WCDMA Handover Optimization Guidelines

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Abstract: - This article tries to give some guidelines to optimize the 3G-2G and 3G-3G handovers, from the extracted experience of a real network in development. The purpose of the adjustment of the 3G-2G handover parameters is to offer the users with dual terminals a quality, equal or better than those ones with only 2G terminals, where in general, the 3G coverage is minor that the 2G one. On the other hand, having the 3G cells coverage area well adjusted implies a substantial increase of their quality and capacity.

Key-Words: - Handover, InterRat, Overlap, Coverage, Threshold, Detected

1 Introduction

When an operator puts in service a 3G network along with other 2G existing network, it is necessary to optimize the interrelation between them to obtain the maximum yield of the whole system. Due to capacity reasons , normally it is recquired that the mobile is connected to the 3G network as much time as possible, whenever the quality is enough to support the call, and in case of the UE, it reaches the 3G coverage borderline then pass the call to 2G network withenough guarantees to continue with the call (Handover InterRat).

In a certain moment and in a given point the power of the 2G network signal is usually greater than the 3G network one, because normally the cells of both networks are cosite and the coverage area of the 2G cells is larger than the 3G ones. When the level or quality of the server cells falls down below certain thresholds defined in the RNC then the 2G handover procedure is activated.

2 WCDMA Handover Problem

In a moment and in a given point the power of the 2G network signal is usually greater than the 3G network one is, since normally the cells of both networks are cosite and the coverage area of the 2G cells is larger than the 3G ones. When the level or quality of the server cells falls down below certain thresholds defined in the RNC then the 2G handover procedure is activated.

Three strategies exist at the time of defining the 3G-2G handover depending on the magnitude that the EU is ordered to check by the RNC (Radio Network Controler). The first strategy is only to consider the RSCP of the P-CPICH of the 3G cells, that is to say, the average power of the received signal after de-spreading and combining in the RAKE receiver. The second one is to check only the signal to noise relation of the P-CPICH, Ec/No, which is the way the quality is evaluated. And the third one is to take into account both magnitudes simultaneously.

In a WCDMA network having cells with too large overlaps implies the reduction of the global capacity caused by the exceeded interference produced, and caused by the duplicity of the power, codes and transmission resouces consumed.

2.1 3G – 2G Handover

In general an UE is in soft/softer handover with several cells, what means, the mobile establishes a radio link (RL) with each of these cells. This set of cells is named the Active Set. As soon as the Ec/No or the RSCP of the best cell of the Active Set falls downs below any of the thresholds, quality or/and power, the measurements are activated on the 2G (900/1800) neighbour cells. If the UE has only one receiver then it must enter into compressed mode to be able to measure the 2G band. Since now, if the quality or power of the best cell of the Active Set keeps on degrading overcoming the quality or power handover threshold, and at the same time the level of the 2G cell measurement is greater than a threshold of minimal level, the UE warns about the above mentioned situation the RNC. Then, It is said that the 3G-> 2G handover event has been activated.

If the RNC decides to trigger the handover to a 2G neighbour cell, then the UMSC (UMTS Mobile Services Switching Center), from which the RNCS hangs on, must contact with the target MSC (Mobile Services Switching Center), so that this MSC reserves transmission paths and radio resources at the target BSC (Base Station Controler) and BTS (Base Transceiver Station). During the time that this signalling lasts , it can happen that the radio link quality of the UE has degraded so much that loses the link before having received the 2G handover order.

Up to the arrival of the last RNC software versions only the magnitude Ec/No was evaluated for the 3G-> 2G handover procedure. It was only possible to control the handover trigger by means of the quality threshold which had to be quite conservative, typically between -10 and -12 dB, to avoid the call drop before the 2G handover is completed caused by a deep fading of signal level. This might happen, for example, entering a tunnel, elevator, metro, … where there was no yet 3G coverage.

The relation between RSCP and Ec/No of a communication in a certain moment depends on the activity of the network at this moment and on the situation of the EU inside the network. Every RNC controls a group of cells. There exist RNCs that control very nearby cells which have a lot of traffic, whereas others can control dispersed cells with little traffic. Therefore, it is expected that every RNC have a characteristic RSCP - Ec/No graph.

This article tries to study the relation between the Ec/No (quality) and the RSCP (level) of the users of the network in order to propose concrete values for both thresholds as the needs of the operator.

At the present, the above mentioned thresholds can only be adjusted at cell level, although ideally they should be able to adjust at neighbour level, then it could be treated in different way different zones of the cell coverage area, for example, a zone could be a 3G-2G coverage boundary then it would need a fast handover to the 2G neighbour cells of this area, another zone could have a good 3G coverage overlap then it is not needed such an aggressive threshold for the 2G neighbour cells of this area.

