Evaluation of BER for AWGN, Rayleigh Fading Channels under QAM Modulation Scheme: Review

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Abstract - 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. 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 technologies are implemented in order to estimate the effect of propagation delay and channel synchronization. Channel estimation methods can be classified into two categories: blind channel estimation and pilot-aided channel estimation.

Keyword – OFDM, BER, QAM, Modulation scheme. Fading Channel.

I. INTRODUCTION

The third generation (3G) wireless communication systems, mainly based on the WCDMA technology, have been confronted with a number of new challenges regarding to the design of the required wireless communication systems. The main challenges the 3G technology has been facing can be summarized as follows:

The typical delay spread observed in wireless channel puts a strong limitation on the symbol duration period if it is transmitted serially. To struggle with the time delay spread of the wireless channel, the delay spread should be smaller than the symbol period, which is not the case for high data rate serial transmission, where, in general, the delay spread is much bigger than the transmitted symbol period. It is well known that the delay spread of the channel causes Inter Symbol Interference (ISI) which can be undone often only partially by means of complex equalization procedures. In WCDMA, since the signal is transmitted serially in time it is highly challenging to increase the data rate of the transmitted signal.

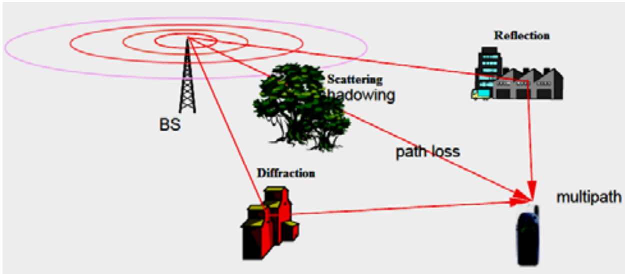

Figure 1.1 Wireless communication environments.

To contend with the above mentioned challenges and to achieve good system performance, the choice of an appropriate modulation and multiple access schemes applicable to mobile wireless communication systems is then critical. In this context, the parallel multi carriers schemes have shown their efficiency in many wireless applications. More specifically, the Orthogonal Frequency Division Multiplexing (OFDM) which is a special case of multi carrier transmission is a good choice. In OFDM, the frequency selective fading wide band channel is used as frequency multiplex of non frequency selective (flat fading) narrow band parallel sub channels. To avoid the need to separate the carriers by means of guard-bands and therefore make OFDM highly spectrally efficient, the sub channels in OFDM are overlapping and orthogonal. Initially, only analog design was considered, using banks of sinusoidal signal generators and demodulators to process the signal for multiple sub channels. The tremendous advancement in digital signal processing made the implementation of digitally designed OFDM possible and cost effective using the Discrete Fast Fourier Transform (DFFT).
Bit-error-rate (BER) is a key factor to measure the capacity and performance of communication system. Much effort has been made to explore the characteristic and BER performance of hyper-Rayleigh fading. However, there is little work on evaluating BER performance of OFDM system under such radio propagation environment. Herein, the research exploration is focused on the investigation of OFDM system performance under various fading environment, especially hyper-Rayleigh fading. 2-D pilot-aided channel estimation, convolutional coding and cyclic

prefix are also implemented in OFDM system. The performance of OFDM system can be determined by evaluating system's BER.

II. SYSTEM MODEL

Orthogonal Frequency Division Multiplexing (OFDM), which is also referred to as Discrete Multi-tone Modulation (DMT), is a multi-carrier transmission technique, is widely applied to wireless communications, such as digital audio broadcasting, digital video broadcasting and wireless local area network (WLAN). OFDM is also regarded as one of the most promising technologies for the fourth generation (4G) mobile communication system. OFDM technology has distinctive advantages on high data transmission, anti-interference and low equipment complexity.

