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Analytical Calculation of a Radio Propagation Model in the Implementation of Cellular Mobile System of Valley of Dehradun City

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Abstract

Coverage and capacity are two important issues in the planning a process for cellular and mobile networks. To understand and design a cellular system, the Knowledge of the propagation characteristics of a mobile radio channel is required. When designing or estimating the link budget of a cellular system based (either Time Division Multiple Access system or Code Division Multiple Access), a suitable propagation model is required. This paper deals with parametric analysis for propagation path loss considering macro cell region using Okamura-Hata model for the implementation in the designing of a cellular mobile system in the valley of Dehradun city.

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Keywords

Radio Propagation Model, Cellular Mobile System.

Introduction

Markets, technology, and range of services are continuously growing in the field of Wireless cellular communication. The most recent challenge in cellular communication systems is to achieve improved economics through enhanced coverage during early life cycle of its network and then achieving high spectrum efficiency later in its life-time. Use of the advancements of phase shift keying modulation with time division multiple access (TDMA) technology and spread spectrum modulation with code division multiple access (CDMA) technology is an attractive approach for economically, spectrally efficient, along with high quality digital cellular and personal mobile communication services.

Cell coverage primarily depends on user-defined parameters such as transmitting power, antenna height, antenna gain, antenna location, and antenna directivity. Several other parameters such as propagation environment, hills, tunnels, foliage and buildings greatly affect the overall RF coverage. These types of parameters are not user defined, vary from place to place, and are difficult to predict. As a result, a practical cell is highly irregular in multipath environment. Consequently, several prediction models have been developed in recent years. The most widely used propagation models, accommodating most of these anomalies of propagation, are the Okumura- Hata and Walfisch-Ikegami propagation models. The foundation of most computer-aided prediction tools available today is also based on these models. Extensive experimental data and its statistical analysis enabled us to calculate the level of received signal in a given propagation medium and lead these prediction models.

Radio-frequency (RF) propagation in a multipath environment is generally fuzzy because of irregular terrain, numerous RF barriers, and scattering phenomena. Building codes also vary from place to place and from one civil structure to another, requiring wider-ranging databases. As a result, a precise mathematical model is not available. Although sophisticated computer-aided prediction tools are available, these tools require user-defined clutter factors, thereby introducing impurities into the database. This result is an inevitable error in these prediction tools. Nevertheless, these tools are essential during the initial planning and deployment of cellular communication systems. Once the deployment is complete, various RF parameters such as RF coverage verification,

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interference reduction, and hand-off parameter adjustments are routinely carried out by means of a RF survey.

Path loss (Loss_{path}), in radio propagation is the measure of interest, which can be defined as the ratio of the received power ($Power_{rd}$) and the transmitted power ($Power_{tm}$), i.e. $Loss_{path} = Power_{rd} \ / \ Power_{tm}$. Propagation models are used to calculate the requirements of number of cell sites to provide the coverage for the networks. An initial network design is typically engineered based on coverage and later the network grows on the basis of its capacity. The propagation models also help engineers to determine the cell sites locations to achieve an optimal position in the network. Calculated Predictions of signal strength and its propagation coverage area are the vital parameters in the designing and planning of wireless communication systems. There are several methods for the calculation of propagation loss in the wireless communication systems, as follows: These are Hata-Okumura modal, Walfisch-Ikegami modal, Bullington modal, Epstien-Peterson modal, and Longley-rice modal. There are two existing classes of propagation models available: deterministic and stochastic. The deterministic model is useful when multiple-path is caused by a large number of paths between the transmitter and receiver. Propagation models should consider phenomenon like multipath propagation, reflection, diffraction and shadowing to obtain accurate results as they have a significant influence on the received power. In the present study we have considered Hata-Okumura model for Jaipur city, India.

An urban propagation environment is perhaps the most common and unpredictable propagation environment in cellular communicating systems. Generally, the density of civil structures varies from one urban environment to the other, requiring fine characterization of the urban environment such as dense urban, urban, sub-urban, etc. The received signals in these environments are a result of direct rays, reflected rays, and shadowing or any combinations of these signal components. Ground elevation also varies while the mobile is in motion. As a result the received signal varies erroneously due to interference. To accommodate these anomalies of propagation, the planning is done on the basis of accurate terrain data and existing propagation models such as Okumura-Hata and Walfisch-Ikegami.