2.2 3G – 3G Handover

The additional of a radio link supposes the consumption of new radio resources (power and codes) and to establish new transmission paths for each of the cells in soft handover. In general in those areas where there are more than 2 equally strong CPICHs, it's called "pollution areas".

It can happen that an UE is connected to a very distant cell, as so, it will need to transmit a lot of power to maintain the radio link, and simultaneously this UE could have cells more nearby that they are not defined as neighbour cells to any of the cells of the Activate Set, in this case the UE will be interfering strongly to these cells, called detected cells, reducing their capacity. The RNC software from the reports sent by the mobile decides if to remove or not the radio link of the distant cell to protect the rest of the system with the consistent interruption of the call, so-called "detected dropped call".

It's important to know these situations of large overlap to evaluate what to carry out, for example, reduction of the coverage area by means of the downtilt of the antennas or/and to correct the list of neighbours adding or removing some neighbour relation to avoid these situations of detected cells that, at the worst, can lead to the communication interruption.

3 Methods

For both problems two sources of measurements were considered. The first one consists of analyzing " drive test " measurements. The second option is to trace all the mobiles connected to an RNC.

The first option has a high cost and besides it has the disadvantage that the measurements are collected along a few certain circuits, for example, the streets of a city, so the result of the measurement statistical analysis will not represent the behaviour of all mobiles of a certain cell or a whole RNC. Unlike the GSM, nowadays only very few WCDMA mobiles have capability to report GPS measurements, so in general WCDMA UEs does not offer distance information in their measurement reports, as the Time Advance in GSM, they only send power and quality reports of the received cells, so the coverage overlaps must be calculated indirectly

All the RNC suppliers provide software to trace the radio link quality of the UEs connections. This software registers when and in what conditions some events defined by the network operator are taken place. In this case three types of events were found especially useful:

- SOHO event: generated each time the Active Set of any UE is updated, contains cell identification, quality and power measurement data of each cell.
- System Release: generated after a call is disconnected
- Detected Cell Event: the UE sends a report when a detected cell is measured. It contains the scrambling code of the detected cell and quality-power information.

These traces can be activated on a chosen group of cells, or on a whole RNC for a selected period of time. Normally as it is a job shared between several processors in the RNC, the data files are generated in each of them. The result is a set of data files that contains the measurement reports sent by all the UE connected to any cell specified in the trace. It was created as software application called PAD to handle so much data. PAD extracts the useful information from the data files, and on the other hand it can consult the WCDMA network parameters defined in that moment, for example, actual neighbour relations, cell identifications, scrambling codes and geographical position data of all nodes.

From data extracted from SOHO event reports it is possible to calculate the relation between RSCP and Ec/No for each cell. The trace must be activated during the busy period of the day, normally between 09:00 and 20:00 h. Each cell has a characteristic RSCP-Ec/No graph. So for any value of Ec/No it is possible to predict the RSCP value. It is considered that a call should be supported by the WCDMA network up to -14 dB Ec/No, below this threshold the voice quality starts being bad.

Then for each cell we can calculate the RSCP threshold for a Ec/No = -14 dB, avoiding too low values to save deep fast fading. A minimal RSCP threshold level of -109 dBm is supposed.

If a greater RSCP threshold value than the optimal one is assigned to a cell, then the 2G handover process is triggered by signal level still having a good radio link quality, what means, the capacity of this 3G cell is wasted.

To find out large overlap coverage of certain cell, PAD shows the number of times that other cells have been in soft handover with it or have been detected, as well as, their average power and quality levels and indicating the distance between them. This data is extracted from SOHO and Detected Cell event reports.

The application analyzing the System Release and Detected Cell event reports is able to know what detected cells have generated dropped calls, average power, quality and distance. Then the network operator could decide to include o not these detected cells in the neighbour cells list or/and increase the antenna tilt of these cells.

4 Results

Fig.1 shows the traffic density of three whole RNCs. RNC-A controls urban zone cells with very high traffic load. RNC-B and RNC-C control large semi-urban zone cells with low traffic.

Fig.2 shows the characteristic mean RSCP - Ec/No graph of RNC-A and RNC-C.

