International Transaction of Electrical and Computer Engineers System, 2014, Vol. 2, No. 3, 81-87
Available online at http://pubs.sciepub.com/iteces/2/3/1

DOI:10.12691/iteces-2-3-1

Evaluation and Analysis of 3G Network in Lagos Metropolis, Nigeria

L.A Akinyemi[1], N.T Makanjuola[1], O.O Shoewu[1,*], F.O Edeko[2]

[1]Department of Electronic &Computer Engineering, Faculty of Engineering, Lagos State University, Epe Campus
[2]Department of Electrical and Electronic Engineering, Faculty of Engineering, University of Benin, Edo State
*Corresponding author: engrshoewu@yahoo.com

Received April 17, 2014; Revised April 21, 2014; Accepted April 28, 2014

Abstract This paper presents an evaluation and analysis of 3G network in metropolitan area in Lagos, Nigeria. It was carried out with the collection of data through drive testing of which five parameters were analysed which are Rscp (Received signal code power), Ec/No, SQI (Speech quality index), Tx power (Transmitting power) and path loss. In this paper, ten (10) different site locations were covered and analysed. It was deduced that the RSCP range of -60 to 0 (db) covers just 25% while the Ec/No range of -8 to 0 covers 23% of the total coverage area both of which fall below the 75% being stipulated by the Nigeria Communication Commission (NCC) of the total coverage area. The transmitting power is even worse with analysis showing the transmitting power of most of the base stations in the area with a very low value and likewise the Speech quality index. Two common path loss models COST 231 HATA and OKUMURA-HATA were used. More so, the COST 231 HATA model yielded the value for the path loss ranges from 84.50≤152.33 and that of Okumura ranges from 79.0000 ≤ 150.00 with distance from 200km to 1400km having an interval of 200km to another. However, of the two models, COST 231 HATA appears to be the most suitable for this area due to its better accuracy when both were compared with the measured values from the field. The Root Mean Square Error differences (RMSE) differences of the path loss models were calculated and compared with all the sites. Site Identification Number (ID) Ulag5130-Ulag3131 was considered to have the least error rate of 4.7018 and 7.9396 respectively. The analysis of the work obtained from this area can be used as a platform and benchmark to aid in the system optimization process for improved performance for service providers in other metropolitan areas in Nigeria.

Keywords: *Received Signal Code Power (RSCP), Ec/No, Transmit Power, Speech Quality Index (SQI), path loss, drive test, sites*

Cite This Article: L.A Akinyemi, N.T Makanjuola, O.O Shoewu, and F.O Edeko, "Evaluation and Analysis of 3G Network in Lagos Metropolis, Nigeria." *International Transaction of Electrical and Computer Engineers System*, vol. 2, no. 3 (2014): 81-87. doi: 10.12691/iteces-2-3-1.

1. Introduction

The last few years witnessed a phenomenal growth in the wireless industry, both in terms of mobile technology and its subscribers. There has been a clear shift from fixed to mobile cellular telephony, especially since the turn of the century [2].

By the end of 2010, there were over four times more mobile cellular subscriptions than fixed telephone lines. Both the mobile network operators and vendors have felt the importance of efficient networks with equally efficient design. This resulted in NetworkPlanning, analysis and optimization of related services coming in to sharp focus [8]. With all the technological advancement, and the simultaneous existence of 2G and 3G networks, the impact of services on network efficiency has become even more critical. Many more designing scenarios have rapidly developed with not only 2G networks but also with the evolution of 2G to 3G networks and now to 4G [2].

2. Investigated Area in the Study

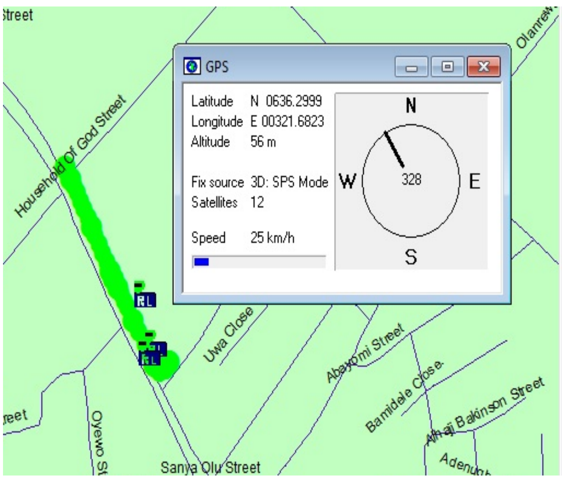

Figure 1. Longitude and latittude of covered area

In this metropolitan terrain, the Ikeja-Oregun-Ojota route was considered for this study. The reason is that Ikeja is the capital of Lagos city and happens to be a very busy and commercial nerve centre of the metropolis. Also the population of the area is more than half of the population of a defined metropolitan environment. It was also observed that out the over five million citizens in that area, about three million are mobile subscribers.

