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Propagation Model Optimization Based on Measurement from Macrocell Sites in Ikorodu-Epe, South-Western Nigeria

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Abstract **- To engage any nation in wealth creation, human capacity development and improved standard of living, the need arises to install trendy technological innovations and efficient infrastructures such as reliable and efficient telecommunication systems. This paper therefore, investigates large scale propagation models used to predict the mean signal strength for an arbitrary transmitter-receiver separation distance with the aim of improving the telecommunication system infrastructure which will engender sustainable infrastructure and technology. The study has been conducted in an urban settlement in the Ikorodu – Epe region to develop and optimize a suitable propagation model based on the existing propagation models. The proposed propagation models are the Free Space Path Loss Propagation Model, Okumura – Hata Model, COST 231 Model, SUI Model and Ericsson Model. The optimized COST 231 model showed better performance and is proposed for propagation prediction involving such terrain. Root Mean Square Error (RMSE) statistical tool was used to achieve the optimization.**

Keywords: Propagation; sustainable development; capacity development; wealth creation; infrastructure, path loss.

I. INTRODUCTION

A major determinant for sustainable development of any nation can be attributed to deliberate efforts in ensuring technology integration and infrastructural implementations. While national wealth follows directly a number of indicators such as economic metrics, standard of living of the populace, national policies across sectors, technology transfer and integration among others, connecting with global wealth can only become a reality by integrating national processes through the interconnecting strands of globalization resulting from the ever growing technological innovations of information communication technology.

To ensure sustainable development, nations must engage in maintaining and improving the existing infrastructural base while innovatively developing new and more efficient techniques in handling human activities. An easy approach to this will be capacity development which will lead to wealth transfer such as knowledge, technology, capacity, capability to mention a few.

As the population of any nation increases, the need for infrastructural expansion arises since the capability of existing infrastructure has no capacity to cater for the ever growing subscribers. This has a direct implication on the quality of service of subscriber dependent infrastructures like the wireless mobile communication systems. It has been asserted that high population growth has implication on the improvement of community infrastructural needs [1]. Although deficient and inefficient infrastructures have become the bane of developing nations, policies have been prepared despite the challenges of insufficiency and poor quality of service [2, 3, 4, 5]. Despite policy making, the continuous existence of a thing can only be traceable to its creation and continuous improvement else it goes extinct. Further to this, this work seeks an approach to improving the wireless mobile communication infrastructure.

The importance of mobile communication in nation building and sustainable development is not far-fetched as it interconnects all other strands of the society. It has provided the platform through which we execute business ideologies, transfer initiatives, engage wireless broadband activities, communicate and even globalize. The flip side to the enormous benefits provided by wireless mobile communication network is its prevalent poor quality of service, increasing number of dropped calls, blocked calls and even handover issues which can be attributed to poor planning and integration. To alleviate this challenge, path loss prediction is carried out to measure the signal strength with respect to the coverage distance so as to help develop an appropriate model for both planning and integration.

II. PROPAGATION MODELS

Propagation models are mathematical tools used for the planning, design and implementation of wireless mobile networks [6]. These models could be empirical; based on measured data or deterministic based on specified parameters of antenna height, transmitter-receiver distance etc, or stochastic based on a series of random variables [7, 8]. Some of the existing models which have been well validated are the free space path loss propagation model [9], Okumura-Hata model [10, 11], COST 231 model [12], Stanford University Interim model [6] and the Ericsson model [13]. While these models were built based on the characteristic of the terrain in which the signal strength was measured, prediction errors are inevitable when such models are used to predict the signal strength of a particular terrain with absolute diverse characteristics in comparison with the original terrain. To make these models suitable for other terrain, it is required that the models be optimized relative to the terrain of interest so as to better predict the signal strength which will engender efficient wireless mobile communication infrastructure.

III. RESULTS

Received signal strength was measured from the existing base stations around Ikorodu Epe and its Environs in Lagos state, south-western Nigeria using TEMS investigation tool [14]. Measured data was compared with existing models to investigate the model that predicts the signal strength with a fairly good approximation. The outcome of the existing models is shown in Fig. 1.

