Some Parameters That Affect CDMA Capacity Analysis. Results Using GIS Based Simulation

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Abstract: *In this paper we use a model that we have developed for CDMA capacity analysis, and a planning tool developed in Technical University of Valencia, to see how different conditions like propagation model, number of cells and overlapping affect the estimation of CDMA and WCDMA capacity. We will show that the overlapping is not a direct parameter that affect capacity, and there are other factors to consider.*

1 INTRODUCTION

In [2] and [3] 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 and "clustering" CDMA in order to improve planning process for third generation systems.

In this paper we will show results for variations of some of this parameters, specifically cell size and number of cells. In CDMA systems is quite common supposing only one carrier frequency for capacity estimations, and is intuitive think that for more base stations, more users. However the Multiple Access Interference problem in CDMA systems could establish a limit for that supposition in a similar way that occurs in FDMA and TDMA systems.

Paper is organized as follows; following section makes a description of simulation conditions and restrictions, next section shows some results obtained for voice traffic with a nine cells test system and next shows results for voice traffic with a nineteen cells system. Finally, there are some conclusions.

2 SIMULATION CONDITIONS

As we explain above, our main concern is to know how a CDMA (or WCDMA) system is affected by cell size and number of cells in the system assuming one carrier frequency. One of the aspects well known in CDMA systems is that overlapping can affect negatively the Multiple Access Interference (MAI) problem, the we have considered one test system with a relatively big grade of overlapping, and a test system with less overlapping, to see how this factor influence in capacity.

Then, our test systems have the following conditions. The first test system has nine cells with transmitters located at 6m high and 24dBm of power with omni directional antennas. The propagation model used was Saunders-Bonar irregular because transmitters were below building rooftops.

The second test system has the same characteristics than first, but with nineteen cells. It implies that exists a relatively big overlapping because we are simply introducing more base stations in the system.

For traffic generation, we are using a Poisson model, with mean duration of calls bigger than simulation time with the objective of heavily load the system. We are not considering users mobility, then we do not estimate call loss because of handover. Both systems use the same traffic model, and then the only thing that limits the number of calls is the interference produced by users.

Simulation time for both systems was 300 seconds with time slices of 0.5 seconds. Figure 1 and Figure 2 shows test systems with nine and nineteen cells respectively.

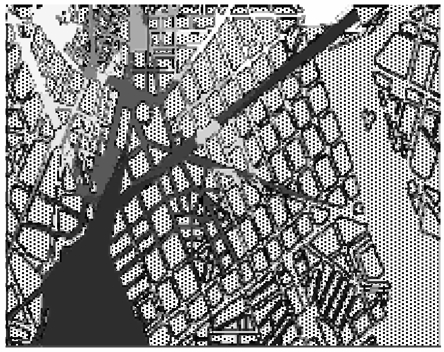

Figure 1: Best Server map for test system

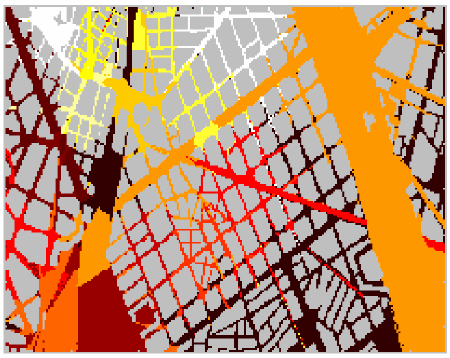

Figure 2 : Best server map for 19 cell test system

3 SOME RESULTS FOR NINE CELLS SYSTEM

Figure 3 shows the state of the system at end of simulation and shows Eb/No and number of active calls. We can observe in the figure that cell No.3 have less calls than cell No.6, however the Eb/No relation is better for cell No.6.

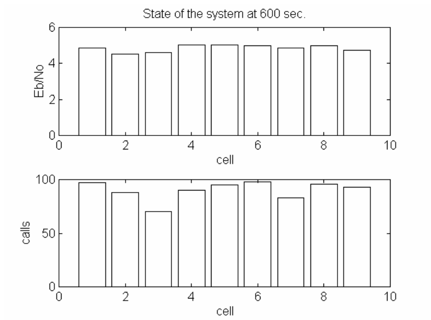

Figure 3 : Number of calls at end of simulation

In Figure 5 we can observe the overlapping zones in the system. Note that grade of overlapping is big, but in a micro cellular environment is difficult to avoid such overlapping because you need give service in all service area.

With nineteen cells, we increase the service area, but we increase the overlapping area too, as we can se in Figure 4.

As we have mentioned above, cell No.3 have a relatively small number of calls (70), but the interference is bigger than cell No.6. We can observe that cell No.3 have a big overlapping compared with cell No.6. More exactly, cell No.3 presents overlapping in 93% of its area while cell No.6 presents overlapping in 55% of its area, as we can see in Figure 7.

