

Implementation of Particle Swarm Optimization Technique for Enhanced Outdoor Network Coverage in Long Term Evolution Network in Port Harcourt, Nigeria

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Abstract—This paper describes the development of optimized model for urban outdoor coverage in Long Term Evolution (LTE) network at 2300 MHz frequency band in Port Harcourt urban region, Nigeria. Signal attenuation and fluctuation remain amongst the major channel impairments for mobile radio communication systems. This arises as a result of model incompatibility with terrain and Line of Sight (LOS) obstruction of the channel signals. Some path loss models such as Okumura-Hata, COST 231, Ericsson 999, Egli and ECC-33 models were evaluated for suitability and compared with the modified model for the environments. The models were based on data collected from LTE base stations at three geographical locations in Port Harcourt namely- Rumuokoro, Eneka and Ikwerre roads respectively. The simulation was implemented using MATLAB R2014a software. The modified model was further optimized with some selected parameters such as Root Mean Square Error (RMSE) and Mean Absolute Error (MAE) using Particle Swarm Optimization (PSO) technique. The results obtained gave rise to 3.030dB for RMSE and 0.00162dB for MAE respectively. The results obtained from the PSO optimized model demonstrated a better performance which is suitable for cell coverage planning and smooth handoff processes.

Index Terms—Quality of Service; Path Loss; Mean Absolute Error; Root Mean Square Error Models; Long Term Evolution; Particle Swarm Optimization.

I. INTRODUCTION

Recently, the use of mobile wireless system became the most popular technology as a result of lots of services available in mobile cellular phone [1]. Some of these include voice call, video call, conference call, data based services and other multimedia applications. Despite the increase in number of base stations to augment high rate of subscribers, the quality of service delivery by the network providers still remains in poor state [2]. It is observed that the poor quality of services experienced could be due to several challenges experienced in the network channel [3]. On that note, it

becomes paramount to identify these problems and propose solutions through research analysis.

The communication channel experience Rayleigh fading as a result of obstruction to Line of Sight (LOS), resulted in reflection, absorption and scattering of transmitted signal [4], [5]. The knowledge of the propagation characteristic of a mobile radio channel is essential for designing any wireless communication system in a given region [6]. One of the most important problems of propagation environment is path loss [5]. Propagation path loss has great influence on the quality of service of a mobile communication system, the transmitted signal power get reduced with increased distance from base station to mobile station. Therefore, accurate estimation of propagation path loss is important factor for the good design and planning of mobile system [7]. The quality and coverage reliability of a wireless network design depends on the accuracy of the path loss model [4].

There are many propagation path loss models proposed in previous works to predict coverage. These model are not sufficient for accurate analysis of the path loss on other terrain, the suitability of such models differs with different environment [8]. The objective of optimization is to make sure the network operates close to the original design in terms of handoff points, coverage, received signal strength and Quality of Service (QoS) [2], [3]. In order to overcome the problem of path loss, the parameters of certain models must be adjusted with reference to the targeted locations. This will enable the system achieve minimum error between Transmitted Signal Strength (TSS) and Received Signal Strength (RSS) [2], [9].

The performance of Long Term Evolution (LTE) networks recently deployed in Port Harcourt region, Nigeria, is investigated in this study. LTE remains one of the latest technology development from the cellular 3rd Generation (3G) to 4th Generation (4G) services [10], primarily designed to meet the requirements of 4G technology. The Technology

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was based on Universal Mobile Telecommunication System (UMTS), developed by the 3rd Generation Partnership Project (3GPP). It is also known as Evolved Universal Mobile Telecommunication Service Terrestrial Radio Access (e-UTRA) [11]-[13]. It uses Wideband Code Division Multiple Access (W-CDMA) as a standard [11]. LTE has downlink and uplink of 100 Mbps and 50 Mbps respectively, scalable bandwidth from 1MHz to 20MHz and supports multitude of user types and high spectra efficiency [10]. LTE uses multicarrier modulation such as Orthogonal Frequency Division Multiple Access (OFDMA) and Multiple Input Multiple Output (MIMO) antennal system at the transmitter and receiver. This enables 4G to achieve higher spectral efficiency and higher data rates [11].