The figure above shows the GPS showing the latitude and longitudeof the area.

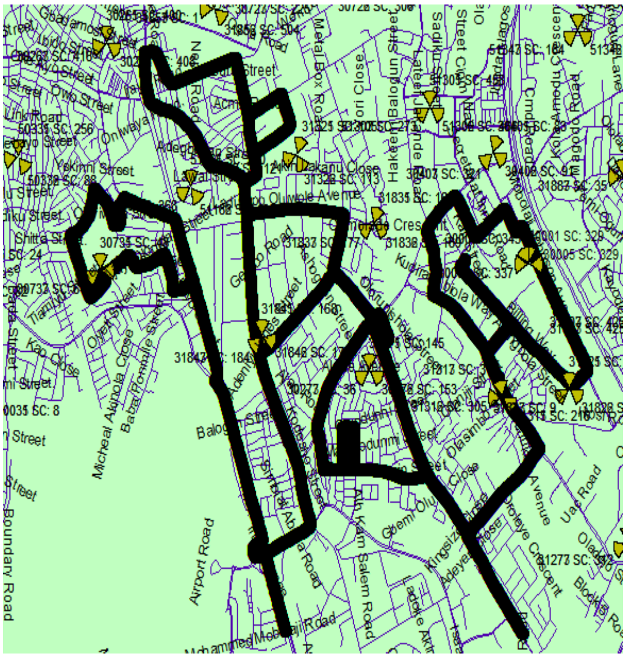

Figure 2. Export of ikeja-Oregun-Ojota area on TEMS

3. Measured Parameters in the Study

3.1. Received Signal Code Power (Rscp)

RSCP denotes the power measured by a receiver on a particular physical communication channel. It is usedas an indication of signal strength, as a handover criterion, in downlink power control, and to calculate the path loss.

3.2. Ec/No Service Quality

Technically Ec/No is usually used to measure equipment capability. In Universal Telecommunication Mobile system (UMTS), Ec/No and Ec/Io are often used interchangeably. This is the ratio of the received energy per chip (= Ec) and the interference level (Io), usually given in decibeld B [17].

3.3. Speech Quality Index (SQI)

SQI is a performance metric for voice quality in telecommunication. It is specific only to the TEMS family of drive testing/field testing tools.

SQI aims to provide a reasonable estimate of the voice quality, as perceived by a human ear.

3.4. Transmitting Power (Tx power)

This is the performance metric used to measure the transmitting ability of a base station.

3.5. Path Loss

The path loss is the difference (in dB) between the transmitted power and the received power. It represents signal level attenuation caused by free space propagation, reflection, diffraction and scattering. Total path loss increases only substantially and appreciably with an increase in path-length, foliage distance, and reduction in transmitted frequency [1]. Analyzing the relationship between the base station heights and the path loss exponents will add much value as the experimental data show better path loss exponent with higher base station heights [15].

4. Methodology

The method adopted for data collection in this paper isdrive testing usingthe well known software called theTEMS. The data collected were carefully and analyzed with TEMS 9.1 and MapInfo. The path loss was analysed with the use of MATLAB and proper suggestions and recommendations made for adequate optimization to be carried out in this area.

The tools that were used to carry out the drive test for the data collection for this paper include

- A Vehicle
- Global Positioning System
- Laptop
- Sony Ericsson TEMS pocket Mobile Phone
- Dongle
- Data Card
- Compass
- Inverter

a. Experimental Set Up of the Drive Test

All the components were connected appropriately to the laptop. The first tool to be connected to the laptop is the dongle which gives a license to the TEMS interface on the system. It should be noted that even though the TEMS interface can be opened without the dongle, a drive test cannot be carried outbecause the TEMS phone with which calls are made can never be viewed and accessed. The first step is to power ON the laptop after which the dongle will be connected to it through of one of the USB (Universal Serial Bus) ports. The next step is to connect the TEMS phone through the phone's USB cable and the GPS. The dongle allows accessibility to these two pieces of equipment. One of the good things about TEMS is the audio capability which helps to quickly detect any disconnected component. This is achieved with the encrypted voice in the TEMS which loudly says any of the components that has been disconnected. It should also be noted that the laptop is always connected to an inverter which provides constant electricity for the laptop in other to overcome the battery drainage due to the number of components being connected to the laptop. After the successful connection of these tools, the next step is to get into the car and begin the drive test.

