Radio Frequency Optimization of a Global System for Mobile (GSM) Network

by

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ABSTRACT

Global System for Mobile (GSM) is a second generation cellular standard that was developed to solve the fragmentation problems of the first cellular systems and it specifies digital modulation techniques and network level architectures and services. To keep up with the change in the technology, organizations must be a learning organization to keep them in the competitive level.

The study will analyze the GSM architecture and will develop a simulated GSM system that will effectively optimize the performance of a GSM networks on a band limited system for a mobile company located in the Himalayan ranges in South East Asia in capital of Nepal.

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Chapter I: Introduction

In today's world communication technology plays a vital role. It has become an important tool for sharing information in a personal life or in any organizations for the transfer of data. The telephone was introduced to the public in 1876.Although the wire bound tele-service was growing at that time, there was a need of wireless communication for army, police etc. In the late 1940's, Frequency Modulation (FM) push to talk on the telephone were used to connect with the public telephone network. This analog system used a single high power transmitter and a large tower to cover the distance of 50km. It used the 120 KHz of radio frequency bandwidth in a half duplex mode. These systems were unable to support the large number of subscribers because of spectrum shortage.

Around the world different analog cellular systems were developed in later years in 34 different countries. These analog systems soon became inefficient because a mobile telephone developed for one system cannot be used with another so roaming was limited. In order to overcome these problems, the conference of European Posts and Telecommunications (CEPT) formed. In 1982, a Group Special Mobile (GSM) was developed which was using a digital technology. In 1989, GSM responsibility was transferred to European Telecommunication Standards Institute (ETSI), and phase 1 of the GSM specifications was published in 1990. Commercial service was started in the mid of 1991 with GSM 900 which uses 25MHZ and band width (890-915MHZ from mobile to base station and 935-960MHZ from base station to mobile). With the development of digital telephony GSM became popular due to these features:

- Superior speech quality
- Low terminal and service costs
- International roaming under one subscriber directory number.
- ISDN compatibility.

- High level of security.
- Support new range of services and network facilities.

Purpose of Research

The purpose of this research is to find a solution for network planning and optimization of GSM for one of the pioneer mobile operator company located in the Himalayan ranges of South East Asia, capital of Nepal. For the confidential purposes the name of the company will not be stated throughout the research but will be called XYZ Company.

Problem Background

Company XYZ is one independent, middle range communication company that has been providing a mobile service from more than14 years. It is a nation's leading communication company with a reputation of providing good and efficient service. Company XYZ launched GSM mobile services in May 1999 for the first time in Nepal. Company XYZ provides mobile as well as land line services along with DSL network for internet. The network of the company is expanded all over the country which covers almost all the major cities. People have been showing a great interest in mobile service of XYZ Company. The customer rate of increase for the company is almost greater than a double every year. Company XYZ has a public pressure to fulfill the demand of a prepaid mobile which is cheaper and popular throughout the country. There are millions of customers that are waiting for the service throughout the country due to the better quality of service and the various offers such as free receiving of the calls in between same service of line and no roaming charges throughout the county. Radio propagation in uneven lands is unpredictable. Radio network planning and optimization in the valley is the toughest job due to the uneven part of the land. The other major problem is the construction of the tall buildings near the base stations and the very high density of traffic. The customer concentration in the downtowns and in the major part of the cities is also high which will build the high traffic density. Despite having a tough geographical region and limited resources, Company XYZ is looking for various optimization techniques for proving a quality service and to fulfill the market demand.

Research Question

How do we find a proper network optimization and radio frequency planning method which would eliminate the resolve the increasing mobile customer demand with the good quality and service?

Chapter II: Literature Review

What is GSM?

Global system of mobile (GSM) is a second generation cellular standard that was developed to solve the fragmentation problems of first cellular systems and it specifies digital modulation techniques and network level architecture and services (Rappaport, 2001).