Optimization is the process of obtaining the best solution to a system function efficiently as a result of the modification of existing models. The optimizations of these existing models have been carried out by many researchers in other regions, but some of them are based on Least Square (LS) method. Other optimization methods such as Genetic Algorithm (GA), Particle Swarm Optimization (PSO) and Bee Colony Algorithm (BCA), have not been commonly used relative to the reviewed literature. The particle swarm optimization uses the ideas of bird flocking and its survival of fitness by randomly chosen positions and velocities [2]. In this paper, we investigated the performance of some propagation models while appropriate modified model was developed for the terrain. PSO technique was further deployed to obtain the best model that suits the environment and optimize for urban outdoor coverage in LTE network.

II. METHODOLOGY

The drive test routes survey was carried out at each location before the actual commencement of the measurements. Accessible routes were selected to avoid being stranded during measurements in any of the selected locations. The massive measurements were taking by driving through the selected road in each location in order to obtain the path loss and signal strength in those areas. The measurement taken was on LTE, the base station height is 35 meters, mobile station height is 1.5 meters and the operating frequency is 2300 MHz. The TEMS phone, Global Positioning System (GPS), Power Supply Unit (PSU) were connected to the laptop containing the installed TEMS 11.0 investigation software arranged inside the drive vehicle. The measurements were made as the vehicle moved in the already planned routes, the signal strength was observed on the computer screen showing established calls and end calls. The RSS and other information were recorded on the log files.

A. Large-Scale Propagation Models

This section discusses some commonly used empirical models used to predict power attenuation between base station and mobile station. Their approach in terms of complexity and accuracy differs from one location to another.

B. Okumura-Hata

Okumura – Hata model is one of the commonly used propagation path loss models that suit the urban area propagation. The frequency range is between 150 MHz – 1500 MHz the base station antenna height is limited to 30m

- 200 m, and transmission distance (d) is between 1 km – 20 km. The mobile antenna height ranges from 1 m – 10 m [14], [15]. Okumura-Hata model is given as;

$$L_p(\text{urban})\text{dB} = A_o - 13.82 \log_{10} h_{bt} - a(h_{cf}) + [44.9 - 6.55 \log h_{bt}] \log_{10} d_t \quad (1)$$

where

$$A_o = 69.55 + 26.16 \log f_c$$

f_c = is the carrier frequency (in MHz)

h_{bst} = base station antenna height (in metres)

h_{mcf} = mobile antennal height (in metres)

$a(h_{mcf})$ = mobile antenna height correction factor

d_t = base station to mobile separation distance (in km)

For a large city, the mobile antenna correction factor ($a(h_{mb})$) is given by

$$a(h_{cf}) = 8.29 [\log(1.54h_{mb})]^2 - 1.1 \text{ dB} \quad (2)$$

for $f_c \leq 300 \text{ Mhz}$

$$a(h_{cf}) = 3.201 [\log(11.75h_{mb})]^2 - 4.97 \text{ dB} \quad (3)$$

for $f_c \geq 300 \text{ Mhz}$

For a small or medium size city, the mobile antenna correction factor is

$$a(h_{cf}) = 1.11[\log(f_c) - 0.7]h_{mb} - [1.56 \log(f_c) - 0.8] \quad (4)$$

Hata formula for suburban area path loss is modified as;

$$L_p(\text{suburan}) (\text{dB}) = L_p(\text{urban})\text{dB} - 2[\log \frac{f_c}{28}]^2 - 5.4 \quad (5)$$

For rural area, the formula is modified [8]

$$L_p(\text{rural})(\text{dB}) = L_p(\text{urban})\text{dB} - 4.78[\log f_c]^2 + 18.33[\log f_c] - 40.98 \quad (6)$$

C. Electronic Communication Committee (ECC-33)

ECC-33 is an extended Okumura-Hata model extrapolated from original measurements by Okumura and modified its assumptions to have close values on models. The original experiment of Okumura was carried out at the suburban areas of Tokyo [16]. The Authors refer to urban areas subdivided into large city and medium city categories and gave correction factors to suburban and open areas. The built-up characteristics of Tokyo city are quite different to those found in typical European suburban areas. The path loss model is defined as shown in (7), [17].

