Study of Path Loss Model in Wireless Network

Anupa Saini[1] Varsha Chauhan[2]
[2]Assistant Professor
[1,2]Shri Krishna Institute of Engineering & Technology, India

Abstract—*Path loss models are useful planning tools that allow the inventor of wireless communication networks to achieve optimal levels for the base station deployment and meeting the expected service level requirements. Path loss is a major factor in the examining and design of wireless communication system. Moreover, the electromagnetic waves usually cannot directly reach the receiver due to many hurdles that block the line of sight path. Multipath propagation is known as the travelled signals from transmitter to receiver via a lot of many reflection ways.*

Keywords—DSL, WiMAX, SS, CSN

I. INTRODUCTION

In wireless communication system, the losses that occurred between transmitter and receiver is known as Propagation path loss. Path loss is a major factor in the survey and design of wireless communication system. Moreover, the electromagnetic waves usually cannot directly reach the receiver due to many hurdles that block the line of sight path. Multipath propagation is known as the travelled signals from transmitter to receiver via a lot of many reflection ways which usually causes oscillation in the received signal's phase and amplitude, the description of the main implementation that influence the signal propagation are as follows [1]:

- Reflection.
- Diffraction.
- Scattering.
- Doppler Effect.

The propagation models are developed to predict the loss of signal strength or reportage in a particular location. Thus, they are mathematical apparatus used by engineers and scientists to plan and cultivate wireless

Communication systems. Moreover, path loss can be defined as the ratio of the transmitted to receive power, usually expressed as the following form in decibels [2]:

- $PL (d) = PL (d0) + 10n \log_{10} (d=d0)$; (1)
- Where d is the distance,
- d0 is the reference point at 1 km,
- n is the path loss exponent.

Moreover, path loss normally comprises propagation losses caused by the natural expansion of the radio wave propagation in free space.

II. INTRODUCTION TO WIMAX

WiMAX is a standards-based technology qualifies the carriage of last mile wireless broadband access as an alternative to wired broadband like cable and DSL. DSL (digital subscriber lines) are not able to provide broadband services in many urban and suburban areas because it can provide services into three mile of region. DSL also does not provide support for terminal mobility. To overcome these difficulties Mobile Broadband Wireless Access which have advantages of high speed quality services like voice, data and multimedia to large number of users is introduced. WiMAX deliver established, ambulant, and portable and, soon, mobile wireless broadband connectivity without the need for directs line-of-sight with a base station. In a typical cell radius deployment of three to ten kilometers, WiMAX Forum Certified™ systems can be expected to convey capacity of up to 40 Mbps per channel, for fixed and portable access applications. WiMAX is to 802.16 as the Wi-Fi Alliance is to 802.11.

This is enough bandwidth to simultaneously support hundreds of businesses with T-1 speed connectivity and thousands of residences with DSL speed connectivity. Mobile network deployments are expected to provide up to 15 Mbps of capacity within a typical cell radius deployment of up to three kilometers. It is expected that WiMAX technology will be incorporated in notebook computers and PDAs by 2007, allowing for geographical area and cities to become "metro zones" for movable outdoor broadband wireless access.

A. IEEE 802.16 & WiMAX

The first standard of the WiMAX family is the IEEE 802.16-2001 which was deployed in 2002 and was accepted in December 2001. Doings of hundreds of participants situated across worldwide resulted in this standard. Focus on providing Wireless MAN (Metro Politian Area) access for fixed applications was the objective of the working group of this standard (Air Interface for Fixed Broadband Wireless Access System).IEEE 802.16-2001 operates at a radio frequency range between 10 and 66GHz. It has an average bandwidth performance of 70 Mbps and a peak rate up to 268 Mbps. It provides network access to buildings through exterior antennas by communicating with a radio base station using point-to-point and point-to-multipoint (PMP) infrastructure design. [3]

III. WIMAX ARCHITECTURE

WiMAX architecture comprises of several components but the basic two components are Base Station (BS) and Security Sublayer (SS). Other components are Mobile Station (MS), Access Service Network (ASN), Connectivity Service network (CSN) and CSNGW.[4]The WiMAX Forum's Network Working Group has developed a network reference model according to the IEEE 802.16e air interface to make sure the objectives of WiMAX are achieved. The overall network may be logically divided into three basic parts:

1) To access the network, Mobile Stations (MS) used by the end user.
2) The access service network (ASN), which comprises one or more base stations and one or more ASN gateways that form the radio access network at the edge.
3) Connectivity service network (CSN), which provides IP connectivity and all the IP core network functions.