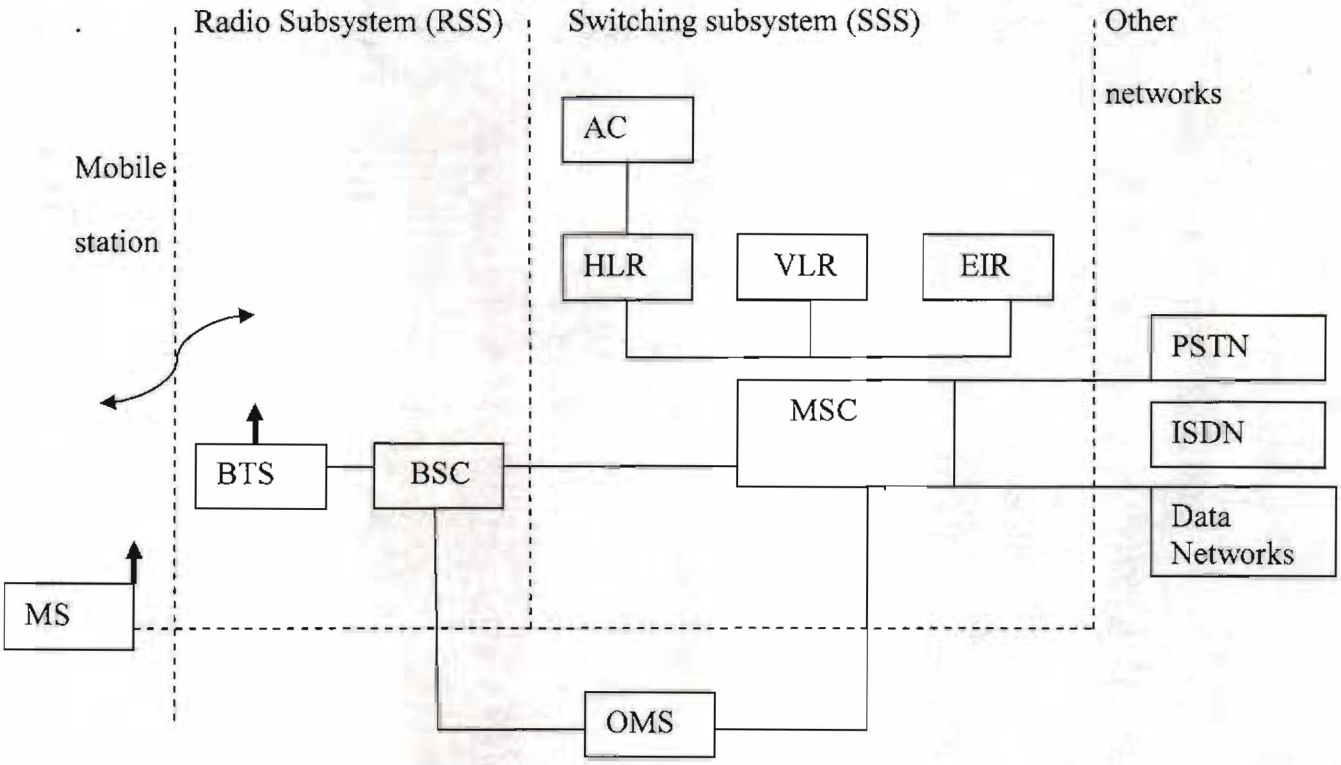

Figure 1. GSM Architecture (Lee, 2002)

The above figure shows several functional entities and interface of a GSM network. The GSM network can be divided into three broad parts (Lee, 2002).The mobile station is carried by the subscriber; the base station substation controls the radio link with the mobile station. The network subsystem, the main part of which is the mobile services switching center, performs the switching of calls between the mobile and other fixed or mobile network users, as well as management of mobile services, such as authentication operation and management center, which oversees the proper operation and setup of the network. The mobile station and the base station subsystem communicate across the Um interface, also known as the air interface or radio link. The base station subsystem communicates with the mobile service switching center across the A interface (between MSC &TCU). According to Lee (2002) the different blocks of the GSM architecture has different functions and are described as follows.

Mobile Station

The Mobile Station (MS) is the user equipped in GSM. According to Garg and Wilkes (2001), MS is consist of the physical equipment, such as the radio transceiver, display and digital signal processors, and a smart card called Subscriber Identity Module (SIM).The SIM provides personal mobility, so that the user can have access to all subscribed services irrespective of both the location of the terminal and the use of a specific terminal. By inserting the SIM card into the another GSM cellular phone, the user is able to receive calls at the phone, make calls from the phone, or to receive other subscribed services.

The mobile equipment is uniquely identified by the international Mobile Equipment (IMEI). The SIM card contains the international mobile subscriber identity identifying a subscriber (IMSI), a secret key for authentication, and other user information. The IMEI and the IMSI are independent, thereby providing personal mobility. The SIM card may be protected against unauthorized use by a password personal identity number.

Base Station Subsystem

Base station subsystem is composed of two parts; the Base Transceiver Station (BTS) and the Base Station Controller (BSC).

Base Transceiver Station

The Base transceiver Station (BTS) is the entity corresponding to one site communicating with the mobile stations (Siemens, 1999). Usually, the BTS will have an antenna with several TRXs (Radio transceivers) that each communicate on the radio frequency. The link-level signaling on the radio channels is interoperated in the BTS, whereas most of the higher level signaling is forwarded to the BSC and MSC. Speech and data transmission from MS is recorded in the BTS from the special encoding used on the radio interface to the standard 64 Kbps encoding used is used in telecommunication networks. Like the radio interface, the abis interface between BTS and the BSC is highly standardized.

The Base Station Controller

Each Base Station Controller (BSC) controls the magnitude of one or several BTSs. The BSC takes care of a number of different procedures regarding call set up, location update, radio channel setup, frequency hopping and handover for each MS. Hand over is accomplished by analyzing the measurement results that are sent from the MS during a call an ordering the MS to perform handover if this is necessary. The continuous analyzing of measurements from many MSs requires considerable computational power. This puts strong constraints on the design of the BSC. The BSC is the connection between the mobile and the Mobile Switching Centre (MSC).

Mobile Switching Center

The Mobile Switching Centre is a normal ISDN switch with extended functionality to hand mobile subscribers (Lee, 2002). The basic function of the MSC is to switch the data connections between BSCs , other MSCs , other GSM networks and external non mobile networks. It provides all the functionality needed to handle a mobile subscriber, such as registration, authentication, location updating, handovers, and call routing to a roaming subscriber. These services are provided in conjunction with several functional entities. There will normally exist only a few BSCs per MSC, due to the large number of BTSs connected to the BSC. The MSC and BSCs are connected via the highly standardized interface.

Home Location Register (HLR)

A Home Location Register (HLR) is a database that contains semi permanent mobile subscriber information for a wireless carrier's entire the subscriber base. The HLR contains all the administrative information of each subscriber registered in corresponding GSM network, along with the current location of the mobile. The current location of the mobile is in the form of a Mobile Station Roaming Number (MSRN) which is a regular ISDN number used to route a call to the MSC where the mobile is currently located. There is logically one HLR per GSM network, although it may be implemented as a distributed database.

Visitor Location Register (VLR)

A Visitor Location Register (VLR) is a database which contains temporary information concerning the mobile subscribers that are currently located in a given MSC serving area, but whose Home Location Register (HLR) is elsewhere. The Visitor Location Register contains selected administrative information from HLR, necessary for call control and provision of the subscribed services for each mobile currently located in the geographical area controlled by VLR. When the subscriber roams into the location area of another VLR/MSC, the HLR is updated. At mobile terminated calls, the HLR is interrogated to find which MSC the MS is registered with. Because the HLR is a centralized database that needs to be accessed during every call setup and data transmission in the GSM network, this entity needs to have a very large data transmission capacity.

