Evaluation of BER for AWGN, Rayleigh Fading Channels under M-QAM: A Review

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Abstract - An increasing demand for high data rates in wireless communications has made it essential to investigate methods of achieving high spectral efficiency which would take into account the wireless channel. M-QAM (M-Quadrature Amplitude Modulation) is the most effective digital modulation technique as it is more power efficient for larger values of M [1] which helps to maximize the data rates that can be transmitted over wireless channels. The technique accomplishes this by adapting to the changing channel conditions and by making use of spectrally efficient modulation schemes like Quadrature Amplitude Modulation (QAM). As compared to QAM, adaptive modulation achieves similar spectral efficiency with better energy efficiency. When channel conditions are poor, energy efficient schemes such as BPSK or QPSK are used.

Keywords – QAM ,MQAM,OFDM,BER,SNR.AWGN.

I. INTRODUCTION

The appearance of the digital technologies provided the second generation of wireless mobile networks with strong advantages. In this line, it was the beginning of the digital radio signals and its standards can be divided in two main groups depending on the channel access method, TDMA-based (the most important is GSM) and CDMA- based. From a network perspective, the waveform transmitted for both options were a evolution in mobile communications. In the case of GSM, the first systems were using a Frequency Division Multiple Access (FDMA), splitting the bandwidth in several carrier frequencies. Moreover, the resources for each of these frequencies were shared using a Time Division Multiple Access (TDMA) technique, splitting the voice or data information in fragments and transmitting them over time slots. From the user perspective, the main difference with the 1st generation was that in addition to the voice traffic it was also possible to send data at a very low rate. The communications were digitally encrypted and the networks started offering innovative services such as short text messages (SMS).

In between the second and the launch of the third generation we find what it is commonly known as 2.5G. In this category are included GPRS and the subsequent EDGE technology that can be considered an expansion of GSM. This intermediate step is justified by the demand of higher data rates that at the same time made affordable the creation of other services such as the MMS (Multimedia Message Service).

The third generation of mobile telecommunications technology is based on the standards designed around the specifications of the IMT-2000, a group specifically created by the ITU for this purpose. 3G uses W-CDMA as it most widespread technology providing better spectral efficiency with a bigger range of services. The 3G data traffic rate for the downlink varies between approximately 400 kbit/s of the firsts standards and more than 100 Mbits/s for the latest releases (HSPA+). Currently we are in a phase characterized for the commercialization of 4G products. However, as it was discussed in the previous point, the market trend always points higher, so the investment and research on the future generation already started a few years ago. The predictions for the upcoming years are elaborated based in studies on long term historical tendency within information technologies, regarding several aspects, including the services already known to be incorporated in the near future.

High-speed data transmission over wireless channels has been an area of intensive research in past years. One of the frequently occurring problems in wireless communications is signal multipath - the transmitted signal arrives at the receiver through multiple propagation paths with different delays. As a result, those signal components from different paths may add up destructively or constructively, causing signal fading - variation in the received signal strength. This situation is aggravated by the time-variant nature of wireless channels, where those multiple propagation paths vary with time. To demodulate the received signal coherently, this time-variant channel state information must be accurately estimated. The error rate in Rayleigh fading channels decreases only inversely with signal-to-noise ratio (SNR), while it decreases exponentially with SNR in nonfading channels. Therefore in multipath fading channels, a large amount of transmitting power is required to achieve a low probability of error.

For fast multipath fading channels, it remains a challenging task to estimate time-variant and frequency-selective channel state information efficiently. Since the fading on each individual path can be treated as flat, efforts have been made to resolve multiple paths and estimate the parameters of each path separately. One of them is the Rake receiver for DS-CDMA (Direct-Sequence Code Division Multiple Access), where each Rake finger handles one path with a certain delay. But the resolution of this method depends on the channel bandwidth, which limits it mostly to wide-band signals. For narrow-band signals, oversampling, either spatial or temporal, must be used to resolve multiple paths. With multiple antennas coming into use more and more frequently, the problem of channel estimation in fast multipath fading channels demands more and more attention. Recently, a special form of multicarrier communications, orthogonal frequency-division multiplexing (OFDM), has received much attentions due to its simplicity in implementation - it uses the IFFT at the transmitter and the FFT at the receiver.

Orthogonal Frequency Division Multiplexing (OFDM) is a modulation technique for the transmission of data over a group of subcarriers. The main benefit of this format is the orthogonality between the subcarriers, what brings the possibility of setting a very narrow space between subcarrier while avoiding their mutual interference.

Although OFDM is known for a long time, its practical application in wireless communication was unaffordable until recently, given the complexity of the equipment needed at both ends. However, OFDM practical implementation has become possible with the introduction of the IFFT. OFDM use is nowadays very extended, being the modulation technique implemented in LTE for the downlink. It is also the radio transmission format for the standards IEEE 802.11a/g (WiFi).

Figure 1.1 shows the spectrum in absolute value for the case of 5 subcarriers. As it can be observed, each subcarrier is located so its nulls coincide with the frequencies of the others subcarriers. Therefore, each channel can be demodulated at the receiver independently without any leakage from other subcarriers.

