THE INFLUENCE OF PROPAGATION MODEL AND SECTORIZATION OVER WCDMA CAPACITY

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Abstract: In this paper we use a dynamic model that we have developed for WCDMA capacity analysis using MATLAB and a GIS based planning tool, to estimate the capacity of a mobile system under different conditions like number of cells, propagation model, sectorization and handover margin.

Keywords: CDMA, WCDMA, simulation, 3G, Third Generation, Mobile Radio, Capacity, 3G Planning.

I. INTRODUCTION

In second generation cellular systems, the planning process was static in the sense that when you have the cell size, obtained from estimated traffic conditions, the next thing to do was calculate coverage and maximize the service area. In WCDMA third generation systems, the planning process is a dynamic process, because appears the cell breathing effect.

Then, planning process in third generation become a dynamic process, and we need tools that can help us to predict that dynamic behaviour. Additionally, multiple services make more complicated this process, because each service require different performance parameters, i.e. each service have different Eb/No requirements. Traditionally, capacity estimation for CDMA and WCDMA was based on theoretical models like paper of Gilhousen[2] and many others. We thing that capacity is affected by other variables simplified in such analysis, like propagation conditions in real environments.

In 14 and 15 we describe a model for capacity analysis in CDMA systems using DC-Cell, a GIS based planning tool developed at Universidad Politécnica de Valencia, and MATLAB. We show some initial results of that model, and now, we are exploring different parameters like cell size, proximity between cells, number of cells in the system, regular or irregular cells and propagation model, in order to improve planning process for third generation systems.

We have improved our model to show cell breathing effect and model users mobility and soft handover.

When we consider the performance parameters of CDMA and WCDMA (its similar for UMTS or CDMA-2000), usually we consider interference, sectorization, voice activity and soft handover margin; besides, when we consider interference, there are two sources of interference: intra and inter cell interference. Most models like Gilhousen , Prasad and others model inter cell interference as a fraction of intra cell interference. We consider inter cell interference directly generated by users in neighbor cells, “measuring” the propagation losses between user and interfered cell and calculating interference from user’s transmission power.

II. DESCRIPTION OF THE MODEL AND SIMULATION CONDITIONS

A. DESCRIPTION OF THE MODEL

Figure 1 shows a general model for the system. The model used in this project is based on coverage maps and Best server map calculated with DC-Cell or Cell-View, a GIS based planning tools developed at Valencia Technical University; the difference between DC-Cell and Cell-View is that DC-Cell is based on Arc-Info and Cell-View is based on Arc-View. It permits to obtain irregular cover patterns, that is the normal situation in cellular systems when diffraction is considered and modify in a big sense the normal conditions used to estimate capacity in mobile systems. Like any other planning tool, we can use many propagation models like Hata, Saunders-Bonar, Walfisch-Bertoni and others.

Coverage maps and Best Server map are loaded in MATLAB in order to run simulations, because MATLAB capabilities to manipulate matrixes make scripts simple. However, matrix sizes make the simulation computationally demanding and time consuming.

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 of BS. 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. In a similar manner, we can use demographic information to generate users spatially distributed over the system.

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 or Cell-view.

The calls module can generate different kind of traffic using different statistical models, i.e. we can generate voice calls, data calls with 64Kbps, 144Kbps, 384Kbps or any other data rate. 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.

Another module estimates cell breathing and recalculates best server map and terminal's power using a SIR based approach.

Finally, one module simulates user mobility and softhandover for moving users. On this way, we can change model parameters or include new ones.

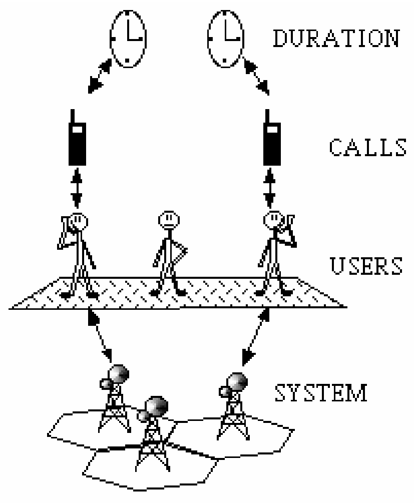

Figure 1 System model

B. SIMULATION CONDITIONS

In this paper we will show results for four scenarios simulated using the city of Madrid. Two scenarios have the same number of cells but use different propagation models, and two scenarios have the same number of cells, the same propagation model but one use omnidirectional antennas and the other use sectorized antennas.

