Modified Approach to Estimate the Propagation Path Loss in Urban Area

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Abstract*—GSM is one of the most widely used technologies in the world of mobile communication. In this paper, we would discuss the influence of propagation environment in a GSM mobile network. Here we discussed the path loss during summer (when dust storms take place) in jaipur (State: Rajasthan; Country: India) by computing the received signal strength at various distances for four different visibility conditions. The Hata and many other path loss propagation models are compared with the measured data taken in the drive test. The result shows that the measured data and the Hata model are close while the other models undervalue the path loss phenomena. The significance here is that various forms of precipitation such as storms of sand and buildings in the urban region of Rajasthan lead attenuation in the received signal strength. The modification of hata model is given by considering building effects and dust storm effects in the above mentioned area.

***Keywords*— Propagation path loss, Hata model, Dust storm, Global system for mobile (GSM), Quality of Service (QoS).**

I. Introduction

The wireless communication trusts on the propagation of waves in the free space and the possibility of transmitting data. Wireless communication works highly to provide mobility for customers and try to satisfy all the general demands of the subscribers at any location covered by the wireless network [1, 2]. It is important to give accurate estimation of coverage for high quality and capacity networks, important. Therefore, for more accurate design coverage of modern cellular networks, signal strength measurements must be taken into consideration in order to provide an efficient and reliable coverage area. This editorial gives the comparison between the theoretical and experimental analysis at GSM frequency band. Without Radio wave propagation we cannot imagine the wireless communication, It is one of the most important phenomenon in our daily life. In the same time we can say it is very Complex because Number of predictable factors affect the radio propagation. When a radio signal travels from transmitter station to receiver station in mobile communication passes through the earth's environment and this can introduce certain impairments [3].This Transmission process at higher frequencies is usually changed by surrounding conditions and climatic conditions such as rain, vapor, dust, snow, cloud, fog, and mist. Here we are discussing only about dust storms usually occur in Jaipur city. Dust storm is a dry and dusty (sand particles) wind that blows in some areas of Rajasthan during summer. The dusty wind picks up dust particles of radius in micrometers and it was observed both by the meteorological sensors and by the radio links. Visibility reduction was measured by using the known marked distance method. The average dust storms, wind speed and temperature of Jaipur city during summer in year 2011 are shown in figure 1, 2 and 3 respectively.

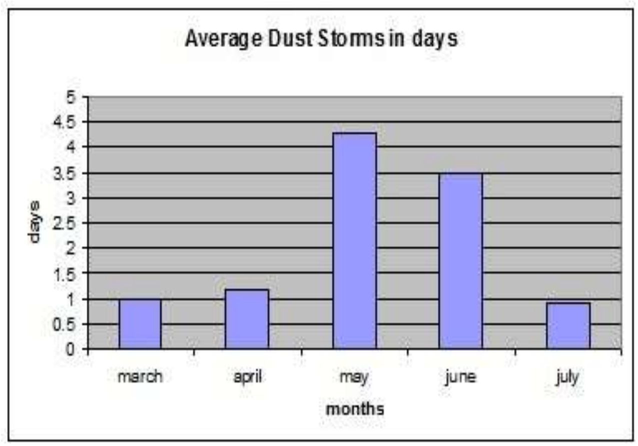

Figure 1 Average dust storm

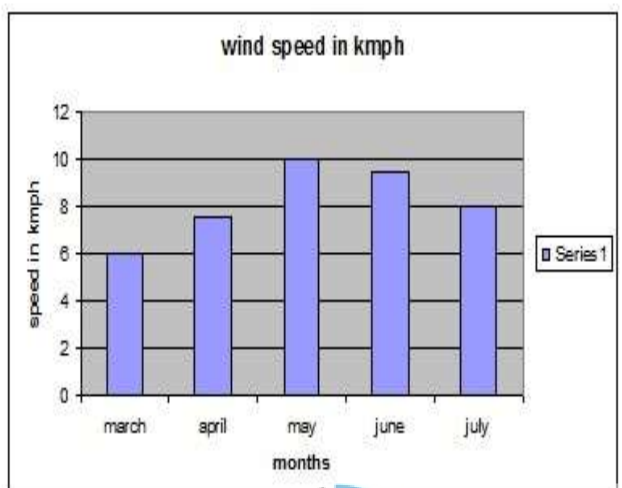

Figure 2 Average Wind speed

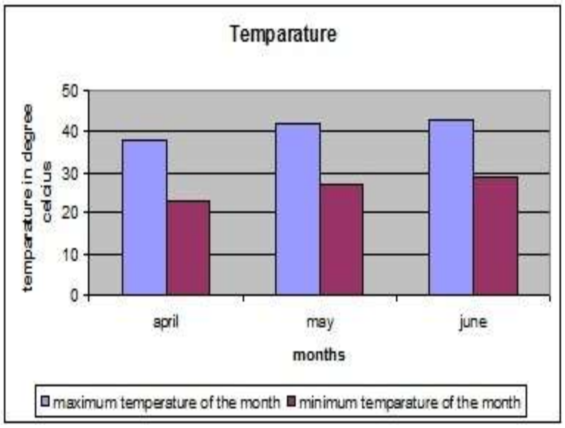

Figure 3 Maximum and minimum temperatures

The Received Signal strength of a radio signal between the mobile station (MS) and Base transceiver station (BTS) were taken during drive tests with the use of a Global Positioning System (GPS) receiver, laptop, and Transmission Evaluation and Monitoring System (TEMS) phone. However, in this work, we have developed a simple mathematical model that is based on measurements taken in jaipur region. The empirical model developed was tested with the measurements in different climatical conditions [4].

