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An Evolution Wireless Channel Model System and Its Diversity Schemes

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ABSTRACT

Wireless channels operate through electromagnetic radiation from the transmitter to the receiver. A channel can be modeled physically by trying to calculate the physical processes which modify the transmitted signal. Channel models may be continuous channel models in that there is no limit to how precisely their values may be defined [1]. In the telecommunication system diversity scheme refers to a process for improving the reliability of a message signal by using two or more communication channels with different characteristics.

Key word: Wireless, channel, PCS, AWGN, LOS, Fading.

INTRODUCTION:

Wireless communication has gone through major changes in the last few decades. While it mostly had been used for satellite, terrestrial links and broadcasting until the 1970s, cellular and wireless networking and other Personal Communication Systems (PCS) presently dominate the technology of modern wireless communications [2].

The generally used Additive White Gaussian Noise (AWGN) model does not adequately represent the channel for these modern applications. Moreover, the Line-Of-Sight (LOS) path between the transmitter and the receiver may or may not exist in such a channel.

An important characteristic of the wireless channel is the presence of many different paths between the transmitter and the receiver Figure 1-1.

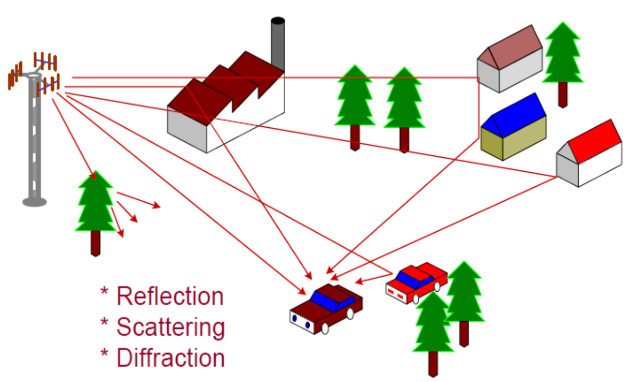

Figure 1: Multipath channel in wireless communications.

Electromagnetic (EM) wave propagation

Basic Electromagnetic (EM) wave propagation phenomena such as scattering that occur along these paths further increases the number of the paths between the communicators [3]. Common propagation phenomena encountered are:

1. Reflection: EM waves are reflected when impinging on objects in their paths if the physical size of the objects is much greater than the wavelength λ of the EM waves.

2. Diffraction: Characterized as the sharp changes in the propagation path of EM waves that occur when they hit an obstacle with surface irregularities such as sharp edges.

3. Scattering: Occurs when EM waves visit a cluster of objects smaller in size than the wavelength, such as water vapor and foliage [4]. Scattering causes many copies of the EM wave to propagate in different directions.

There are other infrequent phenomena such as absorption and refraction that might take place in common wireless channels.

The signal power is the critical parameter in a communication channel. The power reducing effects have been studied in two major cases:

1. Large-scale effect characterizes the signal power usually with respect to long propagation distances and results in the mean path loss of the signal.

2. Small-scale effect or fading concerns the relatively fast changes in the signal amplitude and its power. It characterizes the signal power fluctuations over short distance and time intervals around the mean signal power.

Large Scale Fading

In general, the average power of the received signal decreases logarithmically with the distance between the transmitter and the receiver [5]. The attenuation caused by the distance is called *large scale effect* or *path loss*.

The propagation medium and the environment would also have some effect on the total loss of the signal strength.

The averaged received power at a certain distance from the transmitted is measured by keeping the distance to the transmitter constant (as the radius of a circle) and moving the mobile antenna on the circle. The difference between the transmitted power P_t and the averaged received signal power ***P (d) as*** expressed in ***d Bm*** at certain distance is the path loss in ***dB***, which is denoted by ***L(d).***

$$\mathcal{P}(d) = \mathcal{P}_t - L(d)\,, d > d_o \quad \text{............(1)}$$

The average of the path loss in dB units, with respect to a referenced distance d_0 at which the path loss is measured and is known, is given by:

$$\bar{L}(d) = \bar{L}(d_o) + 10n\ \log_{10}\left(\frac{d}{d_o}\right) \quad \text{.............. (2)}$$

The order ***n*** has the constant value of 2 for LOS links but is usually higher than 2 for multipath channels in cities and urban areas. The model in (1-20 is known as the *log-distance* path loss model.

