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RF LINK BUDGET DESIGN IN SUB URBAN PROPAGATION MACRO-CELL ENVIRONMENT FOR GSM COMMUNICATION SYSTEM LINK PLANNING

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Abstract: This paper presents a study to calculate Path loss of an "RF link budget analysis model" with a primary focus on the real sub urban macrocell environment to analyze the mobile signal loss factors during the propagation and to calculate the received signal power at receiver end and accordingly a correction factor factor will be introduced for suburban areain cost-231 hata model. Correction factor which is considered as 0 db in cost-231 Hata model for suburban area but practically it is not possible so correction factor is calculated for cost-231 Hata model.This link budget analysis prediction system will be helpful to develop a flexible RF link budget analysis prediction model for mobile communication system cellular link planning in sub urban propagation macrocell environment.

Index Terms -Terms-Link Planning, Sub Urban macrocell , Mobile communication system, RF Planning,cost-231Hata Model, correction factor.

I. INTRODUCTION

Communication is one of the most important part of science that has always been a focus point for exchanging information among different people who are distance apart. Now days no one can imagine one's life without communication. Today, mobile communication has become the backbone of the society. All the mobile system technologies have improved the way of living and all the communication works which take a great efforts arenow become so easy because of new and improved technology.

Our society has been looking for acquiring mobility in communication since then. Initially the mobile communication was limited between one pair of users on single channel pair. The range of mobility was defined by the transmitter power, type of antenna used and the frequency of operation. With the increase in the number of users,providing services to all simultaneously becomes a difficult task.To overcome this problem, the concept of cellular communication was evolved. The present day cellular communication system connects people throughout the world easily. RF link planning is a key part of mobile communication. If we design a system without planning and when we implement it then it may happen that it will not give proper functioning i.e. due to various factors desired functioning of system will not be obtained and our efforts will be wasted and most importantly poor system performance will be obtained. An Rf Link budget power analysis prediction model can be expressed logarithmically by equation [1]:

PRx = PTx + GTx – LTx – LP – LRx + GRx [1]

Where PRx and PTx are received and transmitted Power in dbm respectively, GTx and GRx are receive and transmit antenna gains respectively, LRx and L are receive and transmit path losses and LP is propagation loss is usually factored out into three main components shown in equation[2]:

$$L_P = L_o \times L_S \times L_L \quad [2]$$

Where Lo is the average path loss,Ll is long term fading (e.g.,due to shadowing), and Ls is the short term fading due to multipath.

II. RADIOWAVE PROPAGATION

In mobile communication systems,When the signal is transmitted from transmitter it may lostits energy during the propagation from a transmitter to a receiver.These losses are called as Pathloss.The basic phenomenon due to which these losses took place are as follows:

Reflection : It Occurs when signal encounters a surface(eg. Large buildings) i.e. large relative to wavelength.

Diffraction: It is referred to the change in wave pattern caused by interference between waves that have been reflected from a surface or a point (eg. Hilly terrain).

Scattering: It Occurs when incoming signal hits an object whose in the order of wavelength of signal or less.(eg. Small objects).

A. Plane Earth Loss

When the radiowave propagates near the ground with a line of sight (LOS) condition, the path loss can be described by the plane earth loss that includes the effect of ground reflections.

L (db) = 40log (d) – 20log (hTx) – 20log (hRx)

Where d is the distance between the transmit and receive antenna in meters, h and hare the transmit and receive antenna heights, respectively, also in meters.

B. Foliage Loss

It Occurs because of presence of foliage environment on its way. Foliage mainly comprises of dense trees or vegetation of any type. Foliage loss is the signal loss due to size of

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trunks of trees & branches. The appearance of foliage medium in the path of communication link plays a significant role on the PHY quality of service for mobile communication and includes an additional effect on propagating radiowaves .signals propagating in foliage medium naturally experiences multiple scattering ,diffaraction, and absorption of radiation.

C. Penetration Loss

When the Rf signal penetrates into building through a wall, certain amount of energy may be absorbed by the wall or bounced off from the wall.

D. Diffaraction Loss

Diffraction occurs when the propagating path between the transmitter and receiver is obstructed by a dense body with large dimensions compared to wavelength. It allows radio signals to propagate around the curved surface of the earthbeyond the horizon, and to propagate behind obstructions and only a portion of the energy is unblocked. The phenomenon of diffaraction can be explained by Huygen's principle, which states that all points on a wavefront can be regarded as point sources and give rise to secondary wavelets. Combination of all the wavelets produces a new wavefront in the direction of propagation. It can be shown that the diffraction losses increase with a decrease in the wavelength or increase in the frequency of the propagating radiowave.

E. Shadowing Loss

Shadowing is the time-variant part of the absorption and diffraction loss which is frequency-nonselective since different multipath components see a different absorption and diffraction loss. Shadowing causes the received RF signal power to fluctuate due to objects obstructing the propagation path between transmitter and receiver. Empirical evidence shows path loss is not constant with respect to distance but rather depends on paths of different obstructions.