$$PL_{P(\text{ECC-33})}(\text{dB}) = P_{f_{sp}} + P_{bm} - G_{tx} - G_{rx} \quad (7)$$

where,

$P_{f_{sp}}$ is free space attenuation,

P_{bm} is basic median path loss,

G_{tx} is transmitter antenna (BS) height gain factor

G_{rx} is received antenna (MS) height gain factor

The parameters are defined by [2] as;

$$P_{f_{sp}} = 92.4 + 20 \log(d) + 20 \log(f) \quad (8)$$

$$P_{b_{m}} = 20.41 + 9.83 \log(d) + 7.894 \log(f) + 9.56 [\log(f)]^2 \quad (9)$$

$$G_{t_{x}} = \log\left(\frac{h_{t_{x}}}{200}\right) [13.98 + 5.8(\log d)^2] \quad (10)$$

For medium sized cities

$$G_{r_{x}} = [42.57 + 13.7 \log(f)] [\log(h_r) - 0.585] \quad (11)$$

For large cities

$$G_{r_{x}} = 0.759 (h_r) - 1.862 \quad (12)$$

d = distance base station and mobile station (km)

h_{bs} = base station antenna height (m)

h_{ms} = mobile antenna height (m)

D. Egli Model

The model was introduced by Egli John in 1957 to predict the path loss in higher terrain environment. Egli model is suitable for cellular communication scenarios where one antenna is fixed and other is mobile [19]. The model is applicable to scenarios where the transmission has to go over an irregular terrain at frequency from 40 MHz to 900 MHz [20]. Egli model is not applicable to the area where some vegetative obstruction, such as trees or shrubbery is in the middle of the link [19]. The Egli's model expressed by [1], [20] as

$$L_p(\text{dB}) = K_0 - 20 \log h_b + 76.3 - 10 \log h_m, \quad (13)$$

for $h_m \leq 10$

$$L_p(\text{dB}) = K_0 - 20 \log h_b + 85.9 - 10 \log h_m, \quad (14)$$

for $h_m \geq 10$

Where,

$$K_0 = 20 \log f_c + 40 \log R$$

h_b = height of the base station antenna (m)

h_m = height of the mobile station antenna (m)

R = distance from base station antenna (km)

f_c = frequency of transmission

E. Ericsson 9999 Model

The model stands on the modified Okumura-Hata model to give room for changing in parameters according to the propagation environment [17]. This model is used for frequency up to 1900 MHz. Path loss according to Ericsson 9999 model is evaluated by [19] as;

$$L_{P(\text{ERIC})}(\text{dB}) = a_0 + a_1 \log(d) + a_2 \log h_b + [a_3 \log(h_b) \log(d)] - P_0 + g(f_c) \quad (15)$$

Where,

$$P_0 = 3.2 [\log(11.75 h_r)^2]$$

$$g(f_c) = 44.49 \log(f) - 4.78[\log(f)^2]$$

f = frequency in MHz,

h_b = transmitter antenna height (m) and

h_r = receiver antenna height (m)

The default values of these parameters a_0, a_1, a_2, a_3 for different terrain are contained in Table I, it shows the asterisk (*) values of parameter a_0, a_1 based on the Least Square (LS) method.

TABLE I: THE PARAMETER VALUE FOR DIFFERENT TERRAIN FOR ERICSSON 9999 MODEL¹

Environment	a_0	a_1	a_2	a_3
Urban	36.20	30.20	12.00	0.10
Suburban	43.20*	68.93*	12.00	0.10
Rural	45.95*	100.6*	12.00	0.10

F. COST 231- Hata model

The European Co-operative for Scientific and Technical research (EURO-COST) formed the COST-231 working committee to develop COST-231- Hata model. The COST-231 is the extension of the Hata model restricted to the following range of parameters: frequency of 1500 – 2000 MHz, base station antenna height of 30 m – 200 m, mobile antenna height is between 1 m – 10 m, and separation distance between transmitter antenna and receiver antenna of 1 km – 20 km. It is designed to be used in the operating frequency band between 1500 MHz to 2000 MHz. The basic equation for path loss in dB is given in [4], [8] as;

$$L_P(\text{COST}) \text{ dB} = A_0 - a(h_{mb}) + [44.9 - 6.55 \log h_{ms}] \log d + C_{AC} \quad (16)$$