The Equipment Identity Register (EIR)

The equipment identity register (EIR) is an optional register. The EIR is a database that contains a list of all valid mobile equipment on the network, where each mobile station is identified by its International Mobile Equipment Identity (IMEI). An IMEI is marked as invalid if it has been reported stolen or is not type approved. EIR maintains tree lists of IMEIs which categories MS as being permitted to use a network (white list equipment), prohibited from using the network (black list equipments), temporary failure of the equipment (grey list equipments).

Authentication Centre

The Authentication Centre is a protected database that stores a copy of the secret key stored in each subscriber's SIM card, which is used for authentication and ciphering of the radio channel. Before any MS access network necessary processing is done to authenticate that MS.

Why Frequency Reuse?

In the beginning of 1960's, the automatic system was established for controlling the calls instead of continuing each call through the mobile operator (Lee, 2002). For example, if a customer had a call already established in one new area, that call would drop as the caller moved into another area and a new process would have to be initiated. Such a system had a small number of channels, poor signaling protocols and limited capacity of modular growth, and could not cope with the demand of the subscribers. Frequency reuse is the core factor in GSM network (Lee, Xu, Mayekar & Mohile, 1997). The user in the different cells may use the same frequency channels which will increase the spectrum efficiency. Reusing the identical frequency channel in different cells may introduce co-channel interference. Co-channel interference may be introduced by some of the other factors as number of co-channel cells in the vicinity of the centre cell, the type of geographical region, antenna height, base station location etc.

According to Rappaport and Brickhouse (2001) effective use of spectrum maintaining the increasing number of subscribers in the region, GSM employs the low power transmitter stations over the whole coverage area. The geographical area is divided into small cells with BTS's which are connected to BSC. Different set of frequencies are used in each cell forming the cluster. This eliminates the problem of interference due to mobile station using the same frequency. The efficiency of the system is increased by the principle of frequency reuse (Chan, 2002). The radio frequency spectrum available for mobile communication is limited and there is increasing number of users in the area; to cope up with this situation frequency reuse concept is used (Garg & Wilkes, 2001).

Since low power transmitters are used in the cells, the radio signals are prone to degradation caused by the physical environment. At some distance the signal strength level drops to low level that it is harder for the receiver to distinguish the signal. At such distances where the signal of one frequency is very low, we can use the same frequency to communicate within that area without much harm. Following this principle, the frequencies are reused at the regular distances computing the distance of frequency reuse that depends upon the factors like loss, interference, signal strength, cell design. Thus the same frequency can be used in several cells the system is able to handle more number of users of that area (Rappaport, 2001).

Mobile network optimization is a regular process which never ends. Optimization is necessary after the construction of the buildings around the base stations, increase in the number of subscriber, change in traffic density and installation of a new base station. According to Poudyel (2007) Network quality depends upon the number of factors such as radio resources used, radio network planning, network equipments, transmission links, network congestion, landscape, equipment environment and faults clearance period.

Some of the factors such as radio resources and landscape are limited and natural that cannot be altered by any methods while others can be maintained by better network management.

Radio frequency planning and optimization plays the vital role in GSM network quality. Quality of radio network is indicated by receive signal level (RxLev), carrier to interference ratio (C/I), bit error rate (receive quality RxQual). Network performance can be measured from several performance indexes from BSC statistics, some important indexes are radio switch rate, traffic channel (TCH) allocate failure rate, TCH call drop rate, handover success rate, TCH service rate.

A large capacity of mobile telephone network often requires hundreds of base stations to cover the whole service area and meet the high traffic density requirements, while frequency resource is very limited. According to Deissner and Fettweis (2001) frequency planning for hierarchical cellular network especially to cover indoor areas and hot spots is a complicated and expensive task. According to Dejoie , Ding, Dioume and Lominy (2002), GSM network frequency reuse has been a basic tool for optimizing the spectrum management. This method is sometimes insufficient if the population of the users and population of the buildings around the base station increases, increase in the number of subscriber change in the traffic density and installation of the new base station.

The third generation technology is excluded these days because it has a low penetration and coverage (Sergiadis, 2005). As the total number of the subscriber increases and if the number of the service providers is more in the town the necessary resources in the transmitter and receiver exceed the available GSM spectrum and therefore frequency reuse becomes necessary.

Since frequency spectrum is divided between various service providers multiple frequency reuses is only the possible solution for the provider for satisfying the quality criteria. According to Dejoie , Ding, Dioume and Lominy (2002), the frequency hopping method is used which allows to expand the capacity of available mobile networks. It is a method which helps to improve the quality of service through interference averaging and frequency diversity. According to Pipikakis (2004) frequency hopping (FH) means that multiple frequencies are used to transmit speech and data in a single connection.

The concept of frequency hopping is used when large number of base stations in a particular area is needed to be operated within a limited band of frequency (Paudel, 2007).Compared to random frequency hopping (FH) where each user hops independently according to its FH pattern, uniform FH relies on explicit side information in order that all the subcarriers subsets are uniformly occupied and the multiuser interface is cancelled (Cariou & Helard, 2005). According to Paudel each macro base station has three cells and every cell has at least one fixed frequency for Broadcast control channel (BCCH) and other frequency may be considered as hoping in sequence. In hopping system the planning for BCCH channels and hopping channels must be done separately. BCHH frequency cannot be reused within a cluster but hopping frequencies can be reused in different cells of same base stations with proper allocation of hopping sequence number (HSN) and mobile assisted hand over.