The drive testing lasted for about one and a half hour of which a total of 10 sites were covered.

b. Algorithm of a Drive test.

Step I. Initial Drive test

Step II.Drive test analysis

Step III.Change proposal made

Step IV. Changes Implemented

StepV.Verification of changes implemented by carrying out another Drive test

Step VI. Do the analysis of the new drive test.

Step VII. Any positive change? If yes make a cluster report of the whole are /if no, go back to step III

Step VIII.Cluster report of the whole region.

Step IX. Move to next cluster area

The flowchart of the drivetest is shown below:-

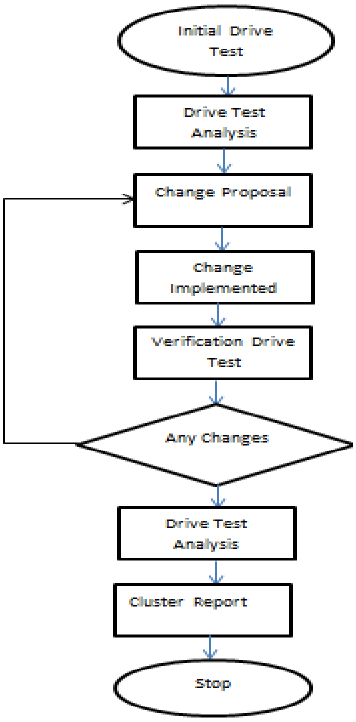

Figure 3. Flow chart of a drive test

5. Analysis of Results

Figure 1-Figure 14 shows the analyses of the stated parameters on MapInfo and TEMS respectively with Table 1-Table 4 showing the colour indications.

