An Extensive Review on Error Rate for Wireless Communication Channels

Nikhil Malkhede[1], Prof. Achint Chugh[2]

[1]Mtech. Scholar, [2]Research Guide

Department of Electronics and Communication, Mittal Institute of Technology, Bhopal

Abstract – Designing an efficient wireless communication system is always a challenge. With increase in demand for high data rate this task has become even more challenging. Wireless communications is, by any measure, the fastest growing segment of the communications industry. As such, it has captured the attention of the media and the imagination of the public. Fading and interference are the major performance degrading factors in wireless/mobile communications. In order to improve and testify the system's effectiveness to resist fading, modeling and simulation of communication system under fading channel is of great significance in the design of communication system. For different propagation environment, the characteristic of fading channel is diverse and complex. Therefore, design of proper fading model in particular communication circumstance is essential in this regard. Bit-error-rate (BER) is a key factor to measure the capacity and performance of communication system. Proposed work explores the characteristic and BER performance of AWGN Rayleigh Fading Channels with the help of literature survey.

Keywords- Bit error rate, AWGN, Rayleigh Fading Channels, wireless communication system.

I. INTRODUCTION

Fading is used to describe the rapid fluctuations of the amplitudes, phases, or multipath delays of a radio signal over a short period of time or travel distance. Fading is caused by interference between two or more versions of the transmitted signal which arrive at the receiver at slightly different times. This sort of fading is known as multipath fading shown by fig.1.1.

In urban areas, fading occurs because the height of the mobile antennas are well below the height of the surrounding structures, so there is no single line- of-sight (LOS) path to the base station. Even when LOS exists, multipath still occurs due to reflections from the ground and surrounding structures. The incoming radio waves arrive from different directions with different propagation delays. The signal received by the mobile at any point in space may consist of a large number of plane waves having randomly distributed amplitudes and phases. Even when a mobile receiver is stationary, the signal may fade due to movement of the surrounding objects in the radio channel.

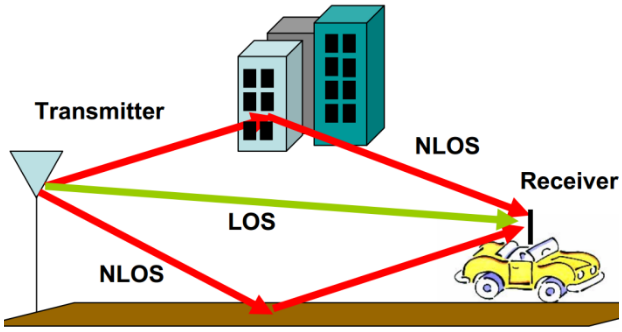

Figure 1.1 Multipath Transmissions.

The effects of multipath include constructive and destructive interference, and phase shifting of the signal. This causes Rayleigh fading, which would be elaborated on in the chapters that follow. The standard statistical model of this gives a distribution known as the Rayleigh distribution. Rayleigh fading with strong line of sight content is said to have a Rician distribution, or to be Rician fading.

A mobile channel is characterized by a multipath fading environment. Due to which the received signal contains not only the direct line-of-sight radio wave but also a large number of reflected waves that arrives at the receiver at different times. Delayed signals are a result of reflections from trees, hills, mountains, vehicles and building. These reflected delayed waves interfere with the direct wave causing inter symbol interference (ISI) and thereby loss of information and degradation of network performance. Frequency Division Multiplexing (FDM) was used for a long time to carry more than one signal over a telephone line. FDM divides the channel bandwidth into sub channels and transmits multiple relatively low rate signals by carrying each signal on a separate carrier frequency. To ensure that the signal of one sub channel did not overlap with the signal from an adjacent one, some guard-band was necessary which is an obvious loss of spectrum and hence bandwidth.

In order to overcome the problem of multipath fading environment and bandwidth efficiency OFDM technology was proposed. OFDM stands for Orthogonal Frequency Division Multiplexing. OFDM is a combination of modulation and multiplexing. OFDM is based on a parallel data transmission scheme that reduces the effect of multipath fading and makes the use of complex equalizers unnecessary. OFDM is derived from the fact that the high bit stream data is transmitted over large number sub-carriers (obtained by dividing the available bandwidth), each of a different frequency and these carriers are orthogonal to each other.

The idea of OFDM is to divide the original data steam into several parallel narrowband low-rate streams modulated on corresponding orthogonal sub-carriers. This orthogonality characteristic of OFDM system can also be understood in the view of frequency domain. As shown in Figure 1.2, all sub-carriers are controlled to maintain orthogonality by making the peak of each sub-carrier signal coincide with the nulls of other signals.