A. Principle of OFDM system

The idea of OFDM is to divide the original data steam into several parallel narrowband low-rate streams modulated on corresponding orthogonal sub-carriers [7]. To be specific, each sub-carrier has integer periods in OFDM symbol duration. Neighboring sub-carriers have one period difference to maintain orthogonality. This orthogonality characteristic of OFDM system can also be understood in the view of frequency domain. As shown in Figure 2-1, all sub-carriers are controlled to

maintain orthogonality by making the peak of each sub-carrier signal coincide with the nulls of other signals.

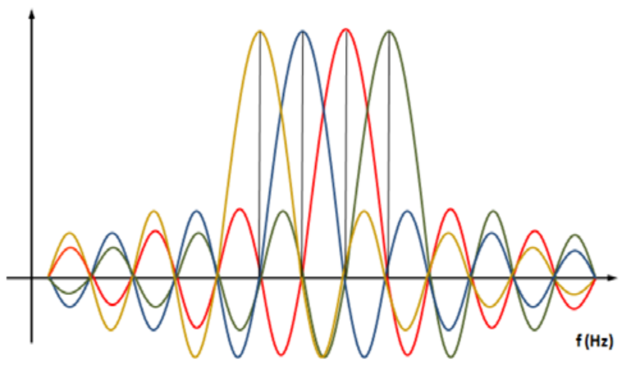

Figure 2.1 Frequency spectrums of OFDM sub carriers.

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.

B. Model of OFDM System

OFDM system is presented in figure 2.2, where some significant functions are analyzed. Coding and modulation schemes are essential in developing a feasible OFDM communication system. Moreover, cyclic prefix is considered as an indispensible part of OFDM system to combat inter-carrier interference (ICI), since OFDM system is particularly vulnerable to ICI.

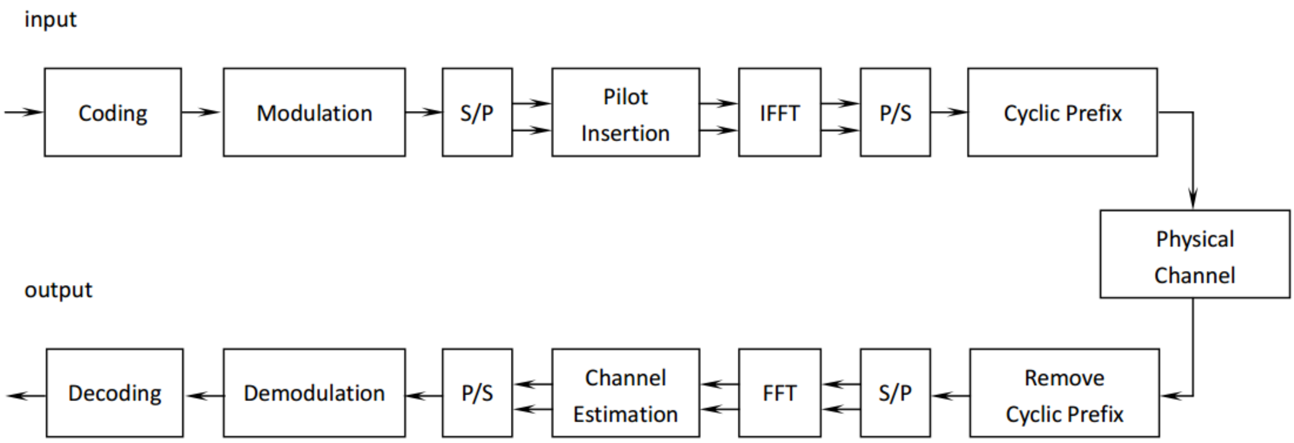

Figure 2.2 System model of OFDM.

C. Modulation Scheme

Modulation is the technique by which the signal wave is transformed in order to send it over the communication channel in order to minimize the effect of noise. This is done in order to ensure that the received data can be demodulated to give back the original data. In an OFDM system, the high data rate information is divided into small packets of data which are placed orthogonal to each other. This is achieved by modulating the data by a desirable modulation technique (QPSK). After this, IFFT is performed on the modulated signal which is further processed by passing through a parallel - to - serial converter. In order to avoid ISI we provide a cyclic prefix to the signal.