F. Multipath Fading Loss

Multipath fading is due to the constructive and destructive combination of delayed, reflected, scattered, and diffracted RF signal components which is relatively fast and is responsible for the short-term signal variations. The Rayleigh channel distribution is frequently used to model multipath fading with
non-line-of-sight (NLOS) path, and agrees with experimental data for mobile systems where no LOS path exists between the transmitter and receiver antennas.

III. METHODOLOGY AND TOOL USED

The network radio link planning of mobile systems requires Propagation models, which are aimed at predicting the radio signal losses existing in the different environments where the systems can be located as well as estimating other parameters. The prediction of the path loss may start with reconstruction of ground profile before analyzing the chosen terrain model. Then the appropriate equation should be employed to describe the loss in that particular Suburban propagation macrocell area. In this case Okumura Hata and Cost 231 Propagation Loss prediction model are used in order to consider the losses during transmission. The Okumura-Hata model predicts the path loss L between the transmitter and receiver, taking into consideration the frequency, the height of antennas, the propagation distance, and the terrain type. The model predictions correlate reasonably well with measurements, especially in urban and suburban areas. This is not the case in rural areas with irregular terrain. Correction factors are used for irregular terrain types such as: rolling hills, isolated mountains, general slopes (up or down), and mixed land-water paths.

Specific formulas

The path loss L can be found by the standard path loss formulas for GSM-900, GSM-1800, and GSM-1900 according to the Okumara-Hata model

GSM–900 formula

The path loss formula for GSM-900 is:

$L = 69.55 + 26.16 \cdot \log f - 13.82 \cdot \log hb - a \cdot h_m + [44.9 – 6.55 \cdot \log hb] \cdot \log d - Lc.$

GSM–1800/1900 formula

The path loss formula for GSM-1800/1900 is:

$L = 46.3 + 33.9 \cdot \log f - 13.82 \cdot \log hb - a \cdot hm + [44.9 – 6.55 \cdot \log hb] \cdot \log d - Lc.$

IV. COST-231 HATA PROPAGATION MODEL

A model that is widely used for predicting path loss in mobile wireless systems.It operating frequency is from 500-2000MHZ.It contains corrections for urban, suburban and open rural environments.

The general expression for medium path loss in the urban area as given by COST-231 hata model is:

$L_{pch(urban)}(db)=46.3+33.9\log f_c-13.82\log h_t-a_r+(44.9-6.55\log h_t)\log r+C_m$

Where, f_c=frequency of transmission $h_{t=}$antenna height

a_r=correction factor for effective mobile antenna height which depends on the size of the coverage area.

c_m =3db for urban environments and 0db for suburban or open environment.

Clutter class

The radio wave propagation in built-up areas is influenced considerably by the nature of the urban environment, such as:

- Size of the buildings
- Width of the roads
- Parks and open areas

In cost 231 hat a propagation model correction factor for only two parameters is defined:

- Urban area -3db
- Suburban area-0db

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V. TOOL USED

Atoll RF Planning Tool

Atoll is a 64 bit multi-technology wireless network design platform that supports wireless operators throughout network cycle.It includes advanced multi-technology automatic cell. This tool will help us to study various terrains and propagation modelsand.The most important part of Atoll Planning Tool is that it has a high performance built-in geographical information system which is mainly designed for radio network planning.

Supported-Technologies-GSM/GPRS/EDGE, WIFI. CDMA,. LTE (4G).

The Atoll working environment is both powerful and flexible. It provides a complete and integrated set of tools and features that allow you to create and define your radio-planning project in a single application. Atoll includes advanced multi-technology network planning features (e.g., CDMA/LTE), and a combined single-RAN, multi-RAT GSM/UMTS/LTE Monte Carlo simulator and traffic model. You can save the entire project as a single file, or you can link your project to external files.The Atoll working environment uses familiar Windows interface elements, with the ability to have several document windows open at the same time, support for drag-and-drop, context menus, and support for standard Windows shortcuts, for example cutting and pasting. Atoll not only enables you to create and work on your planning project, but it allows us to check the expected performance of the project. The Tool provides a wide variety of tools to work in radio-planning, such as a search tool to locate either a site, a point on the map, or a vector.Every required Tool is simply defined in the explorer window and operators can easily implement them. The Network explorer, the Geo explorer, and the Parameters explorer play a central role in Atoll. The explorers contain most of the objects in a document arranged in folders.By Using the explorer windows, operator can manage all objects in the Atoll document: sites, transmitters, calculations, etc., as well as geographic data such as the Digital Terrain Model, traffic maps, and clutter classes, for example, define various coverage predictions. The content of the folders in the explorer windows can be displayed in tables. Operator can sort and filter the data in a table, or change how the data is displayed. Operator can also enter large amounts of information into a table by importing data or by cutting and pasting the information from any Windows spreadsheet into the table. The map is the working area for your document and Atoll provides many tools for working with the map. operator can change the view by moving or zooming in or out and one can choose which objects are displayed and how they are displayed. All the features like altitudes, vectors, places, terrain type, vegetation area, hilly terrain, highway etc can be installed in the map and according to our use it can be manage whether in which terrain operator wants to work.

