BER Estimation: Mitigation Methods

Savita
Assistant Professor, Deptt.of ECE
Manav Rachna International University (Faridabad)

ABSTRACT
Several transmission modes are defined in IEEE 802.11 a/b/g WLAN standards. A very few transmission modes are considering for IEEE 802.11 a/b/g in physical layer parameters and wireless channel characteristics. In this paper, a MATLAB based approach for is used for BER estimation of AWGN channel using Monte-Carlo method. Further BER estimation of AWGN channel is compared with that of Rayleigh fading channel. MATLAB based Monte Carlo simulation example is presented, which comprises performance estimation of Binary phase shift keying (BPSK) signaling over a Rayleigh fading channel [13].Also various mitigation effects are studied and their effects are shown[11].

General Terms
Digital Modulation, Fading, BER (Bit Error Ratio), Mitigation Methods

Keywords
AWGN, Rayleigh, Rician

1. INTRODUCTION
The ever-growing demand for Multimedia services, high mobility and global connectivity demands, research on new technologies for wireless communication system. All components of wireless communication system ranging from digital modulation techniques, higher layer protocols or influenced by characteristics/behavior of a mobile radio channel. A thorough understanding of radio channel is therefore crucial for designing, testing and performance optimization of existing and futuristic mobile radio systems. This is why modeling of communication system is necessary. There is two ways of studying the behavior of Communication Channel

- Measurement
- Simulation

Measurement Campaign is not easy because they are time consuming and they are not easy to do, resources are not easily available. For this reason simulation technique is better option in which various techniques are there. One of them is Monte Carlo technique. Numerical Monte-Carlo (MC) simulation is a popular technique to estimate bit error rate (BER) of a digital communication system and various signal processing algorithms, which is especially valuable when the system/algorithm is complex enough so that analytical analysis is not feasible or too complex [14]

There are many improved versions of the basic MC method, including various variance reduction techniques (e.g. Importance sampling). However, while increasing the simulation efficiency, all these techniques have a common drawback: [7]. The generality appeal of the original Monte Carlo method (problem- independence) is lost as all improved be problem-specific [8].. In digital communication theory the most frequently assumed model for a transmission channel is the additive white Gaussian noise (AWGN) channel [1]. However, for many communication systems the AWGN channel is a poor model, and one must resort to more precise and complicated channel models. One basic type of non-Gaussian channel, which frequently occurs in practice, is the fading channel. A typical example of such a fading channel is the mobile radio channel, where the small antennas of portable units pick up multipath reflections [4]. Thus, the mobile channel exhibits a time varying behavior in the received signal energy, which is called fading. Using MATLAB for digital communication systems simulation one has the advantage of exploiting the powerful features of its Communications Toolbox along with a nice programming language [9].

1.2 Bit Error Rate (BER)
The BER, or quality of the digital link, is calculated from the number of bits received in error divided by the number of bits transmitted.

BER= (Bits in Error) / (Total bits received)

In digital transmission, the number of bit errors is the number of received bits of a data stream over a communication channel that has been altered due to noise, interference, distortion or bit synchronization errors [1].

1.3 Eb/No (Energy per bit to power spectral Density ratio):
E_b/N_0 is an important parameter in digital communication or data transmission. It is a normalized signal- to-noise ratio (SNR) measure, also known as the "SNR per bit". It is especially useful when comparing the bit error rate (BER) performance of different digital modulation schemes without taking bandwidth into account.

2. CHANNEL MODEL
The mobile radio channel is characterized by two types of fading effects: large-scale fading and small scale fading . Large-scale fading is the slow variation of the mean (distant-dependent) signal power over time. This depends on the presence of obstacles in the signal path and on the position of the mobile unit. The large-scale fading is assumed to be a slow process and is commonly modeled as having lognormal statistics. Small-scale fading is also called Rayleigh or Rician fading because if a large number of reflective paths is encountered the received signal envelope is described by a Rayleigh or a Rician probability density function (PDF) [2-3]. The small-scale fading under consideration is assumed to be a flat fading (i.e., there is no inter- symbol interference). It is also assumed that the fading level remains approximately constant for (at least) one signaling interval. With this model of fading channel the main difference with respect to an AWGN channel resides in the fact that fading amplitudes are now Rayleigh- or Rician- distributed random variables, whose values affect the signal amplitude (and, hence, the power) of the received signal.