Figure 4: Overlapping zones for 19 cells

Figure 5: Overlapping zones for 9 cells

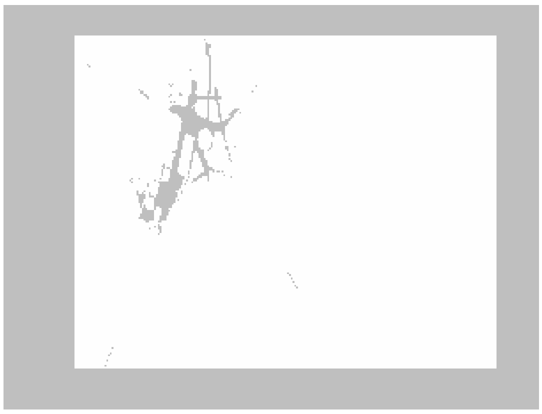

Figure 6: Area of Cell No. 3

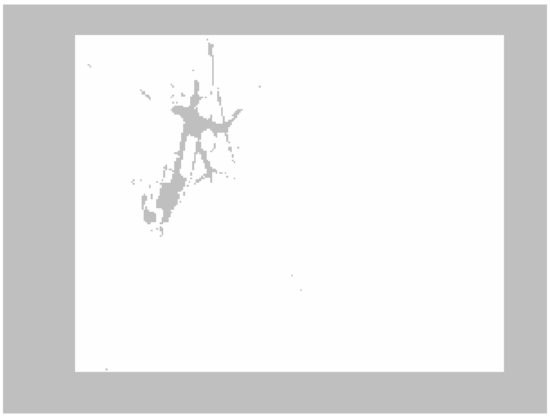

Figure 7: Overlapped area of cell No. 3

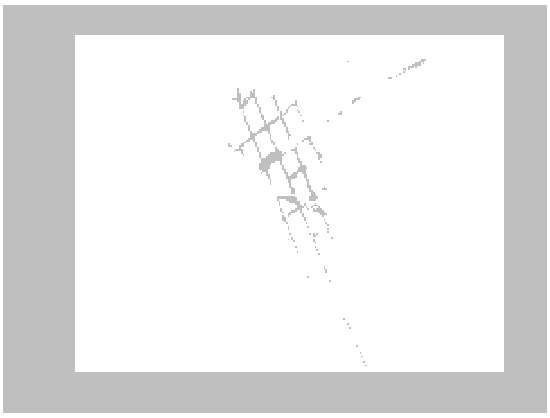

Figure 8: Cell No. 6

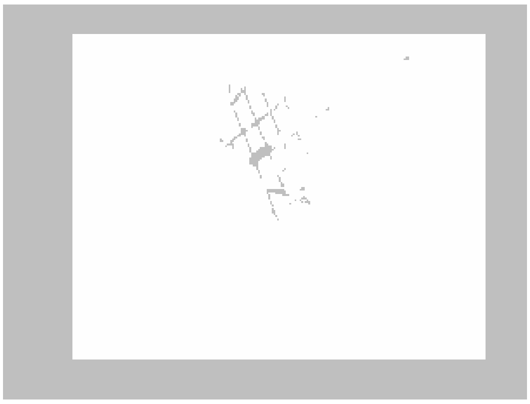

Figure 9: Overlapped area of cell No. 6

In Table 1 we can see the percentage of overlapping of each cell in the nine cells system. If we compare this percentage with the number of calls in each cell and the relation Eb/No, then we cannot see a clear relation, except for cell No.3.

The counterexample for situation in cell No.3 is the case of cell No.9, with similar number of calls of cell No.8, similar Eb/No, but percentage o overlapping in cell No.9 is only 20%.

Cell No.	Percentage overlapping
1	69.5856
2	56.1422
3	92.9739
4	67.9825
5	68.2475
6	55.0675
7	50.3300
8	64.0565
9	19.6517

Table 1: Percentage of overlapping of cells for nine cell system

4 SOME RESULTS FOR NINETEEN CELLS SYSTEM.

As we can observe in **Figure 2**, the system with 19 cells is a system with better coverage area, but with very closer coverage zones, then the overlapping is bigger than overlapping in nine cells system.

In Figure 10 we can observe the number of active calls in the system and the Eb/No at the end of simulation. The figure shows clearly two things, the number of calls in cell No.10 is much bigger than other cells, with a Eb/No high, and the number of calls in cell No.1 is the lowest in the system and it have the worst Eb/No.