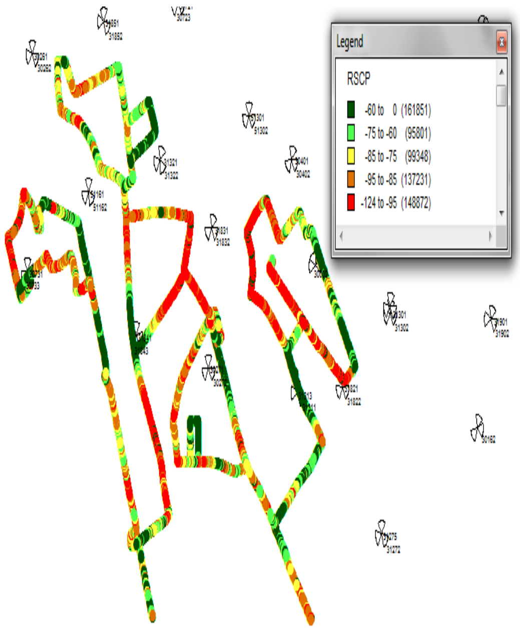

Figure 4. Analysis of RSCP on Mapinfo

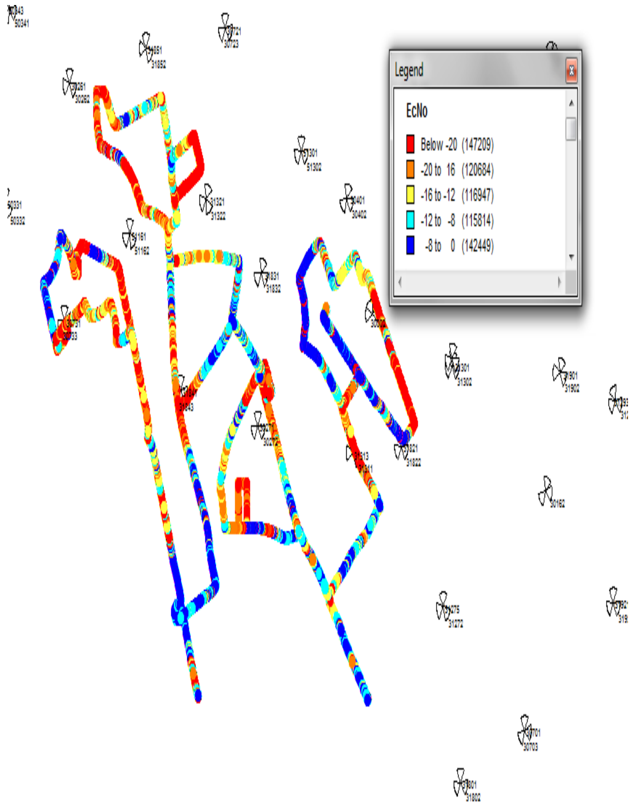

Figure 5. Analysis of Ec/No on Mapinfo

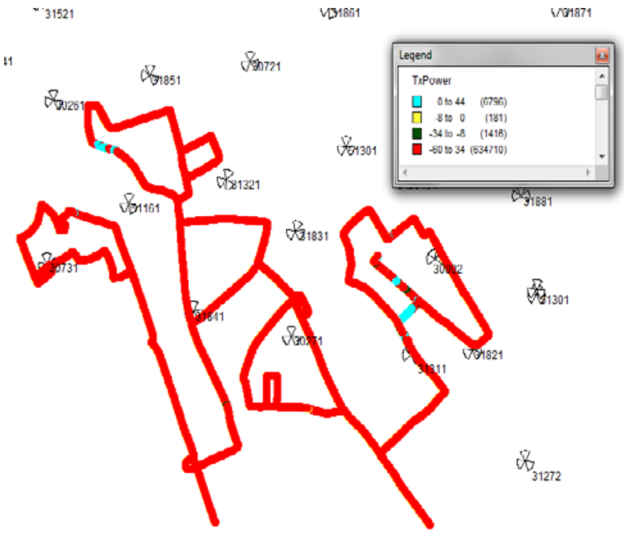

Figure 6. Analysis of Tx Power on Mapinfo

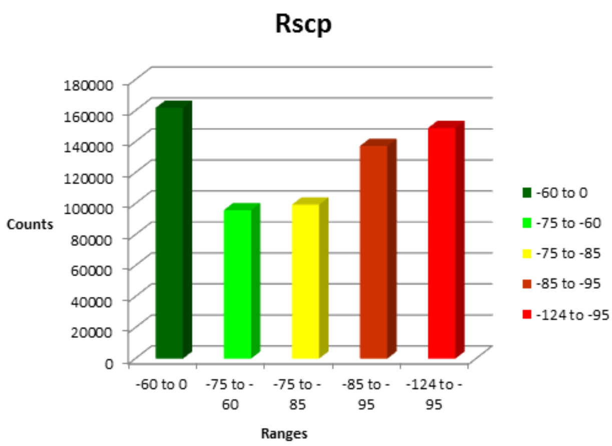

Figure 7. Bar chart depicting the ranges and counts of the RSCP level

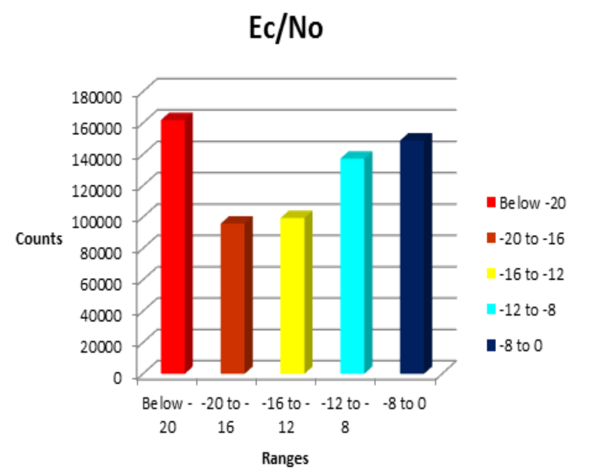

Figure 8. Bar chart depicting the ranges and counts of the Ec/No level

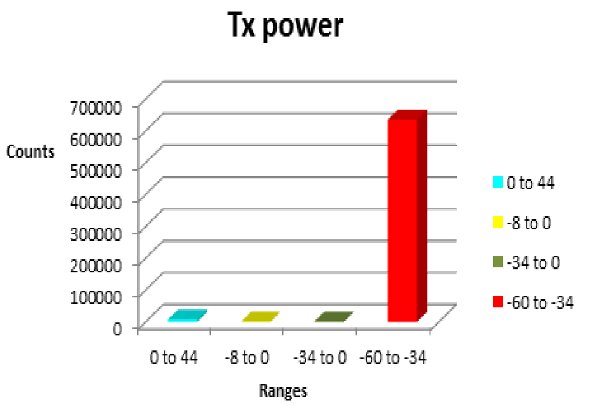

Figure 9. Bar chart depicting the ranges and counts of the Tx Power

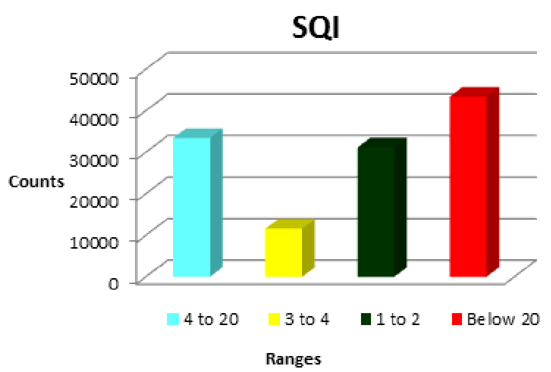