II. Propagation Path Loss

Signal path loss can be caused by many factors. In a global environment there are many factors that affect the actual RF path loss. When planning any radio or wireless system, it is necessary to have a broad understanding the elements that give rise to the path loss, and in this way design the system accordingly. The following are some of the major elements causing signal path loss for any radio wave system [5, 6].

- *Free space loss:* This loss occurs as the signal travels from transmitter to receiver through space without any other effects attenuating the signal. The energy of any signal decreases when it travels a larger distance in the space according to the conservation of energy.
- *Multipath*: In a real global environment, signals will be reflected and they will reach the receiver via a number of different paths. These signals may add or subtract from each other depending upon the relative phases of the signals. This entire process leads to a loss which is multipath loss. Mobile receivers (e.g. Mobile phones) are subject to this effect which is known as Rayleigh fading.
- *Atmosphere*: it affects radio signal paths. It affects at low frequencies, especially below 30-50MHz, the ionosphere has a major effect, reflecting them back to Earth. At frequencies above 50MHz and more the troposphere has a major effect on the radio path. For UHF broadcast this can extend coverage to approximately a third beyond the horizon.

Path loss plays vital role to decide the QoS for wireless communication at network planning level . Path loss causes poor signal strength at the receiver side [7]. So that the receiver is not able to detect the original signal. All wireless communication operators use Key Performance Indicators to judge their network performance and they evaluate the Quality of Service (QoS) regarding end user perspective. All the events being occurred over air interface are triggering different counters in the Base Station Controller (BSC). To measure path loss we have many more models. In all those models Hata model is giving more reliable results which are near to the data taken after comparing with the practical drive test. All the path loss models are designed by calculating field data in different environments [8]. The Hata model [9] is an empirical formulation of the graphical path loss data provided by Okumura and is valid over roughly the same range of frequencies, 150-1500 MHz. This empirical model simplifies calculation of path loss since it is a closed-form formula and is not based on empirical curves for the different parameters. The standard formula for median path loss in urban areas under the Hata model is

$$L_{50,urban}(dB) = 69.55+26.16 \log_{10}(f_c)-13.82 \log_{10}(h_{te})-a(h_{re})+(44.9-6.55 \log10(h_{te})) \log_{10}(d). \quad (1)$$

The parameters in this model are the same as under the Okumura model, and $a(hre)$ is a correction factor for the mobile antenna height based on the size of the coverage area.

$$a(h_r) = 3.2(\log_{10}(11.75h_r)^2 - 4.97 \text{ dB}. \quad (2)$$

Hata's model does not provide for any path specific correction factors, as is available in the Okumura model. The Hata model well-approximates the Okumura model for distances d > 1 Km. Thus, it is a good model for first generation cellular systems, but does not model propagation well in current cellular systems with smaller cell sizes and higher frequencies. Indoor environments are also not captured with the Hata model [10].

III. Modified Propagation Path Loss model

With the help of the above model we are not getting the exact result that means some more factors are dominating the signal strength in the mentioned environment where drive test is conducted. There are many reasons for this difference between the predicted loss and the measured loss. Here we will focus mainly on the two reasons because the area considered is an urban environment so the effects of buildings must be considered and in this area particularly in the summer dust storms are frequent so we ave to consider the effect of storms on the received signal strength.

A. *Effect of Dust storm*

Based on the analysis of [11,12], the attenuation of radio waves propagating through airborne sand particles of permittivity and effective radius *ae* is given by

$$A_T = 0.1887 * 10^3 (\frac{a_e}{\lambda}) \frac{G}{V_0} \quad (3)$$

in db/km

Where the G is the permittivity factor which depends on real and imaginary parts of complex dielectric constant of sand particles

$$G = \frac{3\varepsilon^{"}}{\left[(\varepsilon^{'}+2)^2 + \varepsilon^{"2}\right]} \text{ and Permittivity} \quad (4)$$

$$\varepsilon = \varepsilon^{'} + j\varepsilon^{"}$$

measurements by the Samir I. Ghobrial the dielectric constant of nine samples of dust particles after dehydration revealed that the average dielectric constant is 5.23-j0.26 [13]. *Vo* is the visibility in kilometers and ʎ is the wavelength measured in the same units as the particle size *ae.* The effective radius *ae* is equal to *3a,* where *a* is the average radius [14].

