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Impact of GSM Spectrum Auction in 900 & 1800 MHz Band

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Abstract: *Recently Government of India Auctioned 2G spectrums in both 900 MHz & 1800 MHz Band For the GSM operators whose spectrum License is getting over shortly. If an existing 900 MHz band operator receives 1800 MHz band in the New Auction Process, then it will be interesting to learn about the impact on signal coverage of sites at the same location working at different GSM Frequency Band, before and after the new allocated spectrum implementation on field. In order to estimate the signal parameters accurately for mobile system, propagation analysis provides a good initial estimate of the signal characteristics and path loss. The path loss is associated with the design of base stations as this tells us how much a transmitter has radiated to service a given region. Planning tool is used to assist engineers in designing and optimizing wireless networks by providing an accurate and reliable prediction of coverage, which gives RF engineers a state-of-the-art tool to Design wireless networks, Plan network expansions, Optimize network performance & Diagnose system problems. This paper gives an overview of the differences in the propagation losses for 900 MHz and 1800 MHz frequency band using the suitable propagation model and ATOLL tools. It presents a description of the practical propagation modal, their methodology to plot Coverage predictions.*

Keywords: GSM, Planning Tool, propagation losses, propagation model

INTRODUCTION

The commercial success of cellular communication, since its initial implementation in the early 1980s, has led to an intense interest among wireless engineers in understanding and predicting radio-propagation characteristics in various urban and suburban areas, and even within buildings. As the explosive growth of mobile communications, it is very valuable to have the capability of determining optimum base-station location, obtaining suitable data rates, and estimating their coverage, without conducting a series of propagation measurements, which are very expensive and time consuming. It is therefore important to develop effective propagation model tools for mobile communication, in order to provide design guidelines for mobile systems.

A very crucial factor in mobile cellular network projects is the ability to make an accurate prediction of propagation path loss within an environment. Propagation models are empirical mathematical formulations to characterize how radio waves behave as a function of frequency, surrounding environment and distance. Several propagation models exist for different link scenarios and these are helpful to service providers for designing and deploying their networks in the best possible way.

By selecting proper Model & loss calculations, a proper RF Planning keeping the future growth plan in mind can reduce a lot of problems that we may encounter in the future and also reduce substantially the cost of optimization. On the other hand a poorly planned network not only leads to many Network problems, it also increases the optimization costs and still may not ensure the desired quality. A planning tool will help by providing an accurate and reliable prediction of coverage

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Literature Review

Hemant Kumar Sharma et.al. [6] study some propagation model and fading model and also describes two main characteristics of wireless channel path loss and fading. Propagation model depends on the transmitter height, when transmitter height is high Okumara and cost231 wi model are perform better. But when transmitter height is below to roof height prediction of these models is poor. The accuracy of every model in any given Condition will depend on the suitability among parameter required by the model and available terrain, no single model is generally acceptable as the best.

Julie C. Ogbulezie et al. [10] explained Path loss predictions are required for the coverage planning, determination of multipath effects as well as interference and cell calculations. These calculations lead to high level network planning. Drive test measurements were taken along certain routes in Port Harcourt and Enugu, cities in Nigeria. These measurements were compared with calculated values from Okumura- Hata and COST231 Hata models at 900 MHz and at 1800 MHz.

Shewta et al. [21] attempts to investigate the effectiveness of the Okumura-Hata model in a typical Nigerian terrain. A GSM base station operation at 900 MHz band was used for the experiment in a typical sub-urban area within the Northern part of Nigeria. The field measurement results were compared with Okumura-Hata model for rural and sub-urban area. This research thus shows that the Okumura-Hata model for radio wave propagation is very effective for radio wave propagation pathloss prediction in suburban areas in Northern part of Nigeria.

Concepts

A propagation model models how the radio waves react to elevation changes and clutter (e.g., reflection, diffraction, and scattering). Few of the basic definations & concepts of Radio wave propagation is given below.

