International Journal For Technological Research In Engineering
Volume 2, Issue 7, March-2015 *ISSN (Online): 2347 - 4718*

A SURVEY ON INTERFERENCE FREE ALLOCATION OF SPECTRUM FOR MILITARY APPLICATIONS USING PROPAGATION MODELS FOR LTE

Priyanka N[1], Prasad S N[2]
Reva Institution of Technology and Management, Bangalore, India

Abstract: Military missions of the last 20 years appeared as a great experience in the area of simultaneous exploitation of huge number of wireless networks in small area. Such situations abounded with collisions of this system creating serious danger for own combat units. The problem of spectrum consumption using more effective spectrum management methods is treated as major problem which demands an urgent solution. Radio Propagation model is intended for knowing cell radius which is a very important factor during planning phase of network deployment. In this paper we would like to implement the various propagation models for LTE using Matlab for various regions such as urban suburban terrain and rural where we would avoid path loss for the signals transmitted in the required spectrum using military networks.

Key Terms: Long Term Evolution, Standard Propagation Model, Stanford University Interim Radio Propagation Model

I. INTRODUCTION

LTE stands for Long Term Evolution and it was started as a project in 2004 by telecommunication body known as the Third Generation Partnership Project (3GPP).LTE evolved from an earlier 3GPP system known as the Universal Mobile Telecommunication System (UMTS), which in turn evolved from the Global System for Mobile Communications (GSM).LTE is a standard for wireless data communications technology and a development of the GSM/UMTS standards. The goal of LTE was to increase the capacity and speed of wireless data networks using new DSP (digital signal processing) techniques and modulations that were developed around the turn of the millennium. A further goal was the redesign and simplification of the network architecture to and IP-based system with significantly reduced transfer latency compared to the 3G architecture. The LTE wireless interface is incompatible with 2G and 3G networks, so that it must be operated on a separate wireless spectrum. Path loss is a major component in the analysis and design of the link budget of a telecommunication system. It is the attenuation undergone by an electromagnetic wave in transit between a transmitter and a receiver in a communication system. Path loss may be due to many effects, such as free-space loss, refraction, diffraction, reflection, aperture-medium coupling loss, and absorption. Path loss is also influenced by terrain contours, environment (urban or rural, vegetation and foliage), propagation medium (dry or moist air), the distance between the transmitter and the receiver, and the height and location of antennas. There are several path loss models, prominent of which are reviewed below.

II. RELATED WORK

A. LEE MODEL

The Lee model for point-to-point mode is a radio propagation model that operates around 900 MHz built as two different modes, this model includes an adjustment factor that can be adjusted to make the model more flexible to different regions of propagation. This model is suitable for using in data collected in a specific area for point-to-point links. The Lee model for point to point mode is formally expressed as:

L = L0 + ɣ g log d -10(log FA – 2log (H30ET))

Where,

L = the median path loss. Unit: decibel (dB)

L0 = the reference path loss along 1 km. Unit: decibel (dB)

γ = the slope of the path loss curve. Unit: decibels per decade

d = the distance on which the path loss is to be calculated. Unit: kilometer (km)

FA = Adjustment factor.

HET = Effective height of terrain. Unit: meter (m)

The reference path loss is usually computed along a 1 km or 1 mi link. Any other suitable length of path can be chosen based on the applications.

L0 = GB + GM + 20(log ƛ – log d) – 22

where,

GB = Base station antenna gain. Unit: Decibel with respect to isotropic antenna (dBi)

ƛ= Wavelength. Unit: meter (m).

G_M = Mobile station antenna gain. Unit: decibel with respect to isotropic antenna (dBi).

B. HATA MODEL(URBAN)

In wireless communication, the Hata model for urban areas, also known as the *Okumura–Hata model* for being a developed version of the Okumura model, is the most widely used radio frequency propagation model for predicting the behavior of cellular transmissions in built up areas. This model incorporates the graphical information from Okumura model and develops it further to realize the effects of diffraction, reflection and scattering caused by city structures. This model also has two more varieties for transmission in suburban areas and open areas.

The Hata model for urban areas is formulated as following:

$L_U = 69.55 + 26016 \log_{10} f - 13.82 \log_{10} h_B - C_H + [44.9 - 6.55 \log_{10} h_B] \log_{10} d$

For small or medium sized city,
$C_H = 0.8 + (1.1 \log_{10} f - 0.7) h_M - 1.56 \log_{10} f$
and for large cities,
8.29 (10(1.54ℎ))2 − 1.1 , 150 ≤ ≤ 200 = {3.2 (10(11.75ℎ))2 − 4.97 , 200 < ≤ 1500
Where,
L_U = Path loss in urban areas. Unit: decibel (dB)
h_B = Height of base station antenna. Unit: meter (m)
h_M = Height of mobile station antenna. Unit: meter (m)
f = Frequency of transmission. Unit: Megahertz (MHz).
C_H = Antenna height correction factor
d = Distance between the base and mobile stations. Unit: kilometer (km).

