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BER Performance Analysis of MIMO-Wimax Wireless Communication System for the Transportation of Multimedia Data

By Owk. Srinivasulu & Dr. P. Rajesh Kumar

Abstract- There is a recent trend in communication because it's changed to a great extent in current days and necessity of all human being. As there is need of internet and recent multimedia data for every user, there is a high demand for wide-band and high data rate robust communication systems. As there is a requirement of huge data rate users preferred to use a famous novel technique of multiple inputs and multiple output (MIMO) system for the more feasible solution of gain in data rate in wireless communication through fading channels. The MIMO has been used especially for increasing the bit error rate (BER) performance analysis of WiMAX based wireless systems. Different modulation and fading channels are analyzed by the Alamouti STBC. The two fading channels used are Rician and AWGN channels. Different space-time block coding (STBC) schemes including Alamouti's STBC for two transmit antennas. At first, STBC techniques are developed in MATLAB after that analyzed for bit error-rate performance using different modulation schemes. Finally, there is a use of many variants implemented to get improved performance of the system, however, in this implementation, we focused the study on Alamouti's based space-time block code (STBC) encoder to obtain both space diversity and maximum combining ratio-based equalizer to combat the effects of the Rician fading channel.

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Strictly as per the compliance and regulations of:

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Keywords: OFDM, WiMAX, maximum combining ratio, alamouti's STBC, MIMO, rician channel, QPSK, BER.

I. Introduction

In recent broadcasting, the term communications refer to all the sending, receiving as well as processing of information by electronic means. Demands for capability in wireless Communications, driven using a Cellular cell, Internet, and Multimedia offerings have been rapidly growing to very high- level international standards. On the alternative hand, the available radio spectrum is constrained, and the Communication ability wishes. Advances in different coding such as inclusive of Turbo codes, Low-density parity test codes and space-time block codes made it simpler as well as more feasible to approach the Shannon ability limit in a machine with a single antenna hyperlink. Significant further advances in spectral performance are available by increasing the antennas both at transmitter and receiver is known as MIMO technology.

There is consideration of one of the numerous types of the smart antenna-based era. In reality, the recent MIMO concepts are useful and embrace many other scenarios inclusive of digital subscriber line (DSL) structures as well as single-antenna frequency-selective channels. MIMO system era has attracted a lot of interest in wi-fi communications because it gives considerable increases in data throughput as well as hyperlink variety without extra bandwidth requirement or transmits energy requirement. It is performed based on higher spectral performance and hyperlink trustworthiness. Due to necessities in MIMO, it is an important consideration that present-day wi-fi conversation standard along with all the techniques, IEEE 802.11n (Wi-fi), 4G, 3GPP LTE and Wi-MAX, HSPA+.

The objective of this paper is to increase the wireless communication system performance by using the Alamouti's encoder and Maximum ratio combining equalizer techniques through AWGN and Rayleigh fading channels.

MIMO has additionally incited wireless local area networks (WLANs) because the IEEE 802.11n standard exploits the practice of MIMO structures to collect throughputs as high as 600Mbps.This proposed paper offers a short history on MIMO schemes consisting of the gadget classical, overall the performance evaluation and analysis with typical fading channel fashions. The attention is then specified to space-time block codes (STBC) and Alamouti's encoder.

II. MIMO System Model

When speaking for a wireless fading channel, transmitted data may be afflicted by attenuation as well as fading due to the reason of multipath within the given fading channel, consequently making it difficult for the receiver to determine these effects. Diversity techniques take advantage of the multipath propagation traits to improve receiver sensitivity to a great extent. MIMO structures are utilized for antenna diversity to achieve

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the stated improvement and subsequently lowest fading.

Compared with the conventional systems a MIMO system is advantageous concerning ability and variety gain. Channel capacity theorem according to Shannon's law is given by

$$C = B\log2\,(1 + SNR)$$

From the Channel capacity theorem according to Shannon's law as the bandwidth increases channel capacity reaches to the maximum limit. The most blessings of MIMO networks finished traditional SISO channels are the array gain, the variety benefit, and the multiplexing gain.

a) The MIMO Channel Model

MIMO network comprises of N_T transmit antennas and N_R receive antennas for a signal model is given as

$$Y = Hx + n$$

Where, X, Y, H and n are vectors of the transmitted signal, received signal, channel matrix and noise added in the channel respectively.

