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Code Planning of 3G UMTS Mobile Networks Using ATOLL Planning Tool

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Abstract – *This paper involves hands-on simulation exercise on planning of 3G UMTS RF network with the help of Atoll planning software tool. It involves planning of coverage, quality & capacity of UMTS Network which uses WCDMA in radio interface between 3G base station and the User equipment. It also involves planning of scrambling codes for 3G WCDMA Network.*

1. Introduction:

This WCDMA radio network planning, including dimensioning, detailed capacity and coverage planning, and network optimization. In the dimensioning 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. 3G Americas is the company played significant role for evolution of UMTS to Release5 (Rel'5) of 3GPP in 2002 March. UMTS Rel'5 offers higher speed wireless data services with vastly improved spectral efficiencies through the HSDPA feature. Addition to HSDPA, UMTS Rel'5 introduces the IP Multimedia System (IMS), UMTS Rel'5 also introduces IP UTRAN concepts to realize n/w efficiencies and to reduce the cost of delivering traffic and can provide wireless traffic routing flexibility, performance and functionality advantages over the Rel'99 and Rel'4 standards.

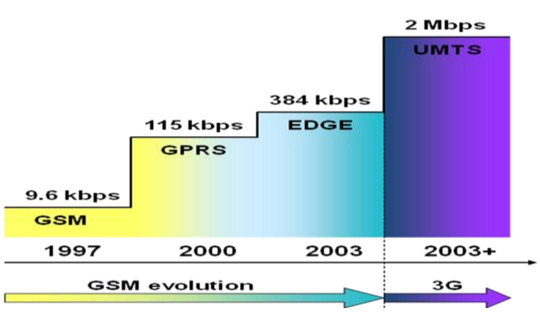


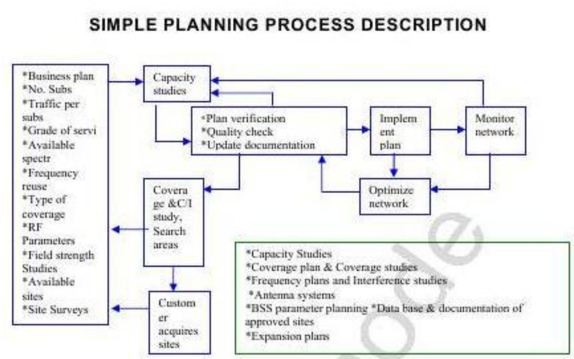
Figure. a. Evolution Of 3G UMTS

2. 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,



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

- Capacity Planning
- Coverage Planning
- Parameter Planning
- Frequency Planning
- Scrambling Code Planning

➢ WCDMA Radio Network Planning:

WCDMA radio network planning, including dimensioning, detailed capacity and coverage planning, and network optimisation. The dimensioning must fulfill the operator's requirements for coverage, capacity and quality of service. Capacity and coverage are closely related in WCDMA networks, and therefore both must be considered simultaneously in the dimensioning of such networks. Capacity and coverage can be analysed for each cell after the detailed planning. The planning and the optimization process can also be automated with intelligent tools and network elements.

I. Dimensioning:

WCDMA 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.

a) Radio Link Budgets:

There are some WCDMA-specific parameters in the link budget that are not used in a TDMA-based radio access system such as GSM.

- Interference margin: The interference margin is needed in the link budget because the loading of the cell, the load factor, affects the coverage. The more loading is allowed in the system, the larger is the interference margin needed in the uplink, and the smaller is the coverage area.

- Fast fading margin: Some headroom is needed in the mobile station transmission power for maintaining adequate closed loop fast power control. This applies especially to slow-moving pedestrian mobiles where fast power control is able to effectively compensate the fast fading.

- Soft handover gain: Handovers – soft or hard – give a gain against slow fading by reducing the required log-normal fading margin. This is because the slow fading is partly uncorrelated between the base stations, and by making a handover the mobile can select a better base station. Soft handover gives an additional macro diversity gain against fast fading by reducing the required E_b/N_0 relative to a single radio link, due to the effect of macro diversity combining.

b) Load Factors:

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

c) 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.

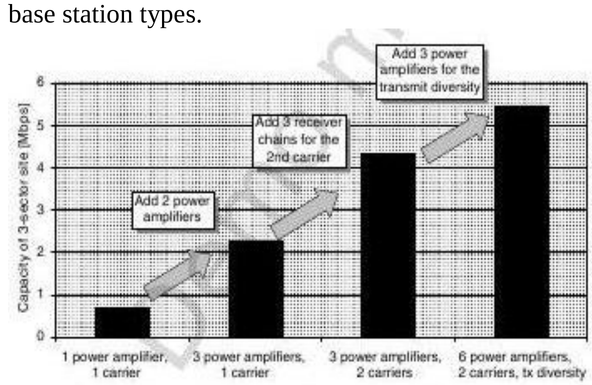
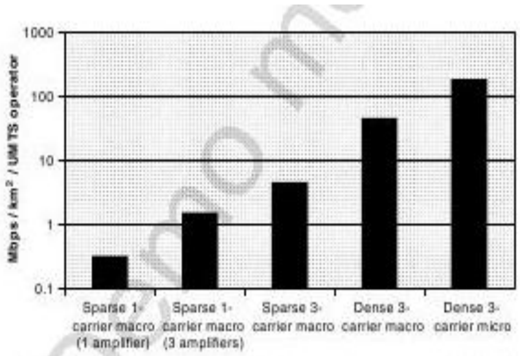


Figure 8.11. An example capacity upgrade path for 3-sector macro site

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 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.

d) 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.