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Hata-Okumura Propagation Model

Among the many technical reports that are concerned with propagation prediction methods for mobile radio, Okumura's report is believed to be the most comprehensive one. In his report, many useful curves to predict a median value of the received signal strength are presented based on the data collected in the Tokyo area. Based on Okumura's prediction curves, empirical formulae for the median path loss, $Loss_{path}$, between two isotropic antennae were obtained by Hata and are known as the Hata Empirical Formulae for Path Loss. The Hata propagation formulae are used with the link budget calculation to translate a path loss value to a forward link cell radius and a reverse link cell radius. Hata model illustrate a slightly more complicated path loss model that's a function of parameters such as frequency, frequency range, heights of transmitter and receiver, and building density. The Hata model is based on extensive empirical measurements taken in urban environments. In its decibel form, the generalized model can be written as:

$$Loss_{path} = K1 + K2log(f_c)13.82log(h_{bsant})a(h_{mant}) + [44.96.55log(h_{bsant})]log(d) + K0 \quad (1)$$

where f_c is the carrier frequency (in MHz), h_{bsant} is the antenna height (in mt.) of the base station, h_{mant} is the mobile antenna height (in meters), d is the distance (in kms) between the base station and the mobile user. For these parameters, there are only certain ranges in which the model is valid; that is, h_{bsant} should only be between 30 m to 200 m, h_{mant} should be between 1 m to 10 m, and d should be in between 1 km to 20 km. The penultimate term in the above equation is the slope of equation in dB/decade. The terms a (h_{mant}) and K0 are used to account for whether the propagation takes place in an `urban` or a `dense urban` environment. In particular, for `urban`

$$Equation2 \quad (2)$$

or for `dense urban`

$$Equation3 \quad (3)$$

and $K0 = 0$ for `urban`, or $K0 = 3dB$ for `dense urban` environment.
The term $K1$ and the factor $K2$ are used to account for the frequency ranges. Specifically, $K1 = 69.55$ for frequency range $150 \leq f \leq 1000MHz$, or
$K1 = 46.3$ for frequency range $1500 \leq f \geq 2000MHz$, and
$K2 = 26.16$ for frequency range $150 \leq f \leq 1000MHz$, or
$K2 = 33.9$ for frequency range $1500 \leq f \geq 2000MHz$.

According to Hata model the path loss is expressed as,

$Path_{Loss}$ = 69.55 + 26.16 $log(f_c)$ - 13.82 $log(h_{bsant})$ - (1.1 $log(f_c)$ - 0.7)h_{mant} + (1.56 $log(f_c)$-0.8) + (44.9 - 6.55 $log(h_{bsant})$) $logd$ (Eq. 2)

Modification for suburban city yields:

$Path_{LossM} = P_{Loss(Urban)} - 2[log(\frac{f_c}{28})]^2 - 5.4$ (Eq. 3)

Whereas, for an open area, the path loss is:

$Path_{LossM} = P_{Loss(Urban)} - 4.78(log(f_c))^2 + 18.33\ log(f_c) - 40.94$ (Eq. 4)

Results and Discussion

Figure 1-3 shows a comparative depiction of path-loss for three radio propagation environments. These environments are urban, sub urban and open area. The plots are done using the equations 1, 3 and 4 respectively for the environments.

Figure 4 is the plot of propagation path loss in the urban environment

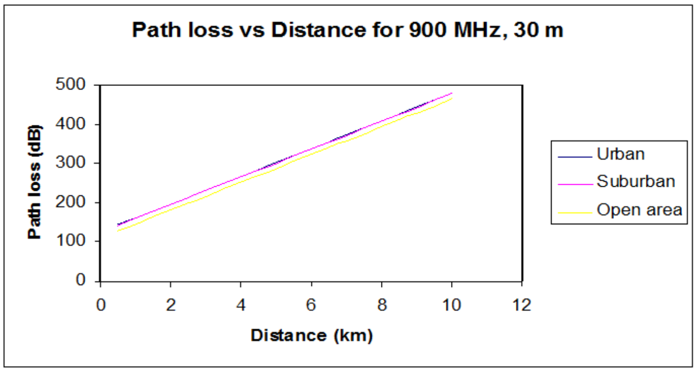

Figure 1: *Path loss for 900 MHz, at 30 m base antenna height*

at 900 MHz. In the dense urban area, it can be seen that the loss is very high due to tall, closely packed buildings and other obstacles. Because of the very a proximity in the environment for the urban and sub urban city the path loss in the two cases are very near to each other. Figure 5, shows the plot of different