The measured path loss ***L (d)*** at distance ***d*** can be significantly different from the average value due to, for example, shadowing effects, and in fact, is a Gaussian random variable given by:

$$L(d) = \bar{L}(d_o) + 10n\ \log_{10}\left(\frac{d}{d_o}\right) + X_\sigma \quad \text{................ (3)}$$

$X\sigma$ is a zero-mean Gaussian random variable (in dB) with standard deviation σ also in dB. The path loss so described is known as log-normal shadowing [6].

The various measurements of path loss at different distances are collected in a graph of the loss in dB versus the distance in dB that is ***10 Log** $_{10}$ **d***. The constant can be approximated by the best fitted line (Least-Squares, for example) of the data.

With the distance ***d*** equal to the radius of the wireless cellular network, the probability ***[Pr (d)γ]*** is equal to the *likelihood of the coverage* within the cell.

Small Scale Fading

Due to multipath propagation, more than one version of the transmitted signal arrives at the mobile receiver at slightly different times. The interference induced by these multiple copies, also known as multipath waves, has become the most significant cause of distortion known as fading and *Inter-Symbol Interference* (ISI) [7]. The radio signal experiences rapid changes of its amplitude over a relatively short period of time See Figure 2.

The waves travelling different paths, therefore travelling different distances, sum up at the receiver antenna (or antenna array in some cases) to generate ISI of such a magnitude that the effects of large-scale path loss can be completely ignored by comparison.

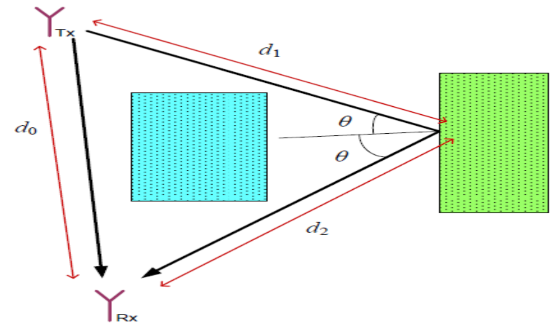

Figure: 2 Example of two-ray geometry

There are a variety of ways to statistically model the wireless channels in order to represent the random behavior of multipath fading [8]. One simple and popular model represents the fading channel with a linear and time-varying Channel Impulse Response (CIR) denoted by the function h (t, τ).

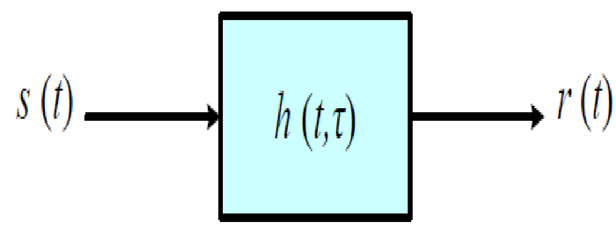

Figure: 3 Channel modeling by Channel Impulse Response (CIR)

Time Dispersion Parameters

A perfect channel from a communications point of view is one that has a constant gain and a linear phase response, or at least possesses these features over a desired frequency range or bandwidth [9]. Such a frequency range should be larger than the frequency spectrum of the transmitted signal to preserve the signal spectral characteristics.

Consequently, such an ideal channel can be symbolically shown as h (t, τ). = $g_o\,\delta(\tau)$ See Figure 4, with g_o as a constant.

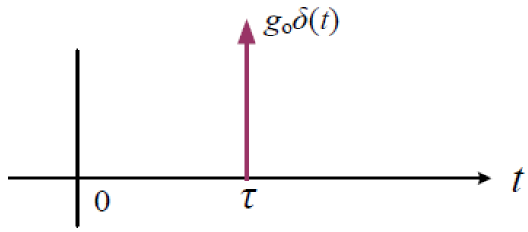

Figure: 4 An ideal Channel Impulse Response (CIR) Conclusion

In this research paper, Wireless channels operate through electromagnetic radiation from the transmitter to the receiver. An important characteristic of the wireless channel is the presence of many different paths between the transmitter and the receiver. Due to multipath propagation, more than one version of the transmitted signal arrives at the mobile receiver at slightly different times.

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