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Technical challenges and Constraints for Spectrum Planning in GSM networks

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Abstract**:** *GSM is the most widespread, most commonly deployed and fastest growing system standard for mobile telephony in the world. Even though UMTS, the third generation mobile system has entered the market. Network quality of service continues to be a key differentiator in the race for subscribers. One must meet expectations for outstanding performance for every user, on every call. Radio network system is a vast optimization task because different parameters of freq. planning like coverage, capacity and quality affect each other. So these parameters are required to be optimized at reasonable cost, at a true competitive edge with maximizing the efficiency. Quality of service of a network can only be achieved through proper spectrum and radio interface planning and with knowledge of radio propagation environments.*

In this paper we present the issues related to Network Design, , Design Constraints of System design and Expansion of coverage and Capacity, Cost Elements in Network Design ,Quality of Service & Radio Planning Methodology.

I. INTRODUCTION

Mobile Communication is one of the most active area of technology development of our time. This development is being driven primarily by transformation of what has been largely a medium for supporting voice telephony into a medium for supporting other services such as the transmission of video, images, text and data**.** GSM network is the most widespread, most commonly deployed and fastest growing system standard for mobile telephony in the world. Network quality of service is a key parameter in the race for subscribers, which can only be achieved through proper spectrum and radio interface planning and with knowledge of radio propagation environments.

Spectrum planning of a network system requires optimization of different parameters like coverage area, capacity and quality etc. These parameters are required to be optimized in terms of cost and efficiency in the competitive world.

II. Technical Challenges of Cellular Engineering

- Adequate Coverage and Capacity
- Quality of service
- Network growth accommodation and Cost effective design

1) ***Adequate Coverage and Capacity***: There are two main points regarding an adequate coverage of mobile radio system. First point is to achieve a large contiguous coverage with least coverage holes. Second point is to adequate depth of coverage (Indoor, Outdoor) meeting marketing plans. The mobile radio system should be capable of handling maximum possible traffic in busy hour with low Blocking Probability.

2) ***Quality of Service (QOS):*** Service should be with least Call Drops & Congestion and high Setup Success Rate and Voice Quality levels in service.

3) ***Network Growth Accommodation and Cost effective design*****:**

There should be scope for Coverage and Capacity expansion , maintaining the high quality levels. Simultaneously the cost for the expansion and maintenance should be minimum without affecting
Quality levels.

III. DESIGN CONSTRAINTS OF RADIO NETWORK PLANNING (COVERAGE AND CAPACITY)

The objective of Radio Network Planning is a technical realization of the Marketing requirement,keeping in mind the following constraints:

a) License Requirements (Technical requirements based on License conditions)

- To cover(class 4) 60% of population within 12 months of Commercial launch
- Availability of service in 90% of the area for 90% of the time
- To achieve certain Grade of Service (System Reliability is included)
- Availability of Limited Bandwidth divided over all licensed operators' frequencies allotted to a Radio Network System.

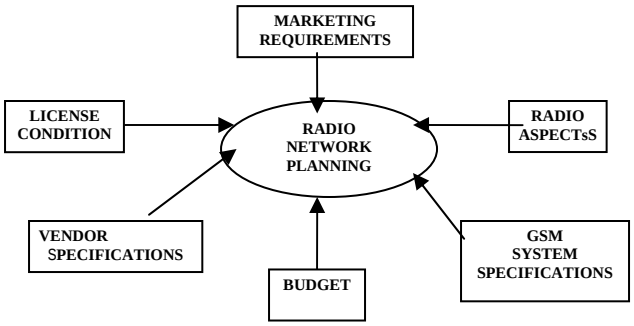

Figure 1: Design Constraints of Radio Network Planning

b) GSM Specifications (as per ETSI recommendations for Radio Transmit and Receive):

- Frequency Bands of operation
- Mobile Station Transmit Power(Class) class 4 , 2 W , 1800 - 1 W.
- BTS Transmit Power
- Receiver Sensitivities of MS and BTS, -102 dBm, -104 Dbm.
- Carrier to Interference Ratio(C/I), C/I - better than 9 db.

c) Vendor Specifications:

- BTS Transmit Power
- Receiver Sensitivity
- Cable Loss(Generally it is defined per 100 meters)
- Antenna Specifications, beam width etc.
- BTS Capacity, number of transceivers.

d) Radio Aspects:

- Radio wave propagation loss(due to diffraction, reflection, refraction, absorption)
- Shadowing (large scale fading)
- Multipath Fading (small scale fading, flat fading, freq. select fading, slow fading fast fading etc.)
- Interference
- Power Link Budgets

e) *Budget*: Budget is governed by Business plan. Areas are identified and prioritized based on return on investment.