Figure 10. Bar chart depicting the ranges and counts of the SQI

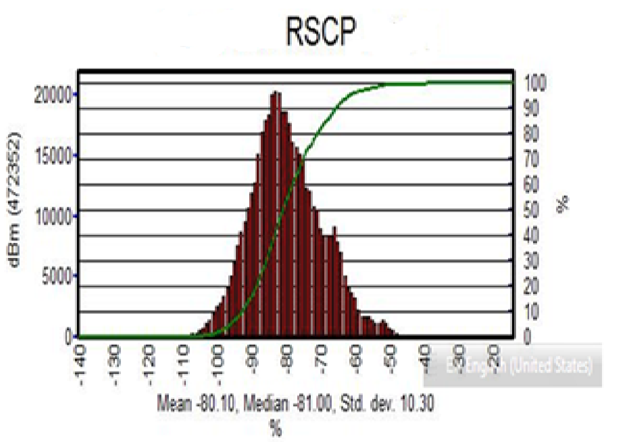

Figure 11. Graph depicting the mean, median and standard deviation of theRSCP

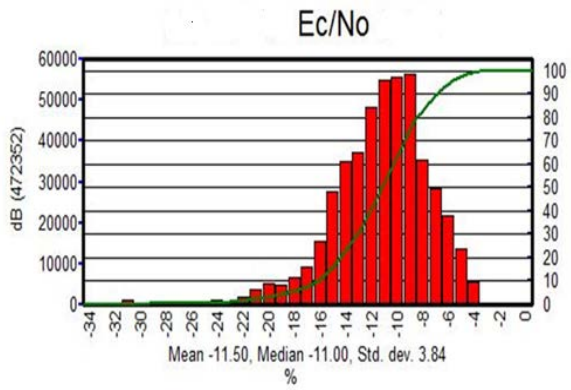

Figure 12. Graph depicting the mean, median and standard deviation of theEc/No

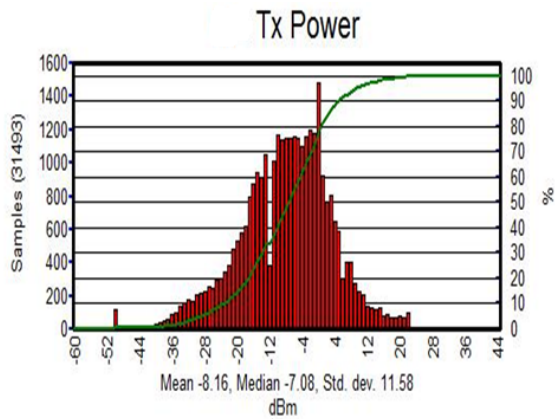

Figure 13. Graph depicting the mean, median and standard deviation of the Tx Power

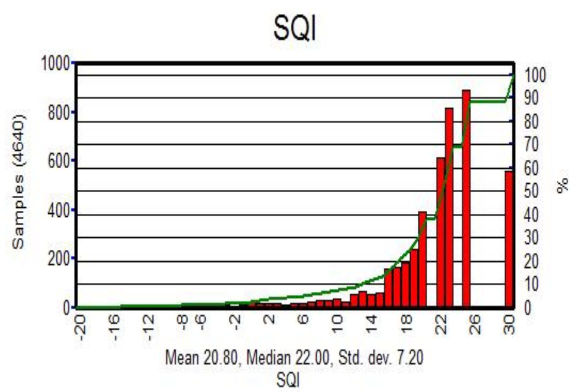

Figure 14. Graph depicting the mean, median and standard deviation of the SQI

5.1. Path Loss

The models used for the path loss were COST-231Hata and Okumura-Hata.