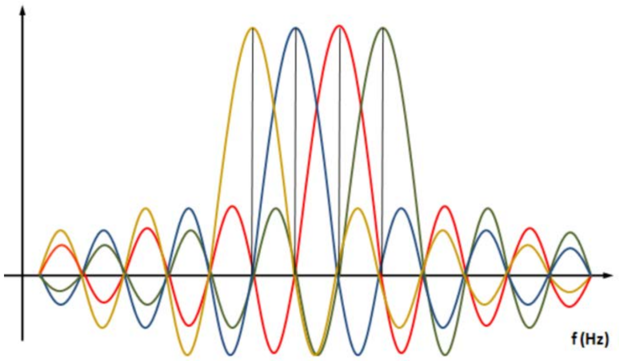

Figure 1.2 Frequency Spectrum of OFDM system sub-carriers.

The orthogonal characteristics of sub-carriers enable OFDM system to have higher spectral efficiency than conventional multi-carrier technique. For conventional multi-carrier techniques, guard intervals are inserted between sub-carriers so that sub-carrier signal can be separated from other signal by corresponding filter at the receiver. In the case of OFDM system, however, sub-carriers overlap each other and can be demodulated without guard interval. Another significant feature of OFDM system is that modulation and demodulation procedure is implemented by IFFT and FFT respectively, which will greatly reduce the complexity of equipment and structure.

II. MODULATION SCHEMES

For the generic communication system signals need to be modulated before being transmitted and they need to be demodulated after reception. Modulation is the process of encoding information from a message source in a manner suitable for transmission. It generally involves translating a baseband signal to a bandpass signal at frequencies that are very high when compared to the baseband frequency. The bandpass signal is called the modulated signal and the baseband signal is called the modulating signal. Demodulation is just the reverse process of modulation which is a process of extracting the baseband message from the carrier so that it may be processed and interpreted by the intended receiver.

Modern mobile communication systems use digital modulation techniques. Digital modulation is much more robust to channel impairments, has greater noise immunity and greater security then analog modulation techniques. New multipurpose digital programmable signal processors have made it possible for modulators to be implemented strictly by software rather then having particular modem design frozen as hardware.

There are various modulation schemes used in digital wireless communication, such as Differential Quadrature Phase Shift Keying (DQPSK), Gaussian Minimum Phase Shift Keying (GMSK) and Differential offset- Quadrature Phase Shift Keying (DO-QPSK). The modulation technique used in this research work is Differential Phase Shift Keying (DPSK). But to understand DPSK need to understand Binary Phase Shift Keying which is the basis of DPSK. Discrete phase modulation known as M-ary Phase Shift Keying, is among the most frequently used digital modulation techniques. Biphase or binary phase shift keying (BPSK) systems are considered the simplest form of phase shift keying (M=2).

Differential Phase Shift Keying is a non coherent form of phase shift keying which avoids the need for a coherent reference signal at the receiver. Non coherent receivers are easy and cheap to build, and hence are widely used in wireless communication. In DPSK systems, the input binary sequence is first differentially encoded and then modulated using a BPSK modulator.

As mentioned for BPSK and QPSK there is an ambiguity of phase if the constellation is rotated by some effect in the communications channel the signal passes through. This problem can be overcome by using the data to change rather than set the phase.

For example, in differentially-encoded BPSK a binary '1' may be transmitted by adding 180° to the current phase and a binary '0' by adding 0° to the current phase. The modulated signal is shown below for both DBPSK and DQPSK as described above. It is assumed that the signal starts with zero phase, and so there is a phase shift in both signals at t = 0.