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.

e) 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 neighbouring 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.

f) 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, RAN. This solution offers cost savings in site acquisition, civil works, transmission, RAN 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 RAN and continue with separate RANs.

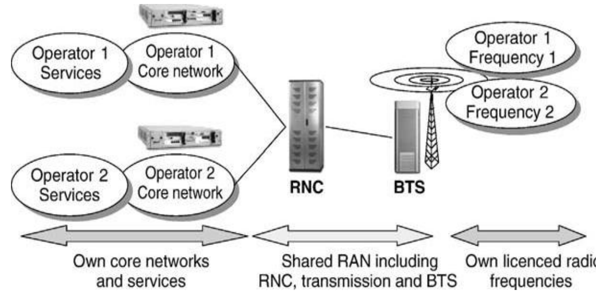


Figure: Sharing of a WCDMA radio access network

II. Capacity and Coverage Planning and Optimisation:

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 WCDMA, all users are sharing the same interference resources in the air interface, they cannot be analysed 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.

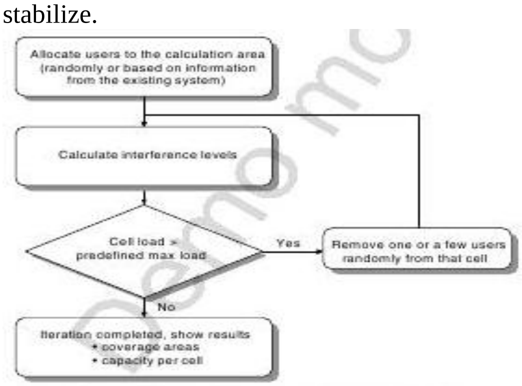
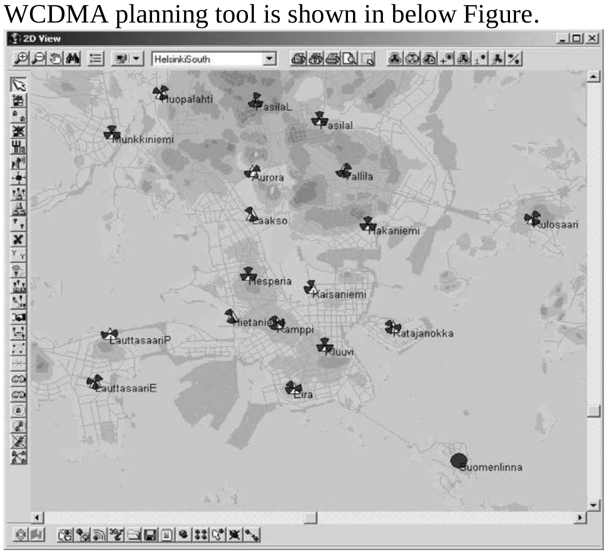


Figure 8.16. Iteration capacity and coverage calculations

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 WCDMA 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 WCDMA and TDMA/FDMA coverage prediction is that the interference estimation is already crucial in the coverage prediction phase in WCDMA. 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. In the case of WCDMA the base station sensitivity depends on the number of users and used bit rates in all cells, thus it is cell- and service-specific. Note also that in third 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. In third generation systems, a more detailed interference planning and capacity analysis than simple coverage optimisation is needed. The tool should aid the planner to optimise 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 WCDMA planning tool is shown in below Figure.



c. Network Optimisation:

Network optimisation is a process to improve the overall network quality as experienced by the mobile subscribers and to ensure that network resources are used efficiently. Optimisation 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 WCDMA 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.

3. Conclusion:

In this paper of UMTS-WCDMA radio network planning, primarily Node-B’s are planned. Apart from the number of NodeB to meet the coverage, quality and capacity requirements, the various parameters that are determined in this paper exercise are: location of base stations, number of antennas to be connected to each base station, EIRP, altitude, azimuth & down tilt of each antenna, etc.

The UMTS radio network of Gachibowli is planned with around thirty UMTS Node-Bs or base stations in such a way that the signal at street is better than -65dBm so that indoor coverage of atleast -85dBm is available assuming losses of around 20dB in Gachibowli wherein IT Park, Financial Village, L&T Infocity, are covered in an effective manner. The parameters of various Node-Bs planned are obtained by tuning antenna radio resource parameters and scrambling codes. Also the load capacity of the network is considered from marketing survey data & network is planned considering the Cell breathing process present in 3G networks.

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