VI. THE ATOLL WORK AREA

The Atoll work area, shown in Figure 1, consists of the main window where the map window and data tables and reports are displayed and the explorer windows. The explorer windows contain the data, objects, and parameters of a document, arranged in folders. It is presented in detail in "The Explorer Window

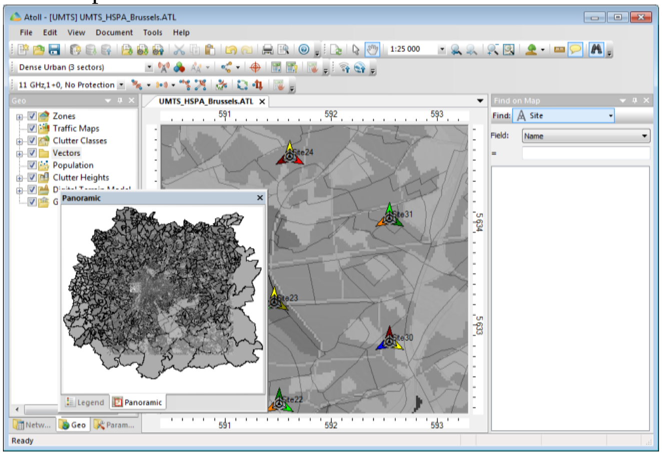

Fig 1. "The Explorer Window" of Atoll planning Tool

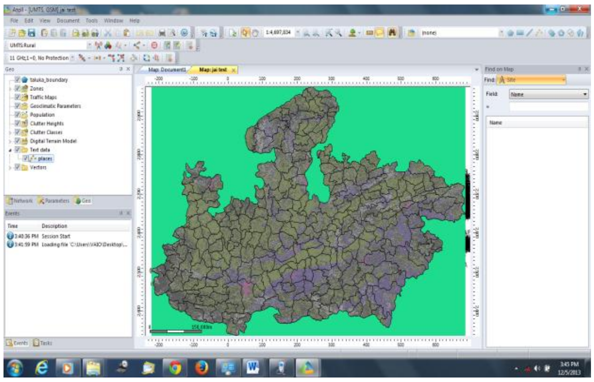

Fig 2. The digital map of M.P imported on tool.

Atoll offers a variety of tools to help you plan a network and enables you to keep all the tools you need open at the same time to simplify your work. Additionally, you can have several Atoll documents open at the same time or several different views of the same document open at the same time. Atoll enables us to manage the use and appearance of these tools easily so that users can use these tools easily and more efficiently.

VII. CONCLUSION AND RECOMMENDATION

The following observations can be made from the empirical real time calculation of Path loss in a suburban area Jabalpur (Madhya Pradesh, India) and according to the calculation correction factor for suburban area is suggested. Firstly, an RF link budget power prediction model has been developed in order to make a flexible link budget system which will be helpful for network operators to design a RF link planning for mobile communication system throughout the network cycle. And secondly, the RF link budget prediction model undertakes an empirical analysis of the chosen terrain model and has the characteristics of high accuracy and good flexibility and can also be used for suburban areas. The RF link budget analysis system can further extended to calculate different correction factors for different terrains for cost-231 hata propagation model. As in cost-231 Hata propagation

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model correction factor for urban area is defined as 3db and for suburban area correction factor is defined as 0db but for different clutter classes path loss will be more and thus correction factor will vary so correction factor can be calculated.The Table [1] is given below in which Pathloss are shown for suburban area and accordingly Cm is suggested.All the losses will be calculated in db.

Distance (in km)	Pathloss(Calculated as per Cost-231 Hata propagation model)(in db).	Correction factor(Cm) as per defined in cost-231 Hata model	Pathloss (calculate according to the tool)	Correction factor(cm) suggested (in db).
5	151.93	0	-141	10
4.5	150.3	0	-139.5	10
4	148.99	0	-137.5	10
3.5	146.45	0	-135.5	10

Table 1. Pathloss as per propagation model and Tool.

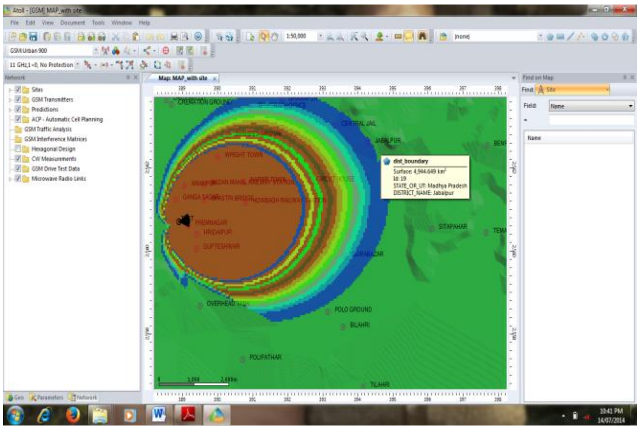

Fig 3.Coverage area in a suburban area (Jabalpur).

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