W-CDMA CAPACITY ANALYSIS USING GIS BASED PLANING TOOLS AND MATLAB SIMULATION

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INTRODUCTION

The evolution of cellular systems towards third generation (3G) or IMT-2000 seems to have a tendency to use W-CDMA as the standard access method, as ETSI decision have showed. However, there is a question about the improvements in capacity and the wellness of this access method. One of the aspects that worry developers and researchers planing third generation is the extended use of the Internet and the more and more bandwidth hungry applications related.

This work show the performance of a W-CDMA system simulated in a PC using cover maps generated with DC-Cell, a GIS based planning tool developed by the Technical University of Valencia, Spain. The maps are exported to MATLAB and used in the model. The system used consists in several microcells in a downtown. We analyse the interference from users in the same cell and in adjacent cells and his effect in the system, assuming perfect control for each cell. The traffic generated by the simulator is voice and data.

This model allows us work with coverage that is more accurate and is a good approach to analyse the Multiple Access Interference (MAI) problem in microcellular systems with irregular coverage. Finally, we can compare the results obtained, with the performance of a similar system using TDMA.

Paper is organised as follows; following section makes a general description of the model, next section shows some results obtained for voice traffic with a test system and next shows results for data traffic with fixed velocity. Finally, there are some conclusions.

BRIEF DESCRIPTION OF THE SYSTEM

The model used in this project is based on coverage maps and Best server map calculated with DC-Cell, in an urban environment, specifically the downtown of a city. It permits to obtain irregular cover patterns, that is the normal situation in microcelullar and indoor environments and modify in a big sense the normal conditions used to estimate capacity in mobile systems. Cover maps has been calculated using omnidirectional antennas situated below buildings, as usual in microcellular systems. Many propagation models can be used to obtain coverage maps, depending on system conditions, computation time and environment. Results showed here used neural network model developed at the Technical University of Valencia for microcellular systems.

Coverage maps and Best Server map are loaded in MATLAB in order to run simulations, because MATLAB capabilities to manipulate matrixes make scripts simple.

Model estimates the interference generated by users over each base station, considering both the intra-cell interference and the inter-cell interference, assuming perfect power control. In this way, it is possible to analyse the evolution of the interference over base station and interference blocking condition for it. As a first approach, we use a uniform distribution for users along the system, and an exponential distribution for call duration. However, we can use any available statistic distribution for both users generation and call duration.

Model contains various modules. One module generates traffic spatially distributed, using different statistical distributions; another module manages system map and coverage maps, loading it from DC-Cell. Using coverage maps, other module calculates interference from users over BS, and the core module calculates blocking, grade of service, lost calls and attended calls. On this way, we can change model parameters or include new ones.

We are not considering, in first tests, users mobility and lost calls by non-successful handover.

The model used for the first tests, uses as blocking condition the specified in IS-95 standard (Eb/No=5, or 7dB), and we are actually extending the analysis to bandwidth_on_demand systems.

SOME RESULTS FOR VOICE TRAFFIC

We work initially with a test system conformed by nine cells. Base Stations were distributed arbitrarily over a hexagonal grid generated by DC-Cell, with cell radius of 300m. Figure 1 shows best server map for test system; irregularities of coverage can be observed.

Results showed were obtained for two runs of simulation; first one with an offered traffic of 360 erlang and 10 minutes (600 sec.), second one using an offered traffic of 600 erlang, during 12 minutes (720 sec).

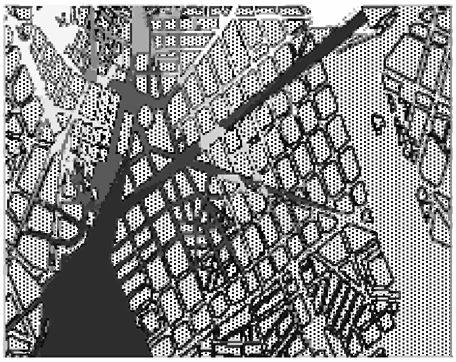

Figure 1: Best Server map for test system

For the first test, Figure 2 show the evolution of Eb/No from 10 seconds to 600 seconds for cell No.1. We can observe that in the interval from 10 to 100 seconds relation Eb/No decreases while number of calls is stabilised in 97.

Figure 3 show similar information as Figure 2, but is restricted to a time interval between 20 and 60 seconds. We can observe in Figure 3 the decreasing of Eb/No while calls are increasing. When calls is stable, there are a little variation in Eb/No.