"Considerable network performance gain can be made by fully utilizing the available functionality and fine tuning the network parameters using statistics to evaluate the result" (Pipikakis, 2004). These seven functions play a most important role in the optimization phase:

- Frequency Hopping
- Mobile station Dynamic power control

- Cell load sharing
- Locating penalty timers
- Flow control timers
- Cell selection and access
- Signal strength measurement

Faruque (1997) has used a directional frequency reuse for high density, high capacity cellular networks. A group of channels are reused in the same direction the antenna is pointing at, which reduces number of dominating interfering cells by enhancing C/I (carrier to interference) margin and capacity which out performs the existing cluster reuse plan. This type of frequency reuse is suited for both tri cellular platform and Hexa-Cellular platform. In Hexa cellular platform it exploits antenna front to back ratio and increases the C/I performance. Now a days it has been seen that due to the increase in the system capacity, soft hand off and ease of frequency planning code division multiple access (CDMA) systems are being popular (Avila & Yacoub ,1998). CDMA is interference limited due to the unity reuse factor.

Due to the increase in the interest of mobile data applications, General Packet Radio Service (GPRS) uses a transmission of a packet data using the random access channels within the existing GSM infrastructure (Flament & Unbehaun, 2000). Wu and Meng-che Wu (2000) state that spectrum utilization becomes more and more useful due to the increase in the demand of the wireless communication system and has introduced a dual polarization frequency reuse system which employs two orthogonally polarized electromagnetically wave to carry the system information can double the system capacity.

The mobile telephone market has been increased in a volume of demand and quality requirements. Frequency spectrum is the limited resource in the required market. People are currently using the data packets for sending video, text and voice data at the same time which makes the network more congested and their needs the different tools for optimizing spectrum management.

Okumura Hatta Model

Hatta model is the method for predicting the path loss encountered in the cells in mobile communication (Barclay, 2003). While designing the cell for the given area a designer's focus should be on overall area, rather than the specific field strength at the particular locations. It is one of the model which is has been developed from the survey done around Tokyo City between 200MHz – 2 GHz. This model is not based on the plain earth loss .All the predictions are based on the survey and series of measurements which is converted into the graph and is stated in the form of set of formulas. This formula is also known as a cell prediction model. According to this model any area can be divided into a number of regions as open areas like Clear field, no tall trees or buildings. Suburban areas like place with less population, some obstacles. Urban areas are highly populated cities with tall buildings.

According to (Barclay, 2003) Hattas approximation's is stated in a mathematical form as:-

Urban area: - $L_{db} = A+B\log R-E$

Suburban areas: - $L_{db} = A+B\log R-C$

Open areas: - $L_{db} = A+B\log R-D$

Where

$A= 69.5+ 26.16 \log f_c - 13.82 \log h_b$

$B= 44.9 - 6.55 \log h_b$

$C = 2 (\log (f_c/28))^2+ 5.4$

$D=4.78(\log f_c)^2+ 18.33 \log f_c +40.94$

$E = 3.2(\log (11.75h_m))^2- 4.97$ for large cities $f_c>= 300$ MHz

$E = 8.29(\log (1.54h_m))^2 - 1.1$ for large cities $f_c < 300$ MHz

$E = (1.1 \log f_c - 0.7)h_m - (1.56 \log f_c - 0.8)$ for medium to small cities

The defined model is valid for the carrier frequency 150MHz $\le f_c \le$ 1500 MHz, height of base station should be in the range 30m $\le h_b \le$ 200m height of mobile 1m $\le h_m \le$ 10m and the radius of the coverage are should be greater than 1 Km. For the fc greater than 1500 MHz and less than 2000 MHz the model is given as

$L_{db} = F + B\log R - E + G$

Where $F = 4.63 + 33.99\log f_c - 13.82\log h_b$

The value of E will be for the medium and the small cities.

G is 0db for medium and suburban cities and 3db for metropolitan cities.

Chapter III: Research Methodologies

In order to analyze the problem faced by the company ABC, a team of engineers and programmers were appointed within the company. The research has been divided into two parts; first part is to study the GSM system parameters that include the cellular concepts, GSM architecture used by the company, Radio links, traffic engineering and services provided by the company. Next part is to build a graphical computer simulation to demonstrate the various features of GSM system that will have an impact on RF optimization. From the simulation program user can learn about the cellular concept, frequency reuse, location updates, call procedures, sectorization, emergency call location, billing and its different operations such as mobile terminating call, mobile originating call, and cluster size. The simulation is developed in visual basic and is able to demonstrate the different aspects i.e. design aspects, number of users handling capacity and C/I ratio trade off, concept of frequency reuse, and the other operation of GSM system.

Using Visual Basic to Develop the Project

Visual basic 5.0 /6.0 is designed for its user to provide an opportunity to develop a real time programming project. Visual basic tool set can be used by experienced professionals to simplify rapid application development. Users can build their windows application graphical user interface (GUI) using the pre built objects, like controls, and drag and drop approach to design the appearance and location of interface elements. In addition to event driven, Visual Basic is also an object oriented programming language because the programmer uses the objects to perform the tasks. Interface elements located on the form represents objects called controls in the Visual Basic, that programmer can use to perform tasks, which include the complete set of events associated with an object. Each object has a default set of characteristics associated with it called properties and predefined set of action called methods. Properties control the appearance and behavior of the object. A programmer can use the Visual Basic developing environment to change the default settings. Methods expedite rapid application development for common actions performed in objects.

Procedure

It has been assumed that there are 100 numbers of users whose mobile ISDN number ranges from 98510-00001 to 98510-00100. The above work can be made realistic by adding real time system parameters and integrating all the existing databases, so the system seems to be complete one. Programming process in consists of five step process: Plan the application, build the user interface, code the application, test and debug the application and deliver the application. Formula based techniques, which are based on Okumura Hata propagation models, provide considerable insight into the relationship between design parameters and system performance and they are useful in early stage of design. The developed flow chart for the program follows.

