© 2018 IJSRST | Volume 4 | Issue 3 | Print ISSN : 2395-6011 | Online ISSN: 2395-602X

National Conference on Advances in Engineering and Applied Science (NCAEAS)
29th January 2018
Organized by : Anjuman College of Engineering and Technology (ACET) Nagpur,
Maharashtra, India, In association with
International Journal of Scientific Research in Science and Technology

# A Review on Propagation Models for Wireless Communication System

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## ABSTRACT

This paper gives an overview of the propagation models in wireless communication systems. Wireless communication system uses several physical media, ranging from sound to radio to light. These characteristics are affected by the physical environment between the transmitter and receiver. Wireless communication system suffers from various unwanted effects of fading which may be caused due to multipath propagation, path loss, shadowing, Doppler spread and co-channel interference. There are various signal propagation ranges in wireless communication channels.

**Keywords:** Characteristics of wireless communication system, path loss, fading, interference, types of propagation models-outdoor & indoor propagation model.

## I. INTRODUCTION

The wireless communication system posses several challenges for the reliable and a high speed communication. It is not receptive of noise channel and other channel hindrance, but these obstacle changes with time in unforeseeable ways due to user movement. We will characterize in detail the variation in the received signal power over the distance due to path loss and shadowing. Path loss models describe the signal attenuation between a transmitter and receiver antenna as a function of propagation distance and other parameters which is caused by the dissipation of the power radiated by the transmitter as well as effects of the propagation channel. Shadowing is caused by obstruction between the transmitter and the receiver that attenuate the signal power through absorption, reflection, scattering, and diffraction. A very important practical issue is to test and validate the ability of the "smart" antenna array to meet performance requirements. For this purpose, a channel model is needed to take into account the temporal and spatial characteristics of radio propagation.

## II. WIRELESS CHANNEL

The wireless signal proliferate in space, based on the rule of physics. An electromagnetic Radio Frequency (RF) signal which proceed in a medium suffers an attenuation (path loss) based on the nature of the medium. In addition, the signal experiences objects and gets reflected, refracted, diffracted, and scattered. The cumulative effect results in the signal getting absorbed, signal travel across multiple paths, signal's frequency being shifted due to relative motion between the source and objects (Doppler Effect), thus are getting modified in a sufficient way. It is clear that the radio frequency signal is a space-time-frequency signal.

Where,
The wireless signal proliferate in space, based on the rule of

- ✓ **$G_t$** is the transmitter antenna gain physics. An electromagnetic Radio Frequency (RF) signal
- ✓ **$G_r$** is the receiver antenna gain which proceed in a medium suffers an attenuation (path loss)
- ✓ **d** is the distance between the transmitter and receiver based on the nature of the medium. In addition, the signal
- ✓ λis the wavelength of the signalexperiences objects and gets reflected, refracted, diffracted, and scattered. The cumulative effect results in the signal

Two-way model also called as two path models is widely used path loss model. The free space model givea detail amount of above assumes that there is only one single path from the transmitter to the receiver.

It is actually experienced that the signal reaches the receiver through the multiple paths. The two path model strugglesto capture this phenomenon. The model assumes that the signal reaches the receiver through two paths, one a line-of-sight and the other the path through which the reflected wave is received.

According to the two-path model, the power which is received is given by

$$P_r = P_t G_t G_r \left(\frac{h_t h_r}{d^2}\right)^2$$

Where,

Pt is the transmitted power
Gt represent the antenna gain at the transmitter
Gr represent the antenna gain at the receiver
d is the distance between the transmitter and receiver
ht is the height of the transmitter
hr are the height of the receiver

Fading

Fading mentions the fluctuations in strength of the signal when the signal is received at the receiver. Fading can be classified into two types –
Fast fading/small scale fading and
Slow fading/largescale fading
Fast fading refers to the swift fluctuations in the amplitude,

phase or multipath delays of the received signal, due to the interference between the multiple versions of the same transmitted signal arriving at the receiver at slightly different time interval.