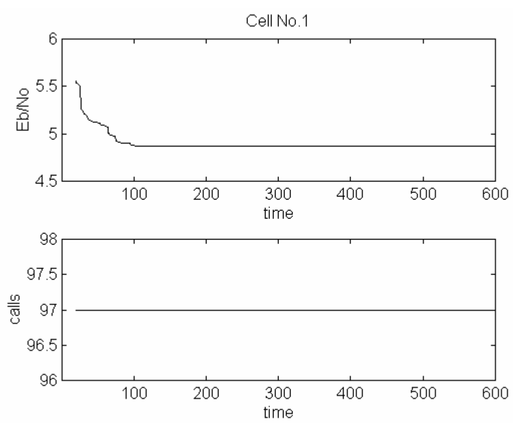

Figure 2: Evolution of Eb/No and calls in cell No1

Figure 4 show the state of the system at the end of first simulation. For cells No.7 and No.8, we can observe that relation Eb/No is worst for cell No.7 than for cell No.8, while cell No7 have less calls. Similar situation can be observed in cell No.6, with almost 100 calls and an Eb/No relation almost equal to the Eb/No of cells No.7 and No.8.

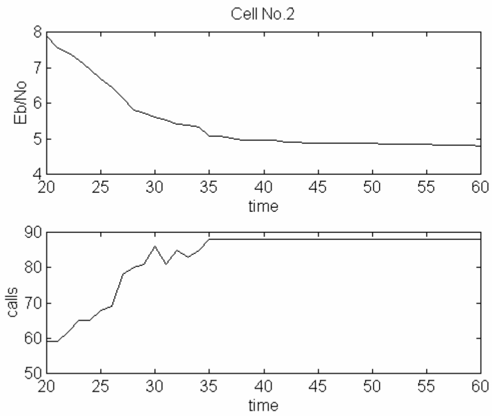

Figure 3: Evolution of Eb/No and calls for cell No.2

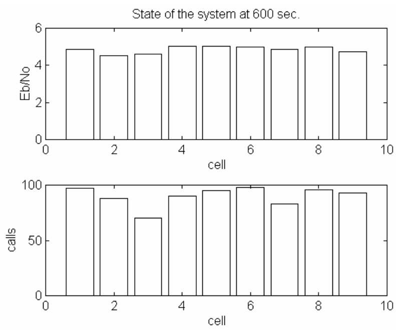

Figure 4: State of the system at end of simulation

The expected situation in an ideal system would be that both cells have similar Eb/No. In the system, cell No.8 is at the upper left corner, then it has little influence from other cells. Cell No.7 is neighbour of cell No.8 and could be influenced by other cells. Cells No.2 and No.3 show a similar situation than cells No.7 and No.8. The main difference is that they are not neighbours.

For the second test, Figure 5 show the Eb/No for cell No.7 and calls for cells No.7 and No.2. The figure shows that when a call occurs in cell No.2, the Eb/No relation drops, because a user near cell No.7 generated the call. The same figure shows also that a call generated later, in second sixteen, does not effect cell No.7, probably because user is far enough from cell No.7 or is located in a shadow region for cell No.7.

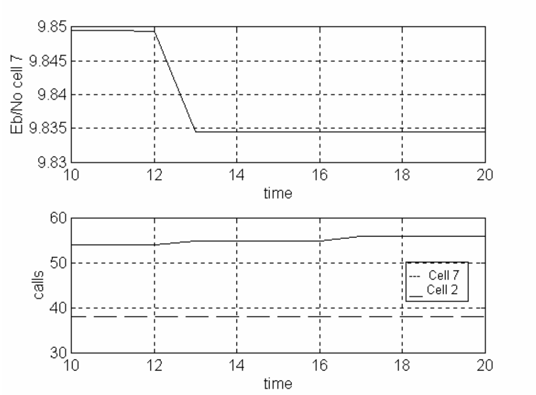

Figure 5: Eb/No for Cell No.7 and calls for cells No.7 and No.2

Figure 6 show the situation of the cells in the system, and Figure 7 show cell No.7 and users attended by cell No.2. We observe that a significant number of calls are located near cell No.7. This situation explains behaviour showed in Figure 5. In this case, cell No.2 are relatively far away from cell No.7, but some users attended by cell No.2 are closer enough to cell No.7 to interfere it and cause blocking.