FREE SPACE PROPAGATION

Path loss (PL) is a measure of the average RF attenuation difference between transmitted signals when it arrives at the receiver, after traversing a path of several wavelengths. It is defined by

$$P_r = (d)\frac{P_t.G_t.G_{r.}\lambda^2}{(4\pi)^2 d^2 L} \quad P_L(dB) = 10\log\frac{P_t}{P_r} \tag{1}$$

Where, Pt and pr are the transmitted and received power. In free space, the power reaching the receiving antenna which is separated from the transmitting antenna by a distance d is given by the Friis free-space equation:

$$P_r = (d)\frac{P_t.G_t.G_{r.}\lambda^2}{(4\pi)^2 d^2 L} \tag{2}$$

Where, Gt and Gr, are the gain of transmitting and receiving antenna, respectively. L is the system loss factor, not related to propagation. λ is the wavelength in meters.

PROPAGATION MECHANISM

There are some propagation mechanisms that effect propagation in mobile ad hoc network. They are explained as follows.

Absorption: Absorption is a loss that occurs if the signal passes through varying mediums or obstacles in which some of the transmitted signal is converted into another form of energy, usually thermal, and some of it continues to propagate. Any material or atmospheric condition that is non-transparent to electromagnetic signals will result in absorption of the transmitted signal. The conversion of energy occurs at the molecular level, resulting from the interaction of the energy of the radio wave and the material of the medium or obstacle.

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Refraction: Refraction occurs when a radio wave passes from one medium to another with different refractive indices resulting in a change of velocity within an electromagnetic wave that results in a change of direction.

Reflection: Reflection occurs when a propagating electromagnetic wave impinges upon an object that has very large dimensions compared to the wavelength of the propagating wave. Reflection occurs from the surface of the ground, from walls, and from furniture.

Diffraction: Diffraction losses occur when there is an obstacle in the path of the radio wave transmission and the radio waves either bend around an object or spread as they pass through an opening. Diffraction can cause great levels of attenuation at high frequencies. However, at low frequencies, diffraction actually extends the range of the radio transmission.

Scattering: Scattering is a condition that occurs when a radio wave encounters small disturbances of a medium, which can alter the direction of the signal. Certain weather phenomena such as rain, snow, and hail can cause scattering of a transmitted radio wave. Scattering is difficult to predict because of the random nature of the medium or objects that cause it.

Multipath: Multiple Waves Create "Multipath". Due to propagation mechanisms, multiple waves arrive at the receiver. Sometimes this includes a direct Line-of-Sight (LOS) signal. Multipath propagation causes large and rapid fluctuations in a signal These fluctuations are not the same as the propagation path loss.

Fading: The communication between the base station and mobile station in mobile systems is mostly non-LOS. The LOS path between the transmitter and the receiver is affected by terrain and obstructed by buildings and other objects. The mobile station is also moving in different directions at different speeds. The RF signal from the transmitter is scattered by reflection and diffraction and reaches the receiver through many non-LOS paths. This non-LOS path causes long-term and short term fluctuations in the form of log-normal fading and rayleigh and rician fading, which degrades the performance of the RF channel.

RF PROPAGATION MODALS

Propagation models available in Atoll are listed in the table below along with their main characteristics.

Table 1
Propagation models and characteristics

Propagation model	ITU 370-7 (Vienna 93)	ITU 1546	ITU 526-5	WLL	Standard Propagation Model	ITU 529-3	Erceg-Greenstein (SUI)	COST-Hata Okumura-Hata
Frequency band	100-400 MHz	30-3000 MHz	30-10000 MHz	30-10000 MHz	150-3500 MHz	300-1500 MHz	1900-6000 MHz	150-2000 MHz
Physical phenomena	Free space loss Corrected standard loss	Free space loss + Corrections	Free space loss Diffraction loss	Free space loss Diffraction loss	L(d, H_{Txeff}, H_{Rxeff}, Diff loss, clutter)	L(d, f, H_{Rx}) (per environment) Diffraction loss	L(d, f, H_{Tx}, H_{Rx}) (per environment) Diffraction loss	L(d, f, H_{Rx}) (per environment) Diffraction loss
Diffraction calculation method	-	-	Deygout (3 obstacles) Deygout corrected (3 obstacles)	Deygout (3 obstacles)	Deygout (3 obstacles) Epstein-Peterson (3 obstacles) Deygout corrected (3 obstacles) Millington (1 obstacle)	Deygout (1 obstacle)	Deygout (1 obstacle)	Deygout (1 obstacle)
Profile based on	-	-	DTM	DTM Clutter	DTM Clutter	DTM	DTM	DTM
Profile extraction mode	-	-	Radial	Radial	Radial Systematic	Radial	Radial	Radial
Cell size	Macro cell	Macro cell	Macro cell	-	Macro cell Mini cell	Macro cell Mini cell	Macro cell Mini cell	Macro cell Mini cell
Receiver location	Rooftop	Rooftop	Street	Street Rooftop	Street Rooftop	Street	Street	Street
Receiver	Fixed	Mobile	Fixed	Fixed	Mobile and Fixed	Mobile	Fixed	Mobile
Use	d > 10 km Low frequencies Broadcast	1 < d < 1000 km Land and maritime mobile, broadcast	Fixed receivers WLL	Fixed receivers WLL, Microwave links, WiMAX	1 < d < 20 km GSM, UMTS, CDMA2000, WiMAX, LTE	1 < d < 100 km GSM, CDMA2000, LTE	Urban and suburban areas 100 m < d < 8 km Fixed WiMAX	GSM 900, GSM 1800, UMTS, CDMA2000, LTE