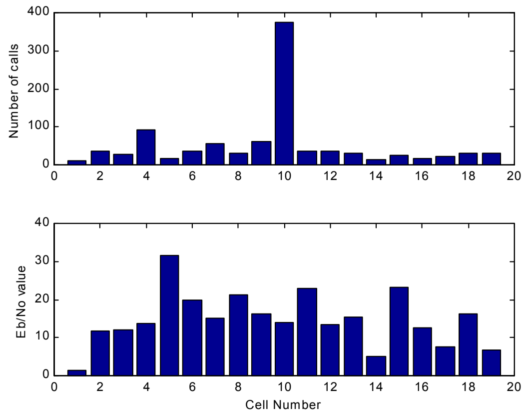

Figure 10: Number of calls and Eb/No at end of simulation

Lets analyse first the case of cell No.1. The overlapping of cell No.1 is 99.9%, that is, we can eliminate it without degrade coverage area. Besides, we can appreciate in Figure 11 that cell No.1 is affected mainly by cells No.13 and No.14. Then, calls cursed in cell No.14 and cell No.14 affect the value of Eb/No in cell No.1 after the cell has reached the blocking condition.

Now, looking the situation in cell No.13 and cell No.14, is the next. Cell No.13 have 32 calls, an overlapping of 92.9% and Eb/No=15. Cell No.14 have 14 calls, an overlapping of 78.8% and Eb/No=4.99.

Figure 11: Position of cell No1 relative to cells No.13 and No.14

Now the question that seems obvious is that there is no relation, or at least not a clear one, between the percentage of overlapping and the individual capacity of a cell. The example is cell No.14 and cell No.13. Cell No.14 have less overlapping, less calls and less Eb/No than cell No.13. Specifically, cell No.14 is blocked with only 14 calls. In Figure 11, cell No.14 is the left one, and then it has fewer cells around it than cell No.13 that is crossed by cell No.1.

But if look at Figure 13 and Figure 14, then we can understand better what is happening. Figure 13 show the number of users that can be served by cell No.14 if it would be alone, without neighbors and Figure 14 show the real number of users attended by cell No.14.

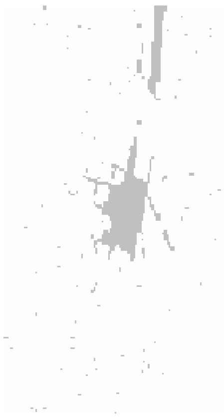

Figure 12: Cell No.1 and users around it

The users that appear in Figure 13 are 50 and the users attended by cell No.14 are 14. The other 36 users cause interference but are served by another cells in the system.

In other words, cell No.14 is receiving interference from users attended by neighbor cells with the same intensity that those users would be attended by cell No.14, because the best server selection process assigns other BS to those users.

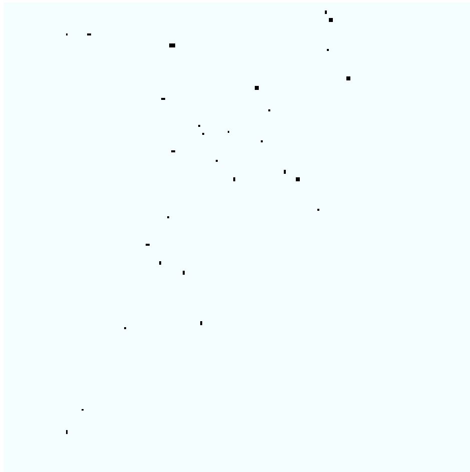

Figure 13: Users that could be attended by cell No.14

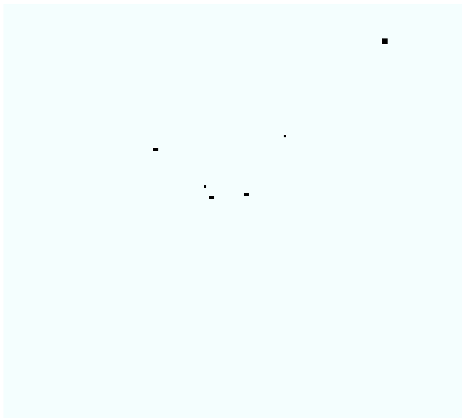

Figure 14: Users attended by cell No.14

The situation is similar for cell No.1 and its neighbors. In that case, cell No.1 gives adequate coverage to 170 users, but is only attending 10. Other cells are attending the other.

5 CONCLUSIONS

The final thing to revise is the total number of calls that each system can attend. In this case, we have to consider that service area is bigger with nineteen-cell system, and then we expect a total number of active calls bigger than nine cells system. However, the number of calls by unit area is a good approximation to compare capacity and how the overlapping affects it. For nine cells system, we have 3.6 calls by 1000 square meters with the system at maximum capacity, and for nineteen cells system, we have 3.0 calls by 1000 square meters without blocking. Extrapolating results we obtain numbers a little bigger for nineteen cells system, then the number of cells in a similar coverage area does not affect capacity in a linear way. This is an expected result because of nature of CDMA based systems and the more interference when we have more cells.