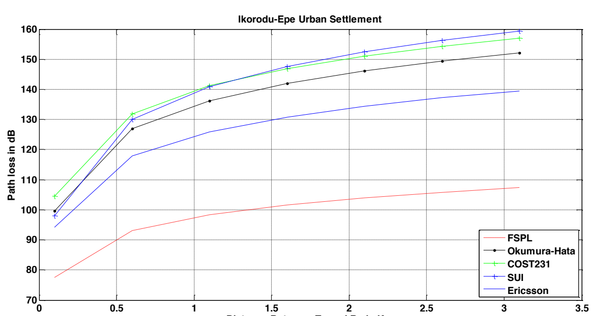

Fig.1 Comparison Existing Propagation Models

To obtain a better approximation, measured data is compared with the existing models as shown in Fig.2. It is observed that the COST 231 provides a better fit for the measured data.

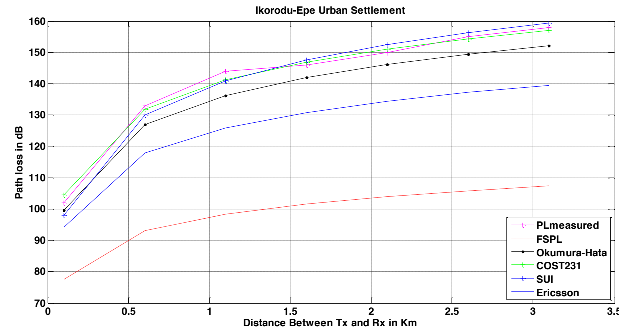

Fig. 2 Comparison of Measured data with Existing Models

Considering the error relative to the fitting, optimization of the COST 231 model will provide an absolute model for error-free prediction in the terrain. This will help in minimizing the number of dropped calls, blocked calls and even interference issues, thereby optimizing the network. This approach to sustainable technology will help in preserving the existing technological infrastructure while preparing it for future expansion, innovation and integration. Using the Root Mean Square Error (RMSE) statistical tool to optimize the COST 231 model, we have:

$$PL_{COST231(OPT)}(dB) = 46.3 + 33.9\, log10\,(f) - 13.82\, log10\,(ht) - a(hr) + [44.9 - 6.55\, log10\,(ht)]\, log10\,(d) + C + RMSE \quad (1)$$

By using a third degree polynomial for the curve fitting between the measured data and the COST 231 model, we have:

$$f(x) = p_1x^3 + p_2x^2 + p_3x + p_4$$

Coefficients (with 95% confidence bounds):

p_1 = 0.0002449 (-0.0006288, 0.001119)
p_2 = -0.1004 (-0.4473, 0.2466)
p_3 = 14.58 (-30.82, 59.98)
p_4 = -604.9 (-2558, 1349)
(2)

Considering a 95% confidence bound relative to the curve fitting, the resulting outcome of the optimized COST 231 is shown in Fig. 3

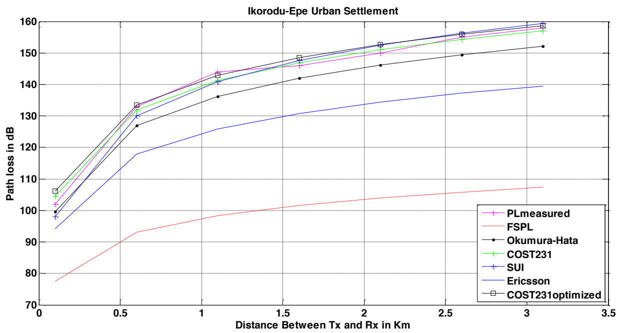

Fig. 3 Comparison of Measured data with Optimized COST 231 Model and other existing models

$$f(x) = p_1x^3 + p_2x^2 + p_3x + p_4$$

Coefficients (with 98% confidence bounds):

p_1 = 0.0002449 (-0.0006288, 0.001119)
p_2 = -0.1006 (-0.4484, 0.2472)
p_3 = 14.64 (-30.97, 60.25)
p_4 = -609.3 (-2576, 1358) (3)

Further to the application of the RMSE statistical tool, using the third degree polynomial for curve fitting between the measured data and the optimized COST 231 model, the confidence level of the curve fitting increased from 95% to 98% as given by Eq. 3 which is a clear indication of the impact of the optimized COST 231 model.