Okumura – Hata Model

This is the commonly employed model for urban and sub-urban areas. This model is the most commonly used for macro-cell coverage planning. This is a combination of the work of Okumura and Hata. Okumura was able to carry out test measurements in Japan. These measurements had a range of clutter type, transmitter height, transmitter power and frequency. He found out that the signal strength decreases at a much greater rate with distance than the predicted free space loss (Medeisis & Kajackas, 2000; Saunders & Hata, 1980; Wilson & Scholtz, 2003).

Hata based his model on Okumura's free test results and predicted various equations for path loss with different types of clutter. The range of tests was carried out from carrier frequency, 150 MHz to 1500 MHz. The distance from the base station ranges from 1km to 20km while the range of the height of the mobile antenna is from 1m to 10 m. Okumura – Hata model is not suitable for micro-cell planning where antenna is below roof height. It is not valid for 1800 MHz and 1900 MHz systems.

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COST 231 Hata Model

COST is an acronym for European Co-operative for Scientific and Technical research. COST 231 Hata is an extension of the Okumura – Hata model. The COST 231 Hata model and is designed to be used in the frequency range 500 MHz to 2000 MHz. It has correction for urban, suburban and rural (flat) environments. Because of its simplicity and correction factors, it is widely used for path loss predictions at these frequency bands (COST, 1999; Hata, 1981; Okumura, 1968; Wong & Teng, 1997; Wu & Yuan, 1998).

Atoll Standard Propagation Model

SPM is based on the following formula:

$$L_{model} = K_1 + K_2 log(d) + K_3 log(H_{Txeff}) + K_4 \times DiffractionLoss + K_5 log(d) \times log(H_{Txeff}) + K_6(H_{Rxeff}) + K_7 log(H_{Rxeff}) + K_{clutter} f(clutter)$$

(3) Where,

K1: constant offset (dB).

K2: multiplying factor for log(d).

d: distance between the receiver and transmitter (m).

K3: multiplying factor for log(HTxeff).

HTxeff: effective height of the transmitter antenna (m).

K4: multiplying factor for diffraction calculation.

K5: multiplying factor for log(d) x log(HTxeff)

K6: multiplying factor for . HRxeff

K7: multiplying factor for log(HRxeff).

HRxeff : effective mobile antenna height (m).

Kclutter: multiplying factor for f(clutter).

f(clutter): average of weighted losses due to clutter.

Sample Values for SPM Path Loss Formula Parameters

The following tables list some sample orders of magnitudes for the different parameters composing the Standard Propagation

Table 2

Sample Values for Standard Propagation model formula

	Minimum	Typical	Maximum
K1	Variable	Variable	Variable
K2	20	44.9	70
K3	-20	5.83	20
K4	0	0.5	0.8
K5	-10	-6.55	0
K6	-1	0	0
K7	-10	0	0

K1 depends on the frequency and the technology.