D. Demodulation

Demodulation is the technique by which the original data (or a part of it) is recovered from the modulated signal which is received at the receiver end. In this case, the received data is first made to pass through a low pass filter and the cyclic prefix is removed. FFT of the signal is done after it is made to pass through a serial - to - parallel converter. A demodulator is used, to get back the original signal.

The bit error rate and the signal - to - noise ratio is calculated by taking into consideration the un - modulated signal data and the data at the receiving end.

E. Bit Rate and Symbol Rate

The signal bandwidth for the communications channel depends on the symbol rate or also known as band rate.

$$Symbol\ rate = \frac{Bit\ rate}{Number\ of\ bit\ trsnmitted\ \ per\ symbol} \ldots .(1)$$

Bit rate is the sampling frequency multiplied by the number of bits per sample. For example, a radio with an 8-bit sampler is sampled at 10 kHz for voice. The bit rate, the basic bit stream rate in the radio, would be 8 bits multiplied by 10k samples per second giving 80 kbps.

- Bit Error Rate (BER)

BER is a performance measurement that specifies the number of bit corrupted or destroyed as they are transmitted from its source to its destination. Several factors that affect BER include bandwidth, SNR, transmission speed and transmission medium.

- Signal-to-Noise Ratio (SNR)

SNR is defined as the ratio of a signal power to noise power and it is normally expressed in decibel (dB). The mathematical expression of SNR is

$$SNR = 10log_{10}\frac{Signal\ Powe}{Noise\ Power}\ dB \ldots \ldots \ldots \ldots \ldots \ldots (2)$$

III. PREVIOUS WORK

M. Raju and K. A. Reddy,[1] The concert of wireless communication systems depends on wireless channel environment. By properly analyzing the wireless channels, we can 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 research work, we 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.

J. A. Sheikh, Uzma, S. A. Parah and G. M. Bhat,[2] The work in the field of wireless communication these days is directed towards the efficient usage of the available spectrum as the spectrum scarcity keeps haunting people in general and communication engineers in particular. This puts an upper limit on the development of new spectrum hungry applications. Spectral efficiency has thus given new direction to the researchers to look for the available option for better utilization of spectrum and to develop techniques that will be compatible with the existing technology. The work presented in this research work is also an attempt towards this direction. The idea is to use the Multiple Input Multiple Output Orthogonal Frequency Division Multiplexing (MIMO-OFDM) for transmission of image data with improved Bit Error Rate (BER) and Pixel Error Rate (PER) as the performance of most of the communication systems developed is measured, in the most common parlance, in terms of BER. The bit error has been improved using bit level scrambling in addition to the convolutional coding. A MATLAB program has been developed to model the MIMO-OFDM system. The model under consideration prompts the user for various inputs and then produces the results in terms of various plots and graphs. The results confirm the significant improvement in the BER and PER of the system.

R. Yoshizawa and H. Ochiai [3] Active constellation extension (ACE) has been proposed for a peak-to-average power (PAPR) reduction of orthogonal frequency-division multiplexing (OFDM) signals, which projects the clipping noise generated by iterative clipping and filtering (CAF) onto the outside region of the constellation such that its minimum Euclidean distance (MED) is not reduced. Due to this arrangement, some amount of average power increase is introduced, but ACE can achieve better trade-off between uncoded bit-error rate

(BER) and power amplifier (PA) efficiency compared to simple CAF. However, the coded BER of ACE has not been analyzed so far, where the degradation of signal-to-noise power ratio (SNR) due to the average power increase may have dominant effect on the performance. Moreover, in order to perform effective error correction, the statistical property of the clipping noise imposed by ACE should be developed. This research work empirically models the clipping noise distribution after ACE such that soft decoding can be employed at its receiver, and investigates its performance in terms of mutual information and coded BER employing near optimal channel coding. It is revealed that the simple CAF may outperform the ACE in terms of both PA efficiency and BER performance when both are protected by practical channel coding.