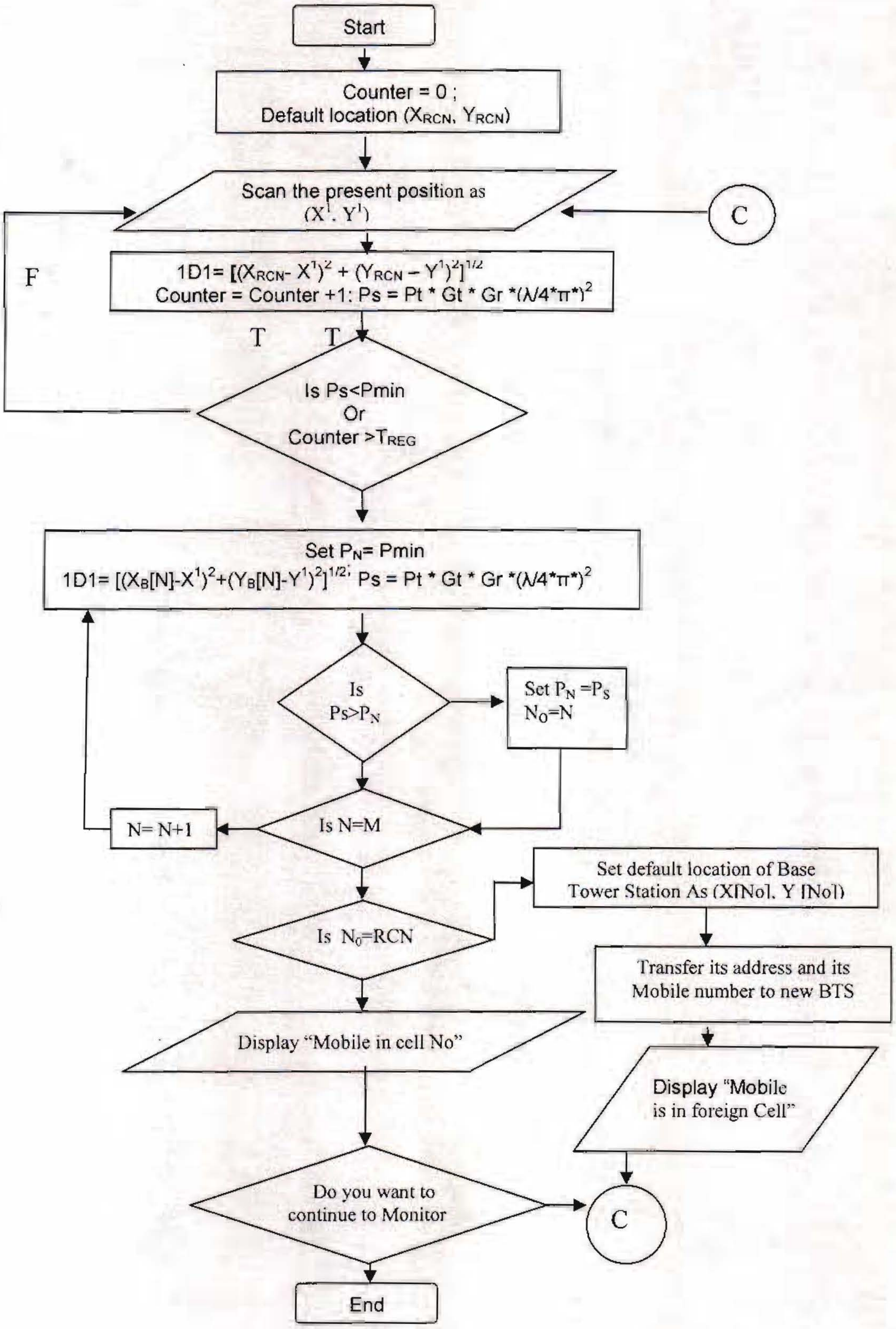

Figure 2. Flow chart of the program

Where the variables are defined as;

Gt: Gain of transmitter antenna

Gr: Gain of receiver antenna

RCN: Number of location of Base stations where mobile is registered

(X_{RCN}, Y_{RCN}): Location of registered base station Towers

(X^1, Y^1): Current position of the mouse pointer

Ps: Signal Power that is received by the mobile station

Pmin: Minimum signal power that can be received by mobile station

T_{REG}: Time in which registration is done

M: Total number of Base station tower in that area

Based on the above flow chart and the radio interface parameters which is given in Appendix A, a simulated program is created using a visual basic software. Additional studies in frequency reuse pattern and the existing service providing by the Company XYZ is also conducted to narrow down the chances of upcoming errors.

Chapter IV: Results, Conclusion and Recommendation

The simulation program is a graphical representation tool of the various functions and procedures of GSM system. The program can be run by its executable file. In the program the coverage radius of the cell is calculated by OKUMURA-HATA model in which the user has to specify the parameters like frequency used, height of the base station, and the height of the mobile station. For the given set of equipments with preset parameters such as maximum transmitted power, receiver sensitivity, and system margin form the coverage radius, the program designs the cells and divides them in base station controller number, Location area code (LAC) number and MSC number for the given site. All these information's of the site together with the gain of the antenna, types of sectorization and base station height are kept as a data base.

The developed program takes user as the mobile subscriber with a given mobile number. It shows all the functions done or supported by or to the user in the GSM system like concept of frequency reuse, number of broadcast control channel and traffic channels, number of simultaneous call, number of user supporting capability with given grade of service, carrier to interface ratio with respect to the cluster size, mobile originating call, mobile terminating call, location update, emergency call location, billing, handover. As a result of the project, a system has been developed that works on a different radio frequency condition and on a different terrain conditions such an urban area, sub-urban area and open area. By changing the different input parameters different required parameters can be obtained. It could determine the value of input parameters if the output of the system is predefined

Calculation of the Radius by Okamura -Hatta Model

In the menu bar from the option button and from the drop down menu one can choose the Design by Okumura-Hatta option. While choosing the option one will be prompted to the form like below where the data which is used to calculate the radius can be entered.