Traffic conditions are the same for all scenarios, in the sense that we use the same parameters for generation of stochastic variables like users and calls. The call generator was adjusted to obtain a mean of 700 call attempts for second. Also we are generating only voice calls for this results, in order to maintain most of the parameters fixed and analyse only one parameter at a time.

Figure 2 shows best server map for system 1, a system with 18 cells using omnidirectional antennas and Univalencia COST-231 propagation model; this model is variation of Walfisch-Bertoni model and is described in COST-231 final report . **Figure 3** shows best server map for system 2, a system with same characteristics that system 1 shown in **Figure 2**, but we use Hata model to calculate coverage maps. It can be observed from the figures that systems have a different topological structure.

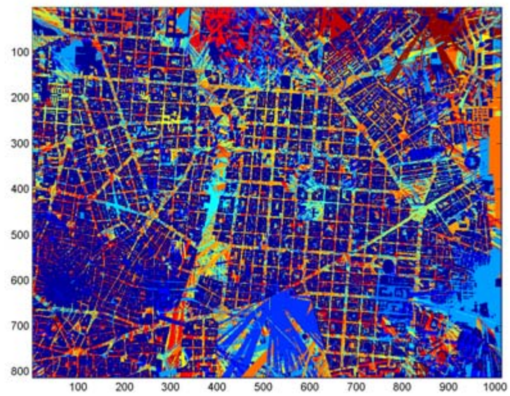

Figure 2. Best Server map for test system with 18 omnidirectional cells

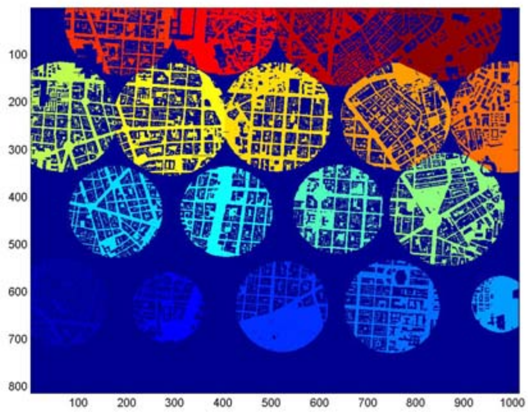

Figure 3 . Best server map for test system with 18 omnidirectional cells calculated with Hata model

Figure 4 shows best server map for system 3, an scenario with irregular cells which size was calculated using the UMTS Forum report 5 recommendations. Coverage maps was calculated using omnidirectional antennas and the Univalencia model.

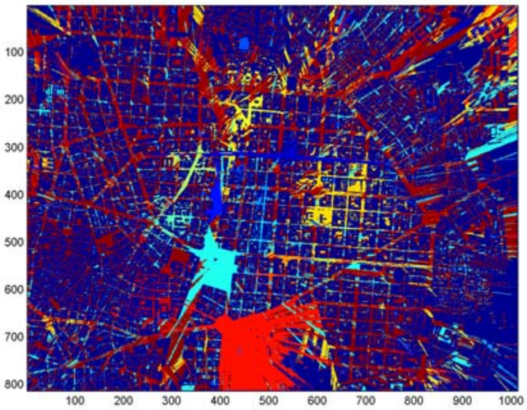

Figure 4 Best server map for system with 15 cells and omnidirectional antennas

In Table 1 we show the EIRP for each cell in the system wit irregular cells.

Cell Nº	EIRPin dBm	Cell Nº	EIRPin dBm
1	8.04	9	11.9
2	8.04	10	22.7
3	6.71	11	7.4
4	10.4	12	6.0
5	12.9	13	18.3
6	15.4	14	20.7
7	13.8	15	24
8	18.3		

Table 1 Cell powers in dBm for system with irregular cells

Last scenario we will discuss here is shown in Figure 5. This is the same system shown in Figure 4, but we use 120 degrees sectors. The EIRP is the same, then the cell radius does not change, the only effect we expect over the capacity is the sectorization.