Y. Goto et al. [4] Light-emitting diode (LED) transmitters based optical wireless communication (OWC) systems offer the potential for new generation communication systems. Particularly, an image sensor based OWC systems consist of the LED transmitters and camera receivers are expected to contribute to intelligent transport system (ITS) for driving supports. For high achievable data rates, orthogonal frequency division multiplexing (OFDM) based OWC systems have attracted a great deal of attention. Despite attractive features of optical OFDM, only few attempts have so far been made to adopt it as a modulation scheme of an image sensor based OWC system. There remains a need for an evaluation of adopting an optical OFDM to the image sensor based OWC systems. Another important issue needs to be addressed is the performance degradation due to a frequency response of an actual image sensor device, especially a signal attenuation loss in higher frequency. In addition to such loss, a narrow band noise generated by its circuits also degrades the performance. The purpose of this research work is to investigate BER performances of the optical-OFDM using an actual image sensor device, the optical communication image sensor (OCI). From simulation results, it is found that the frequency response and the narrowband noise at 12MHz of the OCI lead to the significant reduction of BER performances. Additionally, the results shows that ACO-OFDM shows a little better performance compared to DCO-OFDM with the same bandwidth efficiency.

M. Thanigasalam and P. Dananjayan,[5] Orthogonal Frequency Division Multiplexing is a highly flexible multicarrier modulation technique adapted in frequency selective and time variant wireless channels. In spite of its many advantages, OFDM suffers from high PAPR. Many methods of PAPR reduction techniques have been proposed. Of these, PTS is a distortion-less method of PAPR reduction. But PTS involves more computational complexity with increase in subblocks. To address the issue of high computational complexity, Modified PTS is used. Modified PTS is based on neighbourhood search algorithm, wherein a threshold PAPR is assumed to search the optimum set of phase factors. The optimum set of phase factors are then used to obtain OFDM signal with low PAPR. By combining Modified PTS and interleaving, a further reduction in PAPR is achieved. In this research work, the performance of OFDM receiver is analyzed using MMSE channel estimation. The parameters MSE and BER are used to evaluate the performance of MMSE OFDM receiver. Simulation results show that BER performance improves with reduction in PAPR.

S. R. Chaudhary and M. P. Thombre,[6] In recent years, wireless broadband communication has gained attention due to ever growing demands of multimedia and internet services. The major challenges faced by wireless communication are availability of resources like bandwidth and transmission power. Also the wireless channel suffers from impairments like fading and interference. Technologies that achieved above requirements are Multiple Input Multiple Output (MIMO) and Orthogonal Frequency Division Multiplexing (OFDM). Channel impairments must be mitigated at the receiver by using equalization techniques. In this research work, BER performance improvements of MIMO-OFDM systems using different equalization techniques such as Zero forcing (ZF), Minimum mean square error (MMSE) and Maximum likelihood (ML) are shown and compared. Simulations are carried out under Rayleigh frequency flat channels.

IV. PROBLEM STATEMENT

The error rate in Rayleigh fading channel is also higher than the AWGN channel for same signal. So to provide a reliable communication along with the high data rate, there should be a tradeoff between modulation order and signal power. Bit error rate is major issue in wireless communication system due to fading of the signal and the other impacts are discussed.

V. CONCLUSION

To write a review number of literatures are studied in this brief its investigated the various impact of channel fading on bit error rate in OFDM channel different modulation techniques are used to optimize the Bit error rate and loss o signal and performance enhancement. Due to the limited time, issue of Synchronization is not included in the research exploration, which is, however, an essential issue in developing OFDM system. Accurate synchronization is necessary for OFDM system, since sub-carriers need to be kept strictly orthogonal. The characteristic and applicability of three-wave with diffuse power model has gained more and more attention, which may probably better represent the propagation situation of hyper-Rayleigh fading.

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