B. *Effect of buildings*

In this congested highly populated environment large buildings can be one of the factors which can affect the signal strength that means indirectly path loss. Because when the radio signal passes into a medium like large buildings and foliage which are not totally transparent to radio signals. This can be explained by the traveling of a light signal passing through a transparent glass. The terrain over which signals travel will have a major effect on the signal. The buildings reflect radio signals and they also absorb them. Path loss associated with diffraction down to street level depends on the shape and construction of the buildings in the vicinity of the mobile. A simple approximation to this process for receiving antennas near street level is obtained by assuming a row of buildings to act as an absorbing half-screen located at the center of the row. In this case the field amplitude at the mobile is obtained by multiplying the roof top field by the following factor [8,15-16].

$$A = 5\log\left[\left(\tfrac{d_b}{2}\right)^2 + \left(h-h_m\right)^2\right] - 9\log d_b + 20\log\{\tan^{-1}\left[2\left(h-h_m\right)/d_b\right]\} \quad (5)$$

Where

d_b= Spacing between buildings

h= height of the building

h_m =mobile antenna height

f_c=900MHz

As we already mentioned in equation (1) that the path loss formula of hata is given by

$$L_{50,urban}(dB) = 69.55+26.16\log_{10}(f_c)-13.82\log_{10}(h_{te})-a(h_{re})+(44.9-6.55\log10(h_{te}))\log_{10}(d).$$

By considering the influence of building geometry and the dust storm we can modify the formula as

$$L_{Hatamodified}=L50\ (dB) + A + A_T \quad (6)$$

The equation (6) gives the modified approach for calculation of the path loss.

IV. Comparison with measured data

Measurements has taken in Jaipur (Rajasthan: India) using spectrum analyzer at 900MHz frequency. The power from the transmitter is 43dBm. The data was taken in the highly congested area. The reference distance taken is 1km. Measurements were taken in regular intervals between 1km and 5km. By observing the practical received power strength we got a conclusion that The path loss from the field data is near to the hata model as shown in the above figures. The accuracy of the any existing model is going to suffer when they are used in the surroundings or the fields other than they were designed so the original Hata model needs some correction to get the accurate results in the mentioned environment at which we have taken the field measured data. In this congested urban environment on calculating the path loss first we are considering the large buildings and secondly the regular dust storms occurring during summer. Addition of building and dust storm effects in the original hata model we are getting better results which is shown in figure 4, 5, 6 & 7 at 20, 30, 40, & 50m visibility respectively. As the MSE is in the tolerable range we can say the modification in the Hata model is acceptable [17,18]. At lower values of visibility we found more path loss as comparison with the higher values of visibility.

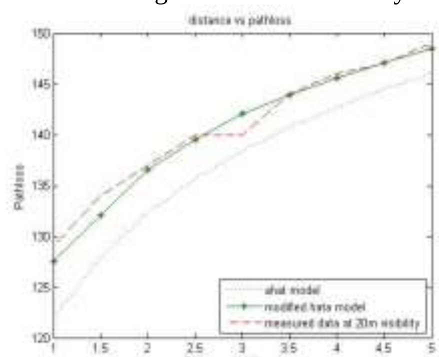

Figure 4 Path loss calculation at 20m visibility

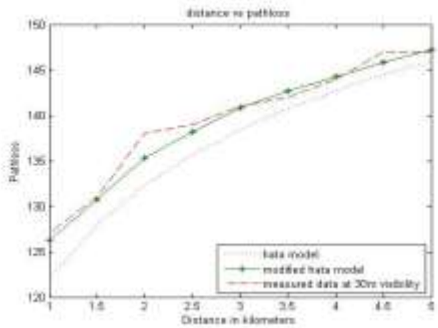

Figure 5 Path loss calculations at 30m visibility

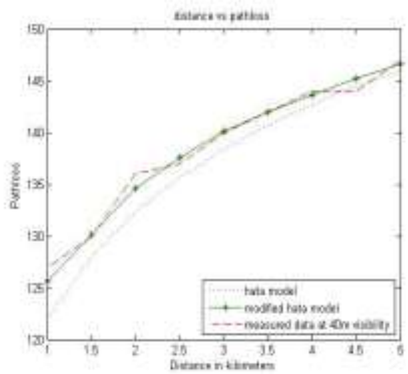

Figure 6 Path loss calculations at 40m visibility

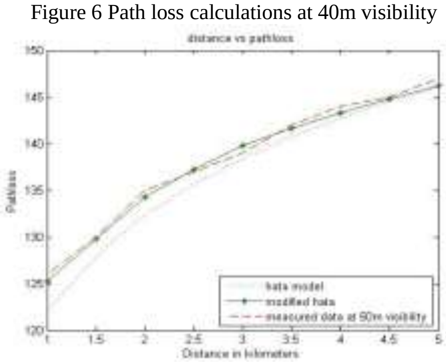

Figure 7 Path loss calculations at 30m visibility

V. Conclusion

The work in this paper reveals a considerable advance in our understanding the role of buildings and dust storms in the signal attenuation. The effect of these conditions on signal strength demands that in regions with these Conditions higher gain antennas need to be installed in addition to the introduction of precisely defined local correction factors for consistent quality of service in and out of season. We gave a modified model in highly populated area of Jaipur city, Rajasthan, India in dust storm environment. With the help of this modified model we can predict the path loss more effectively than the existing models.

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