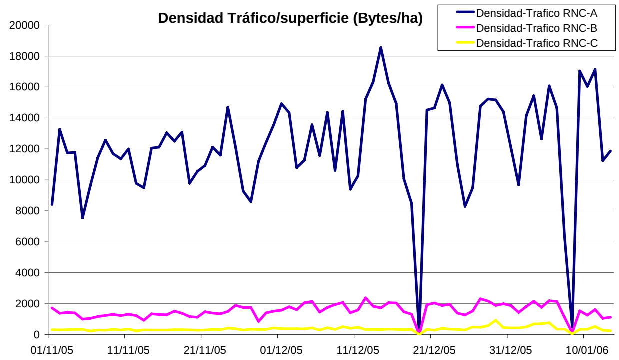

Fig. 1

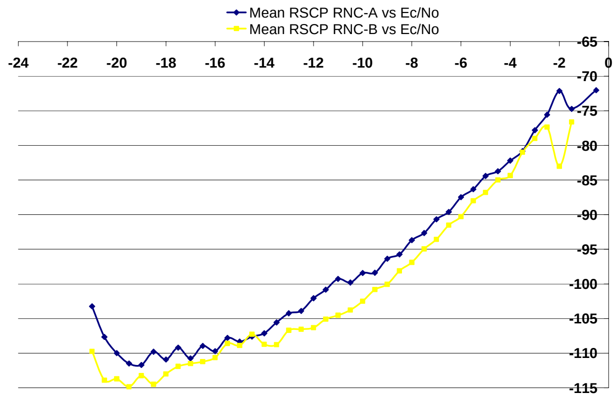

Fig. 2

If we want to assign the same RSCP threshold for all cells of RNC-A, for a fixed Ec/No = -13 dB threshold the best choice would be -105 dBm in the RNC-A case and -108 dBm in the RNC-C case.

This analysis could be done at cell level, then, fixing an Ec/No threshold, each cell could have its own RSCP threshold.

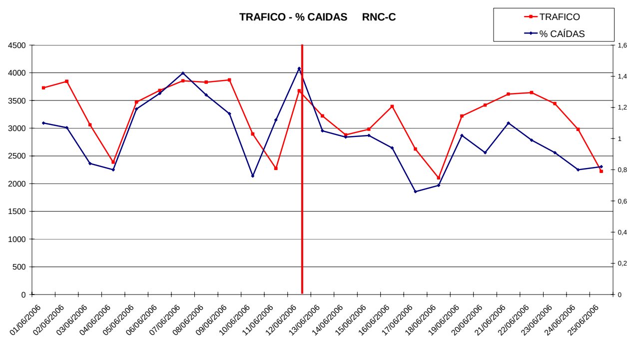

Fig.3

Fig. 3 represents the traffic and dropped calls ratio evolution of RNC-C, after adjusting the RSCP threshold, 3G –> 2G handovers increased, the traffic decreased about 5% but dropped calls ratio was improved about 40%.

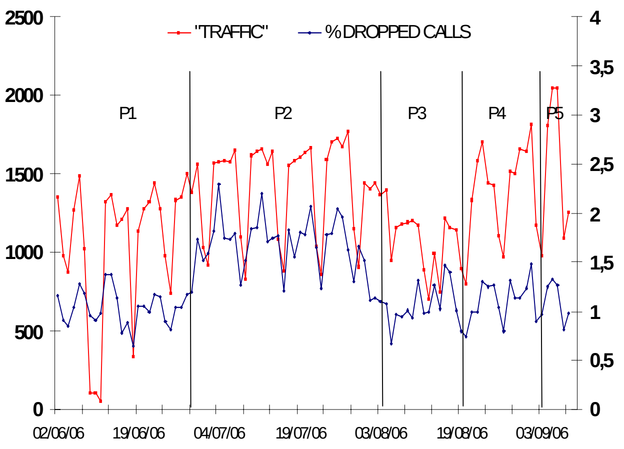

Fig.4

A group of 90 urban cells were selected to adjust their 3G-> 2G threshold parameters. Fig.4 shows the traffic and dropped call ratio evolution. Fig 5 represents the evolution of the mean time between dropped calls, Traffic(Erlangs)*60/(# Dropped_Calls)

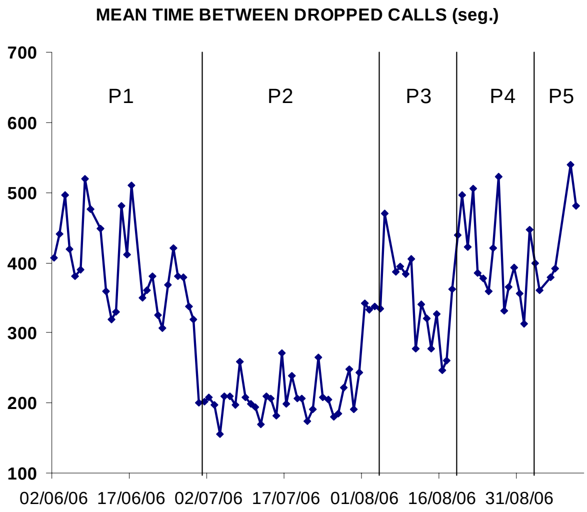

Fig.5

The adjust process was done in five stages. In P1 stage the 3G>2G handover thresholds were Ec/No = -12 dB and RSCP= -100 dBm for all the cells of the set. During the last days of the P1 period the traffic decreased because of the beginning of summer holiday. In P2 stage 2G traffic was forced to handover to 3G network, but dropped call ratio were strongly increased because of most of calls came back to 3G network immediately and the probability of mistake increases too, Fig.6.

