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# UPGRADING MOBILE NETWORK USING FUZZY LOGIC METHODS

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***Abstract:*** *The electronic processes managed by mobiles telecom networks are very shortly, about several hundred milliseconds. The average duration of a voice call is larger, about 2 minutes, and the granularity of the network counters needs more time, tens of minutes. This paper focuses on the need of taking into account this time scale difference and the evolution of the parameterization. The optimization of the data throughput for the services is one of the major objectives of the 3G mobile network operators. The data rate management feature has to be matched to bearer according to the needed throughput. A best rendered service could be obtained by optimization of such mechanisms without wasting network capacity and resources. This task is not easy one because there is a strong the interaction between radio parameters in uncertainly conditions. A new model of optimization parameters based on the fuzzy logic method is described in this paper. The crisp values of the three of most important parameters involved in the data rate management were fuzzyfied (averaging period, number of averaging window and upgrade threshold). The fuzzy-based parameters are designed to provide data required by the selection procedure. The uncertain data are represented as linguistic values which are fully dependent on the user's preference. This paper focuses on the selection of the defuzzyfication method to discover the most appropriate parameters for obtaining crisp values which represent uncertain data.*

***Keywords:*** *mobile network, fuzzy logic, membership function*

## 1. INTRODUCTION

The mobile network dimensioning and parameterization is done by making deep analysis of the network evolution. The analysis is using counters and indicators provided by the network. The usual granularity of the network indicators is one hour and aggregation to a higher scale is done in order to have an easier approach during the analysis. Once defined, the radio parameters allow the normal or, usually, the optimal way of working of a network. But for this approach of "fixed parameters" is no more adapted to the actual conditions: commercial area crowded during the week-end, area near highway needs a more adaptive parameterization. This paper wants to address the needs of a newest approach in term of adaptive radio parameterization, which may be solved by using fuzzy logic approach.

## 2. MATERIALS AND METHODS

The handover procedure is the key factor in supporting mobility in UMTS network. In UMTS there are four different types of handover currently in use [1, 2]. Softer handover involves the UE communicating with two sectors on the same cell site using a common carrier frequency. Eventually the UE changes from its original sector to the new sector. When two or more NodeB forming different cells communicate simultaneously via a common carrier frequency with a UE as it roams between cells, then a soft handover is said to be in process. The process ends when the UE is communicating with a single cell of a NodeB. Sometimes a UE entering a different cell has to have its carrier frequency changed or even to go to the GSM network. This handover procedure is called a hard handover and we will not focus on this.

The management of the handover process at the UE is facilitated using three sets of cells. First, there is the handover monitoring set that contains a list of all the cells the UE should monitor while it is in an active connection. This list is provided to the UE by the network via the BCCH and may contain details of nearby UTRA TDD and GSM cells [3]. The second set is the active set listing the cell or cells that are currently being used in the active connection. Should the UE be in a softer or soft handover, the active set will contain the identities of the sectors or cells, respectively the active set can only contain UTRA cells. The third set is the handover candidate set. This set contains the identities of cells that are not in the active set, but which measurement information suggests that they could support an active connection if required. The names of these cells are reported to the network by the UE. These cells can be on the same or different frequencies, and may contain UTRA TDD cells or GSM cells. The set contents can be changed by using different procedures. The radio link addition procedure, called event 1A, is where a cell is added to the active set and the UE commences transmission with that cell. The radio link removal procedure, called event 1B, is where a cell is removed from the active set and the UE ceases communications with that cell. The combined radio link addition and removal procedure, called event 1C, results in a cell in the active set being substituted by a different cell. A prerequisite to forming sets is making measurements [4,5].

The primary measurement quantity is the ratio $E_C/I_0$ of the primary CPICH. These measurements are made in every frame on the CPICH from cells in the active set (every 10 ms). Other measurements that may be evoked are the downlink path loss, the down-link transport channel BER and the block erasure rate (BLER), and the time difference between the signals from the target cell and the serving cell. Measurements on cells not in the active set are made less frequently.

The UTRA specifications define the format of the measurement information delivered by a UE to the network. It is up to the equipment manufacturers to decide how the network will use the reports to determine whether a soft handover should be performed, i.e. the soft handover algorithm is not in the UTRA specifications. However, these specifications do offer the following suggestions for a soft handover algorithm. There are four parameters:

- an active set threshold ($Thresh_{AS}$)
- an active set hysteresis ($Hyst_{AS}$) level for entry to or removal from, the active set
- an active set replacement hysteresis ($Hyst_{AS\_REP}$) value required for one cell to replace another in the active set
- the trigger time ($\Delta T$) that sets the time between a trigger event occurring and the report sending to the network.

The algorithm utilizes these parameters as. A cell is removed from the active set if its $E_C/I_0$ falls ($Thresh_{AS} + Hyst_{AS}$) below that of the best active cell. Alternatively, a cell is added to the active set when its ratio $E_C/I_0$ exceeds the trigger level which is set at ($Thresh_{AS} - Hyst_{AS}$) below the ratio $E_C/I_0$ of the active cell. Should the active set be full and the best non-active cell is better than $Hyst_{AS\_REP}$ above the worst active cell, then the latter is replaced by the former cell. Figure 1 shows the variation of $E_C/I_0$ as a function of time for three cells. Observe that a report will be send to the network only if the condition is verified during $\Delta T$. After report, the action command will be send by the network.

