Analysis and Modeling of Prediction Model in Heterogeneous Environment

Mr. Prashant M. Goad
M.Tech. (Microwave and Millimeter Engineering.)
R.C.Patel Institute of Tech.
Shirpur (M.S.)

Mr. Amit R.Mahire
M.Tech. (Digital Comm.) (Appeared)
R.C.Patel Institute of Tech.
Shirpur (M.S.)

Mr. Kiran H.Sonawane
M.E (Electronics)
R.C.Patel Institute of Tech.
Shirpur (M.S.)

Abstract

Propagation-loss-prediction models play very vital roles in the characterization and design of precise cellular mobile radio communication systems for their specific technical parameters such as transmission power and frequency reuse. This project presents a comprehensive review of the Okumura and Hata propagation-loss-prediction models for heterogeneous terrestrial wireless communication environments. We will conclude by testing the difference in the path loss between predicting values to improve the systems. Our numerical results prove that there occur similar changes with different frequencies for different distances under identical conditions. The power losses are calculated for various wireless parametric combinations such as the operating frequencies from 150 MHz–1.9 GHz, and the distances between transceivers from 50–200m. Other specific parametric combinations such as the electrical-physical-geographical factors, like different height for transceivers and the operating (suburban or urban) zone related issues are also considered. We analyze all the design features, modeling factors and application-issues of the Okumura and Hata models separately keeping the standard assumptions unchanged. Our simulation results show that these models are effectively applicable for efficient systems in the Indian wireless environments.

1. Introduction

1.1OkumuraModel

There have been many studies of radio wave propagation losses in the urban environment, dating back to 1935,but this project will focus on the widely accepted work of Yoshihisa Okumura. In 1968, Yoshihisa Okumura conducted thorough testing of radio wave propagation between base stations and mobile stations in and around Tokyo, Japan. Many tests were conducted with signals transmitted in scenarios with varying urban geometry [1].Measurements were made using frequencies of 150, 500, 900, 1300 & 1920MHz.For each frequency tested ,measured field strength values were plotted along path distances with varying conditions. Okumura and his colleagues developed a series of curves to fit this plotted data, representing the median attenuation extended along the transmission path as a function of frequency. Okumura developed a set of curve giving a attenuation relative to free space A_{MU}, in a urban area over a quasi smooth terrain with a base station effective antenna height h_{te} of 200m and a mobile antenna height of 3m. These curve were developed from extensive measurement using vertical omnidirectional antenna at both the base and mobile and are plotted a function of frequency in the range of 100MHz to1920MHz and a function of distance from the base station in the range 1Km. To determine the path loss using okumura model, the free space path loss between the points of interest is first determined and then the value of A_{MU} is added to it along with correction factors to account for the type of terrain. Other correction may also be applied to Okumura model [2].

Some important rough type land related parameter like it's without modulating height (Δh), its single height then its average slope of the rough type land. Once the important rough type land related parameter is calculated, the necessary factor can be added or subtracted as required. These entire correction factors are also available as Okumura curve. [3]

$$L_{50}(db) = L_f + A_{mu} - G_{H_{te}} - G_{H_{re}} - G_{area}$$

$$\begin{aligned}\text{FSPL(dB)} &= 10\log_{10}\left(\left(\frac{4\pi}{c}df\right)^2\right)\\ &= 20\log_{10}\left(\frac{4\pi}{c}df\right)\\ &= 20\log_{10}(d)+20\log_{10}(f)+20\log_{10}\left(\frac{4\pi}{c}\right)\\ &= 20\log_{10}(d)+20\log_{10}(f)-147.55\end{aligned}$$

$$G_{H_{te}} = 20\times\log_{10}\left(\frac{H_{te}}{200}\right)$$

$$G_{H_{re}} = 10\times\log_{10}\left(\frac{H_{re}}{3}\right)$$

Here, $L_{50}(db)$ is the 50 percent value of propagation path loss

L_f is propagation loss for open space

A_{mu} is the median attenuation for free space

$G_{H_{te}}$ gain factor of base station antenna height

$G_{H_{re}}$ gain factor of mobile antenna height

G_{area} is gain due to the type of environment.

1.2 Hata Model for Urban Area

The Hata Model for Urban Areas is the original Hata Model. Generally assume that transmission does in urban media and due to that H_{re} correction factor is based on the area covered by particular city & the frequency to be transmitted. Because the calculated losses from the Hata model begin to deviate from the Okumura curves beyond certain limits, the parameter ranges that ensure accuracy are a frequency between 150 and 1500 megahertz, a base station antenna height between 30 and 200 meters, a mobile station antenna height between 1 and 10 meters and a transmission distance between 1 and 20 kilometers.

$$L_{p(urban)} = 69.55+26.16\log(f)-13.82\log(h_b)-a(h_m)+(44.9-6.55\log(h_b))\log(d)$$

Where,

$$a(h_m) = (1.11\log(f)-0.7)h_m-(1.56\ \log(f)-0.8)$$

$L_{p(urban)}$ =Path loss in Urban Area (db)

f =Frequency of transmission (MHz)

h_b =Height of Base station antenna (m)

h_m = Height of Mobile station antenna (m)

d=Distance between the Base Station and Mobile Station (km) [1].

