The International Journal Of Engineering And Science (IJES)
|| Volume || 3 || Issue || 7 || Pages || 38-45 || 2014 ||
ISSN (e): 2319 – 1813 ISSN (p): 2319 – 1805

A comparative Study between Modelled and Received Mobile Phone Signal Strengths in terms of Power Loss and Statistical Analysis

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--ABSTRACT---

This paper focuses on propagation study in indoor environment which is one of the most complicated propagation because of the effect of building structures and materials used in the construction and compares the real received signal strength/power and the theoretical modelled one all considering loses. An important requirement for mobile radio system is the provision of reliable services to the increasing number of users across outdoor to indoor interface. This research work studied, by way of extensive measurements. Five geographical locations at different distances in steps were used as case study within Kaduna metropolis in Nigeria namely: AnguwanKanawa, AnguwanMuazu, Hayen-Danmani, Mararaban Jos and Kabala. Signals radiated from four GSM (namely, MTN, Etisalat, Glo, starcomm and Airtel) and one CDMA (Stacom) which are international service providers were considered

KEY WORDS: *GSM, CDMA, modelled power, loss.*

Date of Submission: 27 December 2013 Date of Publication: 20 July 2014

I. INTRODUCTION

There are several factors that affect radio wave propagation which result in the degradation of signals, these include multipath fading effect, non-line-of-sight, path loss, and absorption by building materials used in construction [1]. With the advent of microcellular, radio networks employed in third-generation mobile communication systems, there is an increased interest in propagation models that are able to provide location – specific predictions of channel parameters such as local mean power, and delay spread [2].Propagation research for mobile communications in urban microcells has hitherto been focused mainly on the modelling of reflection and diffraction from exterior walls and corners of buildings. These buildings are usually treated as opaque at frequencies used for terrestrial mobile communications. Radio propagation inside buildings is governed by mechanisms such as reflection, diffraction, and scattering from various objects.field distribution inside a building is therefore dependent on specific features of its internal structure (e.g. layout, construction materials) [3]Propagation research can be done in both indoor and outdoor environments. Indoor and outdoor radio channels differ largely in terms of the transmitter-receiver separation distance covered (which is usually much smaller for indoor environments, and the variability of the environment is usually greater for indoor environments). Propagation in indoor environments have somewhat, more complex multipath structure than in outdoor environments which is largely due to the nature of the building structures used, the room layouts and the type of materials used in the construction of the building.[4]In outdoor environment, propagation is affected by obstacles within surroundings such as trees, buildings, and moving cars among others. While indoor environment propagation on the other hand is affected by interior walls, metallic objects such as whiteboards, bookcases, standing air conditioners and items of furniture.Since transmission and reception of signals can be from outdoor to indoor environment, there is need to quantify the various contribution by these factors on the signal strength. Quantifying the above mentioned effect is important so that the signal strength may be estimated at the receiving end. Therefore, there is need to have the knowledge of degradation of the signal on its way to the receiving end, in order to know the required transmitted power level at the transmission end.

II. PROPAGATION MODELS

The free space propagation model is used to predict received signal strength when the transmitter and receiver have a clear, unobstructed line of sight path between the

2.2 FREE SPACEPATH LOSS EXPONENT MODEL

The free propagation model predicts that the received power decays as a function of transmitter-receiver raised to some exponent. The power received by the receiving antenna (p_r) when placed at a distance (d, in meters) from the transmitting antenna, which by the free space transmission equation as [2]

$$P_r(d) = 10\log\{GtGr\lambda^2/(4\pi)\,2\} \quad (1)$$

Where G_r and G_t are gains of the receiving and transmitting antenna respectively, λ is the wavelength in meters. Large scale propagation models typically use a close-in distance as a reference distance and this is termed d_0. This value of p_r (d_0) is measured by taking the average received power at this distance from the transmitter. The received power in free space at a distance greater than d_0 is given by [2]

$$P_r(d) = P_r(d_o) = +10nlog\ (d/d_o)(2) \quad (2)$$

The reference distance (d_0) is usually chosen such that it is smaller than any practical distance used in the wireless communication system of interest, and also such that it lies in the far field region. If ‘n’ represents the path loss exponent, which characterizes the relationship between the increase in path loss values with increase in transmitter- receiver separation distance, then path loss at a distance d (such that $d > d_0$) can be expressed as [4]

$$P_l(dB) = P_r(d_o) = +10nlog\ (d/d_o) \quad (3)$$

The model relationship when plotted on a log-log scale is a straight line with a slope equal to 10ndB per decade in distance. The value of ‘n’ depends on specific propagation environment conditions. For instance the value of the path loss exponent in free space is 2 and when obstructions are present and it usually has a larger values. Researchers have estimated the path loss exponent for a loss case inside building can range from a value of 1.6 to 1.8 and when the path loss is obstructed, the exponent value increase to range of 4 to 6.

