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Channel Modelling- Parameters and Conditions to be Considered

S. Venkateswarlu

Sreyas Institute of Engineering and Technology, Bandlaguda, Hyderabad, Telangana State-500068, India

Ch.Radika Rani

Department of Computer Science and Engineering, K.L. University Vaddeswaram, 522502, AP, India.

Abstract

Wireless communication using the mobile phone has become part and parcel of human daily life. This paper is focused on determining effective parameters that must be considered for developing the model which can be used for designing the communication channel. An effective model should be developed that caters for wireless communication using either narrow or wideband. A simulator must also be designed and developed which is absolutely required for testing the model roughly and also to analyze the performance of such as system.

Keywords: Channel Model, Parameters to be considered, Noise, Errors

1.0 INTRODUCTION

Communication using the wireless medium has been a primary means of beyond line of sight (LoS) communication. Despite the advent of several other kinds of transmitting media such as satellite, optical fiber, coaxial cables etc., wireless channel continues to be used extensively owing to the fact that it is economical and flexible. Wireless channels are extensively in use as they are cost effective and economical.

In sky-wave propagation, electromagnetic waves reach the distant receiving points after reflection from the ionized region in the upper atmosphere called Ionosphere either in single hop or multiple hops of reflections. The Ionosphere acts like a reflecting surface for frequencies between 2 and 30 MHz. It is made up of several ionized layers. The number of layers, the height and the amount of sky wave that can be bent by them will vary from time to time in much the same manner as does weather. As a result the signal waves that leave the transmitter at the same time may arrive at the receiver side through different routes leading to time dispersion. The signal received at an instant at the receiver side is the vector sum of all the waves received. This results in different distortions being introduced on the sky waves.

The conditions of Ionosphere are highly dependent on Sun and vary continuously. The variations are of 2 types: *normal and abnormal*. The abnormal variations are due to "Sudden Ionosphere Disturbances (SID) or Mongol-Dellinger effect, Ionosphere storms, sporadic E-layer reflections, tides and winds in ionosphere, sunspot cycles, fading, whistles" etc. Because of the random variations, the received signal strength will fluctuate. The undesirable change in intensity of the received signals is known as *Fading*. This is one of the main technical problems that effect the wireless communication system. These can cause total fadeout or sometimes fading of signal strength up to 20 dB.

Fading is, the time difference between the expected time and the actual time of arrival of a signal at the receiver, effected due to various changes taking place in atmosphere. Rainfall is one of the atmospheric conditions that frequently lead to fading. This kind of a condition occurs in affixed environment. However in a wireless environment two antennae are used relative to each other for effecting communication. The effects on such a communication do not effect in a fixed environment as they change over time leading to complex transmission issues which must be considered while designing a communication system. Fading is caused by a number of factors namely

a. Multi path Propagation,

b. Ionosphere height variations with time,

c. Turbulence of Ionosphere,

d. Doppler Effect and

e. Atmospheric absorption and rain effects.

Magnitude of change in the amplitude of a signal changes as the frequency of the signal changes. The bandwidth is the measure of distance between two frequencies after which the signals are expected to be free from correlated fading which is the effect of one fading over the other.

Frequency components of a signal are independently effected when a frequency is selected from a fading channel. When a deep fade occurs only few of the frequency

components gets effected. The energy associated with each of the signal is dispersed or spread out in a time span. Due to this reason, the signals which are adjacent interfere with each other. To avoid interference of one signal with the other equalizers are used to reduce interference that exists between the symbols.

An equalizer consists of feed forward section and a decision device. The data sequence that is received from the channel by the receiving section of the model, which is to be equalized and previously detected symbols of the receiving section are applied to the feedback section as the input data. The feedback section will remove the portion of the noise and distortion produced by previously detected symbols, for estimating next set of data bits. Equalizer yields good performance in the presence of moderate to severe ISI in a fading radio channel.

Noise and multipath fading are the two aspects that effects the wireless communication. One has to estimate the extent to which the transmission is effected due to both theses aspects. Additive White Gaussian Noise (AWGN) channel is most effected due to theses aspects. AWGN channel is effected and gets degraded due to thermal noise that exists due to the very channel itself and also due the noise inherent in electronics used.

There can be multiple indirect paths that can exist between the transmitter and the receiver in which case Rayleigh fading can occur when no distinct line of sight exists. This kind of a situation is a worst case scenario. However Rayleigh fading can be analyzed analytically making it possible to analyze the performance characteristics of the channel in different operating environments such as downtown, rural or urban areas.

The existence of several indirect paths, and direct LoS is best represented by Ricianfading. This kind of fading occurs within environment which is localized and is contained within the indoor premises and the other hand Rayleigh channel is concerned with outdoor environment. The fading greatly differs when the channel dispersion takes place either indoor or outdoor. Rician fading also occurs within small cells or when environment is wide open.

Every channel can be characterized through a parameter which is the ratio of the power in the dominant path and scattered path. In the case of Rayleigh channel the power used in the dominant path is zero as it does not exists and therefore the ratio is zero. On the other hand, scattered path does not exist in the case of AWGN and therefore the power used in the scattered path is zero which leads and the ratio becomes infinite. Bit error rate drops drastically when the ratio of power consumed in the dominant and scattered path increases. AWGN exhibits excellent performance characteristics even in the presence of the noise on the other hand Rician channel exibits good performance when the ratio of power consumed by direct path and scattered path is huge. Larger ratio implies that environment in which the channel

operates is either close cells or wide open environment. The performance of either AWGN or Rician channels is good enough to support voice applications. When these channels are to be used for the transmission of digital data, more electronics is to be used for compensating the noise. Even though Rayleigh channel is a poor performance channel, the channel can still be used for transmission of digital data. No SNR (Signal to Noise) ratio helps to get good performance when the channel is fast fading.