HATA (OPEN AREA)
$L_O = L_U - 4.78(\log_{10} f)^2 + 18.33 \log_{10} f - 40.94$
Where,
L_O = Path loss in open area. Unit: decibel (dB) L_U = Path loss in urban areas for small sized city.
Unit: decibel (dB)
f = Frequency of transmission. Unit: Megahertz (MHz).

HATA (SUBURBAN)
Hata model for suburban areas is formulated as,

$$L_{SU} = L_U - 2(\log_{10} \frac{f}{28})^2 - 5.4$$

Where,
L_{SU} = Path loss in suburban areas.
Unit: decibel (dB)

III. OVERVIEW OF RADIO PROPAGATION MODELS

Radio planning tools have interfaces for external propagation prediction models, and a large number of different propagation models are commercially available. Radio planning tools also have internal propagation models. The internal models that are used in cellular network planning are typically based on the Okumura-Hata (O-H) formulas. For a given frequency band, the Okumura-Hata formulas are simple functions of distance, but the effect of the digital map is included by adding antenna height, diffraction and clutter corrections into the basic Okumura-Hata loss. The exact implementation of the antenna height, diffraction and clutter corrections as well as other possible adjustments varies from one planning tool to another. To find an accurate model for propagation losses is a leading issue when planning a mobile radio network. Two strategies for predicting propagation losses are in use these days: one is to derive an empirical propagation model from measurement data and the other is to use a deterministic propagation model.

A. Standard Propagation Model

Propagation models in Asset and Atoll are based on Okumura-Hata models which support frequencies higher than 1500 MHz. These models in Asset and Atoll are termed as standard propagation models. Standard Propagation Model (SPM) is based on empirical formulas and a set of parameters are set to their default values. However, they can be adjusted to tune the propagation model according to actual propagation conditions. SPM is based on the following formula
= 1+ 2 + 3)+ 4 ∗ + 5 (∗ + 6
For hilly terrain, the correction path loss when transmitter and receiver are in LOS is given by When transmitter and receiver are not in line of sight NLOS, the path loss formula is
Where, 1=frequency constant . 2 =Distance attenuation constant. d =distance between the receiver and transmitter (m). 3, 4 = Correction coefficient of height of mobile station antenna Diffraction loss: loss due to diffraction over an obstructed path (dB). 5, 6 = Correction coefficient of height of base station antenna. = correction coefficient of clutter attenuation, the signal strength of a given point is modified according to the clutter class at this point and is irrelevant to the clutter class in the transmission path. All losses in the transmission path are included in the median loss. hm , hb = effective height of antenna in mobile station and base station respectively, unit: m In radio transmissions, the value of K varies according to terrains, features and environment of cities. = height( ). f(clutter)= average of weighted losses due to clutter.

B. Stanford University Interim (SUI) Model

Stanford University Interim (SUI) model is developed for IEEE 802.16 by Stanford University[2]. It is used for frequencies above 1900MHz. In this propagation model, three different types of terrains or areas are considered(Table 2.2). These are called as terrain A, B and C. Terrain A represents an area with highest path loss; it can be a very dense populated region while terrain B represents an area with moderate path loss, a suburban environment. Terrain C has the least path loss which describes a rural or flat area.

Parameters	Terrain A	Terrain B	Terrain C
a	4.6	4	3.6
b (1/m)	0.0075	0.0065	0.005
c (m)	12.6	17.1	20

The path loss in SUI model can be described as PL= A+ 10 γ log (/) + + + ---------(4) where PL represents Path Loss in dBs, d is the distance between the transmitter and receiver, is the reference distance (Here its value is 100), is the frequency correction factor, is the Correction factor for Base station height, S is shadowing and γ is the path loss component and it is described as γ=a−bhb +chb -------------(5) Where hbis the height of the base station and a, b and c represent the terrain for which the values are selected from the above table. A=20 log4πdoλ -------------(6) Where A is the free space path loss while do is the distance between Tx and Rx and λ is the wavelength, The correction factor for frequency and base station height are as follows: ΔXf =6log f2000 , ΔX h= — 10.8 log hr2000--(7) & (8) Where f is the frequency in MHz, and hr is the height of the receiver antenna. This expression is used for terrain type A and B. For terrain C, the below expression is used. ΔXh= - 20 log (hr2000), S = 0.65(log f)2−1.3log f +α --------(9) & (10) Here α dB for rural and suburban environments(Terrain A & B) and 6.6 dB for urban environment (Terrain C).

