Chapter 6

Mobile Network Planning

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Introduction

The geographical distribution of the subscribers poses a difficult problem for GSM networks. Without wire-connected telephones the subscribers can be virtually everywhere, but still the network must be able to provide a connection in spite of their movements. A good geographical coverage is the basis for providing network services. Careful network planning is thus a primary aspect of implementing GSM networks.

Network planning is an ongoing process, which requires inputs from a lot competence areas, such as transmission, access systems, data communications, mobile switching, Intelligent Network, site acquisition, etc.

Several requirements must be taken into consideration already in the early stages of the planning process:

- Costs of building the network
- Capacity of the network
- Coverage and location of network elements
- Maximum congestion allowed (grade of service)
- Quality of calls
- Further development of the network.

Various factors that affect the demand for network services must also be considered. These are mostly related to the inhabitants of the area, such as distribution of the population and vehicles, income of the population and statistics on telephone usage.

RF Planning Aspects

In RF planning we are concerned with planning of radio network .It implies-

Deciding number and location of BTS/BSC.

Deciding the Radio Parameters.

Transmission link for backhaul connectivity.

It becomes more important as it is an ongoing process, so as to cater the varying traffic and coverage requirements.

GSM Planning Requirement

The factors that affect the GSM Planning requirement which are Provision of required Capacity, Optimum use of the available frequency spectrum, Minimum number of cell sites, Provision of adequate Coverage of the given area for a minimum specified level of interference and provision of easy and smooth expansion of the network in future.

The main steps of a network planning process are as follows:
1. Collection of all relevant information.

2. Network dimensioning based on coverage and capacity requirements

3. Selection of MSC, BSC and Base Station sites (in this order).

4. Survey of intended MSC, BSC and Base Station sites

5. Detailed network planning.

By co-coordinating different information and different competencies, it is possible to prepare a network plan that includes the coverage predictions and the dimensioning of the network.

The Components of GSM RF Planning:

Before going for GSM planning, the components which are to be considered are-

1. Capacity planning

2. Coverage planning

3. Parameter planning

4. Equipment planning

5. Optimization

Switching network planning

Switching network planning plays an important role in the process. During the network dimensioning process, there are several important tasks to consider. The switches need to be dimensioned in accordance with the estimated needed capacity, for instance, average conversation time, the need for signalling, such as number of handovers, location updates, short message distribution, etc

It is necessary to define the network performance level, for instance the intended capacity of the switching network. The implementation of the switching and signalling network must also be considered.

After the network has been dimensioned, a detailed plan is made with a number of inputs, for instance Data Communications Network (DCN) settings towards the NMS, network diagrams,

the synchronization plan, a detailed routing plan, digit analysis, detailed signalling, numbering and charging plans, etc.

In addition to this, the planners must also consider the future expansion plans in order to have a roadmap to the future.

Cellular transmission network planning

Cellular transmission network refers to the usage of microwave links in the GSM network, for instance between the Base Transceiver Stations and the Base Station Controllers. Usually, the main alternative is to utilize the already existing fixed infrastructure.

In the network dimensioning phase, a lot of different information has to be collected and co-ordinate. The general transmission network diagram for base stations access and core networks must be drawn, in order to get a clear general picture of the network connections. It is also necessary to define the capacity requirements. Furthermore, rules for the general management of the network are to be defined.

Radio network planning

The type and location of the BTS depends on the characteristics of the surroundings. In city areas, cells are usually smaller than in the countryside. A larger traffic volume also affects the number of channel frequencies in a certain cell (TRXs).

The maximum theoretical distance from a BTS to the edge of the cell is 35 kilometers. The timing advance is adapted for these distances (that is the ability of the mobile station to send the bursts in advance so that they arrive in the BTS in the right timeslot). One factor that limits the cell size is the wavelength of the frequency.

The rule is that the higher the frequency, the smaller the size of the cell. It means that the potential cell coverage in GSM 900 is larger than for 1800 and 1900 networks. Another factor that affects the cell size is the geographical condition. As an example, open water attenuates the signal less than for instance forest or city environment.