Where,

$$A_0 = 46.3 + 33.9 \log f_c - 13.82 \log h_{bt}$$

C_{AC} = Area correction factor

L_P = path loss in (dB)

f_c = carrier frequency (MHz)

h_{bt} = base station antenna height (m)

h_{ms} = mobile antenna height (m)

$a(h_{mb})$ = mobile antenna height correction factor

d = mobile antenna separation distance (km)

$C_M = 0 \text{ dB}$ for medium sized city and suburban areas, and 3 dB for urban centres

For a large city, the mobile antenna correction factor is given by

$$a(h_{mb}) = 8.29 [\log(1.54 h_{mb})]^2 - 1.1 \text{ dB} \quad (17)$$

for $f_c \leq 300 \text{ Mhz}$

$$a(h_{mb}) = 3.2 [\log(11.75 h_{mb})]^2 - 4.97 \text{ dB} \quad (18)$$

for $f_c \geq 300 \text{ Mhz}$

For a small or medium size city, the mobile antenna correction factor is

$$a(h_{mb}) = 1.1[\log(f_c) - 0.7]h_m - [1.56 \log(f_c) - 0.8] \quad (19)$$

G. Log-Distance Propagation Model

The mobile radio propagation models are derived by employing a combination of empirical and analytical methods. The empirical approach is based on analytical expressions created by a set of measured data [8]. The

¹ Source: [17]

wireless communication signal propagation may be characterized by some factors such as signal power attenuation, shadowing and fading. Hence, the path loss model ($L_P(d_i)$) as a function of distance is given by [18].

$$L_P(d_i) \propto \left(\frac{d}{d_0}\right)^{np} \quad (20)$$

$$L_P(d_i) = L_P(d_0) \left(\frac{d}{d_0}\right)^{np} \quad (21)$$

If we taking logarithm of (21)

$$L_P(d_i) = L_P(d_0) + 10(np) \log\left(\frac{d}{d_0}\right) \quad (22)$$

Where, np is path loss exponent, d is the distance between the transmitter and receiver, d_0 is the reference distance.

Therefore,

$$np = \frac{L_P(d_i) - L_P(d_0)}{10 \log\left(\frac{d}{d_0}\right)} \quad (23)$$

To compensate for random shadowing effect that can result from terrain, the modified power expression is given by [18] as;

$$L_P(d_i) = L_P(d_0) + 10(np) \log\left(\frac{d}{d_0}\right) + X_{\sigma_x} \quad (24)$$

Where, X_{σ} is a zero- mean Gaussian distributed random variable (in dB) with standard deviation σ_x in (dB). Path loss exponent(np), can be determine in a mean square sense using regression analysis [20] as;

$$np = \frac{\sum_{i=1}^N [L_P(d_0) - L_P(d_i)]^2}{\sum_{i=1}^N 10 \log(d_i/d_0)} \quad (25)$$

where, $L_P(d_0)$ is the measured path loss and $L_P(d_i)$ is the predicted path loss at any distance d_i , N is the number of data points. The standard deviation is given as;

$$\sigma_x = \left(\frac{1}{N} \sum_{i=1}^N [L_P(d_0) - L_P(d_i)]^2\right)^{\frac{1}{2}} \quad (26)$$

The expression $L_P(d_0) - L_P(d_i)$ is an error term with respect to np , from (25) and the sum of the mean square error, $e(np)$ is given as;

$$e(np) = \sum_{i=1}^N [L_P(d_0) - L_P(d_i)]^2 \quad (27)$$

The derivative of (27) can be equated to zero while minimizing the mean square error to solve for np :

$$\frac{\partial e(np)}{\partial e} = 0$$

H. Model Data Analysis and Measurements

The path loss measured in Port Harcourt urban area has been estimated using the propagation models. These models were selected for the fact that they can predict the mean path loss as a function of various parameters. The regression analysis between the measured and the predicted path loss data against distance for Rumuokoro road (location 1), Eneka road (location 2) and Ikwerre road (location 3) respectively are presented in Table II.