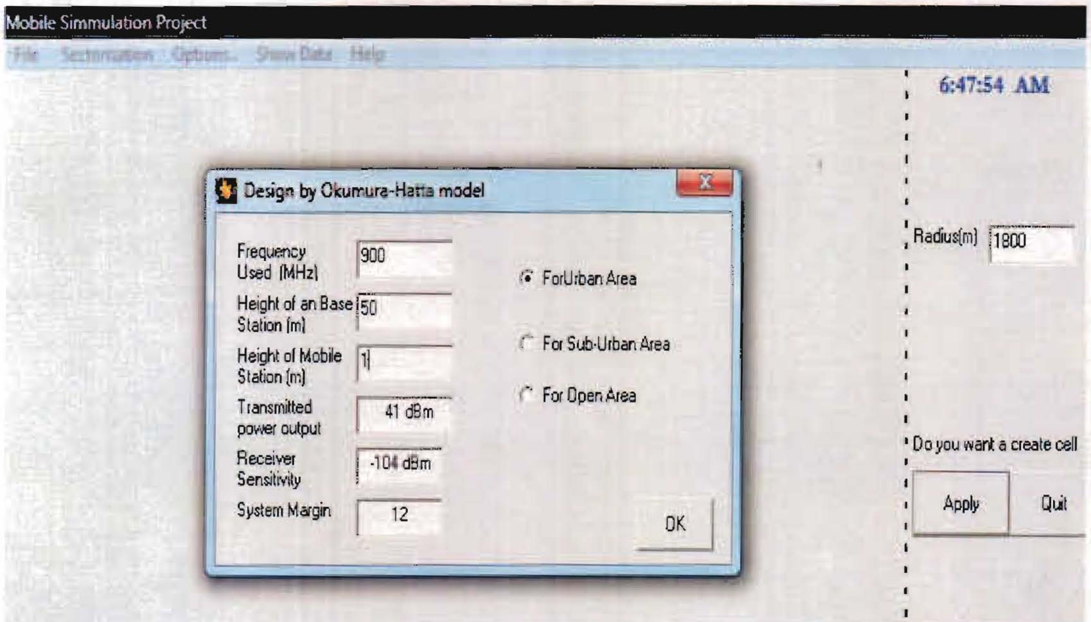

Figure 3. Design by OKUMURA-HATTA model

Design of Cells

The calculated radius is prompted on the radius (m) textbox as shown in figure. Click on the apply button it will show the designed cells on the site as below. The information on each cell and users on those BSC are stored in the database.

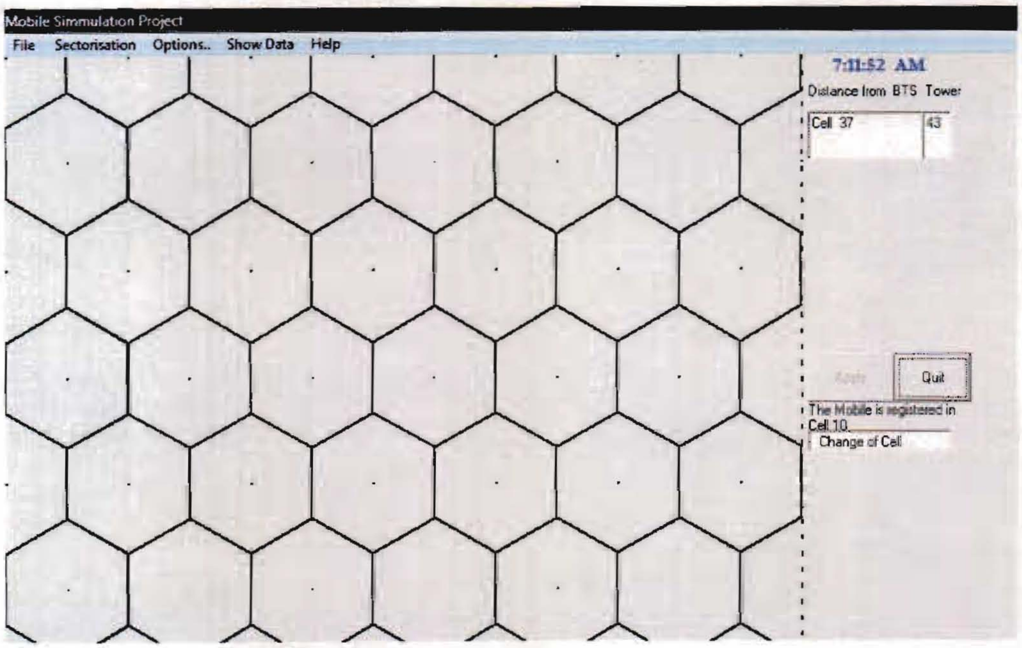

Figure 4 . Design of cell

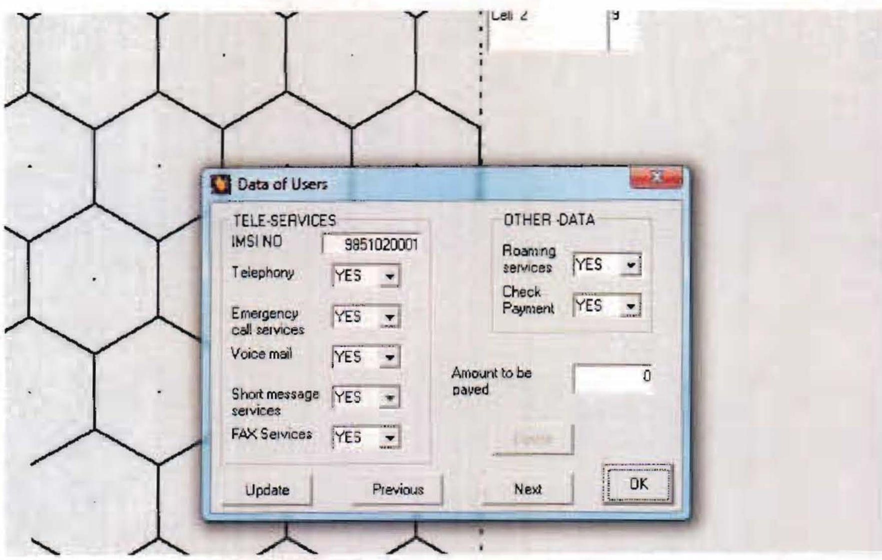

Figure 5 . Data of Users

Frequency Reuse Pattern

The given set of frequencies is reused at regular intervals according to the reuse pattern. The group of cells using the set of frequencies is called clusters. The program shows the different reuse patterns (3, 4, 7 reuse patterns).