III. LITERATURE SURVEY

SR. NO.	Title	Authors	Year	Methodology
1	Evaluation of BER for AWGN, Rayleigh fading channels under M-QAM modulation scheme,	M. Raju and K. A. Reddy,	2016	M-QAM modulation schemes are preferred because in this scheme more than one bit can be grouped and transmit at a time
2	Evaluation of BER of digital modulation schemes for AWGN and wireless fading channels,	B. L. Ahlem, M. Béchir Dadi and C. Belgacem Rhaimi,	2015	evaluation of BER is performed under AWGN, Rayleigh and Rician fading channels
3	Analytical evaluation of BER of the effect of cross-polarization in a polarization diversity MIMO satellite to ground link,	Sharif and S. P. Majumder,	2015	Analysis is developed to found the interference due to cross-polarization in a 2 * 2 MIMO satellite link
4	Evaluation of BER and capacity for ultra wide band communication receivers,	S. S. Pauline and C. V. Lakshmi,	2014	MAI (Multiple Access Interference) degrades the performance of UWB systems
5	Performance evaluation of fountain codes for MIMO-OFDM system over Rician faded channel,	K. Sharma, A. Verma, J. Kaur and Trishla,	2014	quantitative analysis of Fountain Coded Multiple Input Multiple Output (MIMO)
6	Iterative Joint Estimation Procedure for Channel and Frequency Offset in Multi-Antenna OFDM Systems With an Insufficient Cyclic Prefix,	C. Prieto del Amo and M. J. Fernández-Getino García,	2013	a strategy to improve the joint channel and frequency offset (FO) estimation in multi-antenna systems
7	BER evaluation/or 3×3 reconfigurable multiwavelength bidirectional optical cross-connect	S. K. Liaw, P. S. Tsai, Z. Ghassemlooy, H. L. Minh and W. F. Wu,	2013	a power-compensated, 3×3 reconfigurable, multiwavelength and bidirectional optical cross-connect (RMB-OXC)

M. Raju and K. A. Reddy, [1] The concert of wireless communication systems depends on wireless channel environment. By properly analyzing the wireless channels, develop an efficient wireless communication system. M-QAM modulation schemes are preferred because in this scheme more than one bit can be grouped and transmit at a time, which is very effective for band limited channels. M-QAM (M-Quadrature Amplitude Modulation) is the most effective digital modulation technique as it is more power efficient for larger values of M. In this work analyze OFDM system inimitability in AWGN (additive White Gaussian Noise) and Rayleigh fading channel using M-QAM modulation schemes. Rayleigh fading channel is describe by Clarke and Gans model. The performance measured in terms of bit error rate (BER) is evaluated for M = 4, 8 and 16 modulation schemes of M-QAM numerically and verified our analytical results by computer simulation. It has been demonstrated that the BER increases as the modulation order increases.

B. L. Ahlem, M. Béchir Dadi and C. Belgacem Rhaimi,[2] With the growing development of digital communication systems, it has became necessary to ensure the quality of service for real-time transmission of video applications and give users more powerful and efficient services by using better techniques. Digital modulation techniques have various performance characteristics power efficiency, Bandwidth efficiency, Error rate, cost etc. The M-ary Phase Shift Keying and M-ary Quadrature Amplitude Modulation are used in wireless communication to check test the performance of fading channels. In this work, evaluation of BER is performed under AWGN, Rayleigh and Rician fading channels. Among these channels, Rician has showing better performances a compared to AWGN and Rayleigh channels.

Sharif and S. P. Majumder,[3] An analytical approach is presented to evaluate the effect of cross-polarization in a polarization diversity MIMO satellite to ground link. Analysis is developed to found the interference due to cross-polarization in a 2 * 2 MIMO satellite link. The expression of signal to interference plus noise ration (SINR) is developed. The Bit-Error-Rates(BER) performance results are evaluated for different environments like Open Area, Sub-urban, Urban Area and Aeronautical/Marin Area. It is found that the satellite to ground link suffers power penalty due to the cross-polarization which is significant for A/M A and least penalty for OA environment.

S. S. Pauline and C. V. Lakshmi,[4] UWB(Ultra Wide Band) is a radio technology that transmits information spread over a large bandwidth. These systems share the radio frequency spectrum with narrowband signals and also provide high data rates, greater bandwidth and improved channel capacity. Hence it has attracted a lot of interest in researchers worldwide. The various design challenges include channel estimation and interference mitigation. MAI (Multiple Access Interference) degrades the performance of UWB systems. To suppress the multiple access interference, an α-stable model along with Fama/Roll-McCulloch parameter estimation technique is proposed. This model adapts to the noise and interference in the environment and hence it forms a robust technique for adaptive receiver designs. From simulation results, it is verified that the proposed method provides better Bit Error Rate and capacity performance than the linear detectors.