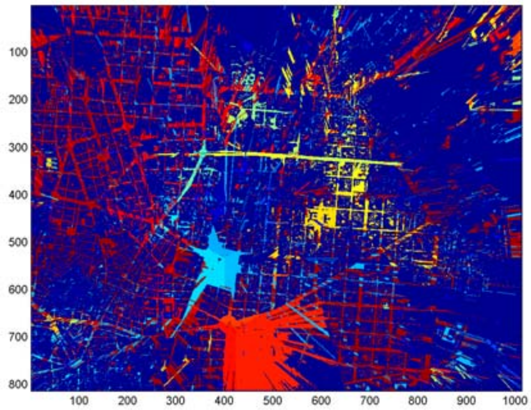

Figure 5 Best server map for system wit 15 irregular sectorized cells

III. SIMULATION RESULTS FOR SYSTEM 1 AND SYSTEM 2

Figure 6 shows the state of the system at end of simulation and shows Eb/No, number of active calls and the Fm factor (i.e. relationship between inter and intra cell interference). We can observe in the figure that cell No.2 have less calls than cell No.1, however the Eb/No relation is better for cell No.1. In cell No.16 there are no calls, but Eb/No is under the minimum specified in simulation parameters.

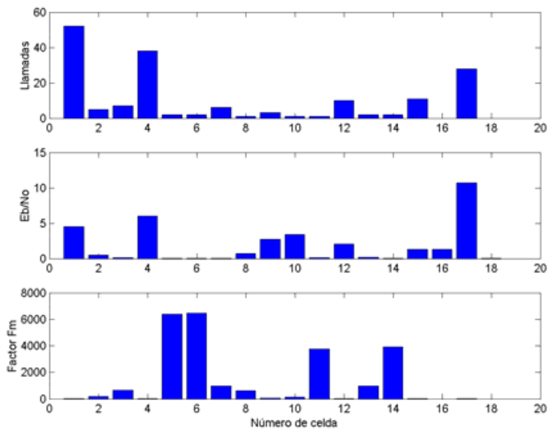

Figure 6. Number of calls, Eb/No and Fm at the end of simulation

Figure 7 shows the values of calls, Eb/No and Fm factor at the end of simulation for system 2. We can observe that the number of calls is bigger than system 1 in almost each cell, and the Eb/No is better. However the figure is not clear with Eb/No because of the high value for cell No.1. The other values are all above the minimum required (Eb/Nomin=5) and the cells are near the pole capacity.

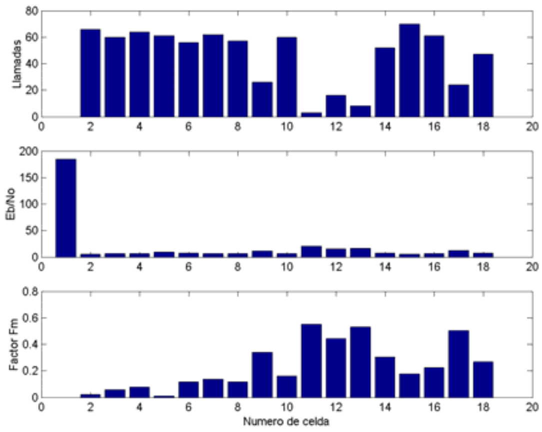

Figure 7 State of system 2 at the end of simulation

Figure 8 shows evolution in time for total calls in the system and Eb/No mean for system 1. We can note two things; one, that maximum number of calls is 140 and, two, Eb/No mean is below minimum required. The mean value of calls is 112 and the mean of Eb/No mean is 2.5.

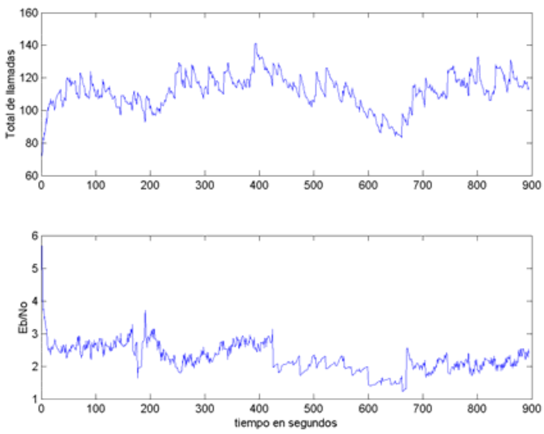

Figure 8. Evolution of total calls and Eb/No mean for system 1.