Planning Process

Planning is a continuous process. Planning, implementation. operation and evaluation are the steps through which the process is completed and this cycle goes on. The main processes involved in GSM planning are-

1. Coverage and traffic Analysis
2. Nominal cell planning
3. Survey
4. System design
5. Implementation

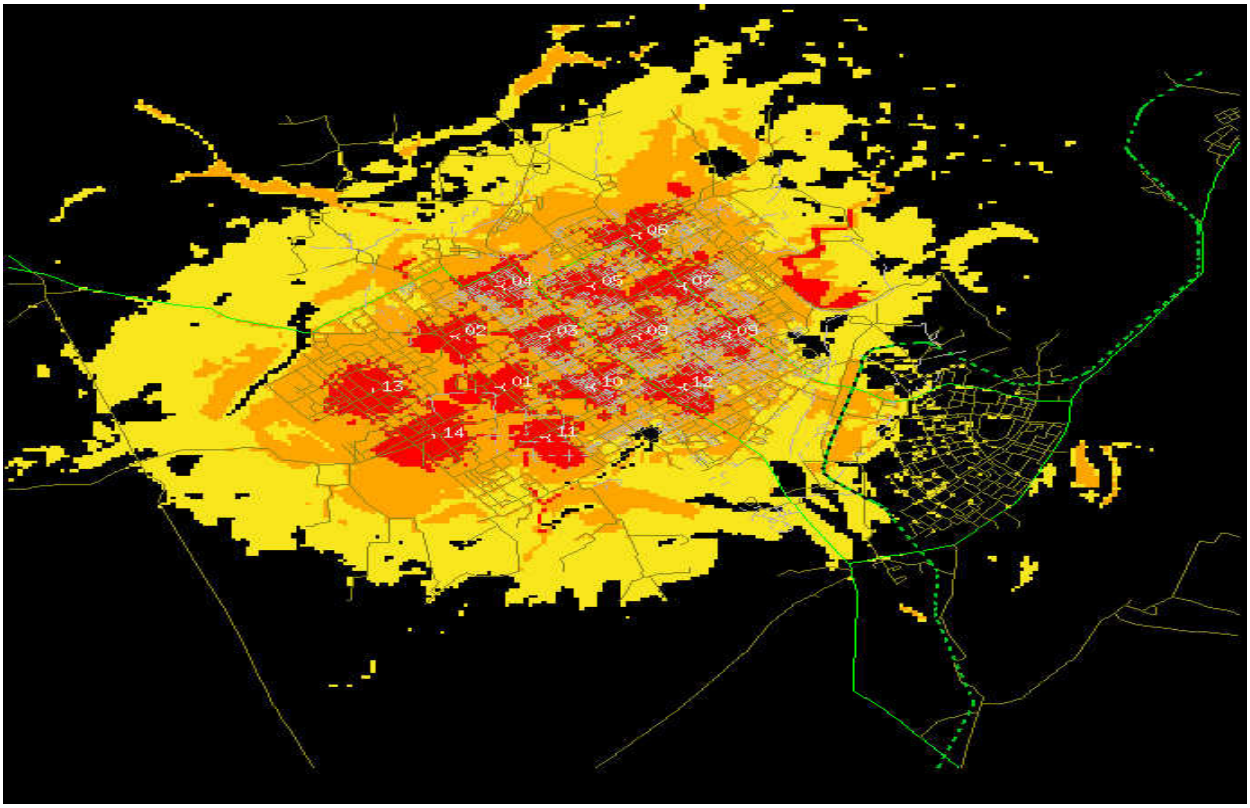
6. System Tuning

Initial Cell Planning

Initial Cell Planning comprises of Creating a Nominal Cell Plan. In it number of sites and distribution required to meet coverage requirement is calculated. At the same time. number of sites and distribution required to meet capacity requirement. is also calculated. In Initial Cell Planning, assessment of available site locations, locating the nominal sites and coverage is finalised along with prediction of coverage is assessed.

Detailed Cell Planning

Detailed Cell Planning comprises of getting a Digitised Terrain Maps (DTM's) of that area and preparation of link budgets. Here a Planning Tool is use to plan for a site and to get Coverage Plots as shown in the Digitised Terrain Maps (DTM's) below:



A Typical Coverage Plot in DTM

Calculating Number of Sites – Capacity

A cell is the basic 'construction block' of a GSM network. One cell is the geographical area covered by one BTS. Here cell dimensioning is done.

Dimensioning a cell means finding answers to two fundamental questions: How many traffic channels (TCH) does the cell need to handle and how many traffic channels are necessary? To solve these problems, that is, to determine the traffic capacity, we have to calculate the number of Erlangs. Erlang is the measuring unit of network traffic. One Erlang equals the continuous use of a mobile device for one hour.