The time between the reception of the first version of the

signal and the last echoed signal can be expressed as delay spread. The multipath propagation of the transmitted signal, which causes fast fading, is because of the three propagation mechanisms, namely –

Reflection

Diffraction
Scattering

The multiple signal paths may sometimes add constructively or sometimes destructively at the receiver causing a variation in the received signal's power level. The received single

envelope of a fast fading signal is said to follow a Rayleigh distribution to see if there is no line-of-sight path between the transmitter and the receiver.
transmission lie between the transmitter and the receiver.

Slow fading is so called because the duration of the fade may last for multiple seconds or minutes.

When the receiver is inside a building and the radio wave

passes through the walls of a building slow fading occurs. The blocking object causes an irregular variation in the power of received signal.

Slow fading may causes the received signal power to vary, though the distance between the transmitter and receiver remains the same.

Slow fading can also be expressed as the shadow fading since the objects that cause the fade, which may be large buildings or other structures, block the direct transmission path from the transmitter to the receiver.

## Interference

Interference is the sum of all signal contributions that are neither noise not the wanted signal. Lets understand how its effect, its type and what possible source for it.

### Effects of Interference

- Interference is an important limiting factor in the performance of cellular systems.
- Interference degrades the quality of the signal.
- It initiates bit errors in the received signal.
- Bit errors are partly recoverable by means of the channel coding and the error correction mechanisms.
- The situation of the interference is not reciprocal to the uplink and downlink direction.
- Mobile stations and base stations are introduced to different interference situation.

### Sources of Interference

- When another mobile is present in the same cell.
- When a call is in progressin the neighboring cell.
- When other base stations areoperating on the same frequency.
- When any non-cellular system leaks energy into the cellular frequency band.

### Co-Channel Interference

- Co-channel interference occurs the because of frequency reuse, i.e. several cells use the same set of frequency.
- These cells are called co-channel cells.
- Co-channel interference cannot be combated by increasing the power of the transmitter. This is because an increase in carrier transmit power increases the interference to neighboring co-channel cells.
- To reduce the co-channel interference, the cells
  must be separated by a minimum distance to provide sufficient isolation due to propagation or reduce the footprint of the cell.
- Some factors other than reuse distance that influence co-channel interference are antenna type, directionality, height, site position etc.

### Indoor Propagation Models

It provides a alternative in to the nature of propagation over irregular terrain and the losses occurred due to obstacles in a radio path. The disadvantage of this model is it cannot assumes propagation effects due to foliage, buildings, and other manmade structures and does not supports multi path communication.

### Free Space Path Loss

The free space path loss model is not directly related with the indoor propagation. As it is required to compute the path loss at a close-in reference distance as desired by the models. The free space model gives a measure of path loss as a function of T-R separation when the receiver and transmitter are under the LOS range in a free space environment. The model is defined by equation given below, which depicts the path loss as a positive quantity in dB:

$$PL(d) = -10\log\left[\frac{G_t G_r \lambda^2}{(4\pi)^2 d^2}\right]$$

Where, $G_t$ and $G_r$ are the individual ratio gains of the transmitting and receiving antennas respectively, l gives the wavelength in meters, and d is the T-R separation in meters. When antennas are removed, we assume that $G_t = G_r = 1$. The free space path loss equation gives desired results only if the receiving antenna is in the far-field or Fraunhofer region of the transmitting antenna. The far-field denoted as the distance $d_f$ given by equation below.

$$d_f = \frac{2D^2}{\lambda}$$

Here, D = largest linear dimension of the antenna. Additionally, for a receiver to be assumed in the far-field of the transmitter, it must satisfy $d_f >> D$ and $d_f >> \lambda$.

### Log-Distance Path Loss

The log-distance path loss model assumes the path loss variations takes place exponentially with distance. The path loss in dB is given by equation (7.3).

$$\overline{PL}(d) = \overline{PL}(d_0) + 10n\log\left(\frac{d}{d_0}\right)$$

Where n gives the path loss exponent, d defines the T-R separation in meters, and $d_0$ defines the close-in reference

### An Additive Path Loss Model

An additional path loss model which has been found out by researchers is named as an additive path loss model. In this model, individual losses occured due to obstructions between transmitter and receiver are approximated and added together. Researchers have proposed tables of recorded average attenuation values for different obstructions including walls, floors, and doors. However, maximum of the recorded information is related to only a few carrier frequencies. Furthermore, the resulting attenuations are not equal among various researchers.

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