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Simulation of GSM Mobile Networks Planning Using ATOLL Planning Tool

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***Abstract** – This project involves hands-on simulation exercise on planning of RF network with the help of Atoll planning software tool. The main aim of radio network planning is to provide a cost effective solution for the radio network in terms of coverage, capacity and quality. Utilizing the available limited bandwidth very preciously so as to cater to millions in a vast area with good quality, coverage, and without interference using ATOLL planning tool is the cream of this project.*

***Keywords** - BSIC,* **CI, LAC, ARFCNs - BCCH & TCH, MAIO, TRXs, HSN.**

I. INTRODUCTION

This GSM radio network planning is to provide a cost-effective solution for the radio network in terms of coverage, capacity and quality. Band width is a scarce natural resource. The bandwidth has to be managed for maximum capacity of the system and interference free communications. The spectrum availability for an operator is very limited and at the same time the operator need to cater to millions of subscribers scattered in a very large area. The uplink or down link frequencies is only 25 MHz in the GSM 900 band width ,which is having 124 carriers each 200khz. All the existing operators need to share these carriers, as a result each operator gets only a few tens of carriers; making spectrum management a challenging area. Utilizing the available limited bandwidth very preciously so as to cater to millions in a vast area with good quality, coverage, and without interference using ATOLL planning tool is the cream of this project

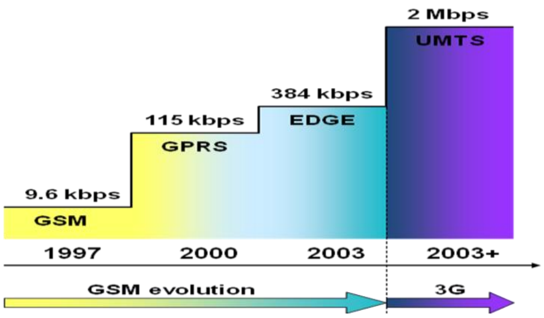

Fig 1. Evolution of GSM Mobile

In designing phase an approximate number of base station sites, base stations and their configurations and other network elements are estimated, based on the operator's requirements and the radio propagation in the area. The dimensioning must fulfill the operator's requirements for coverage, capacity and quality of service. The planning and the optimization process can also be automated with intelligent tools and network elements. higher speed wireless data services with vastly improved spectral efficiencies through the HSDPA feature. to realize n/w efficiencies and to reduce the cost of delivering traffic and can provide wireless traffic routing flexibility.

II. RADIO NETWORK PLANNING

Achieving maximum capacity while maintaining an acceptable grade of service and good speech quality is the main issue for the network planning. Planning an immature network with a limited number of subscribers is not the real problem. The difficulty is to plan a network that allows future growth and expansion. Wise re-use of site location in the future network structure will save money for the operator.

➢ ***Various Steps in Planning Process:***

Planning means building a network able to provide service to the customers wherever they are. This work can be simplified and structured in certain steps. The steps are,

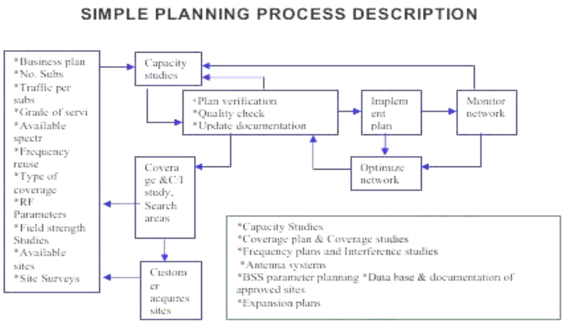

Fig 2. Diagram of Simple Planning

For a well-planned cell network planner should meet the following requirements,

- Capacity Planning
- Coverage Planning
- Parameter Planning
- Frequency Planning

➢ ***Radio Network Planning***

Radio network planning, in terms of capacity and coverage planning, and network optimization. This network planning fulfills the operator's requirements for coverage, capacity and quality of service. Capacity and coverage are closely related in WCDMA networks the radio network design process itself is not the only process in the' whole

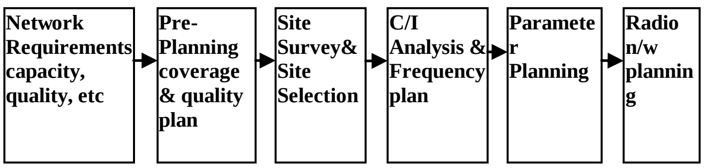

Fig 3. The Radio Network Planning Process

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Network design, as it has to work in close coordination with the planning processes of the core and especially the transmission network. But for ease of explanation, a simplified process just for radio network planning is shown in above Figure. The planning and the optimization process can also be automated with intelligent tools and network elements.

