Modelling Optimized Path Loss Model

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Abstract— Mobile communication is the fastest growing segment of the wireless industry. The evolution of new mobile broadband technologies has led to increase in coverage and capacity to adopt new ITU (International Telecommunication Union) standards. The path loss occurs when there is a decrease in power density when signal is transmitted from transmitter to receiver. The Radio Propagation models i.e. Okumara-Hata Model and Walfish-Ikegami Path loss model predicts the path loss over the link or coverage area of transmitter but it suffers when the varying Environmental factors are considered. This project mainly aims to provide a model for path loss, which considers environmental parameters such as Atmospheric Temperature, Humidity, Pressure, as a factor affecting the signal Strength, which in turn gives more accurate value for the path loss. A graph for signal strength vs. different environmental parameters are plotted. There is a need for considering atmospheric factors of rural areas to achieve better network communication system.

Key words: Path Loss Model

I. Introduction

Wireless communication is one among the major areas in the current era and plays a vital role in mobile communication. Every user wants the information at the tip of his fingers, with a gentle touch on the smart phone, with high speed, accuracy and without degrading the security factor. Transmitting or receiving information between two or more locations, with any system of computer equipment or peripherals is the fundamental purpose of the data communication. The transmission, reception and processing of digital information are together termed as Data communication.

The characteristic features of radio wave propagation are involved, and the entire wireless system is dependent on these features. Slowly after a decade, evolution of mobile or Wi-Fi networks such as 1G,2G,3G,4G and 5G has shrink the globe into a small unit. There is an exponential growth in the number of subscribers subscribing, which has made the mobile communication the fastest growing segment of the wireless industry. [1]

Currently, IOT (Internet of things) is at the epicenter of the trend. Due to convergence of multiple technologies such as, Real time analytics, Machine Learning, embedded systems and wireless communication, all these contribute to enable Internet of Things, through which the IOT has evolved. Another factor, which seems to have turned the world is the ICT (Information and Communication Technology) era. In terms of globalization context, ICT influx has been the significant development.

Mobile communication is entirely dependent on the radio wave propagation. When the radio waves are transmitted from one point to another, they are affected by many factors. One such factor is Path loss. Path loss is the amount of reduction in power density of the electromagnetic wave, when it travels from transmitter to receiver. Path loss may occur due to various factors such as refraction, reflection, diffraction, absorption. Path loss is also influenced by environmental factors, terrain contours, Urban and rural vegetation, propagation medium etc. It is calculated by using many empirical models such as Okumara-Hata model, Walfisch-Ikegami model, Lee model, which gives an accurate value for Path loss. But none of the existing models consider environmental parameters as a factor which affects the Signal transmission. There is a significant change in the Signal strength due to changes in Atmosphere.

This Project mainly aims to a provide an model of Signal Strength correlated with Environmental parameters such as Humidity, Pressure, Temperature, wind speed etc., in rural areas from constant Base Station using drive test tool, where readings are taken from BCCH(broadcast control channel), Trans power is kept constant and only the varying received power is taken.

To achieve optimum design of next generation communication system, there is a need to consider environmental factors in the propagation prediction models.

A. *Cell Concept*

Macro cells are commonly encountered in Cellular telephony, where the main intension is to provide initial network coverage over a wide area. Macro cells are usually found in rural areas where the cell size covers a large area, as no many buildings persist on the terrain. It's mainly used for large empty space areas.

The path loss models associated with the macro cells are dependent on distance, provided that the environmental surrounding the base station is uniform. By increasing the efficiency of the transceiver, the performance of the macro cell could be increased. Power put puts of microcell base stations are typically tens of watts.

For macro cells, the models of statistical nature are more appropriate, as the important parameter for the microcell designer is the overall area covered, rather than the specific field strength.

This project mainly aims to optimize an empirical prediction method under macro cell known as Okumara-Hata Model.

B. *Okumara-Hata Model*

Path loss models helps in the prediction of coverage area and proper placement of the base station in any given terrain.

Okumara Model is fully based on the measured data ignoring the analytical explanation. It is mainly used in areas where there are less buildings, mainly in rural areas. This method involves dividing the prediction area into a series of clutter terrain categories namely, open, suburban and urban.

It states that the signal strength decreases at much greater rate with distance than that predicted by free space loss.

Hata model was based on Okumara's field test results and predicted various equations for path loss with different types of clutter.