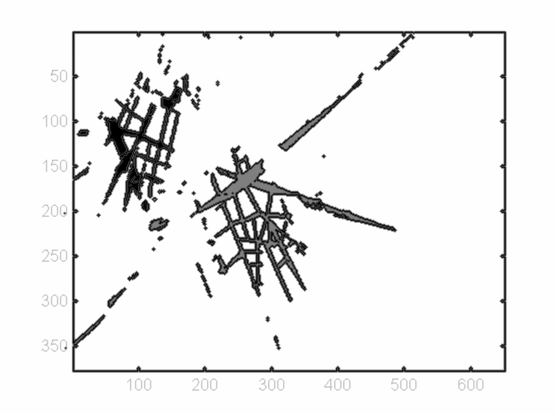

Figure 6 : Relative location of cells No.2 and No.7

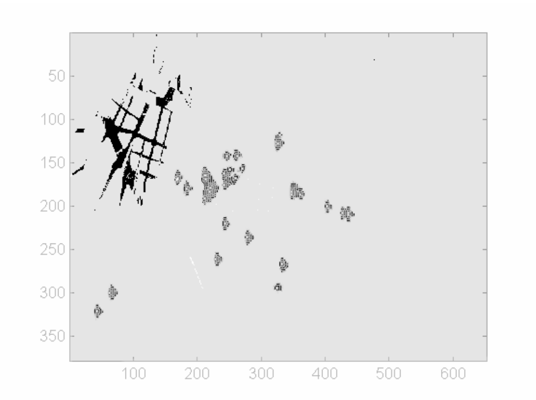

Figure 7: Cell No.7 and users attended by cell No.2

Because irregularities in cover maps and the existence of a cell between cells No.2 and No.7, users generating interference to cell No.2 are attended by cell No.7. It can be observed also, that users generating interference to cell No.7, does not interfere the cell between cells No.2 and No.7 although they are closer to that cell. Again, this is because the irregularities in cover maps.

SOME RESULTS FOR DATA TRAFFIC

We will show results for a particular case, with pure data traffic at 384Kbps, with an offered traffic of 10 erlang during 10 minutes (600 seconds). We assume circuit switching and exponential distribution for calls.

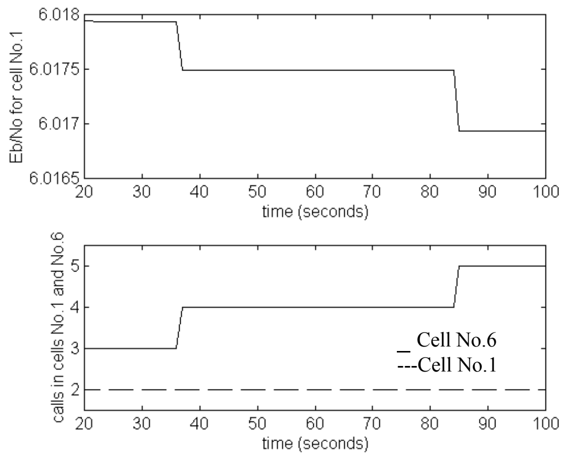

Figure 8: Eb/No for cell No.1 and calls in cell No.1 and No.6

Figure 8 show the influence of call generated at cell No.6 over cell No.1. Both calls in cell No.6 affect the relation Eb/No in cell No.1, while calls in cell No.1 remain the same.

In this case, cells No.1 and No.6 are neighbours, because best server area of cell No.1 “cuts through” cell No.6, and calls were generated near cell No.1, as is shown in Figure 9. In ideal conditions, we did not expect this “cut through” situation. Figure 10 show the location of users (showed as black round points) from cell No.6 and the best server area of cell No.1. It can be observed that some users are very close to cell No.1. Probably, if cell No.6 does not exist, these users will be attended by cell No.1.

Calls generated in cell No.6 not only affect cell No.1, also it affect cell No.9. The case of cell No.9 is relatively different from cell No.1, because it is located near cell No.6.

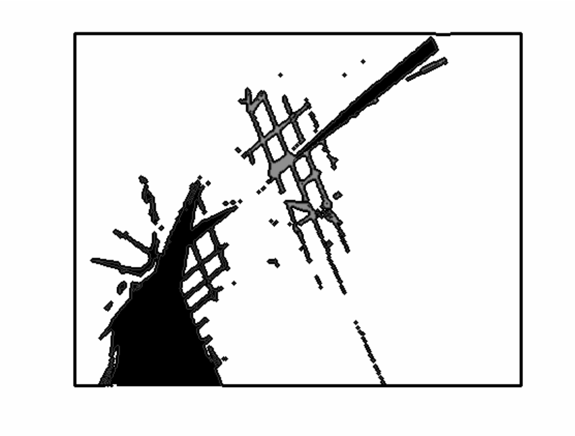

Figure 9: Cells No.1 and No.9

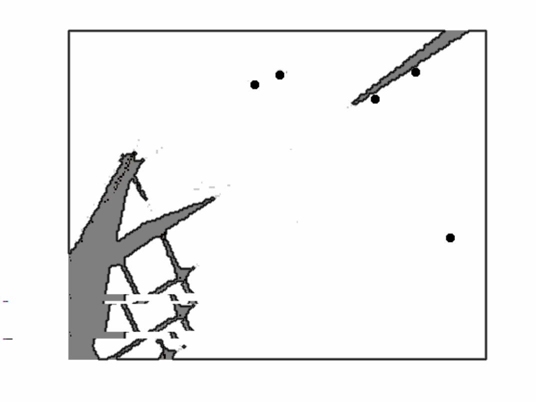

Figure 10: Cell No.1 and users from cell No.6

Figure 11 show the behaviour of Eb/No for cell No.9 when a call is generated in cell No.6 and no call is generated in cell No.9. Variation in Eb/No is bigger than variation occurred in cell No.1, but second call generated in cell No.6 does not affect cell No.9, because user is located out of the coverage zone of cell No.9.