A. Dimensioning:

Radio network dimensioning is a process through which possible configurations and the amount of network equipment are estimated, based on the operator's requirements related to the following.

Coverage:
- Coverage regions;
- Area type information;
- Propagation conditions.

Capacity:
- Spectrum available;
- Subscriber growth forecast;
- Traffic density information.

Quality of Service:
- Area location probability (coverage probability);
- Blocking probability;
- End user throughput.

1. Radio Link Budgets:

The detailed radio network plan can be sub-divided into three sub-plans:

(1) Link budget calculation,

(2) Coverage, capacity planning and spectrum efficiency,

(3) Parameter planning.

Link budget calculations give the loss in the signal strength on the path between the mobile station antenna and base station antenna. These calculations help in defining the cell ranges along with the coverage thresholds. Coverage threshold is a downlink power budget that gives the signal strength at the cell edge (border of the cell) for a given location probability. As the link budget calculations basically include the power transmission between the base station (including the RF antenna) and the mobile station antenna, we shall look into the characteristics of these two pieces of equipment from the link budget perspective.

Link budget calculations are done for both the uplink and downlink. As the power transmitted by the mobile station antenna is less than the power transmitted by the base station antenna, the uplink power budget is more critical than the downlink power budget. Thus, the sensitivity of the base station in the uplink direction becomes one of the critical factors as it is .related to reception of the power transmitted by the mobile station antenna. In the downlink direction, transmitted power and the gains of the antennas are important parameters. In terms of losses in the equipment, the combiner loss and the cable loss are to be considered. Combiner loss comes only in the downlink calculations while the cable loss has to be incorporated in both directions.

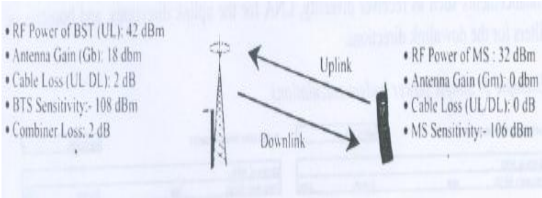

Fig 4.Link Budget Calculation

For the other equipment (i.e. the MS), the transmitted power in the uplink direction is very important. To receive the signal transmitted from the BTS antenna even in remote areas, the sensitivity of the MS comes into play. The transmitting and the receiving antenna gains and the cable loss parameters are to be considered on the BTS

a) Load Factors:

The second phase of dimensioning is estimating the amount of supported traffic per base station site. When the frequency reuse of a GSM system is 1, the system is typically interference-limited and the amount of interference and delivered cell capacity must thus be estimated.

b) Capacity Upgrade Paths:

When the amount of traffic increases, the downlink capacity can be upgraded in a number of different ways. The most typical upgrade options are:

- more power amplifiers if initially the power amplifier is split between sectors;
- two or more carriers if the operator's frequency allocation permits;
- Transmit diversity with a 2nd power amplifier per sector.

The availability of these capacity upgrade solutions depends on the base station manufacturer. All these capacity upgrade options may not be available in all base station types.

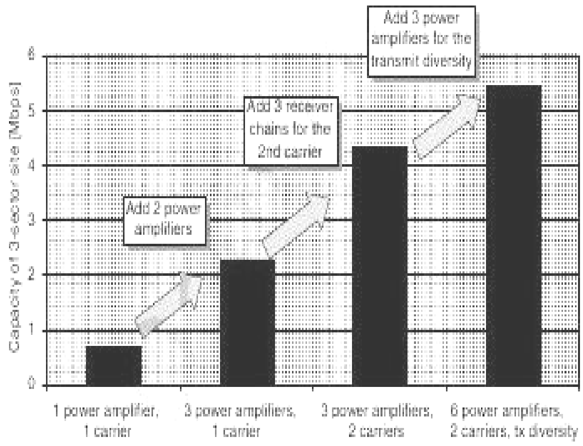

Figure 8.11. An example capacity upgrade path for 3-sector macro site

Fig 5. Graphical Chart 1

These capacity upgrade solutions do not require any changes to the antenna configurations, only upgrades within the base station cabinet are needed on the site. The uplink coverage is not affected by these upgrades. The capacity can be improved also by increasing the number of antenna sectors, for example, starting with Omni-directional

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antennas and upgrading to 3-sector and finally to 6-sector antennas. The drawback of increasing the number of sectors is that the antennas must be replaced. The increased number of sectors also brings improved coverage through a higher antenna gain.

c) Capacity per km2:

Providing high capacity will be challenging in urban areas where the offered amount of traffic per km2 can be very high. In this section we evaluate the maximal capacity that can be provided per km2 using macro and micro sites.