1.3 Hata Model for Open Areas

Just as the name implies, the Hata Model for open areas is the most widely accepted propagation model used to calculated transmission losses in an open area. Although the definition of an open area is vague, during his studies in the late 1960s, Okumura defined an open area as one that is clear for a radius of 300 to 400 meters from the mobile antenna stations. The Hata model for open areas is a function of the Hata model for urban plus a series of correction factors that reduce the loss based on logarithmic degree of the transmission frequency. And a constant which will always result in the open area loss being at least 40 dB less than the calculated urban area loss. A quick qualitative check would suggest that this equation is generally correct based on the fact that a much greater loss would be expected in an urban environment with buildings in the transmission path than a signal propagating through an open area [3].

$$L_{p(open)} = L_{p(urban)}-4.78\{\log(f)\}^2+18.33\log(f)-40.94$$

Where,

$$L_{p(urban)} = 69.55+26.16\log(f)-13.82\log(h_b)-a(h_m)+(44.9-6.55\log(h_b))\log(d)$$

$$a(h_m) = (1.11\log(f)-0.7)h_m-(1.56\ \log(f)-0.8)$$

$L_{p(urban)}$ =Path loss in Urban Area (db)

f =Frequency of transmission (MHz)

h_b =Height of Base station antenna (m)

h_m = Height of Mobile station antenna (m)

d=Distance between the Base Station and Mobile Station (km).

1.4 Hata Model for Suburban Area

Just like the Hata model for open areas, the Hata model for suburban areas is a derivative of the urban Hata model. here the quantitative limits of a suburban area it seems to be recognized as a developed area outside the taller, denser concentration of structures in a bigger city. The suburban Hata Model is a function of the urban Hata model plus a correction factor that reduces the degree of loss based on a logarithmic factor of frequency plus a constant applied to the open area model. The limitation of input parameter for the suburban area model is the same as urban Hata model [3].

$$L_{p(suburban)} = L_{p(urban)}-2\{\log(f/28)\}^2-5.4$$

Where,

$$L_{p(urban)} = 69.55 + 26.16\log(f) - 13.82\log(h_b) - a(h_m) + (44.9 - 6.55\log(h_b))\log(d)$$

$L_{p(urban)}$ =Path loss in Urban Area (db)
f =Frequency of transmission (MHz)
h_b =Height of Base station antenna (m)
h_m = Height of Mobile station antenna (m) d=Distance between the Base Station and Mobile Station (km).

2 RESULT

2.1 Okumura Suburban Area

We analyzed for 50m distance attenuation in L50 (db) -52.7546db and for 100 m distance attenuation in L50(db)- 38.8916db.so that is 50m increase in distance, Loss is increases also with shown measurements. [5] Also different reading of attenuation according to the distance and frequency.

2.2 Okumura Urban Area

As seen earlier that suburban area now in urban area it has also 50m 150MHz attenuation -58.75db, 100m 150MHz attenuation -44.89db .So from that specify that as increase in distance in urban area also increase attenuation. For the distance 50m and 500 MHz frequency attenuation calculated -82.83 db in urban environment. Also at the 100m distance attenuation taken -68.971

All parameter value shows its own attenuation value in urban environment.

2.3 Okumura Open Area

Generally, okumura model is not more useful in the radio propagation loss measurement because it's not appropriate value of the measurement. For the distance 50m and 150 MHz frequency, attenuation calculated -63.754db in open environment. Also at the 100m distance, 150 MHz frequency attenuation calculated -49.8911 db in open environment. Similarly, for the distance 50m and 500 MHz frequency attenuation calculated -87.831db in suburban environment.

2.4 Hata Urban Area

As seen from the okumura model new advance model i.e. Hata model introduce in the prediction propagation loss take place. And for that measurement below given data shows for the Urban, Suburban and open area has given concern measurement with the different equation for the environment [4].

2.5 Simulation Results:-

2.5.1 Okumura Model Output

Figure shows Distance vs. L50 Attenuation for Open Area (Ghte > Ghre), Here different color line shows the particular frequency, e.g. red line shows the 150 MHz frequency, similarly green line shows the 500 MHz frequency, so on [6].