K. Sharma, A. Verma, J. Kaur and Trishla, [5] Fountain Codes are referred to as a class of rateless codes'41 which efficaciously improves the performance of systems used for wireless data transmission. In this work, present a quantitative analysis of Fountain Coded Multiple Input Multiple Output (MIMO) - Orthogonal Frequency Division Multiplexing (OFDM) systems over Rician faded channel. Bit Error Rate (BER) performance evaluation and comparison is carried out on Fountain Coded and Convolution Coded MIMO - OFDM systems for a range of antenna configurations. Utilizing this model investigated the performance merits of Fountain Codes in comparison to that of MIMO - OFDM and Convolution Codes. The simulated results in terms of BER shows that Fountain Coded MIMO - OFDM system has a coding gain of 3 dB as opposed to Convolution Coded MIMO - OFDM system.

C. Prieto del Amo and M. J. Fernández-Getino García, [6] This work addresses a strategy to improve the joint channel and frequency offset (FO) estimation in multi-antenna systems, widely known as multiple-input-multiple-output orthogonal frequency-division multiplexing (MIMO-OFDM), in the presence of intersymbol interference (ISI) and intercarrier interference (ICI) occasioned by an insufficient cyclic prefix (CP). The enhancement is attained by the use of an iterative joint estimation procedure (IJEP) that successively cancels the interferences located in the preamble of the OFDM frame, which is used for the joint estimation and initially contains the interferences due to a CP shorter than the channel length. The IJEP requires at certain steps a proper iterative interference cancellation algorithm, which makes use of an initial FO compensation and channel estimation obtained due to the use of a symmetric sequence in the preamble. After the iterative cancellation of interferences , the procedure performs an additional joint channel and FO estimation whose mean square error converges to the Cramér-Rao bound (CRB). Later on, this subsequent joint estimation permits the removal of the interferences in the data part of the frame, which are also due to an insufficient CP, in the same iterative fashion but saving iterations compared with the use of other estimation strategies. The appraisal of the procedure has been performed by assessing the convergence of the simulated estimators to the CRB as a function of the number of iterations. Additionally, simulations for the evaluation of the bit error rate (BER) have been carried out to probe how the utilization of the proposed IJEP clearly improves the performance of the system. It is concluded that, with a reduced number of iterations in the preamble, the IJEP converges to the theoretical bounds, thus reducing the disturbances caused by a hard wireless channel or a deliberately insufficient CP. Therefore, this eases the interference cancellation in the data part, leading - o an improvement in the BER that approximates to the ideal case of a sufficient CP and, consequently, an improvement in the computational cost of the whole procedure that has been analyzed.

S. K. Liaw, P. S. Tsai, Z. Ghassemlooy, H. L. Minh and W. F. Wu [7] The exploration presents a power-compensated, 3×3 reconfigurable, multiwavelength and bidirectional optical cross-connect (RMB-OXC) for all-optical communications networks. RMB-OXC characteristics and its performance are experimentally verified in a bidirectional 8-channel × 10 Gb/s capacity system. Observed only ~0.5 dB power penalty in the bidirectional transmission in comparison to the unidirectional transmission. The proposed RMB-OXC can be utilised in many applications in high-speed wavelength division multiplexed (WDM) networks.

IV. PROBLEM DOMAIN

The main problem of mobile systems undergoes severe degradation because they suffer from fading in a mobile environment. Because the channel is a randomly behaving entity, it will change the transmitted signal randomly and if do not coherently detect and demodulate the signal, reconstruction is impossible. Fading due to various factors like speed of the transmitter, speed of the receiver, speed of the surrounding objects, channel parameters, like delay and Doppler spread, gives rise to bit error rates (BER), which generally means that the transmitted signal gets corrupted by the channel and the average probability of bit error is what will be considering here.

For wireless communication, OFDM is good multi-carrier scheme due to its nature of strong resistance to interference and high spectra efficiency, high data rate transmission. Channel estimation methods can be classified into two categories: blind channel estimation and pilot-aided channel estimation. The channel estimation techniques studied in the work are all pilot-aided, for pilot-aided channel estimation are more applicable in fast-fading frequency selective radio propagation channel. Different pilot insertion patterns results in diverse BER performances.

V. CONCLUSION

In this work Performance analysis is studied for a wireless mobile communication system with and without space diversity using different transceiver antenna configuration in the presence of slow and fast Rayleigh fading. Also investigated the Channel estimation techniques to overcome frequency selective fading and fast fading channel. BER is the key parameter for indicating the system performance of any data link. The lower order modulation schemes (BPSK and QPSK) experience less BER at receiver thus lower order modulations improve the system performance in terms of BER. Bit error rate (BER) performance of some of digital modulation schemes and different wireless communication techniques are studied and observed in additive white Gaussian noise (AWGN) and fading channels.

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