C. Free Space Loss Model

In telecommunication, free-space path loss (FSPL) is the loss in signal strength of an electromagnetic wave that would result from a line-of-sight path through free space (usually air), with no obstacles nearby to cause reflection or diffraction. It does not include factors such as the gain of the antennas used at the transmitter and receiver, nor any loss associated with hardware imperfections. A discussion of these losses may be found in the article on link budget. Free-space path loss formula Free-space path loss is proportional to the square of the distance between the transmitter and receiver, and also proportional to the square of the frequency of the radio signal. The basic equation is

()=4 / 2 (11)

FSPL(dB)= 32.44+ 20 log 10(d) + 20 log10(f) (12)

Where f is the signal frequency (in megahertz), d is the distance from the transmitter (in km). This equation is only accurate in the far field where spherical spreading can be assumed. It does not hold good when receiver is close to the transmitter.

IV. LTE PATH LOSS MODELS

LTE Rel.10 [2] (LTE-Advanced) added newer low power Hotzone deployment options and introduced newer path loss models that are partially based on measurements conducted by China Mobile [5][6] and include a NLOS formula and LOS formula.

- Initially the two components were added together with a weight based on a probability function but later on changed to be treated separately.
- For consistency [6], the Macro model was changed to include a LOS model and the NLOS model was adjusted
- Hotzone Urban Model
  - $PL_{LOS}(d)=41.1+20.9\log10(d)$
  - $PL_{NLOS}(d)=32.9+37.5\log10(d)$
  - Prob(d)=0.5-min(0.5,5exp(-156/d))+min(0.5, 5exp(-d/30))
- Macro Urban Model
  - $PL_{LOS}(d)=30.8+24.2*\log10(d)$
  - $PL_{NLOS}(d)=2.7+42.8*\log10(d)$

Prob(d)=min(1,18/d)*(1-exp(-d/63))+exp(-d/63)

V. SUMMARY

The problem of spectrum consumption through using more effective spectrum management methods is treated as major problem which demands a urgent solution. These problems are given a solution by using few of the propagation models by calculating the path loss and finding out which model would be better preferred model for managing the spectrum. It has been observed in the past, as the number of users of commercial two-way radios has grown, channel spacing has been narrowed, and higher-frequency spectra have had to be allocated to accommodate the requirements. Narrower channel spacing and higher operating frequencies necessitate tighter frequency tolerance for both the transmitters and the receivers. The need to accommodate more users will continue to require higher and higher frequency accuracies. This management of spectrum saves huge amount to the government as the commercial spectrum are very costlier. This would be proved in our future works

REFERENCES

[1] 3GPP TR 25.814 - Physical layer aspects for evolved Universal Terrestrial Radio Access (UTRA) – Annex A.2 system simulation scenario
[2] 3GPP TR 36.814 - Further advancements for E-UTRA physical layer aspects, Annex A.2- system simulation scenario
[3] Neskovic .A(2000); Modern Approaches in Modeling of Mobile Radio Systems Propagation Environment; IEEE Communiation Surveys.
[4] Lee, W. C. Y(1998): *Mobile Communications Engineering: Theory and Applications*, McGraw-Hill, 1998.
[5] Okumura, Y. a kol, ―Field Strength and its Variability in VHF and UHF Land-Mobile Radio Service‖, Rev. Elec. Comm. Lab, No.9-10, pp. 825 - 873, 1968.
[6] Hata, M, ―Empirical Formula for Propagation Loss in Land Mobile Radio Services‖, IEEE Trans. Vehicular Technology, VT-29, pp. 317 - 325, 1980.
[7] A. S. A Latef and R. Hassan, "Spectrum management system: A study," in *Proc. 2011 International Conference on Electrical Engineering and Informatics*, Bandung, 2011, pp. 1-6.
[8] P. Major, S. Millenderm, and G. C. Wagner, "Spectrum management using network management concepts," in *Proc. Military Communications Conference*, Atlantic City, NJ, 1999, pp. 1153-1155.
[9] A. Goldsmith, *Wireless Communications*, Cambridge University Press, 2005, pp. 470-482.
[10] J. Schiller, *Mobile Communication*, 2nd ed., Great Britain, Pearson Education, 2003, pp. 61-64. Spectrum Management. SKMM (2012). Retrieved December 1.