Fig.1. Distance vs. L50 Attenuation for Open Area (Ghte>Ghre)

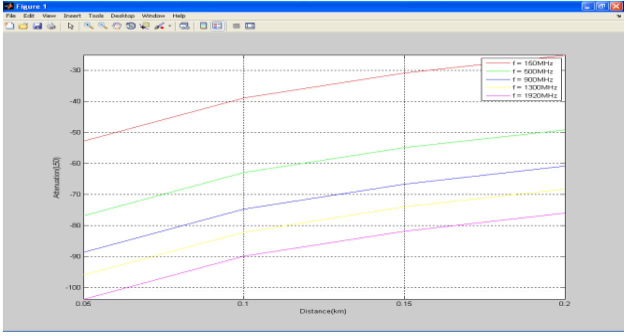


Fig.2.Distance vs. L50 Attenuation for Suburban Area (Ghte>Ghre)

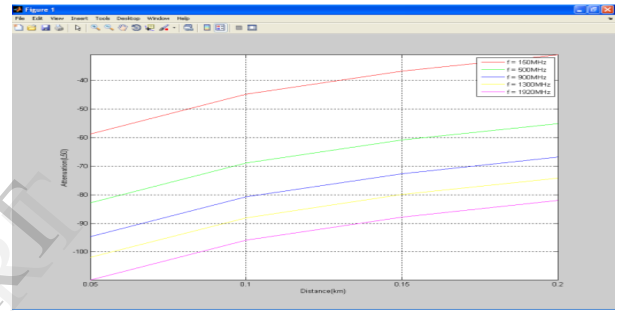


Fig.3.Distance vs. L50 Attenuation for Urban Area (Ghte>Ghre)

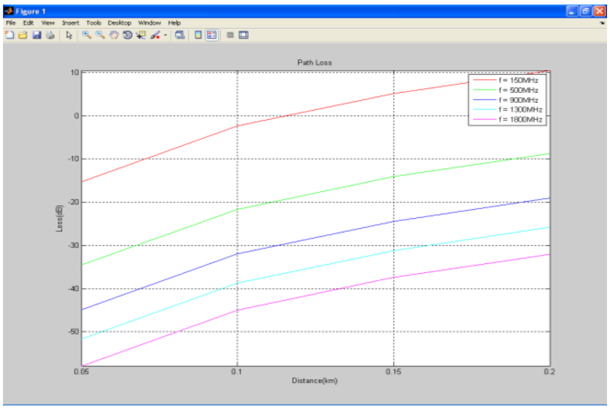
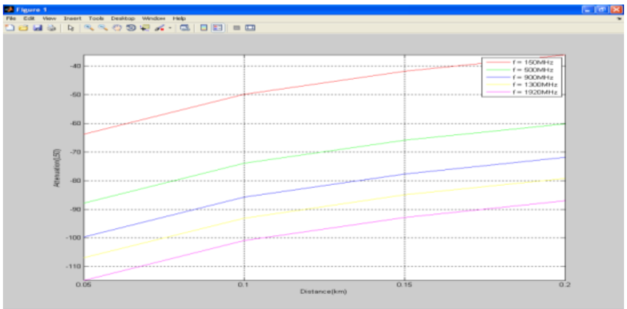


Fig.4.Distance vs. L50 Attenuation for Open Area (Ghte >Ghre)



Conclusion

Propagation path loss is a significant concern when designing or attempting to improve wireless networks. When planning such a system, it is crucial that the communications engineer fully understand the potential losses that exist because these losses will affect the required transmission power, receiver sensitivity, equipment performance and placement of that equipment. Predicting these losses ahead of time could save a great deal of time and money when setting up a cellular type network in an urban environment. Having a general idea of the power and equipment required in a friendly environment can be very beneficial but can also be verified with actual transmission tests before the system is hard wired and required for use. Operators in hostile environments are not afforded the luxury of having access to the environment ahead of time for test or even knowing the exact parameters of the environment that they will be operating in, which makes the estimation of radio wave propagation loss based on minimal input parameters essential to successful military communication operations.

References

1] Y. Okumura E.Ohmori, T. Kauano. and K. Fukud,a “Field Strength and Its Variability in VHF and UHF Land- Mobile Radio Service”, Review of the Electrical Communications Laboratory, Vol. 16, No.9-10. Sept.-Oct. 1968.

2] A. Medeisis and A. Kajackas, “On the Use of the Universal Okumura-Hata Propagaton Prediction Model in rural Areas,” Vehicular Technology Conference roceedings,VTC Tokyo,vol.3,pp.1815-1818,May 2000.

3] Nazar. Elfadhil, M.A. salam, “Modification of an open area Okumura-Hata Propagation Model Suitable For Oman”,IEEE-TENCON ,2005 ,Australia.

4] Keith Allsebrook And J. David Parsons, “Mobile Radio Propagation in British Cities at Frequencies in the VHF and UHF Bands”,IEEE Transaction on Vehicular Techanology,Vol VT-26,No-4.

5] Z.Nadir,“Pathloss Determination Using Okumura-Hata Model and Spline Interpolation For Missing Data for Oman.” Proceding of the world congress on Engi WEC 2008, July 2-4, 2008, London, U.K.

6] A.M.D. Turkrnani A.F. de Toledo,“Modelling of radio transmissions into and Within Multistorey building at 900, 1800 and 2300 MHz” IEEE Proceeding-I,Vol140,No-6.