2.2 LOG-NORMAL SHADOWINNG MODEL

The log-normal shadowing model predicts path loss as a function of T-R separation using equation below [2]

$$P_l(d) = P_l(d_o) + 10nlog\ (d/d_o) + X_\sigma \quad (4)$$

Where X_σ is a zero-mean Gaussian random variable with standard deviation σ.

The random variable X_σ attempts to compensate for random shadowing effect that can result from clutter.

III. LINEAR REGRESSION ANALYSIS

This is a linear model which is use to examine the relationship between dependent and independent variables. After performing an analysis on the data, regression statistic can be employed to predict the dependent variable when the independent variable is known. This is represented by this equation below. [4]

Y=intercept+(slope)+loss (5)

The loss term in equation (5) is because the independent variable X_σ cannot fully accounts for all the observed variation in the dependent variable. This loss is normally distributed. The task here is to determine regression coefficients, $a+b_x$ in linear regression equation represented as $y_i=a+b_x$

Where ‘a’ and ‘b’ represent the intercept and the slope of the regression line respectively, y_i is the fitted value of y data and x_i is the set of points X. We define the estimated loss associated with each pair of data values.

IV. RESULT AND DISCUSSION

The values of n and σ were determined from empirical data obtained from measurements through the use of linear regression model.After determining the values of ‘n and σ as presented in table and were used to calculate the theoretical received power considering log-normal shadowing model.results obtained from the modelled and measured signal power and statistical analysis representing the values of path loss exponents ‘n’ and standard deviation **‘σ’.** The comprehensive evaluation on how these results were obtained using statistical analysis and are presented table 1-5

The table 3 below shows the comparison between signal strength variations in mud building with rusty zinc roof with other building types where measurements were conducted.

Linear regression using standard deviation to evaluate the value of “σ” in dB

Result obtained is presented in this table 5.0 below, Considering the speed of light in the study

λ^2= 3x10^{-8}/960 x10^6= 0.096m, G_t=G_r= 1

and df =2D^2/λ =2$(1.5)^2$/0.3312=12.92m

$$P_l(d) = P_l(d_o) + 10n\log(d/d_o) + X_\sigma \qquad (6)$$

Substituting the values in equation (6) we have

Pl (d_o) = -10log {1*1 *0.096 /(4π)2 $(12.92)^2$ }=54.39dB

$$P_l(d) = P_l(d_o) + 10n\log(d/d_o) + X_\sigma \qquad (7)$$

Substituting the values in equation (7) we have

$P_{L\,(d)=}$54.39 +1.5(10)log (12.92/12.92) +3.7=58.09dBm

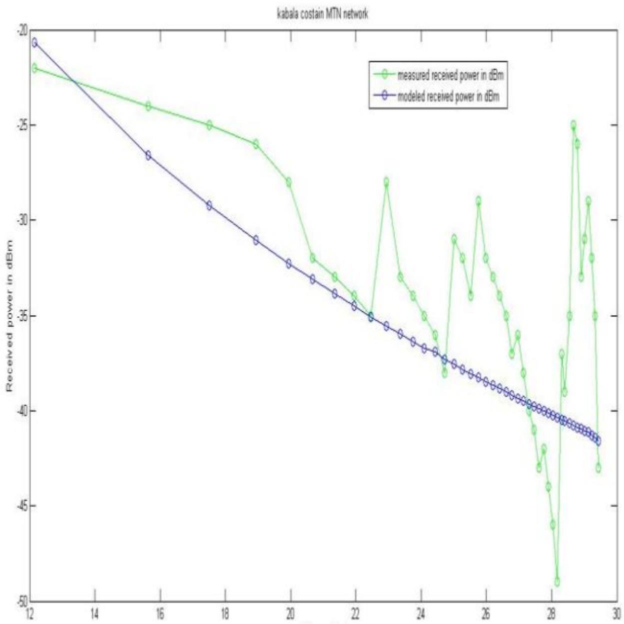
P_r(dBm)=P_tdBm)- $P_{L\,(d)}$ (8)