The problem was that the handover 2G>3G threshold only can be fixed by Ec/No (this is an actual gap of some software providers), its initial value was -8 dB, it means, when a UE in 2G network measures a 3G neighbour cell with a Ec/No value greater than -8 dB then the call is passed to 3G network, but for many of the 3G neighbour cells an Ec/No = -8 dB corresponds to a RSCP lower than -100 dB, then the 3G>2G handover was activated again. In P3 stage the thresholds were changed again like initial P1 stage. In P4 stage this problem was solved by fixing 2G>3G Ec/No threshold to – 5 dB and all 3G>2G RSCP thresholds were optimized.

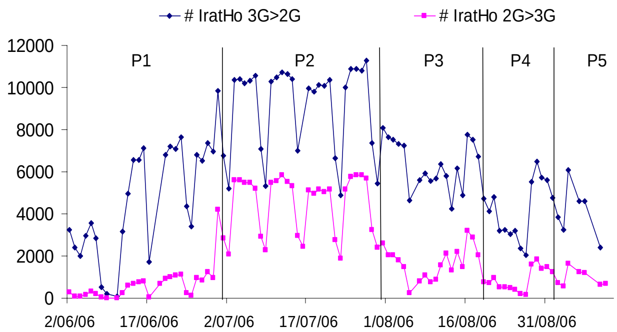

Fig.6

Fig.7 shows the detected dropped call ratio evolution, as well as, the general dropped call ratio of a whole RNC. In this case, detected dropped calls were analyzed by PAD application. The process consist of activating the trace for all RNC cells, process data files with PAD application and adjust antenna tilts or neighbour cell lists. This process must be repeated two o three times.

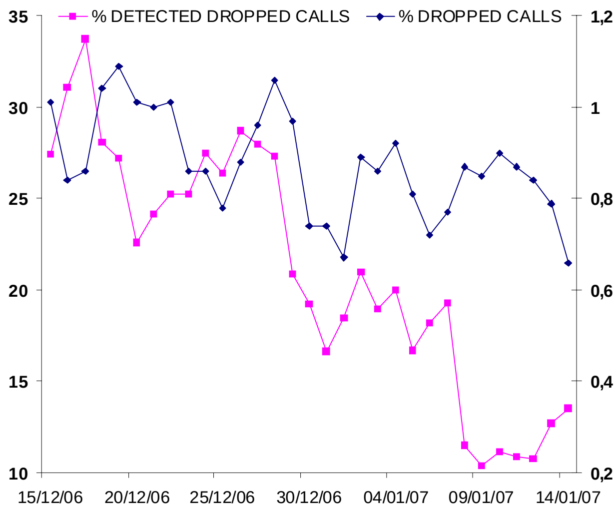

Fig.7

One single trace can include all cells belonging to a same RNC, about 200 cells in this case. So all cells can be adjusted at once. The general dropped call ratio was 20% improved and detected ratio about 60%.

5 Conclusion

Some guidelines have been given to optimize intra and inter Rat handovers in GSM-WCDMA networks. At the present 3G networks are not so extended as 2G ones. Mobile operators must give to dual UEs a quality of service better or at least equal than 2G ones at the worse, and, on the other hand, operator interest is to pass and to retain as much traffic as possible in 3G. So it is important to be well adjusted the inter Rat handovers parameters. It has been proposed to fix Ec/No threshold value between -12 and -14 dB and to calculate the corresponding RSCP threshold value for each cell, by means of analyzing measurement reports from UEs collected by software trace application. The aim is to retain the calls in the 3G network until it is needed to pass it to 2G network by quality motive. The RSCP threshold should be used as an emergency trigger, for example, limit of coverage area or to save any deep and fast fading.

It has been explained which measurement events are useful and how to process them to determine these thresholds. It has been seen that some new parameters are necessary to include in future new RNC software releases to improve control over inter Rat handovers.

One method has been explained to find out large overlap 3G coverage areas and interference problems, and how to solve them.

All these ideas have been applied in a real network in development with positive results.

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