The UMTS standard call the addition to the active set as E1A event, the removing as E1B event and the replacement as E1C event. Usually, the time to trigger values are different for each type of active set changes and the values recommended by the vendor are between 120 ms till 640 ms [2].

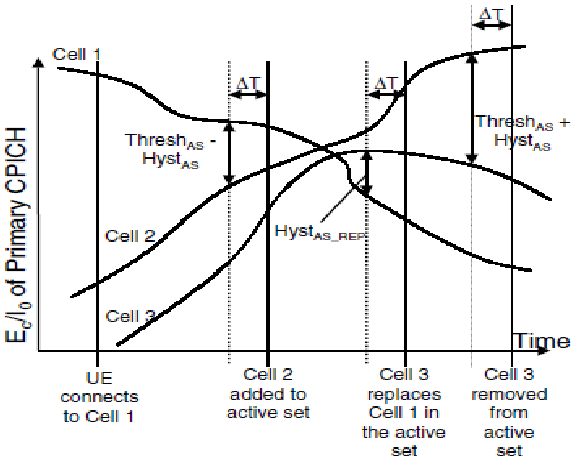


Figure 1. Example of the soft handover algorithm to illustrate changes in the active set

In order to manage the network, counters are implemented at all the levels of the network: NodeB, RNC, MSC etc. The principle is simple: each process is led by a defined protocol and the completion or the fail of certain event inside the process will increase a counter associated to that specific event.

## 3. OPTIMIZATION OF HANDOVER PROCESS

In UMTS, the utilization of multiple cells in active sets improves the mobility of the subscriber, but increases the waste of resources by using them from each cell. In certain situation, i.e. people inside a stadium, this situation must be avoided in order to have available resources. In plus, people in that case are static, so the usage of several cells in the active set is not anymore necessary. A deeper analysis of the situation of the behavior of the cell reveals this type of situation.

Based on these inputs, an optimization campaign was done and for the handover the optimization was declined in three steps:

- reference – the network evolution was monitored before making any changes
- phase 1 - increasing the value of the Cell Individual Offset parameter (a neighbor based parameter) which must delay the entering in the active set of a new neighbor
- phase 2 - deactivating the handover to the neighboring cells, by assuming that the mobility in that area is not needed and the resource availability driving the optimization process table traffic, less handover events. The histogram graph shows the decrease of the active set size too (Figure 2).

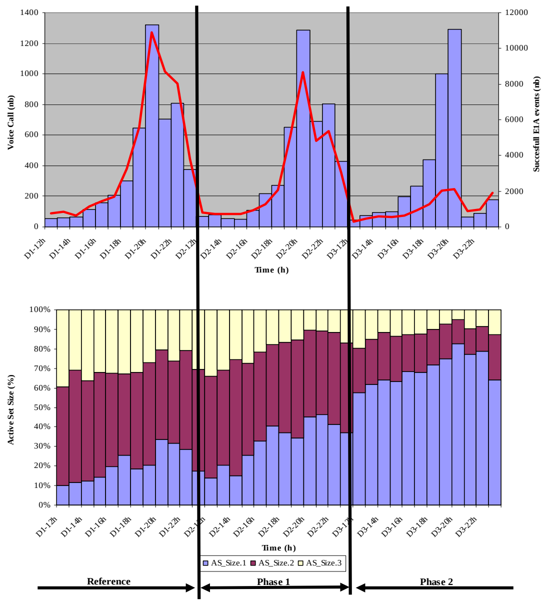


Figure 2 Handover optimization results

These results confirm that in order to improve the network response in case of critical situations, it's suitable to have adaptive parameters templates drive by the network itself. The choice of the suitable template is done by comparing the on-going situation with a collection of situations profile stored in a knowledge database. The build of such knowledge database may be done in an efficient way by using the experience of optimization trials and the completion or the fail of certain event inside the process will increase a counter associated to that specific event [6,7].

In order to implement this concept is need the knowledge database. This will offer a collection of situations with the description of the inputs (in order to realize the identification) and the parameters set to be activated. The knowledge database and the associated template to be built up will be made on analysis done over the existing granularity period, usually one hour due to details needed. But the problem of unpredicted situation or the suitable values for the parameters set still remain.

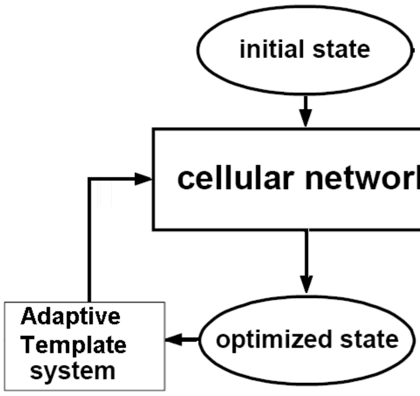


Figure 3. Reconfigurable network structure

In order to answer to such constrain a good approach is to use fuzzy-based parameters for solving these problems where demands are uncertain. The crisp values of the important parameters involved in the process to be optimized must be fuzzified. The fuzzy-based parameters must be designed to provide data required by the selection procedure. The uncertain data will be represented as linguistic values which are fully dependent on the user's preference.

## 4. CONCLUSIONS

The actual mobile networks are using parameterization templates which are fixed or “statics”. The time scale differences between the managed processes and the counters demands an evolution to a reconfigurable network. In order to model and to predict the network behavior, an easy and relevant method is offer by the fuzzy-logic techniques. The authors start to focus on the selection of the defuzzification method to discover the most appropriate parameters for obtaining crisp values which represent uncertain data.

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