I. CONCLUSION

This paper presents a modified propagation model for the prediction of radio frequency signals using root mean square error statistical tool. The optimized COST 231 model can be used for the planning, design and optimization of the existing and intending mobile infrastructure which will improve the quality of service of the wireless mobile network infrastructure. This will reduce the possibilities of dropped calls, blocked calls, missing neighbors, update failures, handover and interference issues. The improvement in quality of service that will arise from the use of this model will engender sustainable development. Since the telecommunication infrastructure acts as a central hub interconnecting all other strata of the nation's organisms, its proper functioning will reduce down-time at all levels of transactions over the mobile network which will definitely improve return on investments.

REFERENCES

[1] Citra Persada1 Santun R.P. Sitorus2 Marimin2 dan Ruchyat Deni Djakapermana, "Determination Sustainability Status in Urban Infrastructure and Policy Recommendation for Development Case Study: Bandarlampung City, Indonesia," Civil and Environmental Research, Vol.6, No.12, 2014, Pp. 49-61

[2] Morrissey J, Iyer-Raniga U, McLaughlin P, Mills A., "*A Strategic Project Appraisal Framework for Ecological Sustainable City Infrastructure," Environmental* Impact Assessment Review 33: 55-65, 2012

[3] Pandit A, Jeong H, Crittenden J C, Xu M, "*An Infrastructure Ecology Approach for City Infrastructure Sustainability and Resiliency*," IEEE/PES Power System Conference and Exposition, PSCE. Phoenix, AZ (US), 2011.

[4] Miharja M, "Institutional Approaches in Transportation Planning-Metropolitan Land Use," Paper presented at the Sustainable Transportation Seminar, Bandung, 2007.

[5] Marvin, S. and Slater, S, "*City Infrastructure: The Contemporary Conflict between Roads and Utilities*," Progress in Planning, 1997, Pp.247-313.

[6] Abhayawardhana V S, Wassel I J, Crosby D, Sellers M P, Brown M G, "Comparison of Empirical Propagation Path Loss Models for Fixed Wirelwss Access Systems," 61st IEEE Technology Conference, Stockholm, 2005, Pp. 73 – 77.

[7] Alatishe Adeyemi, Adu Oluwadamilola, Atayero Aderemi, Idachaba Francis, "A Performance Review of the Different Path Loss Models for LTE Network Planning," Proceedings of the World Congress on Engineering, Vol 1, 2014.

[8] Ajose S O, Imoize A L, "Propagation measurements and modelling at 1800MHz in Lagos Nigeria," International Journal of Wireless and Mobile Computing, Vol. 6, No. 2, Pp. 165-174

[9] Rappaport T S, "Wireless Communication: Principles and Practice," 2nd Edition, Prentice Hall Communications Engineering and Emerging Technologies series, Upper Saddle River, New Jersy, USA, 2002.

[10]Okumura Y, "Field Strength and its Variability in VHF and UHF Land – Mobile Radio services," Review of Electrical Laboratory, Vol. 16, 1968

[11] Hata M, "Empirical Formula for Propagation Loss in Land Mobile Radio Services," IEEE Transactions on Vehicular Technology, Vol. VT-29, No.3, 1980, Pp. 317-325

[12] Simon R. Saunders, Alejandro Aragon Zavala, "Antenna and Propagation for Wireless Communication Systems," Second Edition, John Wiley & Sons Ltd, 2007, pp. 1 – 4

[13] Josip Milanovic, Rimac – Drlje S, Bejuk K, "Comparison of Propagation Model Accuracy for WiMax on 3.5GHz," 14th IEEE International Conference on Electronic Circuits and Systems, Morocco, 2007, Pp. 111 – 114.

[14] S. O. Ajose, A. E. Ibhaze, "Improvement of GSM Coverage using Microcell," IJEER, Research India Publication, Vol.4, No.3, 2012, Pp 233 - 244