on the algorithms is contained in a separate clause, "**Discussion of algorithm**".

Annex A (informative): Example 1 (Siemens AG)

Description of algorithm

Source: Siemens AG

Date: 23.08.95

Subject: Fast Moving Mobiles

A.1 Introduction

This annex specifies an enhanced handover algorithm that may be implemented in GSM or DCS 1 800 hierarchical networks. In accordance with clause 5 of this annex a hierarchical network is understood as a network utilizing large cells for the upper layer for wide area coverage, and a lower layer structure of small or micro cells for capacity reasons. For the sake of simplicity the algorithm is described for hierarchical networks consisting of two layers. Nevertheless the algorithm can be extended to a hierarchy comprising several layers.

The algorithm is based upon the basic handover process, as described in GSM 05.08 [3], annex A. Only differences and supplements to the standard algorithms are explicitly described.

The aim of this annex is to show, how in hierarchical networks useless handovers can be avoided by allocating the mobiles, according to their speed, to the appropriate cell type. This goal is achieved by steering the fast mobile stations to the upper layer structure (e.g. large cells), while ensuring that slow mobile subscribers are served by the lower layer structure (e.g. small or micro cells). A mobile station is considered as fast, if its sojourn time in a cell is short compared to a mean call holding time.

An important aspect of this advanced algorithm is, that there is no implication on the MS type. The procedures described in this annex, work in the same manner for Phase 2 as well as Phase 1 MS types.

A more comprehensive description of the advanced algorithm along with some investigation results based on handover emulations in typical mixed cell scenarios is given in "Mobile Speed Sensitive Handover in a Mixed Cell Environment" (see Bibliography).

A.2 Functional requirements

The present algorithm is based on the following additional assumptions:

- the upper layer structure (e.g. large cells) provides a contiguous wide area coverage for all MS power classes to be supported by the network;
- the lower layer structure (e.g. small or micro cells) is fully embedded in the coverage area of upper layer structure (e.g. large cells);
- the algorithm is based on both a power budget and absolute level criterion. Therefore both criteria shall be enabled simultaneously, giving a higher priority to the absolute level criterion.

A.3 BSS pre-processing and threshold comparisons

A.3.1 Measurement averaging process

In a mixed cell environment one should take into account the different propagation conditions in large and small or micro cells, and the requirement for speeding up the handover decision, when a handover out of a small cell is pending (especially, with the street corner effect in micro cells), an excessive delay of the handover detection can cause a loss of the connection. Regarding this, the following items are recommended:

a) apply different values for the averaging parameters in large and small or micro cells, respectively;

b) define separate averaging parameters applicable to RXLEV and RXLEV_NCELL(n), respectively;

c) the BSS shall evaluate the Power Budget PBGT(n) using the averaging process defined for RXLEV_NCELL(n).

A.3.2 Handover threshold comparison process

The Handover threshold comparison process is similar to the process described in GSM 05.08 [3], annex A, except for section e) in A.3.2.2, which is modified as follows:

e) Comparison of PBGT(n) with the variable hysteresis margin HO_MARGIN_TIME(n). If the process is employed, the action to be taken is as follows:

If PBGT(n) > HO_MARGIN_TIME(n) a handover, cause PBGT(n), might be required.

In a hierarchical network this comparison enables handover into the lower layer structure (e.g. small or micro cells) to be performed for slow mobile stations, while fast-moving ones remain served by the upper layer structure (e.g. large cells).

The variable hysteresis margin is defined by:

HO_MARGIN_TIME(n) = HO_MARGIN(n) + HO_STATIC_OFFSET(n) - HO_DYNAMIC_OFFSET(n) * H(T(n) - DELAY_TIME(n)).

In addition to the HO_MARGIN(n) as defined in table A.1 of GSM 05.08 [3] except that the range has been extended to (-24, 24 dB), the variable hysteresis margin comprises:

- a static offset, HO_STATIC_OFFSET(n);
- a dynamic offset, HO_DYNAMIC_OFFSET(n); and
- a delay time interval, DELAY_TIME(n).

The parameters are related to cells of the lower layer structure only.

T(n) is the time that has elapsed since the point at which the mobile station has entered the coverage area of cell n in the lower layer structure.

The function H(x) is defined by:

$$H(x) = \begin{Bmatrix} 0 \text{ for } x < 0 \\ 1 \text{ for } x \geq 0 \end{Bmatrix}, \text{ with } x = T(n) \text{ - } DELAY\_TIME(n).$$

The simultaneous fulfilment of the following conditions indicates that the mobile station has entered the coverage area of cell n in the lower layer structure:

Condition 1: RXLEV_NCELL(n) > RXLEV_MIN(n) + Max(0,Pa)

Condition 2: PBGT(n) > HO_MARGIN(n),

where Pa = MS_TXPWR_MAX(n) - P.