Pr (dBm)= 33.3-58.09= -24.79dBm

PL (d_o)= -10log (1*1*0.096)/ (4π)2$(15.98)^2$ = 56.23dBm

PL (d)= 56.23 +15log(15.98.12.92)+3.7=66.21dBm and Pr(dBm)= 33.3-66.21= -32.91dBm
3. PL (d_o)= -10log (1*1*0.096)/ (4π)2$(17.75)^2$= 57.15dB
Pl (d) = 57.15+15log(17.75/12.92) +3.7=70.23dB and Pr (dBm)= 33.3-70.23= -.93dBm
pl (d_o)= -10log(1*1*0.096)/ (4π)2 $(19.01)^2$ =57.74dB
Pl (d)= 57.74+15log(19.01/12.92)+3.772.85dB
Pr (dBm)= 33.3-72.85
= -39.55dBm

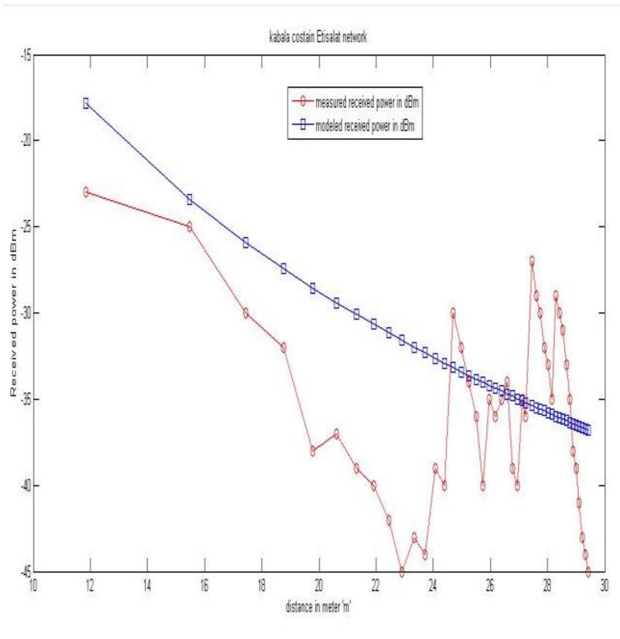
Received power in 'dBm'



Distance in meter 'm'

Fig 1 measured & modelled received power for Etisalat network kabala costain

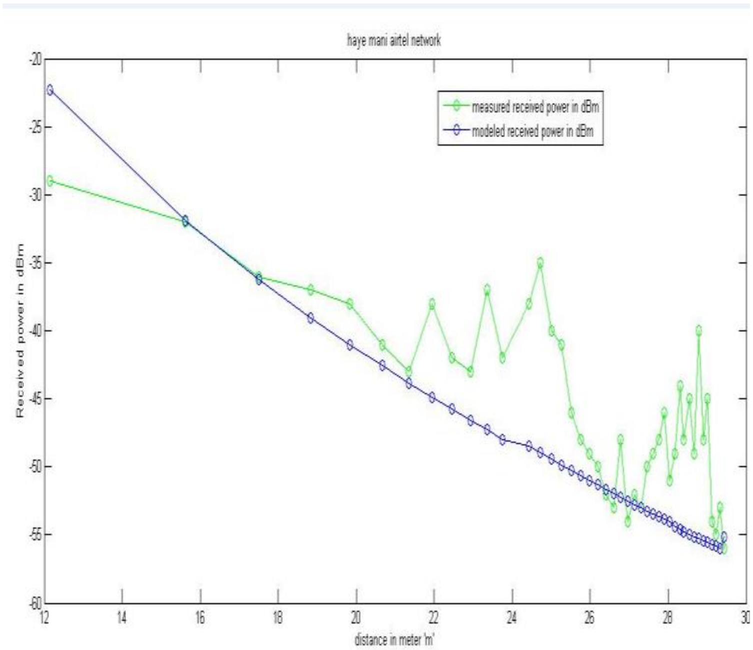
Received power in 'dBm'



Distance in meter 'm'