Signals with multiple transmissions in time discrete index is given as

$$Y(t) = Hx(t) + n(t)$$

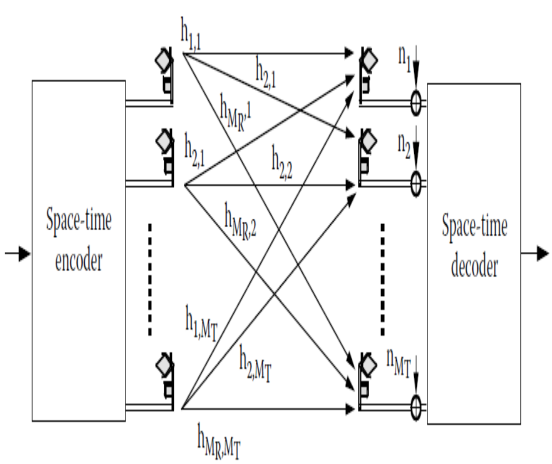

Figure 2.1: A MIMO system Model

The transmitted symbols are mentioned by xi, with the subscript index1 taking integers with non-zero values up to MT. Based on this notation, the channel transfer feature transmits antenna to the receive antenna is denoted by hj,i. To have a MIMO system should get better results to a SISO device, the sum of the transmitted powers of all antennas MT need to be equal to the transmitted strength of a SISO gadget denoted P. Hence, the transmitted energy from each antenna is P/MT.

It is feasible as well as robust technique to generate a MIMO channel with a correlation matrix denoted by H. The channel correlation matrix is commonly measured within the subject, and it considered all the parameters related to the environment setup together with antenna element parameters, spacing among antennas for given conditions, and surrounding reflectors with all its possibilities. The Paper is to assess the performance of different STBC schemes. The channel version is chosen such that the correlation is not produced with the overall performance. Additionally, the normalization of the channel coefficient must be such that at each acquire antenna j the sum of channel gains of all transmit antennas to acquires antenna j is equal to the wide variety of transmit antennas, i.e., MT. The Additive White Gaussian Noise (AWGN) fading channels are introduced to each obtain antenna and are special by way of NJ, with nj being an index taking values from 1 to MR. The AWGN fading channel components are assumed identically and independently dispensed and not depend on any other parameters.

The MIMO system can be given with the help of following formulae,

$$\left.\begin{aligned} r_1 &= \sum_{i=1}^{M_T} h_{1,i}\cdot x_i + n_1 \\ r_2 &= \sum_{i=1}^{M_T} h_{2,i}\cdot x_i + n_2 \\ &\cdots \\ r_{M_R} &= \sum_{i=1}^{M_T} h_{M_R,i}\cdot x_i + n_{M_R} \end{aligned}\right\} \Rightarrow R = H\cdot X + N$$

$$\Rightarrow \begin{bmatrix} r_1 \\ r_2 \\ \vdots \\ r_{M_R} \end{bmatrix} = \begin{bmatrix} h_{1,1} & h_{1,2} & \cdots & h_{1,M_T} \\ h_{2,1} & h_{2,2} & \cdots & h_{2,M_T} \\ \vdots & \vdots & \ddots & \vdots \\ h_{M_R,1} & h_{M_R,2} & \cdots & h_{M_R,M_T} \end{bmatrix} \cdot \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_{M_T} \end{bmatrix} + \begin{bmatrix} n_1 \\ n_2 \\ \vdots \\ n_{M_R} \end{bmatrix}.$$

In the given equations, R is a column vector of size M_Rx1 is composed with the received signals r_j, X is total column vectors of size M_Tx1 composed of the transmitted all constellation points denoted by *xi*, *N* is a column vector of size *MR*x1 added with the noise components n_j , and *H* is channel coefficient of size M_RxM_T matrix with size *j*th component being the channel coefficient $h_{j,i..}$

III. Degradation Effects of Fading

The major problem of correlation between indicators can occur due to the spacing between antennas. To prevent that they are generally spaced as a minimum λ/2, where λ is the wavelength of the carrier frequency. The 2d purpose correlation can occur due to lack of multipath additives. MIMO systems can handle rich scattering in multipath fading channels. The multipath impact we can remove by using each get hold of the antenna being in a specific channel.

a) Fading Effects

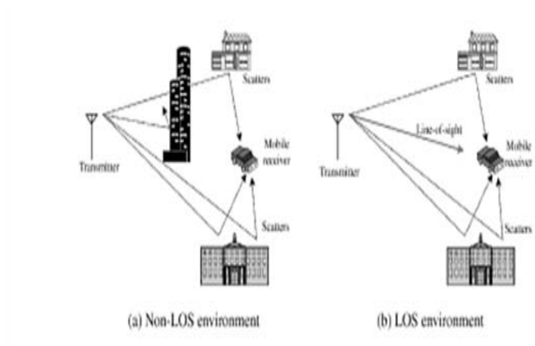

Figure 3.1: Non-LOS and LOS propagation environments

Fading is set the problems due to which there is lack of signal in telecommunications. Fading effects from the superposition of transmitted signals which have skilled variations in attenuation put off and phase shift at the same time as touring from the supply to the receiver.

b) Multipath Fading

In wireless communications, multipath is the propagation phenomenon that consequences on radio indicators reaching the receiving antenna by two or extra paths. Causes of multipath consist of atmospheric ducting, ionosphere mirrored image and refraction and reflection from the terrestrial object which includes mountains, buildings or automobiles. Figure display some of the possible methods in which multipath indicators can arise.