From a planning point of view, the capacity increasing in a WCDMA system is not obtained only with more BS, as we do in TDMA. The need for more BS is given by coverage area more than an increase in capacity.

We show also that overlapping percentage is not a factor per se, but is accomplished by the question of which cell overlaps which cell. Then in a planning process we must be careful with the location of Base Stations to avoid that users from neighbour cells interfere another cells. This is difficult to control in urban micro cellular systems where the coverage shapes are very irregular.

Another particular behaviour showed did users closer to a cell different from those attending call generate the effect of calls, 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.

6 REFERENCES

[1] LEWIS, T.G. and SMITH, B.J. Computer principles of modeling and simulationDallas: Houghton Mifflin Company, 1.979. 393 p. ISBN: 0-395-27143-6.

[2] Cardona, Narcís and Navarro, Andrés. Capacity Analysis in CDMA Systems Using GIS Based Planning Tools. IEEE International Conference on Third Generation Wireless Communications. SanFrancisco, June 14-16, 2000

[3] Cardona,N. And Navarro, A. W_CDMA Capacity Analysis using GIS Based Planning Tools and MATLAB Simulation. International Conference on 3G Mobile Communication Technologies, London, March 27-29, 2000

[4] GILHOUSEN, K.., I. Jacobs, R.Padovani, A.Viterbi, L.Weaver, and C. Wheatley, III. On the capacity of a cellular CDMA system, IEEE Trans. On Vehicular Technology, Vol.40, N∫ 2, May 1991, pp. 303-312

[5] CARDONA Marcet, Narcís, JUAN Llácer, Leandro y REIG Pascual, Juan. Sistemas de Radiocomunicación: Planificación mediante sistemas de información geográfica. En: Mundo Electrónico, Nº267, mayo de 1.996. pp 47-51.

[6] RAPPAPORT, Theodore S. Wireless Communications: Principles and Practice. Upper Saddle River, New Jersey: Prentice Hall. 1.996 pp 69-133.

[7] Jung, Peter Baier, Walter and Seil, Andreas. Advantages of CDMA and Spread Spectrum Techniques over FDMA and TDMA in cellular Mobile Radio Applications. IEEE Trans. On Vehicular Technology, Vol. 42 Nº3, august 1993. Pp 357-364

[8] Viterbi, Audrey and Viterbi, Andrew. Elang Capacity of a Power Controlled CDMA System. IEEE Journal on Selected Areas in Communications. Vol. 11, Nº6, august 1993, pp 892-900

[9] Eng, Thomas and Milstein, Laurence B. Comparison of Hybrid FDMA/CDMA Systems in Frequency Selective Rayleigh Fading. IEEE Journal on Selected Areas in Communications, Vol.12, Nº5, June 1994, pp 938-951

[10] Jalali, Ahmad and Mermelstein, Paul. Effects of Diversity, Power Control, and Bandwidth on the Capacity of Microcellular CDMA Systems. IEEE Journal on Selected Areas in Communications, Vol.12, Nº5, June 1994, pp.952-961

[11] Hass, Zygmunt, Winters, Jack and Johnson, David. Simulation Results of the Capacity of cellular Systems. IEEE Transactions on Vehicular Technology. Vol.46, Nº4, November 1997, pp. 805-817.

[12] Hass, Zygmunt, Winters, Jack and Johnson, David. Simulation Results of the Capacity of cellular Systems. IEEE Transactions on Vehicular Technology. Vol.46, Nº4, November 1997, pp. 805-817.

[13] Dahlman, Erik, et. al. UMTS/IMT-2000 Based on wideband CDMA. IEEE Communications Magazine . September 1.998, pp.70-80

[14] Ewerbring, : Farjh, J. And Granzow,W. Performance Evaluation of a Wideband Testbed Based on CDMA. Proc. VTC'97, Phoenix, AZ, May 1997.

[15] Sundelin,M. Granzow, W. And Olofsson, H. A Test System for Evaluation of the W-CDMA technology. Proc. VTC'98, Ottawa, Canada, May 1998

[16] Navarro, Andres and Cardona, Narcis. Capacity Analysis in CDMA Systems Using GIS Based Planning Tools . IEEE International Conference in 3G wireless and beyond , 3G-2000. San Francisco, June 2000.

[17] Christer, B. And Johansson, V. Packet Data Capacity in a Wideband CDMA System. Conference Record of IEEE 48th Vehicular Technology Conference. Ottawa, 1.998.

[18] Lee, Jhong Sam and Miller, Leonard E. CDMA systems engineering handbook. Artech House, 1998