In Figure 9 and Figure 10 we shown the evolution of total calls and Eb/No mean, respectively, for system 2. The first thing we note is that maximum number of calls is 960, almost 8 times the maximum number obtained for system 1. A second thing is that Eb/No is above minimum required, indicatibg that system have capacity to process more calls while system 1 only have capacity in one cell as shown in Figure 6.

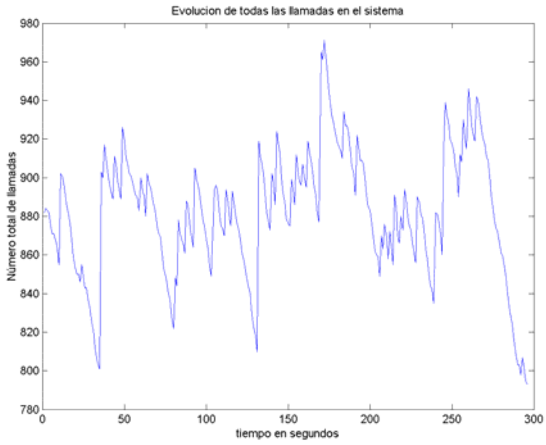

Figure 9. Evolution of total calls for system 2

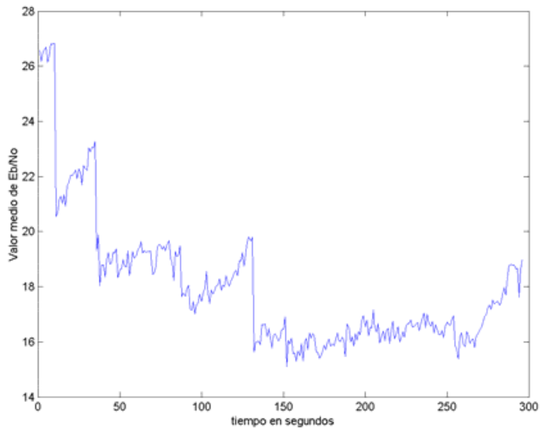

Figure 10 Evolution of Eb/No mean for system 2

IV. SIMULATION RESULTS FOR SYSTEM 3 AND SYSTEM 4

In Figure 11 we show the final state of the system. In a similar manner as occur in system 1, we have some cells with cero calls and an Eb/No below minimum required, like cell No.3.

In Figure 12 we show the Eb/No and the number of calls at the end of simulation. In this case, we have some dissimilar situation, because some cells like cell No.3 does not have calls but have an Eb/No value below minimum required and some cells have a relatively high number of calls and an Eb/No value above minimum, like cell No.28.