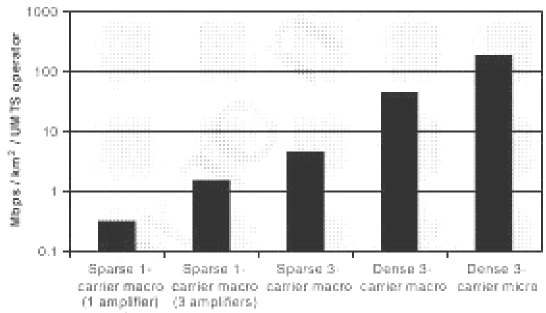

Fig 6. Graphical Chart 2

For the micro cell layer we assume a maximum site density of 30 sites per km2. Having an even higher site density is challenging because the other-to-own cell interference tends to increase and the capacity per site decreases. Also, the site acquisition may be difficult if more sites are needed.

d) Soft Capacity:

Erlang Capacity: In the dimensioning the number of channels per cell was calculated. Based on those figures, we can calculate the maximum traffic density that can be supported with a given blocking probability. If the capacity is hard blocked, i.e. limited by the amount of hardware, the Erlang capacity can be obtained from the Erlang B model. If the maximum capacity is limited by the amount of interference in the air interface, it is by definition a soft capacity, since there is no single fixed value for the maximum capacity. The soft capacity can be explained as follows. The less interference is coming from the neigh bouring cells, the more channels are available in the middle cell, With a low number of channels per cell, i.e. for high bit rate real time data users, the average loading must be quite low to guarantee low blocking probability.

e) Network Sharing:

The cost of the network deployment can be reduced by network sharing. An example of a network sharing approach is illustrated in below Figure where both operators have their own core networks and share a common radio access network, BSC. This solution offers cost savings in site acquisition, civil works, transmission, BSC equipment costs and operation expenses. Both operators can still keep their full independence in core network, services and have dedicated radio carrier frequencies. When the amount of traffic increases in the future, the operators can exit the shared BSC and continue with separate BSCs.

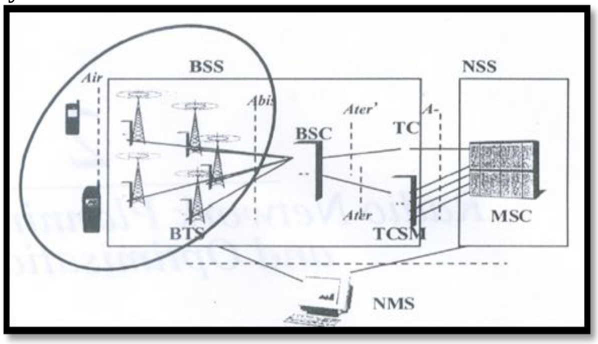

Fig 7: The Scope Of Radio Network Planning

I. Capacity and Coverage Planning and Optimizations:

a. Iterative Capacity and Coverage Prediction:

In this section, detailed capacity and coverage planning are presented. In the detailed planning phase real propagation data from the planned area is needed, together with the estimated user density and user traffic. Also, information about the existing base station sites is needed in order to utilize the existing site investments. The output of the detailed capacity and coverage planning are the base station locations, configurations and parameters. Since, in GSM, all users are sharing the same interference resources in the air interface, they cannot be analyzed independently. Each user is influencing the others and causing their transmission powers to change. These changes themselves again cause changes, and so on. Therefore, the whole prediction process has to be done iteratively until the transmission powers stabilize.