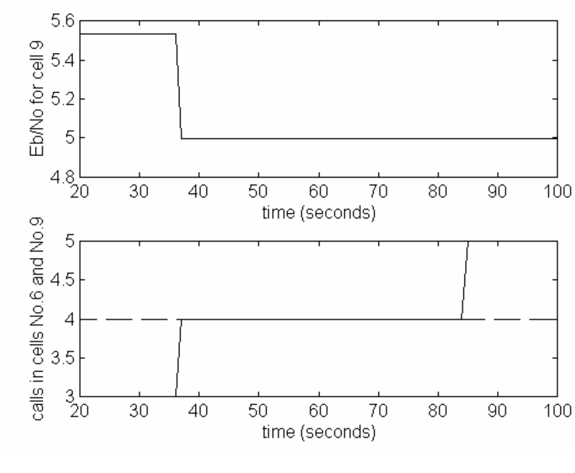

Figure 11: Eb/No for cell No.9 and calls in cells No.9 and No.6

Figure 12 show relative location between cells No.9 and No.6; observe that cell No.9 is also neighbour of cell No.1. Figure 13 show the state of the system at the end of simulation. We can observe that relation Eb/No is similar for cell No.1 (Eb/No=6.01) and Cell No.6 (Eb/No=5.59) while cell No.6 has six calls and cell No.1 has two calls. We can also observe that the number of calls is equivalent to the same number of voice calls multiplied by bandwidth factor (i.e. 384K/9.6K).

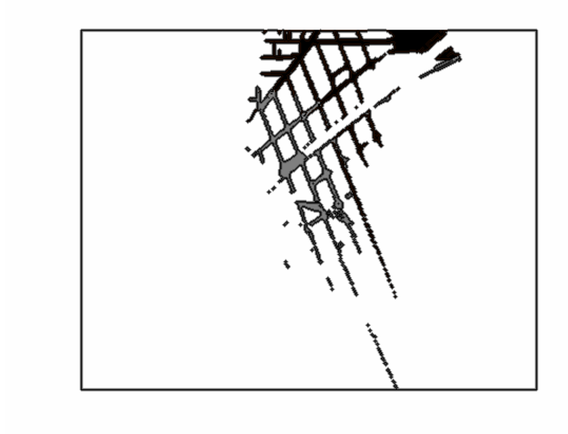

Figure 12: Relative location of cells No.9 and No.6

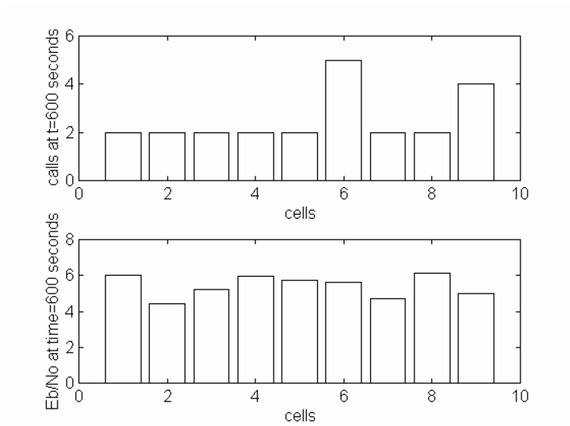

Figure 13: State of system at time=600 seconds

CONCLUSIONS

Although many works have been done about the capacity of CDMA and TDMA and access technologies, the conditions of microcellular systems and data traffic includes more variables to the problem that are difficult to solve analytically, and the use of GIS simulation could be a good approach.

Results discussed above show a particular behaviour of microcellular environments that difficult theoretical analysis, as is the case of cells No.6 and No.9 for data traffic. In a theoretical analysis, we would calculated the interference of the second call using the nth power of the distance model and probably the result would affected in a big sense the Eb/No.

Another particular behaviour showed was the effect of calls generated by users closer to a cell different from those attending call, or the effect of a call generated by a user near to a "best server area" from other cell.

We did not find in literature any similar work using cover maps generated by planning tools to analyse capacity in microcellular environments. We think that this approach permits to obtain a better approximation to the capacity problem, thinking in current mobile data services over third generation systems.

Irregular shapes of microcellular and picocellular systems difficult the traditional planning process and the use of GIS based planning tools and simulation can help to optimise systems for the third generation.

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