5.2. ICOST 231 HATA Model

$$
\begin{aligned}
L_P &= 46.3 + 33.9\mathrm{Log}10(f) - 13.82\log(hbs) \\
&- < 3.2(\log(11.75(hm))2 - 4.97 > \\
&+ 44.9 - 6.55\log(hbs)\ \mathrm{logd} + \mathrm{Cm}
\end{aligned}
\tag{1}
$$

Where

fc= carrier frequency
hm = height of the car
hbs = height of base station

d= distance between the site and mobile station
Cm= 0 dB medium sized cities and suburban areas
Cm= 3 dB metropolitan areas
fc =2100MHz
hm=1.7m
hbs=28m

$$L_P = 46.3 + 33.9\mathrm{Log}10(2100) - 13.82\log(28)[- < 3.2(\log(11.75(1.7))2 - 4.97 > + 44.9 - 6.55\mathrm{Log}28\log d \quad (2)$$

$$L_p = 46.3 + 112.62 - 19.22 - 0.55 - 44.9 - 9.48\log d \quad (3)$$

$$L_p = 142.26 + 35.42\log \quad (4)$$

5.3. IIOKUMURA-HATA Model

Okumura takes urban areas as a reference and applies correction factors

$$\text{Urban areas; } L_{dB} = A + B\log10 R - E \quad (5)$$

$$\text{Suburban areas: } L_{dB} = A + B\log10 R - C \quad (6)$$

$$\text{Open areas: } L_{dB} = A + B\log10 R - D \quad (7)$$

In this paper, the area of study is categorized under urban areas

$$A = 69.55 + 26.16\log10 fc - 13.82\log10\ hbs \quad (8)$$

$$B = 44.9 - 6.55\log10\ hbs \quad (9)$$

$$C = 2(\log10(28\ fc))2 + 5.4 \quad (10)$$

$$D = 4.78(\log10 fc)2 + 18.33\log10\ fc + 40.94 \quad (11)$$

$$E = 3.2(\log10(11.7554\ hm))2 - 4.97 \text{ for large cities, } fc \geq 300\text{MHz} \quad (12)$$

Where
fc= carrier frequency
hm = height of the car
hbs = height of base station
fc =2100MHz
hm=1.7m
hbs=28m

$$Ldp = 136.02 + 35.42\log R \quad (13)$$

Table 1. Colour and Signal Strength Indication of RSCP

Colour	Range	Signal Strength Indication	Counts
	-60 to 0	Very Good	161851
	-75 to -60	Good	95801
	-75 to -85	Fair	99348
	-85 to -95	Poor	137231
	-124 to -95	Very poor	148872

Table 2.Colour and Signal Strength Indication of Tx Power

Colour	Range	Signal Strength Indication	Counts
	0 to 40	Very Good	6756
	-8 to 0	Fair	181
	-34 to 0	Poor	1416
	-60 to -34	Very Poor	634710

Table 3. Colour and Signal Strength Indication of SQI

Colour	Range	Signal Strength Indication	Counts
	4 to 20	Very good	33471
	3 to 4	Fair	11622
	1 to 2	Poor	31219
	Below 20	Very poor	43410

Table 4. Colour and Signal Strength Indication of Ec/No

Colour	Range	Signal Strength Indication	Counts
	Below -20	Very poor	161851
	-20 to -16	Poor	95801
	-16 to -12	Fair	99348
	-12 to -8	Good	137231
	-8 to 0	Very Good	148872

Table 5. Comparison of measured and modeled pathloss values

Distance (km)	Cost-231 Hata model (db)	Okumura-Hata model (db)	3027-3024 at Ojota(db)	3130-3132 at Ojota(db)	5130-3131 at Ikeja(db)	3000-3183 at Ikeja(db)	3040-3142 at Oregun(db)
200	84.50	79.00	90.11	91.27	87.53	88.34	91.13
400	110.43	104.3	114.25	114.01	112.71	114.10	113.21
600	123.05	119.29	129.32	125.07	130.21	131.27	128.13
800	130.35	129.53	137.47	129.68	138.36	135.22	136.81
1000	142.20	137.47	144.11	146.33	145.92	144.16	144.11
1200	146.23	144.85	150.92	151.51	151.48	148.15	152.31
1400	152.33	150.00	158.81	159.43	158.08	160.04	157.14

6. Graphical Analysis of Results

MATLAB simulation software was used for the graphical analysis of the data tabulated above. The resulting graphs from the simulation are shown below