The fading amplitudes can be modeled by a Rician or Rayleigh distribution, depending on the presence or absence of specular signal component. Fading is Rayleigh if the multiple reflective paths are large in number and there is no dominant line-of-sight (LOS) propagation path. If there is also a dominant LOS path, then the fading is Rician distributed [4].

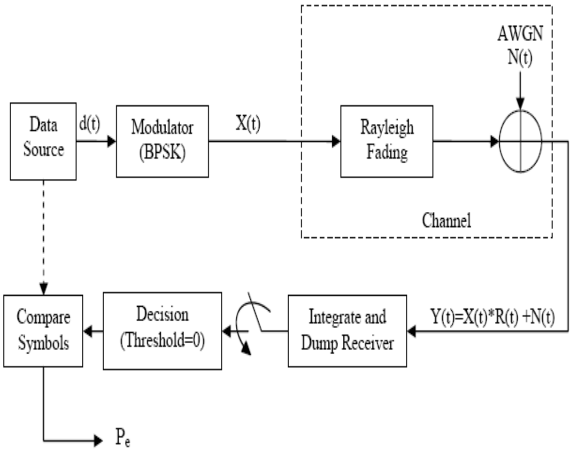

Figure 1. Channel Model

The good, bad, awful performance of various fading channels is represented in terms of Bit error probability versus Eb/No [13].

3. MITIGATION METHODS

The major elements that contribute to fading and their effects in a communication channel were discussed earlier. Here, in this phenomena are briefly summarized, and emphasis is then placed on methods to cope with these degradation effects. Two particular mitigation techniques are examined: the Viterbi equalizer implemented in the Global System for Mobile Communication (GSM), and the Rake receiver used in CDMA systems built to meet Interim Standard 95 (IS-95).The good, bad, awful performance of various fading channels are represented in terms of Bit error probability versus Eb/No. Following Table shows various mitigation methods that can be used to remove fading [10-11].

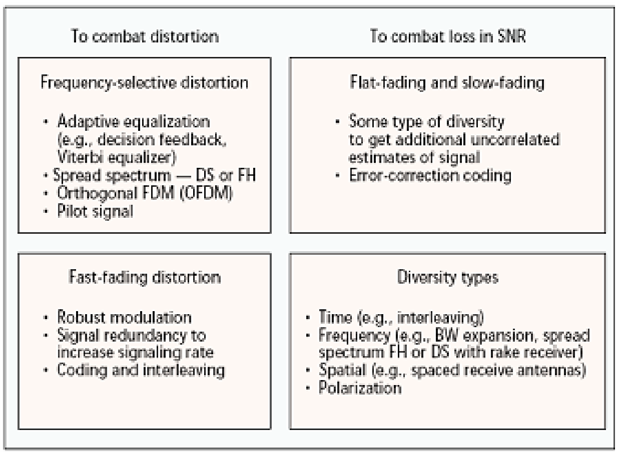

Figure 2. Mitigation methods to combat distortion

3.1 Mitigation methods to combat distortion: Simulation Results

3.1.1 Using Simulink

If we compare the Monte Carlo method with theoretical results then results are:

Eb/No	AWGN	Rayleigh Channel	Simulink Model
0	0.1409	0.1975	0.0775
2	0.0977	0.157	0.041
4	0.0586	0.1198	0.0135
6	0.0278	0.0878	0.0024
8	0.0092	0.0619	2.27E-04