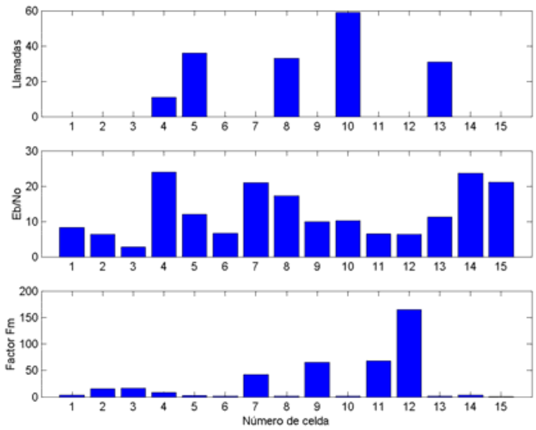

Figure 11. Number of calls, Eb/No and Fm factor at the end of simulation

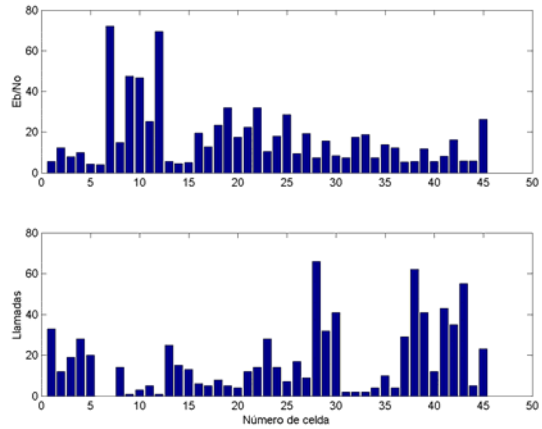

Figure 12 Eb/No and Number of calls for system 4 at the end of simulation

Figure 13 shows the evolution in time of total number of calls and Eb/No mean for system 3. The maximum number of calls is 192, the mean value of Eb/No mean is 14.6 and the mean value of total calls is 166. This means that system have more capacity than system 1 and less capacity than system 2, because we have similar value for Eb/No.

Figure 14 shows the evolution in time of total calls and Eb/No mean for system 4. Here, the maximum number of calls is 780 , the mean of Eb/No mean is 20 and the mean of total calls is 709. It is obvious that system 4 have more capacity than system 3. The result of divide mean number of total calls for system 3 and mean number of total calls for system 2 is 4.3. It means that system 4 have 4.3 times more capacity than system 3 under this simulation conditions. We must note that this relationship is not precise because the mean value of Eb/No differ by a factor of 1.36. System 4 have a bigger value of Eb/No, i.e. have more available capacity than system 3.

However, we want note only the qualitative relationship more that a numeric relationship. The result of this simulation shows that with this conditions of systems structures, sectorization increases capacity more than 4 times, i.e. almost twice times the expected increase in capacity for sectorization.

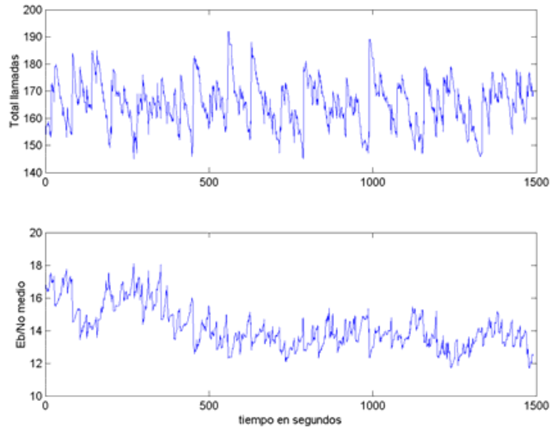

Figure 13 Total number of calls and Eb/No mean against time for system 3

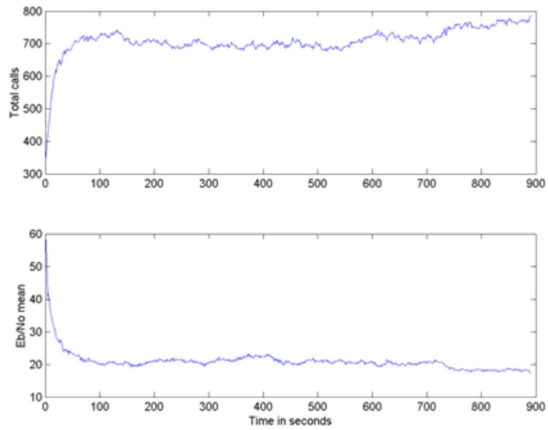

Figure 14 Total number of calls and Eb/No mean against time for system 4

V. CONCLUSIONS

We have shown that results for ideal conditions may differ significantly from results obtained in conditions closer to reality in mobile systems when we consider terrain topology and propagation factors depending of terrain topology. Like diffraction as is the case with Univalencia model that is a modification o Walfisch-Bertoni model.

The case for the first scenarios, system1 and system 2 shows that considering a propagation model almost ideal like Hata gives us a high capacity system, but if we consider diffractions over buildings or some other factors, results may differ considerably and make a system impractical from capacity point of view.

The case for second group of scenarios shows that under similar conditions, a factor like sectorization may ha a bigger impact than theoretically predicted, but capacity is still far from ideal sectorized system.

The main conclusion of this work is that we must consider topological terrain conditions and use different tools to plan third generation systems. We must also consider terrain particular conditions in order to use the most appropriate propagation model that permit us make an adequate plan for a third generation system that maximize coverage and capacity for different kind of services.

VI. REFERENCES

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