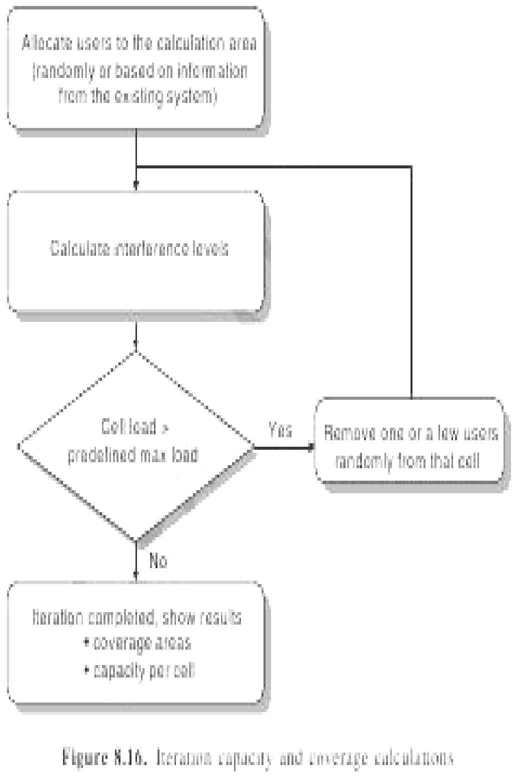

Fig 8. Flow Diagram

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Also, the mobile speeds, multipath channel profiles, and bit rates and type of services used play a more important role than in second generation TDMA/FDMA systems. Furthermore, in fast power control in both uplink and downlink, soft/softer handover and orthogonal downlink channels are included, which also impact on system performance. The main difference between GSM and TDMA/FDMA coverage prediction is that the interference estimation is already crucial in the coverage prediction phase in GSM. In the current GSM coverage planning processes the base station sensitivity is typically assumed to be constant and the coverage threshold is the same for each base station. Note also that all generation networks, the downlink can be loaded higher than the uplink or vice versa.

b. Planning Tool:

In second generation systems, detailed planning concentrated strongly on coverage planning and capacity analysis than simple coverage optimization is needed. The tool should aid the planner to optimize the base station configurations, the antenna selections and antenna directions and even the site locations, in order to meet the quality of service and the capacity and service requirements at minimum cost. An example of a commercial GSM planning tool is shown in below Figure.

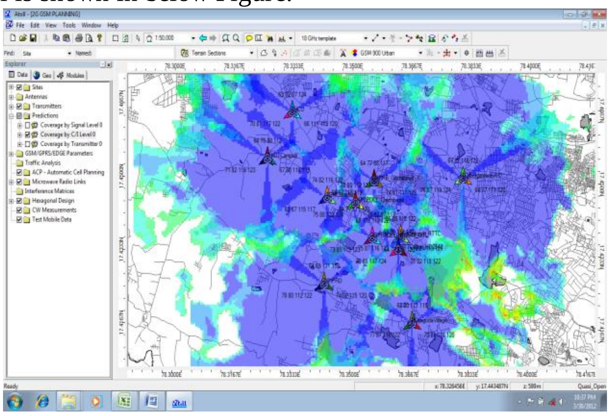

Fig .9. GUI Output

c. Network Optimization:

Network optimization is a process to improve the overall network quality as experienced by the mobile subscribers and to ensure that network resources are used efficiently. Optimization includes:

1. Performance measurements.
2. Analysis of the measurement results.
3. Updates in the network configuration and parameters.

The measurements can be obtained from the test mobile and from the radio network elements. The GSM mobile can provide relevant measurement data, e.g. uplink transmission power, soft handover rate and probabilities, CPICH Ec/N0 and downlink BLER.

The network performance can be best observed when the network load is high. With low load some of the problems may not be visible. Therefore, we need to consider artificial load generation to emulate high loading in the network. A high uplink load can be generated by increasing the Eb/N0 target of the outer loop power control. In the normal operation the outer loop power control provides the required quality with minimum Eb/N0. If we increase manually the Eb/N0 target, e.g. 10 dB higher than the normal operation point, that uplink connection will cause 10 times more interference and converts 32 kbps connection into 320 kbps high bit rate connection from the interference point of view.

III. CONCLUSION

Network RF planning is the foundation of a mobile communication network, especially the wireless parts in a mobile communication network costs great and is of vital importance to network quality, so we must make a good planning at earlier stage, which is helpful for network expansion and service update in the future. Network planning requires engineers to analyze coverage, decide network layers, and analyze traffic based on relative technologies and parameters, and finally output the results of RF planning, including base station layout and scale that provides the good quality, coverage, and without interference.

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