TABLE II: PORT HARCOURT URBAN AREA DATA ANALYSIS

Dist. (m)	Average RSS (dBm)	Measured PL (dB) location1	Measured PL (dB) location 2	Measured PL (dB) location 3	Average PL $L_p(d_0)$ dB	Predicted PL $L_p(d_i)$ dB
100	-76.43	90.20	100.5	99.8	96.83	96.83
200	-79.48	113.1	128.0	141.5	127.5	96.83+3.01n
300	-85.07	113.5	123.5	124.1	120.4	96.83+4.77n
400	-85.03	112.5	120.36	123.3	118.7	96.83+6.02n
500	-81.94	99.60	129.15	158.0	128.9	96.83+6.99n
600	-86.24	104.4	120.5	158.0	127.6	96.83+7.78n
700	-84.17	107.8	125.5	158.0	130.4	96.83+8.45n
800	-79.76	140.5	122.5	116.0	126.3	96.83+9.03n
900	-82.60	115.0	118.8	127.0	120.3	96.83+9.54n
1000	-88.01	145.1	121.3	124.5	130.3	96.83+10.00n
1100	-88.55	117.6	120.95	129.5	122.7	96.83+10.41n
1200	-89.55	158.0	154.7	119.5	144.1	96.83+10.79n
1300	-86.55	130.5	123.9	116.6	123.7	96.83+11.14n
1400	-84.25	113.5	148.0	127.6	129.7	96.83+11.46n
1500	-80.65	120.5	123.9	117.8	120.7	100.5+11.76n

I. LTE data analysis based on measurement locations

The regression analysis was carried out on the measured path loss for locations 1-3, the reference path loss, exponent, and the measured data are presented in Table III.

TABLE III: AVERAGE PATH LOSS EXPONENT, REFERENCE PATH LOSS AND MEASURED DATA FOR URBAN AREA OF PORT HARCOURT

Measurement Locations	Exponent (n= np)	$L_P(REF)$	Measured data
Location 1	3.48	90.2	16804.43 - 7943.442n + 1139.919n ²
Location 2	3.26	100.5	14242.92 - 7436.3734n + 1139.919n ²
Location 3	3.16	99.8	17179.763 - 7211.73 n + 1139.919n ²

$$\text{Average} \quad 3.30 \quad 96.83 \quad 16075.704 - 7530.516 n + 1139.919n^2$$

The path loss exponent (np) was obtained by equating the derivatives of (27) to zero as

$$e(np) = 1139.919n^2 - 7530.516 n + 16075.704 = 0$$

$$\frac{\partial e(np)}{\partial e} = 2(1139.919n) - 7530.516 = 0$$

$$np = 3.30$$

Therefore, the standard deviation, σ_x (dB), about a mean value, was determine from (26) as

$$\sigma_x = \left(\frac{1}{15} (1139.919(3.30)^2 - 7530.516(3.30) + 16075.704) \right)^{\frac{1}{2}}$$

$$\sigma_x = 12.93 \text{ dB}$$

The standard deviation, σ_x (dB) was added to (25) to compensate for the shadowing error of the terrain. Also, $L_{PM}(d_0)_{Ref}$ and np were substituted to produce (28). Therefore, modified shadowing empirical model for Port Harcourt urban area is presented in as;

$$L_{PR}(d_i) = 96.83 + 10(3.30) \log \left(\frac{d_{1...N}}{d_{Ref}} \right) + 12.93 \text{ dB} \quad (28)$$

J. Optimization Technique

PSO algorithm is a population based optimization method for solution of non-linear problems [21]. This is a global optimization algorithm relevant to the social behavior of organisms such as swarm birds within a flock, schools of fish and flying particles in space. The particles shift its position and velocity according to the best previous experience in order to reach the best possible solution. The solution reached by each particle is called personal or local best ($P_{x_{best}}$). The final best solution obtained among all swarm of particle in the search space is called global best ($P_{g_{best}}$). In the iteration stage, each particle in search space updates its velocity and position using (29) and (30).