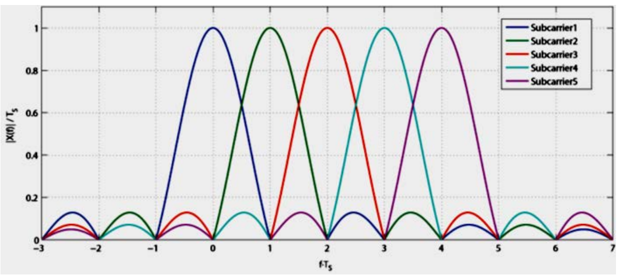

Figure 1.1 Orthogonal subcarriers.

II. OFDM MODEL

The understanding of the blocks constituting the scheme is particularly relevant since many of the other access techniques can be considered as a modification of the one used for OFDM.

A. Transmitter

Figure 2.1 represents the basic scheme used for the transmission in a OFDM modulation technique. On it we can see the different blocks that take part in the modulation process.

Assuming a serial stream of binary digits as an input, the first procedure is the symbol mapping. The bits are mapped to a correspondent symbol stream using a modulation constellation. Dependent on the characteristic of the radio channel it can be selected a more packed constellation.

B. Receiver

The scheme used for the OFDM receiver is represented in Figure 2.2. Most of the blocks used in the scheme are similar to the ones explained in the previous point, thus, just a brief exposition of their function will be state. As it can be observed in the figure, the distribution of the blocks is nearly symmetrical to the receiver, presenting at every step a block with an inverse functionality. The first block is the analogue to digital converter, which will also work with a sampling frequency established in function of the number of subcarriers and the space between their respective frequencies.

C. Fading Channels

development in mobile and wireless communications, the problem of system design for reliable, high-speed data transmission over fading channels have received considerable interests in recent years. Various newly developed techniques have been combined together to combat fading and improve the system performance. Pilot symbol-assisted modulation (PSAM) turbo codes and joint iterative channel estimation and decoding, have been applied together for the demodulation of BPSK signals transmitted over Rayleigh fading channel. However, due to the inherent drawback of the BPSK signal, the above system has limited power and bandwidth efficiency. the system design of transmitting QAM signals over Doppler fading channels. Among fading channels, two kinds of them are of particular interest to us. One is the flat-fading channel, the other is the multipath fading channel, where multipath will cause frequency- selective fading. In the flat fading channel, investigate the application of iterative channel estimation and decoding for turbo-coded M-QAM signals. Pilot symbols are inserted periodically in the encoded data stream for the estimation of the time-variant channel state information (CSI).

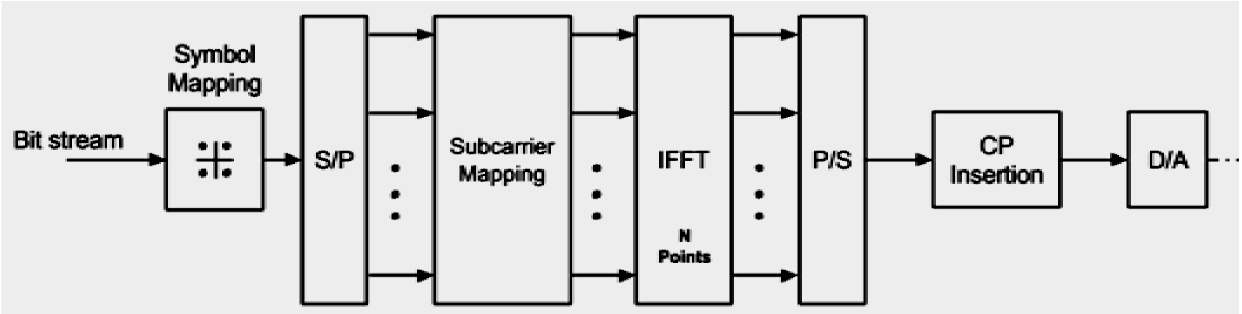

Figure 2.1 OFDM scheme for transmitter.

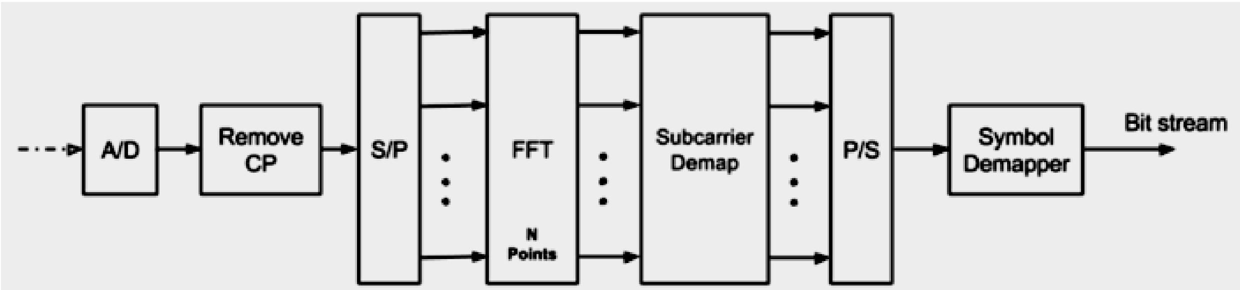

Figure 2.2 OFDM scheme for receiver.