Table 1. BER of AWGN, Rayleigh and Rician Channel

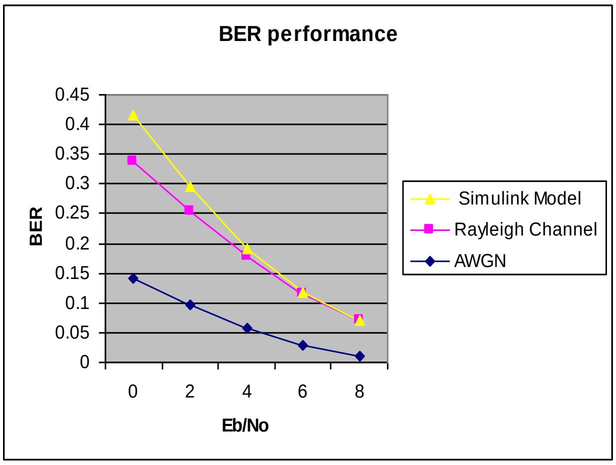

Figure 3. Theoretical results for AWGN, Rayleigh Channel

3.1.2. Using Viterbi Decoder

Eb/No	Simulink Model	With Viterbi Decoder	Rayleigh Channel
0	0.0775	0.3548	0.1464
2	0.041	0.12	0.1084
4	0.0135	0.0061	0.0771
6	0.0024	4.03E-05	0.0529
8	2.27E-04	0.7.02E-9	0.0354

Table 2. BER of Simulink model with/without decoder and Rayleigh Channel

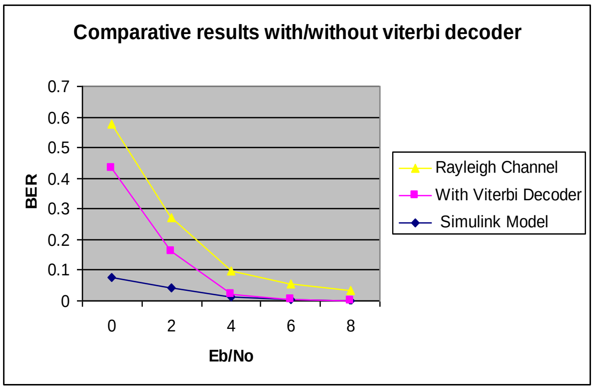

Figure 4. Comparative results with/without viterbi decoder

3.1.3 *Using Diversity Techniques*

Eb/No	BER with diversity10	BER with diversity 50	BER with diversity 100
0	0.0863	0.0802	0.794
2	0.0451	0.039	0.0382
4	0.0182	0.0136	0.013
6	0.0052	2.80E-03	0.0026
8	9.98E-04	2.93E-04	2.38E-04

Table 3. BER with various diversity orders

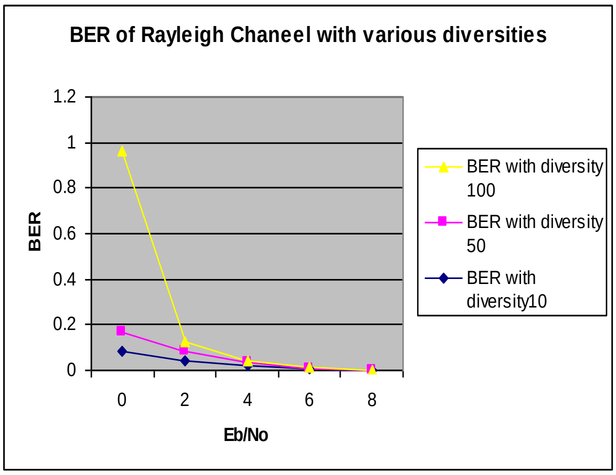

Figure 5. BER with various diversity orders

3.1.4. *Comparative Study*

Eb/No	AWGN	Rayleigh Channel	BER with diversity 10	BER with diversity 50	BER with diversity 100	With Viterbi Decoder	Simulink Model
0	0.1409	0.1975	0.0863	0.0802	0.794	0.3548	0.0775
2	0.0977	0.157	0.0451	0.039	0.0382	0.12	0.041
4	0.0586	0.1198	0.0182	0.0136	0.013	0.0061	0.0135
6	0.0278	0.0878	0.0052	2.80E-03	0.0026	4.03E-05	0.0024
8	0.0092	0.0619	9.98E-04	2.93E-04	2.38E-04	0.7.02E-9	2.27E-04