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Table 3

Sample Values for K1 values

Project Type	Frequency (MHz)	K1
GSM900	935	12.5
GSM1800	1805	22
GSM1900	1930	23
UMTS	2110	23.8
1XRTT	1900	23
WiMAX	2300	24.7
	2500	25.4

All K paramaters can be defined by the automatic calibration wizard. Since Kclutter is a constant, its value is strongly dependant on the values given to the losses per clutter classes. From experienced users, the typical losses (in dB) per clutter class are:

Table 4

losses(in db) per Clutter class

Dense urban	From 4 to 5
Woodland	From 2 to 3
Urban	0
Suburban	From -5 to -3
Industrial	From -5 to -4
Open in urban	From -6 to -4
Open	From -12 to-10
Water	From -14 to -12

Proposed Method

Accurate prediction of radio propagation behaviour for the GSM NW is a major task. This paper study & analyze 900 & 1800 band site coverage prediction by the planning tool.A network model designer may be able to capture the necessary RF propagation effects with one of the network simulators, as some applications require higher fidelity modelling of a given RF environment. These can be more general than networking scenarios such as modelling the path loss at a given frequency over three city blocks. These RF propagation simulators are frequently used by network service providers to predict service coverage To achieve results we will use Atoll planning tools present in GSM world to assist a RF planner. We will provide the test case of rural site planning & its verification using Atoll tool present in the market and getting results using its standard propagation model with different

Experimental Results

We have done initial analysis on two sample sites each of 900 & 1800 Mhz band with three sectors respectively.

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Table 5 site allocation of two different sites

Transmitter	Antenna	Height (m)	Azimuth (°)	ical Downtilt (°)	Power (dBm)	Losses (dB)
1800 site_1	65deg 17dBi 0Tilt 1800MHz	32	10	1	43	3
1800 site_2	65deg 17dBi 0Tilt 1800MHz	32	100	1	43	3
1800 site_3	65deg 17dBi 0Tilt 1800MHz	32	220	1	43	3
900 site_1	65deg 17dBi 0Tilt 900MHz	32	0	1	43	3
900 site_2	65deg 17dBi 0Tilt 900MHz	32	100	1	43	3
900 site_3	65deg 17dBi 0Tilt 900MHz	32	220	1	43	3

900Mhz Band Site Results:

Coverage distribution:

Table 6

Coverage by Signal Level_900

Coverage by Signal Level: SITE_NAME=test 900	KM2
Best Signal Level (dBm) >=-70	1.86
Best Signal Level (dBm) >=-75	3.395
Best Signal Level (dBm) >=-80	5.9
Best Signal Level (dBm) >=-85	10.533
Best Signal Level (dBm) >=-90	17.835
Best Signal Level (dBm) >=-95	28.44
Best Signal Level (dBm) >=-100	40.323
Best Signal Level (dBm) >=-105	44.0,78

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Prediction:

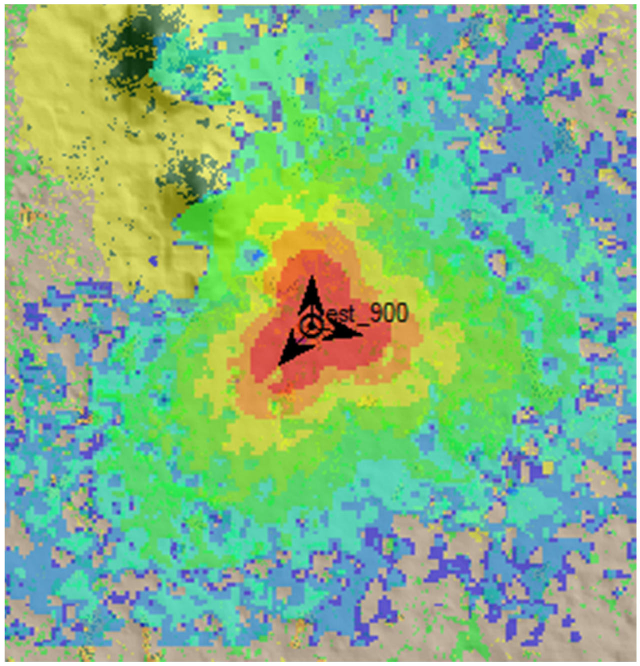

Fig 1:

Covered area by 900 site

Histogram:

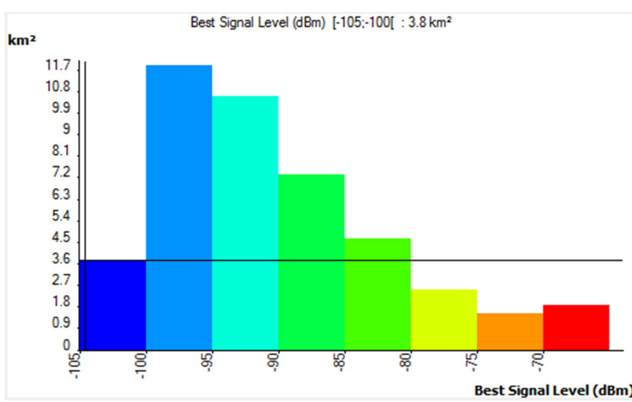

Fig 2:

Histrogram based on Covered Areas in 900

1800 Mhz Band site Results:

Coverage distribution:

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Table 7

Coverage by Signal Level_1800

Coverage by Signal Level: SITE_NAME=test 1800	KM2
Best Signal Level (dBm) >=-70	0.445
Best Signal Level (dBm) >=-75	1.058
Best Signal Level (dBm) >=-80	2.175
Best Signal Level (dBm) >=-85	4.168
Best Signal Level (dBm) >=-90	7.253
Best Signal Level (dBm) >=-95	13.273
Best Signal Level (dBm) >=-100	21.673
Best Signal Level (dBm) >=-105	26.138

Prediction:

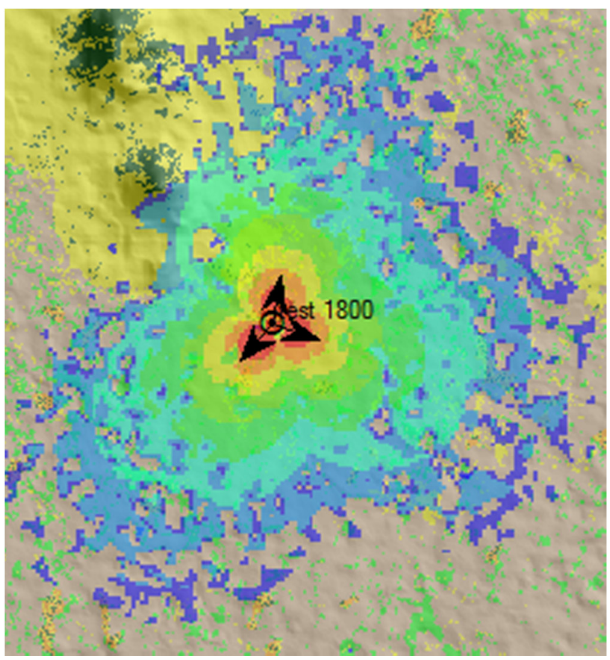

Fig 3:

Covered area by 1800 site

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Histogram:

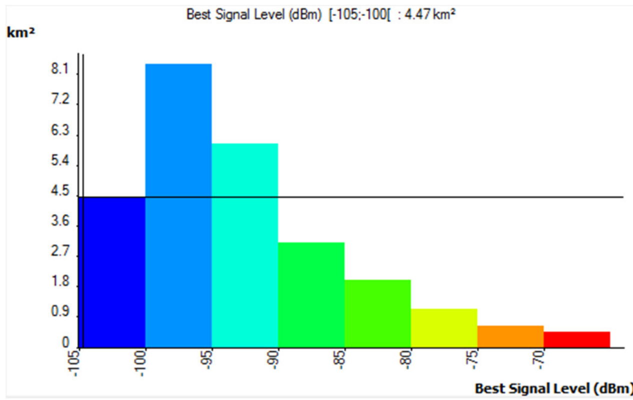

Fig 4:

Histrogram based on Covered Areas in 1800

Conclusion

This analysis of 900 & 1800 band site showing predicated signal strength by the planning tool clearly displays the difference in covered area. It helps us in understanding that 1800 MHz band site covers less area as compared to 900 MHz Band site. And also help in understanding the importance of a good Planning tool. Further, it is also expected that generated coverage prediction will match with the field test results and its verification can be showed in a separate study, if it is considered to replace existing 900 Band Sites with 1800 MHz Band site in a test area.

However, it is out the scope of this work to propose a precise model of the problem, since we use proprietary software which is aware of all these concepts, as well as the consideration of all the existing RF propagation Techniques developed for efficiently using all the possible propagation scenarios.

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