The below network reference model defines a number of functional entities and interfaces between those entities, developed by the WiMAX Forum NWG [4] Below Figure 1.1 shows some of the more important functional entities [1], which are given as:

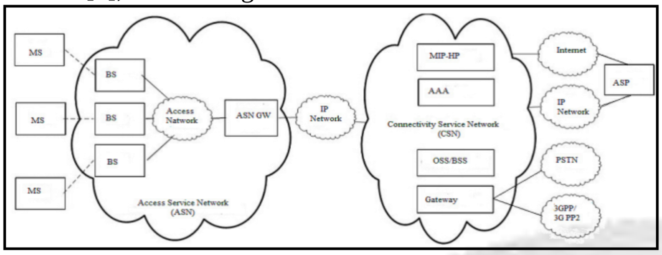

Fig. 1: WiMAX Architecture

A. Base Station (BS)

The BS provides connection between operator networks and wireless subscriber devices. To enable wireless communications consists of antennas, transceivers, and other electromagnetic wave transmitting equipment. Auxiliary functions that may be part of the BS are micro mobility management functions, such as handoff simulating and channel establishment, radio resource management, QoS policy impusion, traffic classification, DHCP (Dynamic Host Control Protocol) proxy, key management, session management, and multicast group management.[4]

B. Subscriber Station (SS)

Also called Mobile Station (MS). The SS is the user that needs to use services while in motion at vehicular speed. These SS are battery operated contrast to the fixed station. Generally mobiles and laptops are used as SS.[4]

C. Access Service Network Gateway (ASN-GW)

The ASN gateway typically acts as a layer 2 traffic gatheration points within an ASN. It is owned by NAP, formed with one or several base stations and ASN gateways (ASN-GW) which creates radio access network. It supplies all the access services with full mobility and efficient scalability. Its ASN-GW controls the access in the network and coordinates between data and networking components. ASN–GW performs traffic management function within the ASN [4].Additional functions that may be part of the ASN gateway include intra-ASN location management and paging.

D. Connectivity Service Network (CSN)

Supplies IP connectivity to the Internet or other public networks. The CSN is owned by the Network Service Provider and includes AAA servers that support authentication for the devices, users, and specific services. The CSN also supplies per user policy management of QoS and security. The CSN is also responsible for IP address management, support for roaming between different NSPs, location management between ASNs, and mobility and roaming between ASNs [8].

IV. VARIOUS PATH-LOSS MODELS

These models can be broadly designate into three types; empirical, deterministic and stochastic.

A. Empirical Models

Observations and measurements factors are only required for these models. These models are mainly used to predict the path loss, rain-fade and multipath have also been recommended. Time dispersive and non-time dispersive are the subcategories of Empirical model

B. Deterministic Models

The deterministic models make use of the laws governing electromagnetic wave propagation to determine the received signal power at a particular location. Complete 3-D map of the propagation environment is required for deterministic models. Ray tracing model is an example of Deterministic model

C. Stochastic Models

Stochastic models, the environment as a series of random variables. These models require the least information about the environment and use much less processing power to generate predictions but they are the least accurate