Table 4. Comparative study among all mitigation methods

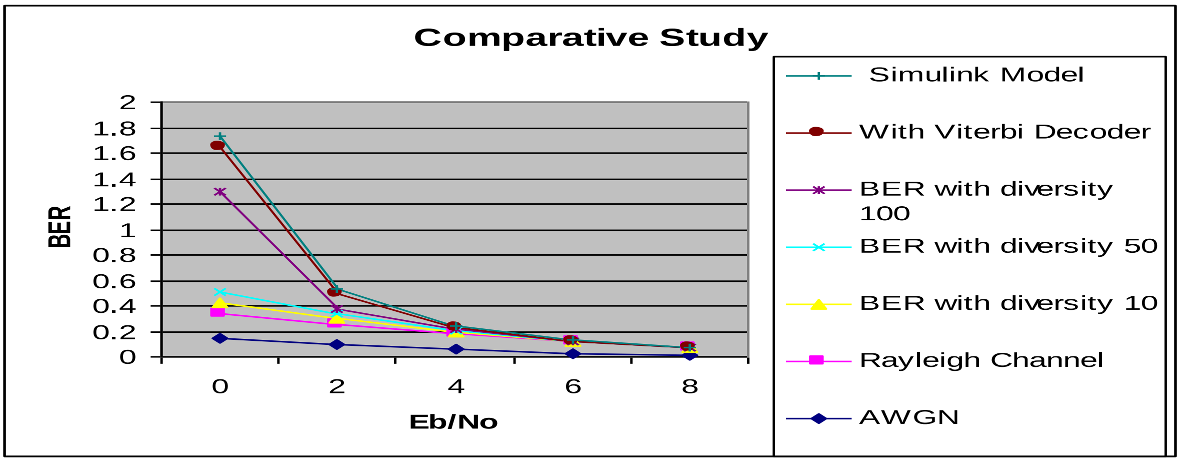

Figure 6. Comparative results using among all mitigation methods

4. CONCLUSION

In this work, a technique Monte Carlo simulation has been implemented to model the Rayleigh Fading channel. Firstly, it is done through one of the mathematical tools of Matlab (with the help of Bit error rate tool).Next it is done through Simulation technique with the help of simulation model. Then the various mitigation techniques are applied with Monte Carlo simulation model to combat the distortion of a signal.

The technique proposed here to model the Rayleigh Channel yields better results compared to the existing methods and it takes lesser time to do so. In fact, the problems encountered in the simulation, for generating the Rayleigh Channel are bypassed with a special technique as suggested in this work. The simulation results show the comparison between various modulation techniques and the results of AWGN channel and Rayleigh channel. With the help various mitigation techniques better BER can be achieved. In terms of diversity it is easy to find a better diversity technique which is suitable for mobile receivers.

5. FUTURE SCOPE

By using mathematical tool like MATLAB, as this work gives procedure about Rayleigh channel modeling, Rician channel modeling can be done with the help of Monte Carlo Simulation technique which gives practical applicability of this method for the most common situation occurred in mobile communications. With the help of various mitigation methods (with viterbi decoder, modulation schemes, with various diversity order) better Bit error rates can be achieved which makes the performance of a system better. From the simulation results, The Bit Error Ratio of a digital communication system is an important figure of merit used to quantify the integrity of data transmitted through the system. Depending on the performance optimization and utility of existing and futuristic mobile radio channels it is easy to find a better technique which is suitable for mobile receivers.

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