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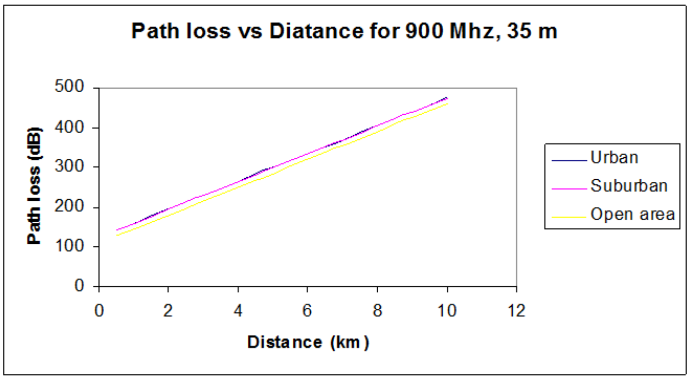

Figure 2: *Path loss for 900 MHz, at 35 m base antenna height*

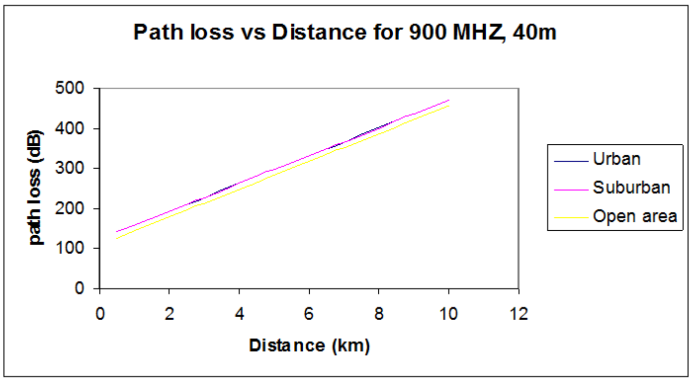

Figure 3: *Path loss for 900 MHz, at 40 m base antenna height*

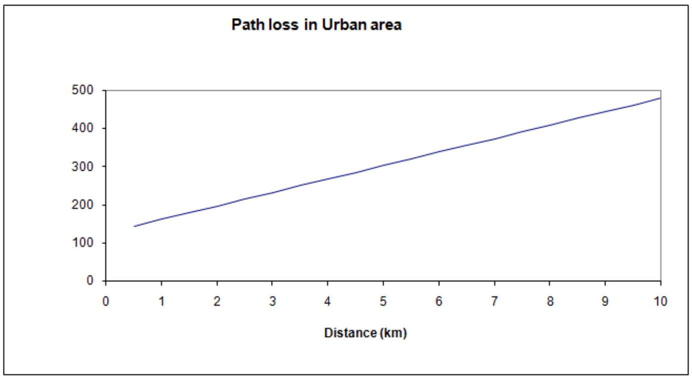

Figure 4: *Path loss for 900 MHz, at 30 m base antenna height for Urban environment*

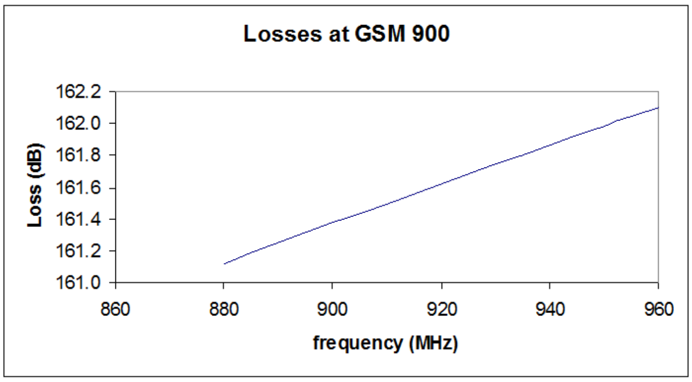

Figure 5: *Path loss for GSM 900 at 30 m base antenna height for Urban environment*

loss occurred in urban environment at GSM 900. It is evident from the plot that with frequency the path loss increases, but this loss is marginally increasing.

Conclusion

We presented a general overview of the standard Hata-Okumura modal. This modal gives a good approximation in urban and sub urban environment. Because of the very a proximity in the environment for the urban and sub urban city the path loss in the two cases are very near to each other. An exact estimation will be calculated by taking into account the other propagation mode that uses path correction factors. This implies that path specific corrections are required to convert Hata-Okumura model's mean path loss prediction to the specific path under study. Wlafish-Ikegami mode is best applicable in dense urban environment. For, IS-95 application operating beyond 1800 MHz, extension of Hata model is to be applied.

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