Okumura's model is one of the extensively used models for signal prediction in urban areas. The range (150-1920) can be covered using this model (although it is typically extrapolated up to 3000 MHz).Also for 30-1000m antennaheights, this model can be used .Okumura developed curves,which were developed from extensive measurements using vertical omni-directional antennas at both the base and mobile, and are plotted as a function of frequency in the range 100–1920 MHz.Firstly the free space path loss between the points of interest is determined using Okumura's model, after that along with the correction factors to account for the type of terrain, the value of Amu (f, d) (as read from the curves) is added to it. The model can be expressed as:

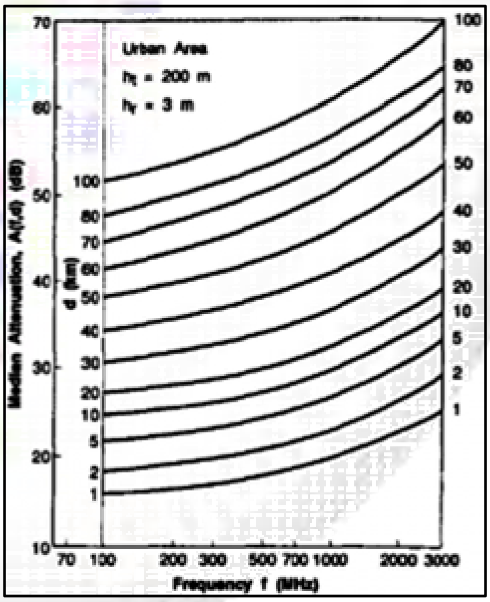

Fig. 2: Media Attenuation Relative to Free Space Over a Quasi-Smooth Terrain

where L50 is the 50th percentile (i.e., median) value of propagation path loss, LF is the free space propagation loss, Amu is the median attenuation relative to free space, G(hte) is the base station antenna height gain factor, G(hre) is the mobile antenna height gain factor, and GAREA is the gain due to the type of environment.

Plots of Amu (f, d) and GAREA for a wide range of frequencies are shown in Figure 2 and Figure 3. Furthermore, Okumura found that G(hte) varies at a rate of 20 dB/decade and G(hre) varies at a rate of 10 dB/decade for heights less than 3 m. G(hte) = 20 log(hte/200) 1000 m >hte> 30 m

G(hre) = 10 log(hre/3) hre<= 3 m G(hre) = 20 log (hre/3) 10 m >hre> 3 m

Other corrections may also be applied to Okumura's model. Some of the important terrain related parameters are the terrain undulation height (A/i), isolated ridge height, average slope of the terrain and the mixed land-sea parameter. Once the terrain related parameters are calculated, the necessary correction factors can be added or subtracted as required. All these correction factors are also available as Okumura curves

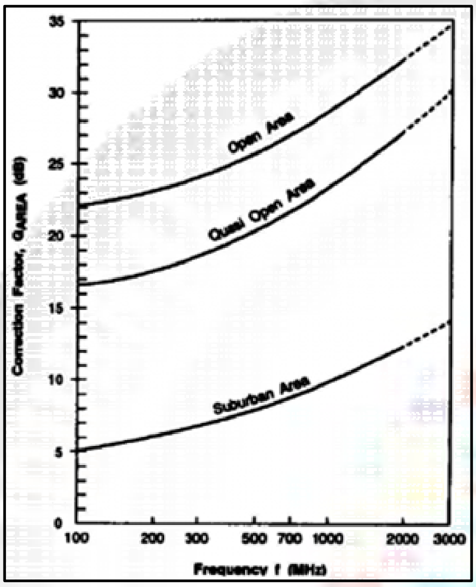

Fig.3: Correction Factor $G_{AREA}$for Different Types of Terrain

Hata Model is defined as a propagation model , which is useful in predicting the path loss of cellular transmissions in exterior environments and valid frequencies are from 150-1500 MHz. It is also called as Okumura–Hata model because its formulation is based on the data from the Okumura Model [5]

The effects of diffraction, reflection and scattering caused by city structures [6] ,are developed from this model and it also incorporates the graphical information from Okumura model. Also correction for applications in suburban and rural environment is also applied in this model.