For calculating the Number of Sites in Capacity view point, the traffic offered as per the configuration required certain input data are required like traffic per subscriber, GoS (Grade of Service), number of TCHs available for each carrier configuration etc and using the Earlang B-table (as shown below), the number of sites are planned accordingly.

No.of Trunks	Grade of Service					
	0.01%	0.10	0.50%	1.00%	2.00%	4.00%
1.	0.0001	0.001	0.005	0.0101	0.0204	0.0417
2.	0.0142	0.0458	0.1054	0.1526	0.2235	0.3333
3.	0.0868	0.1938	0.349	0.4555	0.6022	0.812
4.	0.2347	0.4393	0.7012	0.8694	1.0923	1.3994
5.	0.452	0.7621	1.132	1.3608	1.6571	2.0573
6.	0.7282	1.1459	1.6218	1.909	2.2759	2.7649
7.	1.0541	1.5786	2.1575	2.5009	2.9354	3.5095
8.	1.4219	2.0513	2.7299	3.1276	3.6271	4.283
9.	1.8256	2.5575	3.3326	3.7825	4.3447	5.0796
10.	2.2601	3.092	3.9607	4.4612	5.084	5.8954
11.	2.7216	3.8511	4.6104	5.1599	5.8415	6.7272
12.	3.2069	4.2314	5.2789	5.876	6.6147	7.5827
13.	3.7133	4.8305	5.9638	6.6072	7.4015	8.43
14.	4.2387	5.4464	6.6632	7.3517	8.2003	9.2977
15.	4.7811	6.0772	7.4755	8.108	9.0096	10.175

Excerpts from Erlang B Table

Calculating Number of Sites - Coverage

For Calculating Number of Sites in Coverage view point, certain calculations are carried out. In it the Coverage Distribution is to be analysed. Depending upon Maximum Available Power Loss that is occurring on any link, the total link budget is calculated.

For coverage Predictions**,** Required input data are site locations (longitude, latitude), Antenna design, height, tilt, direction, type, pattern etc. Propagation Model of the planning network are also used for calculations.

This gives an idea about the range up to which the sue MS will get proper power to work satisfactorarily. This leads to calculate the cell radius, depending on which the total number of sites can be calculated.

Rough cell coverage area calculation

Cell coverage area for an omni site = $(3/2)*\sqrt{3}*R2$

Cell coverage area for a sectorised site: = $(9/8)*\sqrt{3}*R2 = 1.95*R2$

Where R = cell radius

Estimation of Number of Sites

On the basis of Cell coverage Area, number of sites for each area is calculated e.g. coverage area per site divided by total Coverage area gives tentative number of sites required i.e.

No. of sites required = Total Coverage Area / Coverage area per site .

This gives the idea about the number of sites will be required for a particular location.

The type and location of the BTS depends on the characteristics of the surroundings. In city areas, cells are usually smaller than in the countryside. A larger traffic volume also affects the number of channel frequencies in a certain cell

The maximum theoretical distance from a BTS to the edge of the cell is 35 kilometres. The timing advance is adapted for these distances (that is the ability of the mobile station to send the bursts in advance so that they arrive in the BTS in the right timeslot). One factor that limits the cell size is the wavelength of the frequency. The rule is that the higher the frequency, the smaller the size of the cell. It means that the cell coverage in GSM 900 is larger than for 1800 and 1900 networks. This factor is also considered in Planning.

Another factor that affects the cell size is the geographical condition.

Surveys

Survey is the most important work on planning. It implies Radio survey (Area visits),Site surveys, Simulation of surveyed site alternatives, Joint site surveys with civil works engineers and Site survey reports.

Site Survey covers the Coverage objectives (site locations), Antenna Mounting (obstructions, etc), Feeder Length (feeder cable loss),,Equipment room (size and location),Cable ducts / Antenna masts (construction),Transmission Links (Microwave, fixed line)and Construction Cost (alternative solutions).

Joint Survey is done after the site candidate is finalized. In some cases the joint survey is carried out in before the site survey in order accommodate some sites. The joint survey team should consist of people responsible for different tasks e.g. radio-planning, construction/civil work (CW), site-acquisition etc.

Other Related Planning Aspects are Dimensioning of BTS equipment, Dimensioning of BSC, Dimensioning E1s needed. Drive test is also done after commissioning for Optimization, Traffic Monitoring and Plan for expansion.

One important task is to choose between leased lines and microwave links and type of configuration to be used.

After the installation work has been completed, the radio environment has to be measured and tested to ensure its proper operation and coverage before putting it into use. This is carried out in the surroundings of each individual site using portable test transmitters.

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