Changes in path delay cause multipath spread and restricts the data rate. Frequency of the received signal changes, if distance between the receiver and the transmitter changes. This effect is known as Doppler spread. Phase errors will also be caused due to motion of either receiver or transmitter of Ionosphere layers. If a mobile radio transmitter with a frequency f_T approaches a stationary receiver at a velocity V_r the receiver will receive the signal with a frequency f_r which exceeds f_T by the Doppler frequency shift$f_{D,}$the magnitude of the received signal strength, relative velocity of approach affects the frequency of received signal.

While the data is being propagated towards the receiving system, errors may enter into the information that is being transmitted because of the atmospheric disturbances. The errors sometimes may even damage the entire information. The general idea for achieving error detection and correction is to add some redundancy into the message, which can be used by the receivers to check consistency of the delivered message, and to recover data if corrupted. Error-detection and correction schemes can be systematic or non-systematic.Systematic scheme derives a fixed number of redundant bits from the data that the transmitter transmits. The redundant bits are called check bits which are received and also computed based on received data bits. The comparison of the received and computed bits on the receiver side reveals the accuracy of transmission. If there is a mismatch, it can be concluded that an error has occurred at some point during the transmission and the receiver has to request for a retransmission of the same packet of data. This will lead to wastage of the time of transmission system and the receiver system. Non-systematic approach transforms the original message into an encoded message that has at least as many bits as the original message.

A scheme is to be selected which suits the characteristics of a communication channel for controlling the error and improves the performance. Errors occurs randomly at a specific probability in Memory-less models and errors occurs in burst manner in dynamic models There is a need to introduce error-detecting and correcting system and such a system can be distinguished between detecting the errors in case of random errors or burst errors.

One can see several advantages when a channel model is used especially the ability to evaluate the performance characteristics of the channel. Large number of channel

conditions when considered in a controlled manner, will help estimating the channel characteristics more precisely and accurately. A model will help to analyze the performance of several systems that uses same channel conditions. Several tests can be carried when the channel conditions are consistent.

The wireless channels are subjected to several interrelated phenomena and therefore leads to a medium that is highly variable. Managing the variability is a challenge. The possibility or the ability to evaluate the engineering designs which are put to implementation of real life engineering applications decides whether a design is proper or otherwise. It is necessary to use a model for designing the channels using shortened life cycles. Tools that implement the models make the design cycles shorter. The tools are invaluable that they not only help designing the basic factors, they also deal with evaluation of a design model.

Many conditions have to be handled and the conditions cannot be repeated in real-time. The condition that has occurred once cannot be repeated making testing of the communication channels impossible. However the channel conditions can be simulated using software and the same set of conditions can be repeated as many as required. Using simulation quantitative measurements of various parameters involved in designing a channel can be achieved. Theoretical concepts can be programmed within a software and the theoretical implementations provides a basis for developing the performance characteristics.

Thus, it is evident that the designing of efficient communication channels requires sophisticated modelling considering many of the associated factors and also be able test the exactness of the same through simulation as construction of a wireless channel system and then moving on to testing of the same is not practical or feasible.

Thus modelling plays important roles that it helps in simulating the channel conditions and helps in testing the efficiency of the channel. The models are useful for the development of software. All channel modelling theoretical concepts can be implemented within the software. The models also help in evaluating the performance characteristics of the channel. The channel models must be built considering various basic aspects of communication and also must support the processes using which performance evaluation can be carried.

2.0 PROBLEM DEFINITION

Estimating the communication channel to utmost accuracy is important for achieving reliable communication. Many factors that are inter-related in one way or the other are to be considered in designing the communication channel. A model representing the channel design is required to facilitate the study of the effect of one parameter over the other and also to assess the efficiency with which communication can be effected

using the channel. The model as such should truly represent the channel that has all valid characteristics.

A model needs to be tested thoroughly before the same is used for developing the real-life systems. Developing a real communication system using the model without testing the same for its correctness is quite expensive, risky and sometimes not feasible. Simulation based testing is an alternative that one needs to adapt for testing a designed model. The testing thus has to be carried thoroughly using a simulator. The simulator chosen must allow for exhaustive testing considering every aspect that has been included so as to confirm the exactness of the model. The model can only be moved to the development of the communication system after testing of the same and finding that the model meets all the desired characteristics.

Thus the problem is to determine a model which can be used for the development of the communication channel and also to develop a simulator that best tests the model exhaustively to ensure the exactness and correctness.

3.0 CONCLUSIONS.

Channel models have to be designed that considers various parametersthat effect the transmission of the data from transmitter to the receiver. Transmission is effected due to existence of various phenomena such as fading, Doppler effect etc. and therefore the design model must consider those phenomenon that effect the transmission. The scope of the research has been fixed considering various aspects that are related to parameter finding, modelling from transmission side, modelling from the receiver side along with the data recovery systems, developing and using a simulator for testing the design models for accuracy and to determine the optimized parameters that govern the model.

The theoretical foundations stated in the overview section clearly reflected the problem which is primarily the modeling of the channels and determination of the simulators which are suitable for undertaking the testing of the models designed.

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