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Okumara takes urban areas as reference and applies correction factors for conversion to the other classification. This is an apt Model, as such areas avoid the large variability present in suburban areas and yet include the effects of obstructions better than could be done with open areas. Correction factors are also added for the other types. [1]

Urban area $L_{dB} = A + B \log R – E$
Suburban area $L_{dB} = A + B \log R – C$
Open area $L_{dB} = A + B \log R – D$

Where

$A = 69.55 + 26.16 \log f_c - 13.82 \log h_b$
$B = 44.9 – 6.55 \log h_b$
$C = 2(\log(f_c/28))^2 + 5.4$
$D = 4.78(\log f_c)^2 – 18.33 \log f_c + 40.94$
$E = 3.2(\log (11.75 h_m))^2 – 4.97$ for large cities, $f_c >= 300$ MHz
$E = 8.29(\log (1.54 h_m))2 – 1.1$ for large cities, $f_c < 300$ MHz
$E = (\log fc – 0.7) h_m – (1.56 \log f_c – 0.8)$ for medium to small cities.

C. *Path Loss*

In the analysis and design of a communication network or a system, Path loss is one of the major components to be considered. As Path loss determines the amount of power density of the signal reduced or the loss of signal strength, it helps the Network administrators or designers to design the network more efficiently, considering path loss, in such a way that it enhances the network performance. It depends on several factors such as distance between the transmitter and the receiver, Environmental factors, type of wave propagation, height and location of the antennas, reflection, diffraction, absorption etc.

For the growth and betterment of Mobile Communication, Path loss is one among the important factors to be considered for the evaluation of network services.

As a result, many Empirical Models were suggested to calculate the Path loss. Amongst them, Okumara-Hata Model and COST-231 Walfish-Ikegami Model are widely used.

Okumara-Hata Model were used in rural areas and COST-231 Walfish Ikegami model was used for urban areas.

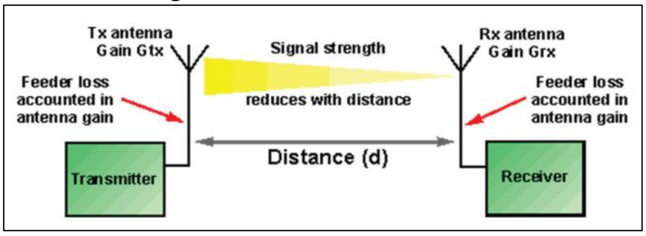

Fig. 1: Radio Path Loss

D. *Atmospheric effects*

The earth's atmosphere has characteristics that affect the propagation of radio waves. These effects happen at different points in the atmosphere. The most important atmospheric effects on radio wave propagation are refraction and reflection. Refraction can occur in the troposphere or the ionosphere. Tropospheric refraction occurs because the refractive index of the atmosphere decreases as altitude increases, leading to a bending of waves back toward the earth. [3]

The factors that affects the signal strength are described below:

1) Temperature: Air temperature is a measure of how hot or cold the air is. It is the most commonly measured weather parameter. More specifically, temperature describes the kinetic energy, or energy of motion, of the gases that make up air. As gas molecules move more quickly, air temperature increases.
2) Air Pressure: Atmospheric pressure, sometimes also called barometric pressure, is the pressure within the atmosphere of Earth (or that of another planet). In most circumstances atmospheric pressure is closely approximated by the hydrostatic pressure caused by the weight of air above the measurement point.
3) Humidity: Humidity is the amount of water vapor present in the air. Water vapor is the gaseous state of water and is invisible to the human eye. Humidity indicates the likelihood of precipitation, dew, or fog.
4) Wind Speed: Wind speed also affects the signal strength but to the some extent. When there is a high speed wind, the signal strength decrease, which is negligible.

1) *Okumara-Hata Model:*

This model is mainly used in the prediction of pathloss in rural areas, as it accounts to microcell concept which is restricted for small coverage areas. This model mainly considers frequency, height of the base station and height of the mobile station. This model is designed for 150MHz to 1500Mhz frequency , height of the base station antenna from 30m t0 200m and height of mobile antenna from 1m to 10m.