D. Bit-Error-Rate (BER)

In analyzing the performance of a system, the quality of the output of the detector in the presence of noise in the channel and transceiver components is measured via a parameter known as the signal-to-noise ratio (SNR). Moreover, for a given transmitted power and noise in the system, such a quality depends on the type of the modem used. In other words, a modem with a higher immunity to noise allows more noise to be tolerated or less power to be transmitted and still achieve a desirable performance. In addition, a measure of how well the corrupted signal is detected is the frequency of occurrence of errors in the decoded sequence - which is the average probability of bit-error. This is measured by the system performance metric, BER defined as the average number of erroneous bits observed at the output of the detector divided by the total number of bits received in a unit of time [2]. In digital modulation, BER is expressed in terms of the SNR.

III. PRIOR 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, 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.

T. Padhi, M. Chandra and A. Kar, [2] Wireless communication technologies have evolved by leaps and bounds in modern times. The ease of communication at the user end and the growth of feature rich mobile systems over the years has added to the ever increasing demand of higher data rates in a communication system. MIMO-OFDM systems have been a breakthrough in achieving appreciable data rates while keeping the issues faced in communication systems at bay. Channel Equalization in MIMO-OFDM systems is an area that has been extensively researched upon with the passage of time, to boost the data rates for high speed communication. In this article, performance analysis of a Fast Recursive Least Squares (FRLS) based adaptive channel equalizer for MIMO-OFDM systems employed in signal transmission using Binary Phase Shift Keying (BPSK) modulation was done and compared with the much popular Zero-forcing equalizer (ZF) and Minimum Mean Square Error (MMSE) equalizer. A qualitative analysis of the robustness of channel equalizers in a MIMO-OFDM systems with two transmit and two receiving antennae, was carried out. Simulations over a wide range of SNRs was done and Bit Error Rate (BER) was determined.

O. Popescu and D. C. Popescu [3] This research studies physical layer performance of LTE and WiMAX schemes used in fourth generation (4G) wireless communication systems when multiple antennas are employed in the receiver to provide diversity. Bit Error Rate (BER) plots obtained from simulations are presented to evaluate system performance with and without diversity and to do a side-by-side comparison of the two main 4G wireless technologies.

J. D. Kene and K. D. Kulat,[4] Turbo code provides relatively better performance as compare to convolution codes at lower Signal to Noise Ratio. Turbo code offers an outstanding coding gain very close to Shannon limit over an AWGN channel to achieve maximum throughput particularly for WiMAX application. The objective of this research is to Study the Mobile WiMAX system performance by implementing the turbo codes using Soft Output Viterbi Algorithm (SOVA). Turbo decoder is optimized by modifying the SOVA that contributed to the system performance optimization. For different transmission conditions, BER performance has been simulated and compared to the conventional Log-MAP decoding algorithm. The performance of mobile WiMAX system has also been tested for the effect of various Decoding algorithms, Frame size and Code rates.

M. Wu, D. Wübben and A. Dekorsy[5] In this research we develop a power allocation scheme for single-relay systems applying Decode-and-Forward (DF) based on the resulting bit error rate (BER) at the destination. First, an analytical expression for the BER of M-QAM modulation considering estimation errors at the relay is derived. Based on this expression, the total transmit power is optimally assigned to the source and the relay in order to minimize the probability of errors at the destination. The preciseness of the derived closed form expression as well as the superior performance of the proposed DF-based relaying system are demonstrated by simulation results.

C. Poongodi, P. Ramya and A. Shanmugam,[6] With the rapid growth of digital communication in recent years, the need for high speed data transmission is increased. OFDM is a promising solution for achieving high data rates in mobile environment, due to its resistance to ISI, which is a common problem found in high speed data communication. A multiple-input multiple-output (MIMO) communication System combined with the orthogonal frequency division multiplexing (OFDM) modulation technique can achieve reliable high data rate transmission over broadband wireless channels. In thisresearch we will investigate the estimation of channel at high frequencies with conventional Least Square (LS) and Minimum Mean Square (MMSE) estimation algorithms which is carried out through Matlab simulation. The bit-error rate (BER) of multilevel quadrature amplitude modulation (M-QAM) in flat Rayleigh fading channel is also analyzed. The performance of MIMO OFDM is evaluated on the basis of Bit Error Rate (BER) and Mean Square Error (MSE) level.

IV. PROBLEM STATEMENT

The signal power is increases the error rate decreases in both AWGN & Rayleigh fading channel but error rate increases as the value of modulation scheme M increases. 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 [1].

V. CONCLUSION

Orthogonal Frequency Division Multiplexing (OFDM) is a multi-carrier modulation technique, in which a single high rate data-stream is divided into multiple low rate data-streams and is modulated using sub-carriers which are orthogonal to each other. Major advantages of OFDM are its multi-path delay spread tolerance and efficient spectral usage by allowing overlapping in the frequency domain. The brief presented the modulation technique for the OFDM system fading channel and also analyzed the performance of the different modulation with reference to the literature survey.

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