1) Model Description

Frequencies covered by Okumura model are not covered by the Hatamodel. Okumura provides support for up to 1920 MHz while Hata model does not go beyond 1500 MHz .The model is suited for both point-to-point and broadcast communications, & covers mobile station antenna heights of 1–10 m, base station antenna heights of 30–200 m, and link distances from 1–10 km.

D. Urban Environments

It is formulated as following:

– L_U=69.55+26.16 $\log_{10}$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,
– CH=0.8+(1.1 $\log_{10}$f-0.7)h_M-1.56 $\log_{10}$f)and for large cities,
– CH= {8.29($\log_{10}$ (1.54h_M)) ^{2}-1.1, if 150<=f<=200= {3.2($\log_{10}$ (11.75h_M)) ^{2}-4.97, if 200<f<=1500

Where

– LU = Path loss in urban areas. Unit: decibel (dB)
– hB = Height of base station antenna. Unit: meter (m)
– hM = Height of mobile station antenna. Unit: meter (m)
– f = Frequency of transmission. Unit: Megahertz (MHz)
– CH = Antenna height correction factor
– d = Distance between the base and mobile stations. Unit: kilometer (km).

V. Conclusion

It concludes that Okumura Model has slow response to rapid changes in terrain; therefore the model is fairly good in urban and suburban areas, but not as good in rural areas. Common standard deviations between predicted and measured path loss values are around 10 dB to 14 dB also the HATA Model applies corrections for applications in suburban and rural environments

VI. Future scope

In future, our simulated results can be tested and verified in practical field. We may alsoderive a more path loss models to check which best model is. These models can also besimulated in line of sight conditions and non- line of sight condition and comparisonbetween them is made. Also in future simulation can be done by changing differentparameters to see how much changes it shows.

References

[1] ABHAYAWARDHANA, V. S., I. J. WASSELL,D. CROSBY, M. P. SELLARS and M. G.BROWN. Comparison of empirical propagation path loss models for fixed wireless access systems. In: Vehicular Technology Conference. Stockholm: IEEE, 2005, pp. 73–77. ISBN 0-7803-8887-9. DOI: 10.1109/VETECS.2005.1543252.

[2] ALAM, D., S. CHOWDHURY and S. ALAM. Performance Evaluation of Different Frequency and of WiMAX and Their Selection Procedure. International Journal of Advanced Science &Technology.2014, vol. 62, iss. 1, pp. 1–18. ISSN 2005-4238. DOI: 10.14257/ijast.2014.62.01.

[3] Anita Garhwal, ParthaPratim Bhattacharya,” A review on WIMAX Technology” (2012)

[4] Ruby Verma, Pankaj Garg “Interpretation of IEEE 802.16e (WiMAX)”(2013)

[5] Rappaport, Thomas S. (2002). Wireless Communications: Principles and Practice (Second ed.). Prentice Hall. p. 153-154. ISBN 0-13-042232-0.

[6] Seybold, John S. (2005). Introduction to RF propagation. John Wiley and Sons. ISBN 0-471-65596-1.

[7] ChhayaDalela,”Comparative Study of Radio Channel Propagation and Modeling for 4G Wireless Systems “(2013)

[8] Sunil Kr. Singh, Ajay Kumar, Siddharth Gupta, Ratnakar Madan” Architectural Performance of WiMAX over Wi-Fi with Reliable QoS over Wireless Communication” (2011)

[9] FirasShawkat Hamid, “The difference between IEEE 802.16 / WiMAX and IEEE 802.11 / Wi-Fi networks for Telemedicine Applications” (2013)
[10] Gurpreet Singh Bola, Gurpreet Singh Saini,” Path Loss Measurement and Estimation Using Different Empirical Models For WIMAX In Urban Area”(2013).
[11] Hemant Kumar Sharma, Sanjeev Sharma,” Survey of propagation Model in wireless Network” (2011).
[12] Hemant Kumar Sharma, Santosh Sahu,”Enhanced Cost231 W.I. Propagation Model in Wireless Network” (2011).