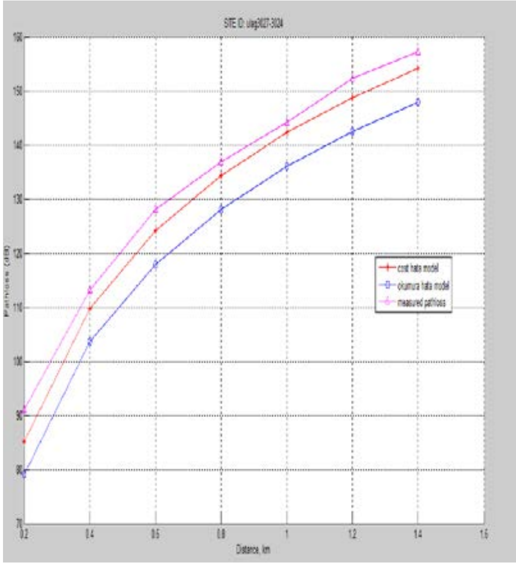

Figure 15. Comparison of measured and calculated pathloss values of site 3027-3024 at Ojota

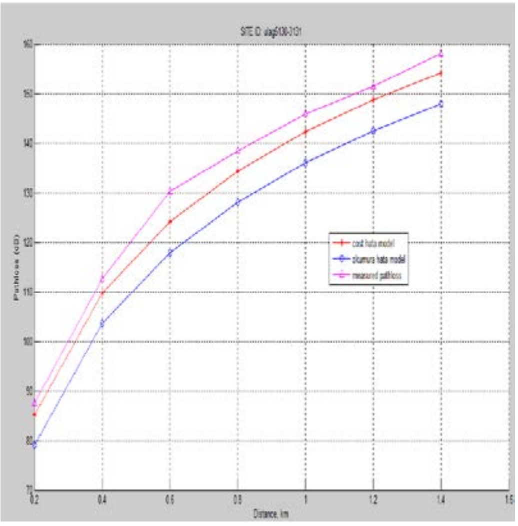

Figure 16. Comparison of measured and calculated pathloss values of site Sites 3130-3132 at Ojota

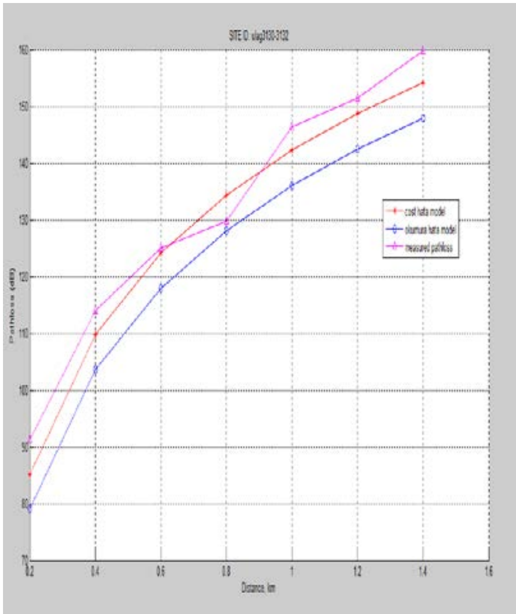

Figure 17. Comparison of measured and calculated values of site 5130-3131 at Ikeja

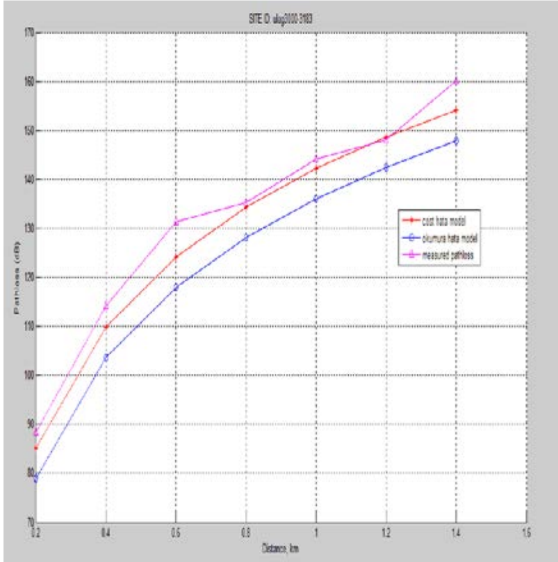

Figure 18. Comparison of measured and calculated pathloss values of site 3000-3183 at Ikeja