Velocity of the particle is given by [21] as;

$$v_i^{(j+1)} = v_i^{(j)} + c_1 \cdot rand_{d1} [P_i^{(j)} - X_i^{(j)}] + c_2 \cdot rand_{d2} [P_g^{(j)} - X_i^{(j)}] \quad (29)$$

Position of individual particle is updated as follows:

$$X_i^{(j+1)} = X_i^{(j)} + v_i^{(j+1)} \Delta(t) \quad (30)$$

where

$v_i^{(j+1)}$ is the modified velocity of individual i at iteration $(j + 1)$,

$X_i^{(j+1)}$ is the modified position of swarm particle i at iteration $(j + 1)$,

$v_i^{(j)}$ is the initial velocity of particle

$X_i^{(j)}$ is initial position of particle

$P_i^{(j)}$ is the best individual particle position

$P_g^{(j)}$ is the global best swarm position

c_1 and c_2 are acceleration constant (cognitive and social coefficients), $c_1 = 1, c_2 = 4 - c_1$

$rand_{d1}$ and $rand_{d2}$ are random numbers between 0 and 1.

$\Delta(t)$ is time step, it is usually chosen as 1 sec

PSO Constriction Factor (PSOCF)

PSO with constriction factor (cf), provides a balance between global and local particle searches. It also maintains better stability and good convergence for optimization. In this, the velocity in (30) is changed as;

$$v_i^{(j+1)} = cf * v_i^{(j)} + c_1 \cdot rand_{d1} [P_i^{(j)} - X_i^{(j)}] + c_2 \cdot rand_{d2} [P_g^{(j)} - X_i^{(j)}] \quad (31)$$

$$\text{where, } cf = \frac{2}{|2 - k - \sqrt{k^2 - 4k}|}, k = c_1 + c_2$$

$$j = 1, 2, 3, 4 \dots \dots N - 1$$

The simulation of the existing models and modified model were carried out using MATLAB tools. The velocity and position of individual particles in the search space are updated using (31) and (30) to reach maximum iteration.

K. Performance analysis and validation of models

This section deals with the validation and performance analysis of existing and modified model. The performance metric such as RMSE and MAE are used to calculate the quantity of error between the received signal and the predicted value. The best fit model for loss prediction in Port Harcourt urban area will be decided using (32) and (33) given by [22], [23] as;

$$RMSE = \sqrt{\frac{1}{n} \sum_{i=1}^n (p_{mx} - p_{rx})^2} \quad (32)$$

$$MAE = \frac{1}{n} \sum_{i=1}^n \left| \frac{p_{mx} - p_{rx}}{p_{mx}} \right| \quad (33)$$

where, p_{mx} (dB) is the measured path loss, p_{rx} (dB) is the predicted propagation path loss and m is the number of data points. The RMSE and MAE analysis for PSO Optimized model, Modified model and existing models are presented in Table IV.

TABLE IV: PERFORMANCE ANALYSIS OF THE MODELS

Error Metrics	Okumura-Hata (dB)	COST-231 (dB)	Ericsson (dB)	Egli (dB)	ECC-33 (dB)	Modified (dB)	PSO-Optimized(dB)
MSE	3.84	9.11	35.43	97.87	196.40	3.57	3.030
MAE	0.00206	0.00488	0.0190	0.0524	0.1051	0.00191	0.00162

III. RESULTS AND DISCUSSION

The results obtained through the measured values from LTE base station in three different locations are presented in

Fig. 1 to 6. The path loss (dB) as contained in Table V are obtained every 100 m and plotted against distance (km).