IV. QUALITY OF SERVICE SPECIFICATIONS

- The Technical plan for Quality service is based on:

a) *Coverage Quality* - Determined by

- Outdoor Coverage - Averaged coverage Probability of 95% across the cell area
- Indoor Coverage - Extra Coverage for Strategic locations
- In Car Coverage - Supplementary level of coverage for highways and remote areas

b) *Interference Margin* - Besides the C/I values recommended by ETSI , extra interference margin should be taken into account.
c*) Blocking Rate* - Probability of an unsuccessful call attempt due to unavailability of radio resource (usually <2%)
d) *Grade of Service* - Probability of a lost call, includes reliability of the system.
e) *Call Success Rate* - Proportion of calls connected and held for 2 minutes within the defined coverage area(desired 98%)
f) *Dropped call rate* - Probability of disconnection due to Handover failure, null areas, interference or congestion(usually<5%)

In **QOS,** There are other plans except Technical plan.

- ***Roll-out Plans*** - Plans considering availability of coverage within certain time limits based on prioritization

- ***Traffic Forecasts*** - Important Considerations
  - Long term projections and trends developed by Marketing
  - Existing Traffic distributions and typical densities in the Existing network

- ***Spectral efficiency*** - Based on
  - Frequency Re-use
  - Clustering
  - Traffic trend design
  - TRX allocation
  - Business plan feedback

V. COSTS ELEMENTS IN NETWORK DESIGN

a)***Cost for Quality Network Design:***

- To Design Optimal N/W - Extensive Modeling and Numerous revision of design is essential.
- Cost in Acquiring the site locations meeting the Design specifications(Acquire as close to Designed sites)
- Extensive Drive tests before commissioning of site
- Integration of field measurements in design**.**

b) Potential Cost due to Improper Design

- Revenue loss due to disconnection
- Loss of Competitive Edge
- Enhanced Service Revenue loss

c) ***Redesigning Cost***

- Modifications of Cell Parameters

- ❖ Equipment modification/Change
- ❖ Relocation/Addition of sites

VI. VARIOUS STEPS OF RF PLANNING PROCESS

1. *Initial planning*: is done according to marketing requirements keeping design constraints which includes
--*CW MEASUREMENTS*
-- *MODEL TUNING*

***CW MEASUREMENTS*:** CW measurement includes parameters like transmitter output power, transmitter feeder cable loss, transmitter feeder cable length, transmitter antenna (omni directional antenna) gain, Effective isotropic radiated power.

While doing CW the following things are to be kept in mind:
- Choose test sites such that each site coverage area has nearly all the clutters.
- The route of each site should have all the clutters (numbers of bins for all the clutters must be same)
- The height of site = average clutter height + 3 meters.
- Use differential GPS.
- Take panoramic photos of CW survey sites and near by area.
- It is recommended that route length should be at least 80 kms.
- Take around 15 files, 13 for tuning the model and 2 for validating it.
- Take out of band frequencies for analysis.

***MODEL TUNING*:**
While calibrating the model we need to compare it with propagation data, so CW measurement help us to produce an accurate prediction model that functions correctly. We analyze the data and tune the model parameters to find out the S.D. in acceptable limits and Mean error to zero.

2. *Surveys:* Coverage maps are drawn and Documentation of the site survey is done for implementation.

TYPES OF SURVEYS—

***SITE SELECTION SURVEYS* -** is conducted before installing a site to consider following aspects:
-Location meeting the search-ring requirements
-Space for antennas
-Antenna Separations
-Obstacles Nearby
-Space for Radio Equipment
-Power supply / Back-up
-Transmission link
-Coverage area study
-Contract with the owner
***DRIVE TEST SURVEYS* -** conducted regularly
-To ensure the health and proper functioning of the Network and its elements.
- To detect Interference areas
- To meet the Subscribers needs
-To provide better coverage
-To solve Quality problems

3. *Testing of site and Drive test*: The tools like Test Mobile Phone**,** Lap Top having Drive Test Tool, UPS**,** GPS and Vehicle are used for the following purposes:
-Initial network coverage verification and benchmarking
- Coverage Verification before and after changes
- Locating and measuring interference
- Locating coverage holes
-Logging excessive handovers due to poor network design
- Preventive maintenance
- Simultaneous measurements of the other networks

4. *Optimisation:* The evaluated design parameters are optimized at reasonable cost and at a true competitive edge and simultaneously maximizing the efficiency and an analysis of traffic, coverage and quality is done. If site meets the quality norms, then commercial launch of the system can be started.

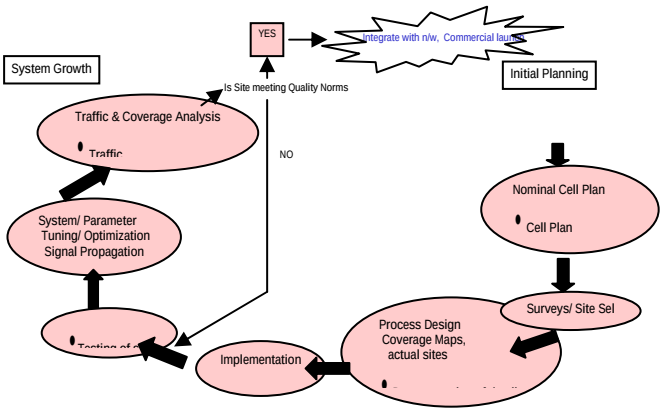

Figure-2. RF PLANNING PROCESS

VII.CONCLUSION

This paper has presented design objectives, technical challenges & their constraints, system requirements and related standardized operations.

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