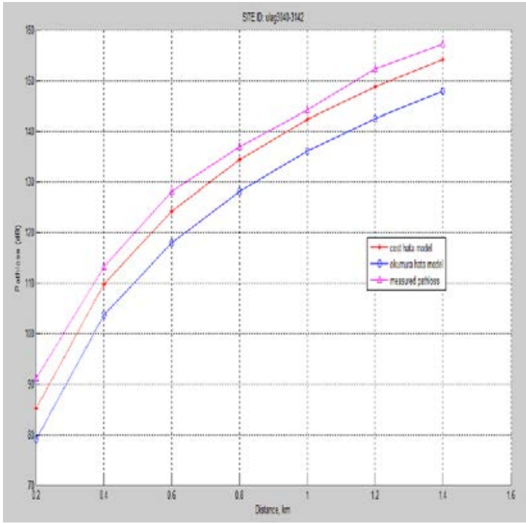

Figure 19. Comparison of measured and calculated values of site 3040-3142 at Oregun

7. Discussion of Results

The results from the analysis of the parameters that were analysed show the quality of service in Ikeja-Ojota-Oregun area is very bad. It can be deduced that the RSCP range of -60 to 0 (db) covers just 25% while the Ec/No range of -8 to 0 covers 23% of the total coverage area both of which fall below the 75% being stipulated by the Nigeria Communication Commission (NCC) of the total coverage area. The transmitting power is even worse with analysis showing the transmitting power of most of the base stations in the area with a very low value and likewise the Speech quality index. Figure 15 to 19 shows a comparison of the measured and modeled path loss with the Cost-231 Hata showing a better accuracy when compared with the measured values which makes it more suitable for areas like this.

8. Conclusion

The transmitting power of most of the parts of this area was very bad due to inefficient line of sites making call initiation somehow difficult resulting in blocked calls. The coverage of this area is bad due to poor RSCP which resulted in call drops during the drive test. The Nigeria Communication Commission (NCC) should take more strict measures against the service providers and make sure proper optimization is done regularly for good quality of service. New sites should be added to complement the existing ones in other to overcome the problem of congestion. We should consider the co-channel and adjacent-channel interference which may occur after the coverage is extended [12]. Up and down tilts of antennas should be made where necessary and changes of the azimuth of antennas should be done in other to avoid the direction of antenna facing to the road, so as to reduce the coverage radius.

References

[1] Akinyemi L.A.O and Shoewu O.O, Path loss Models for Vegetation Areas in Lagos Environs, April 4, 2013.

[2] Amit Kumar1, Dr. Yunfei Liu2, Dr. JyotsnaSengupta, Divya; Evolution of Mobile Wireless Communication Networks from 1G to 4G, December, 2010.

[3] Al-Imran AjayiOluwafemi Samuel “Evaluation of Video Quality of Service in 3G/UMTS Wireless Network, September, 2010.

[4] COST Action 231, “Digital mobile radio towards future generation system final report, “European communities, EURI8957, 1999.

[5] Joseph Isabona Real Time Monitoring ofService Quality of a DeployedUMTS Wireless Network in Campus Environment-an Optimization Perspective

[6] L.S. Ashiho mobile technology from 1G to 4G, June 2003.

[7] Mardeni, R. and Kwan, K.F Optimization of Hata Propagation Prediction Modeling Suburban Area in Malaysia, Progress in Electromagnetic Research, Vol. 13, 2010, pp91-106.

[8] Mishra, Ajay K. “Fundamentals of Cellular Network Planning and Optimization, 2G/2.5G/3G…Evolution of 4G”, John Wiley and Sons, 2004.

[9] N.T SurajudeenBakinde, N. Faruk, A. A. Ayeni, M. Y. Muhammad, M.I “Comparative analysis of radio propagation models for wideband code division multiple access (WCDMA) and global system for mobile communications (GSM)”.

[10] Patil C.S *(et al),*"Review on Generations in Mobile Cellular Technology”, October, 2012.

[11] SapnaShukla*(et al)*, “Comparative Study of 1G, 2G, 3G and 4G”,Journal of Engineering, Computers & Applied Sciences (JEC&AS) Volume 2, No.4, April 2013.

[12] SomerGoksel “Optimization and Log file Analysis in GSM” January26, 2003

[13] Sylvain Ranvier “Physical layer methods in wireless communication systems” 23 October 2004.

[14] TEMS investigation release notes, ASCOM, Document: NT11-21089, www.ascom.com/networktesting, 2011.

[15] Ubom, E.A., Idigo V.E, Azubogu A.C.O, Ohaneme C.O and Alumona T.L “Path loss Characterization of Wireless Propagation for Suburban Enviroment in Nigeria at 800MHz”.