TABLE V: SHOWS THE DISTANCE, MEASURED PATH LOSS, EMPIRICAL MODELS AND MODIFIED MODEL FOR PORT HARCOURT URBAN AREA

Distance (km)	Measured PL (dB)	Okumura-Hata (dB)	Cost231-Hata (dB)	Ericsson 999 (dB)	Egli model (dB)	ECC-33 (dB)	Modified model (dB)	PSO Optimized (dB)
0.1	96.83	100.28	102.79	135.45	190.1	296.84	109.76	109.27
0.2	127.5	110.76	116.22	144.59	202.14	305.82	119.69	119.16
0.3	120.4	116.88	122.35	149.93	209.19	311.08	120.51	119.97
0.4	118.7	121.23	126.69	153.73	214.18	314.8	121.63	121.09
0.5	128.9	124.6	130.06	156.67	218.06	317.69	123.83	123.28
0.6	127.6	127.35	132.82	159.07	221.23	320.06	125.44	124.88
0.7	130.4	129.68	135.15	161.1	223.91	322.05	126.65	126.09
0.8	126.3	131.7	137.16	162.86	226.23	323.78	128.56	127.99
0.9	120.3	133.48	138.94	164.42	228.27	325.31	131.25	130.67
1.0	130.3	135.07	140.54	165.8	230.1	326.67	132.76	132.17
1.1	122.7	136.51	141.98	167.06	231.76	327.91	134.13	133.53
1.2	144.1	137.83	143.29	168.21	233.27	329.04	135.37	134.77
1.3	123.7	139.03	144.5	169.26	234.66	330.07	136.52	135.91
1.4	129.7	140.15	145.62	170.24	235.95	331.03	137.58	136.97
1.5	120.7	141.2	146.66	171.15	237.15	331.93	138.57	137.95

Fig. 1 shows the plot of existing model with measured data and Fig. 2 and 3 illustrate a comparative plot of measured data, existing models data and modified model data. Fig. 4 shows the PSO optimized performance with the measured and existing models while Fig. 5 and 6 depict the plots of measured data, existing model, modified model and PSO Optimized model data. It can be observed from Fig. 1,3-6 that ECC-33, Egli, Ericsson models overestimates the propagation path loss values. At 0.1 km away from the LTE base station, the path loss values are 96.83 dB, 100.28 dB, 102.79 dB, 135.45 dB, 190.1 dB, 296.84 dB, 109.76 dB and 109.27 dB for Measured, Okumura-Hata, COST-231, Ericsson, Egli, Modified and PSO Optimized models respectively. At 1.5 km away the values obtained are 120.7 dB, 141.2 dB, 146.66 dB, 171.15 dB, 237.15 dB, 331.93 dB, 138.57 dB and 137.95 dB. Therefore, the results showed that the PSO Optimized model is the well suited model to be implemented for accurate prediction of mobile radio channel in the selected urban regions in Port Harcourt.