Fig 2 measured & modelled received power for Etisalatnetwk kabala costain

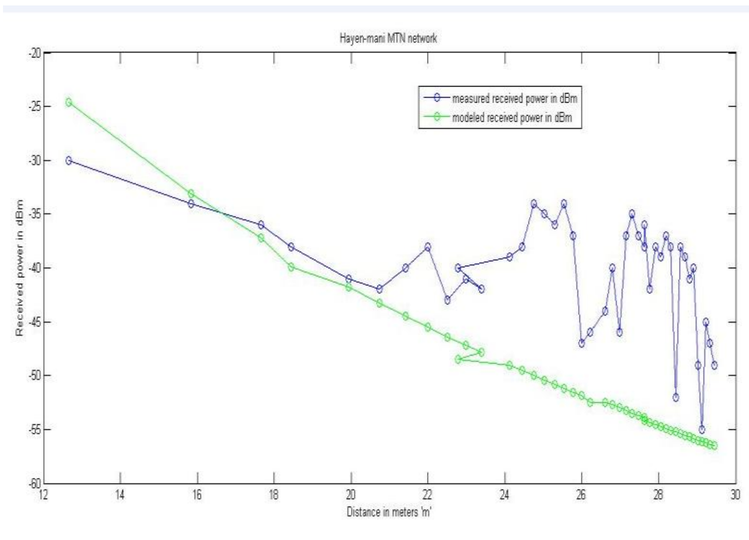
Received nower in 'dBm'



Distance in meter 'm'

fig 3 measured & modelled received power for Airtel network Hayen-Danmani

Received nower in 'dBm'



Distance in meter 'm'

fi4 measured & modelled received power for Mtn network Hayen-Danmani.

Table1 SIGNAL STRENGTH MEARSURED (DBM)

S/No	indoor	outdr	Diffrnc.	Avrg
	Airtel			
1	-50.39	-45.08	-5.31	
2	-54.19	-46.14	-8.05	-7.57
3	-50.13	-40.18	-9.35	
	MTN			
1	-48.18	-44.67	-3.51	
2	-38.09	-31.56	-6.53	-5.59
3	-40.16	-33.23	-6.73	
	Glo			
1	-44.31	-35.01	-9.30	
2	-43.44	-39.07	-4.37	-5.54
3	-39.24	-36.29	-2.95	
	Starcom			
1	-58.03	-41.59	-7.56	
2	-59.12	-40.37	-4.74	-8.04
3	-55.53	-42.05	-2.79	
	Etisalat			
1	-50.04	-41.59	-8.45	
2	-53.08	-40.37	-12.71	-5.03
3	-55.53	-42.05	-2.95	

Table 2 HAYEN-DANMANI AIRTEL NETWORK

Distnc(m)	10log(d)x_i in 'm'	Power receivedy_i'	$x_i y_i$	X_i^2
16.4	12.15	-29	-352	147.6
36.4	15.61	-32	-499	243.6
56.4	17.51	-36	-630	306.6
76.4	18.83	-37	-696	354.5
96.4	19.84	-38	-753	393.6
116.4	20.66	-41	-847	426.8
136.4	21.35	-43	-918	455.8

Table 3 HAYIN DANMANI AIRTEL NTwK

S/N	Distance (m)	Measured Received Power(dB	Modeled Received Power(dBm
1	12.15	-29	-22.29
2	15.61	-32	-31.87
3	17.51	-36	-36.26
4	18.83	-37	-39.04
5	19.84	-38	-41.04
6	20.66	-41	-42.58
7	21.35	-43	-43.84

Table 4 HAYIN - DANMANI MTN NETWORK

S/N	Distance in (m)	Measured Received Power(dBm	Modelled Received Power(dBm)
1	12.65	-30	-24.62
2	15.84	-34	-33.12
3	17.66	-36	-37.23
4	18.44	-38	-39.87

Table 5 HAYIN - DANMANI MTN NETWORK

X	$(X - \bar{X})$	$(X - \bar{X})^2$
12.65	-12.01	145.68
15.84	-8.88	78.85
17.66	-7.06	49.84
18.44	-5.78	33.41
19.93	-4.79	22.94
20.73	-3.99	15.92

REFERENCES

[1] Georgia Institute of Technology, smart Antenna Research/laboratory

[2] Theodore S. Rappaport "wireless communications principles and practice" second edition, PHI learning private limited New delhi-110001 2009, pp (105-177).

[3] N. Yarkoni and N. Blaunstein "prediction of propagation characteristic in indoor radio communication environment" progress in electromagnetic research, PIER59, 151-174 2006

[4] J.D Parsons, "The mobile radio propagation channel second edition copyright 2000 John Wiley and son Ltd print ISBN 0-471-98857-x pp190-195.

[5] S.C Gupta 'Fundamentals of Statistics' Himalaya publishing house PVT. Ltd six editions 20011 (pp9.10).

[6] Amaefule C.S 2003 "The GSM communication explosion in Nigeria" proceedings of the NCS conference 2003.14:163-182