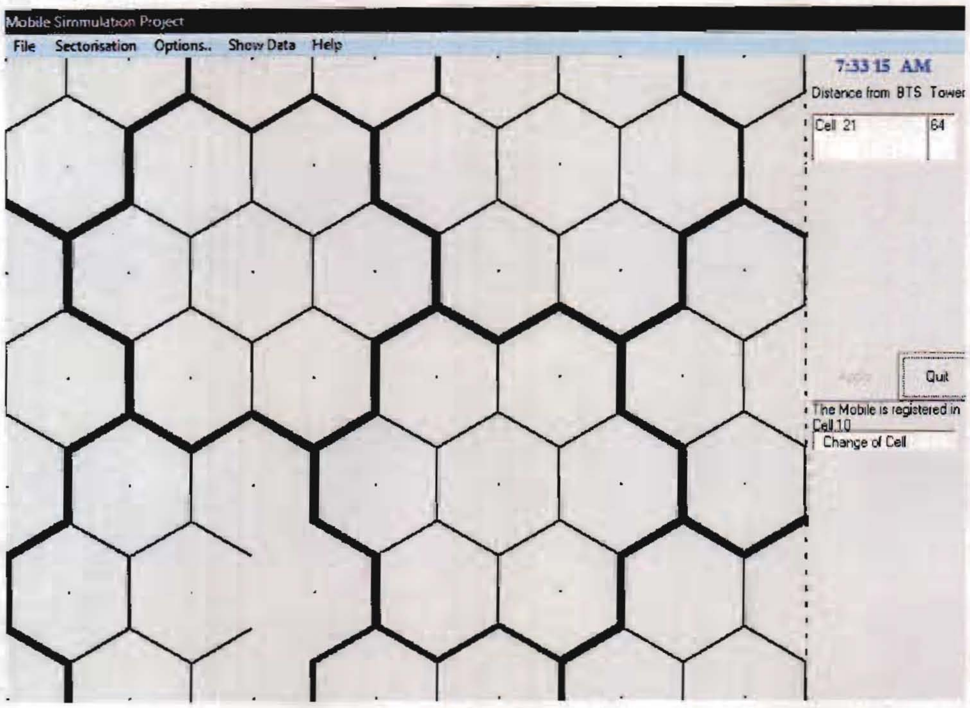

Figure 6 . Seven reuse pattern

Concept of frequency reuse, number of Broadcast control channel(BCCH), Standalone dedicated control channel(SDCCH)and traffic channel(TCH), number of simultaneous call, number of user supporting with given Grade of service (GOS), C/I ratio depends upon the cluster size. This program also shows all these according to the cluster size. The same color in the cell indicates the reuse of the same frequency in all the different cells.

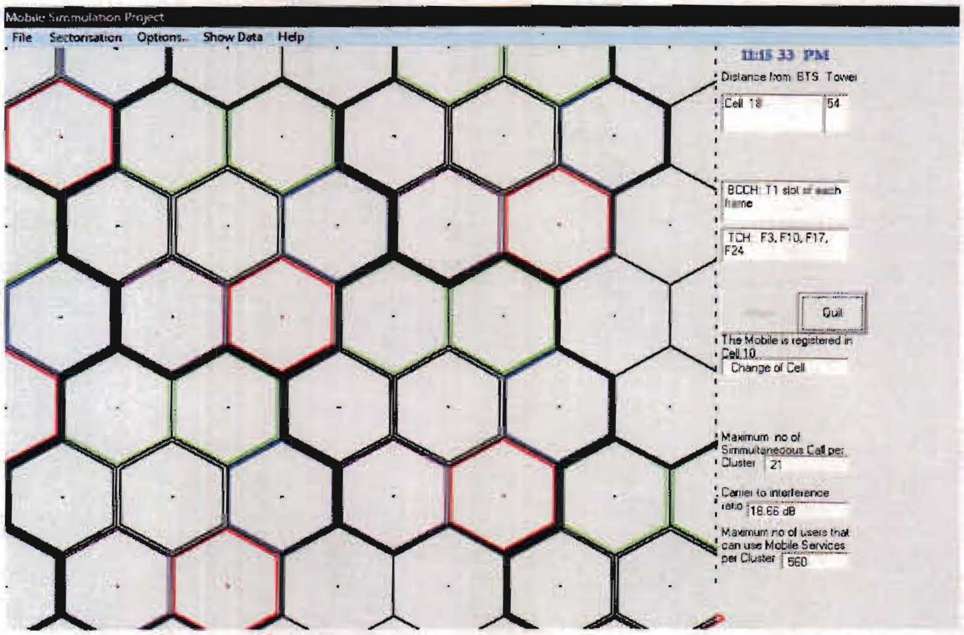

Figure 7. Showing max. Number of simultaneous call, max number of users, C/I ratio, TCH and BCH channels with respect to cluster size, frequency reuse.

According to the increase in the number of mobile subscribers at any area or cell different sectorization technique is used to increase support the increasing number of subscriber.