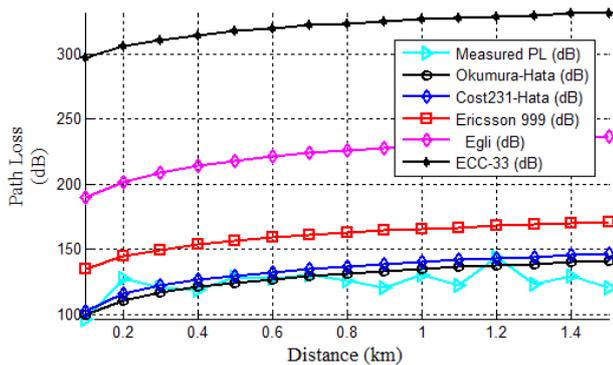


Fig. 1. Plot of existing models with the measured data

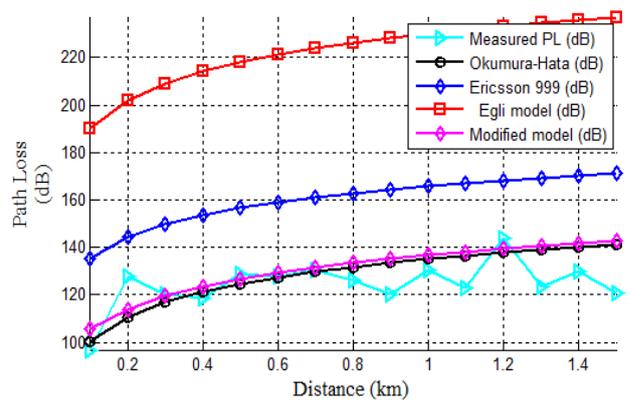


Fig. 2. Plot of existing models with measured data and modified model

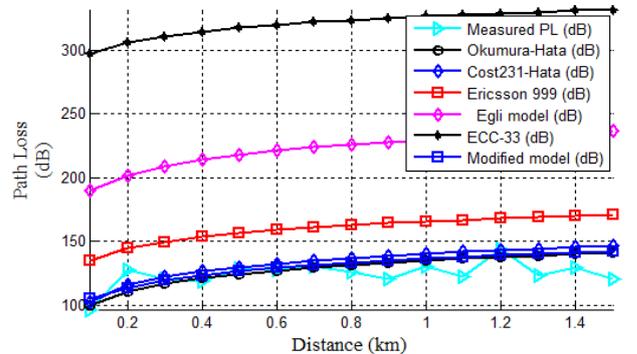


Fig. 3. Comparative plot of measured data, existing models and modified Model data

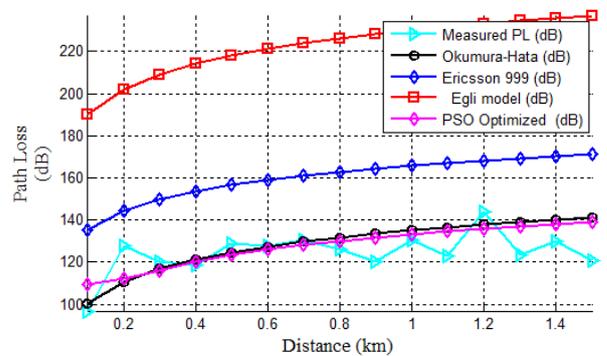


Fig. 4. Plot of PSO Optimized model with measured data and existing models

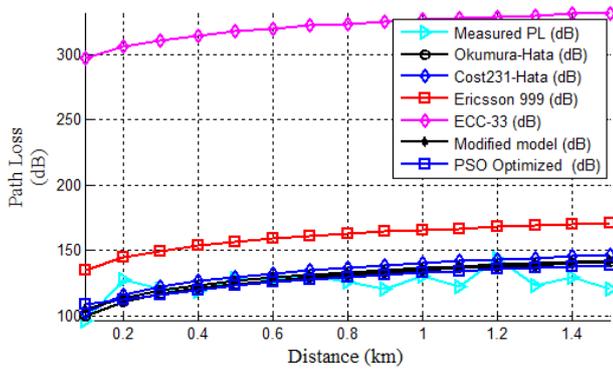


Fig. 5 Plot of PSO Optimized, modified models with measured and existing models

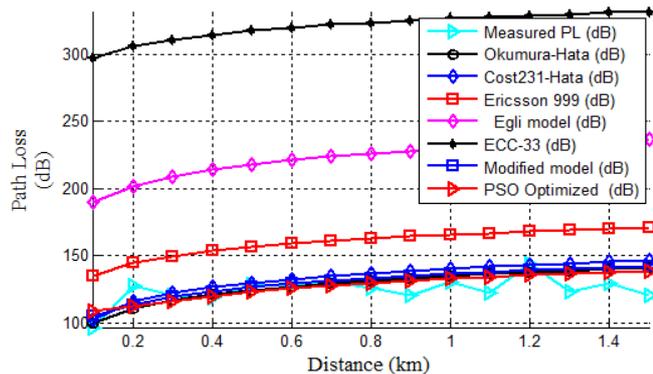


Fig. 6 Comparative plot of PSO Optimized with measured, Modified model and existing models

VI. CONCLUSION

In this paper, the RSS from the LTE base stations at three different cell sites up to a distance of 1.5 km were measured through drive test. The differences between the mean measured path loss values and modified model values were optimized using Particle Swarm Optimization Algorithm for suitability of the terrain. The results obtained showed through error metrics that PSO technique gave a better result compared to the modified model, Okimura-Hata model and other existing models for the LTE system at 2300 MHz. Hence, the PSO Optimized model could be suitably deployed for signal attenuation improvement for LTE network in Port Harcourt, South-South, Nigeria.

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