2) *COST 231 Walfish-ikegami Model:*

This model is used in the prediction of path loss in urban areas, which consists of tall and medium sized buildings, because of which it considers reflection and scattering above and between the buildings. It also considers LOS (line of sight) and NLOS (non-line of sight). This model is designed for 800 Mhz to 2Ghz frequency, 4 to 50m base station height and cell sizes up to 5km

II. EXISTING SYSTEM

Radio propagation models gives a brief idea of the characteristics of the radio wave propagation considering the knowledge of the location, dimension and constitutive parameters of every tree, building and terrain feature in the area to be covered. These models give an empirical mathematical procedure for the depiction of the radio wave which is a function of distance, frequency, height or any other specific condition to calculate Path loss which in turn determines the Signal Strength. One appropriate way of accounting the complexity of the radio wave propagation (Path loss) is via an empirical prediction models. Among them are: Okumara-Hata Model, COST-231 Hata Model, COST-231 Walfish ikegami model. These models depend on the clutter type such as urban, suburban and countryside.

A. *Okumara-Hata Model*

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C. Problem Statement

Both the above models do not consider the environmental changes which affects the signal strength. Due to the variation in the atmospheric factors, signal strength significantly changes. For signal prediction and network planning, propagation models should consider environmental factors.

III. PROPOSED SYSTEM

Several existing path loss models such as Okumara-Hata Model, Wallfish Ikegami model fails in its efficiency when the varying environmental factors are considered. The best existing path loss model with the closest propagation exponent i.e. Okumara-Hata model used for rural areas, will be chosen as a reference and the environmental factors such as Temperature, Humidity, Pressure and Wind speed measurements are correlated with the measured signal strength for the development of optimized path loss model.

Performance Evaluation is done on the signal strength received for different weather parameters such as temperature, humidity and pressure. Different Graphs are plotted for signal strength vs. various environmental factors.

The main intension of a wireless mobile network is to provide f coverage efficiency, quality of service and ultimately subscriber’s satisfaction. If the performance of the mobile cellular network is not as expected, then it results in poor performance and bad customer experience.

IV. METHODOLOGY

Drive Test tool is a field measurement used to record the received signal strength and correlated with the corresponding environmental factors such as temperature, pressure, humidity and wind speed Drive testing is a method of measuring coverage and quality of service of a network. [2]

The variation in signal strength with environmental factors is shown in the graph.

A. Observation

The received signal strength recorded with the help of drive test tool on a particular winter day at a fixed place transmitted by fixed BTS of the control channel at different times is as shown below.

Sl.no	Signal strength in dBm	Temperature In Centigrade	Pressure in KPa	Humidity in percentage
1	-84.39	36	100.96	21
2	-82.32	36	100.97	21
3	-80.81	36	100.97	21
4	-82.83	36	100.97	21
5	-79.21	36	100.97	21
6	-63.44	27	101.37	59
7	-66.20	27	101.37	59
8	-63.74	27	101.37	59
9	-63.07	27	101.37	59
10	-61.72	27	101.37	59
11	-102	26	101.43	11
12	-104	26	101.43	11
13	-105	26	101.43	11
14	-108	26	101.43	11
15	-106	26	101.43	11

Table 1: Signal strength correlated with environmental parameters.

From the above readings, we can conclude that changes in atmosphere at different time has an impact on the received signal strength of mobile communication system.

V. GRAPH

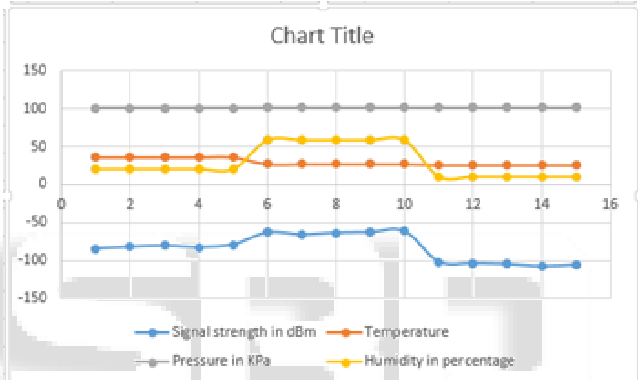

Fig. 2: A graph of signal strength vs. environmental factors

VI. CONCLUSION

The changes in atmosphere at different time has an impact on the received signal strength of mobile communication system. The Quality of service and data rate /bandwidth is dependent on radio signal strength. Bandwidth is enhanced not only by modulation techniques but also by improving signal strength. Since radio propagation is a complex phenomenon, it not only depends on terrain, frequency and distance but it is also affected by environmental changes.

Hence to achieve Quality of service there is a need for proper radio network planning. The present radio network planning is carried by okumara-hata model which doesn’t take into account loss of signal by variation in atmosphere.

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