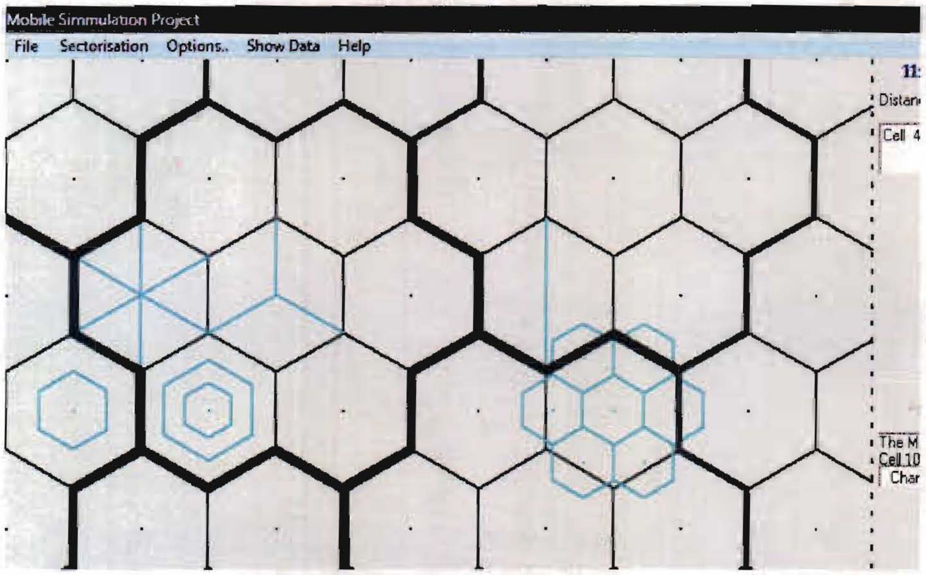

Figure 8. Different Sectorization technique used to support increasing no. of users

According to the out put created by the program in different sectors, different types of antennas are allocated depending upon the traffic load offered to the area. Omni antenna can be used in the place where the traffic load is very low. Two sectors antennas are used in the highway areas with each sectors having greater directivity along the highway so as to cover the highway traffic. Three sector antennas are used at high traffic regions in such a way that the demand area is full covered. The radiation pattern of sectors of adjacent BTS must be overlapped to avoid dead pockets and seamless handoff can be done.

At the completion of the project it has been assumed that there are only 100 numbers of users with a specific mobile numbers ranging from 98510-00001 to 98510-00100 in order to make the work realistic to the existing database. The project mainly provides a best suggestion in order to achieve an optimized system performance. Antenna simulation work and work to reduce the Bit Error Rate can mainly effect on the voice quality of the system.

Problems that may arise during the implementation of the system are bad coverage, interference, Ping-Pong Hand over, Call loss, Traffic Balance. The solutions of the mentioned problems are proper adjustment of antenna, transmitting power, frequency parameters radio resource parameters. The main reason of the interference is seen because each BTS they have installed has a large coverage, MS relates the strongest signal. How ever due the large coverage, there may be interference. The simulation shows the graphical representation of a GSM system, A channel simulation can also be done by using a Mat lab. The main disadvantage seen from the Mat lab is the increase in the processing time so it can be done using visual basic. Some other interesting feature as emergency call location can also be shown through the simulation. The emergency call made from MS is located by triangulation method employed in GPS. This feature is not provided by the Company.

Chapter V: Summary

As stated above, the purpose of this research was to find out the solution for a network planning and optimization of a GSM network provided by a Company XYZ in order to provide a quality service and fulfill the market demand. Company XYZ has a small structure in the mobile service area compared to the land line. The equipment they have can handle a limited number of subscriber's. Besides that, due to the construction of the tall buildings near base stations and increasing number of traffic density it would be harder for the subscriber to receive a proper signal within a range. This problem was due to the distribution of the lines beyond the capacity of the base stations.

After completion of the project it was determined that the network can be optimized by using the same frequency channel for the different geographic location. This method will drastically increase the system efficiency if designed properly. The main disadvantage of this system is it can introduce serious interference if the system is not designed properly. It has been found that a traffic density in the area in busy conditions, transmitting antenna power, carrier to interference ratio, and the height of the base station has created major problems for the company.

The designed software simulation can help a company to design a system having a good capacity, improved method of cell splitting and cell sectorization. Besides these one can estimate the maximum number of users or maximum number of simultaneous call at a time with change in the size of cluster. Increase in the size of the cluster may give a good voice quality and less interference but it will degrade the user handling capacity of the systems. The company can design a great system which would provide good quality of service by using the concept of frequency reuse techniques beside that they should not distribute the lines beyond their handling capacity which may cause these types of problems.

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APPENDIX A:

STUDY OF SOME IMPORTANT PARAMETERS RELATED TO RADIO INTERFACE OF NEPAL TELECOM AS CELLULAR MOBILE COMMUNICATION PROVIDER

Some important Parameters related to radio interface

Frequency spectrum and number of channels
Uplink: 12 MHz (935MHz-947 MHz)
Down link: 12 MHz (890MHz-902MHz)
Number of channels = (12 MHz/200KHz)*8channels
= 480 channels

Voice channels = 417 channels

Control channels = 63 channels

XYZ Company has adopted 120 sectoring i.e. each cell has been divided into three sectors. Each sector is using three control channels, which means 9 control channel/cell yielding total 63 control channels/cluster.

Grade of service = 2 % (for both type of calls: new and hand over)

Traffic/ user = 18 mErlangs

Channel assignment scheme
For newly originating calls: 60% of total channels
For hand over calls: 40% of total channels

Cluster size = 7

Cluster size in initial design of the cellular mobile network of XYZ company was (4 * 3) which means cluster size was of 4 cells with 3 sectors in each cell. Afterwards, it had been changed to (7*3). But in present days, there is not any regularity in frequency reuse pattern. Some times fixed pattern is being followed and sometimes not.