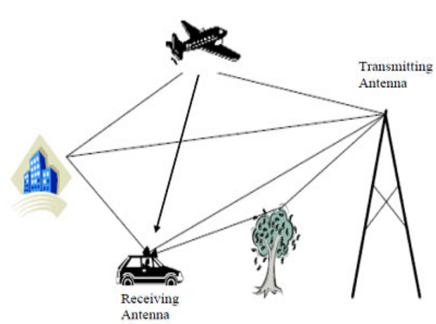

Figure 3.2: Multipath Signals

Fading, or equivalently small-scale fading, is because of interference between two or more versions of the transmitted signal which arrive on the receiver at barely special instances. These signals, called multipath waves, integrate at the receiver antenna and the corresponding matched filter out and provide blended signal. This ensuing signal can vary widely in amplitude and segment. The presence of reflecting gadgets and scatterers creates some converting surroundings. Multipath propagation will increase the time required for the baseband portion of the sign to attain the receiver. The resulting dissipation of the signal electricity in amplitude, section, and time. We have categorized fading channels based on their multipath time put off into flat and frequency selective and based totally on Doppler spread into gradual and rapid. These two phenomena are unbiased of every other and result in the following four types of fading channels. Flat slow fading or frequency, flat, fast fading, frequency selective slow fading, and frequency selective fast fading.

IV. Diversity Schemes

Dissimilar to the Gaussian channel, the noisy channel display experiences sudden decreases in the power. As we talked about some time recently, this is because of the dangerous expansion of multipath motions in the engendering media. It can likewise be because of impedance from different clients. The measure of progress in the got power can be now and then more than 20 to 30 db. The energy of the warm clamor is not changing that much at the collector. In this manner, SNR at the recipient can experience profound blurs and be released drastically. For the most part, there is a base got SNR for which the beneficiary can dependably identify and disentangle the conveyed standard. On the off chance that they got SNR is lower than such a limit, a dependable recovery of the transmitted flag is outlandish. This is typically called a "blackout." The likelihood of blackout can be computed considering the factual model that models the channel or given the real estimations of the channel. It is the likelihood of having a gotten control lower than the given edge.

The primary thought behind "diversity" is to give distinctive imitations of the transmitted signal to the receiver. If these diverse reproductions blur autonomously, it is less likely to have all duplicates of the transmitted signal in a profound blur all the while. In this manner, the recipient can dependably disentangle the communicated flag utilizing these got signals. To characterize assorted variety quantitatively; we use the connection between the got SNR, inevitable by γ, and the likelihood of mistake, meant by G.

A tractable definition of the diversity, or diversity gain, is

$$G_d = -\lim_{\gamma \to \infty} \frac{\log P_e}{\log \gamma}$$

Where P_e is given error probability at given SNR of γ.

a) Alamouti's Scheme

Verifiably, the transmit signal variety procedure proposed by Alamouti was the main technique used for STBC. Henceforth, the data information bits are first adjusted means they are used to divide original data

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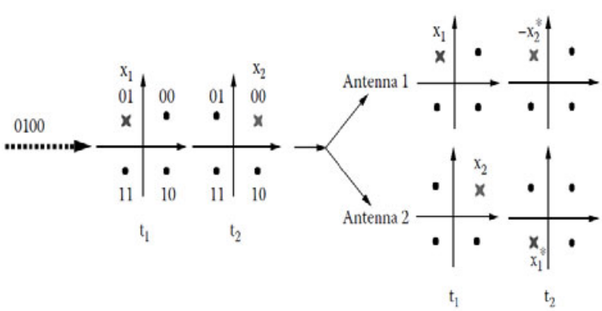
and mapped into their comparing group of stars focus. In this way, let us indicate by and the two-balanced data for transmission that enter the space-time encoder. Often, in frameworks with just a single transmit reception apparatus, these two-data selected are transmitted at two back to back time occasions. In the Alamouti transmission technique the data used are transmitted by the first and the second reception apparatus component, individually. For the second-time case, the negative of the conjugate of the second data, i.e., the data is sent to the primary radio antenna while the conjugate of the primary heavenly body point, i.e., x1, is transmitted from the second receiving antenna. The encoding operation is depicted in Table 4.1. The transmission rate is equivalent to the transmission rate of a SISO framework. Space– time encoding mapping of Alamouti's two-branches transmits attired variety procedure can be spoken to the coding grid as given below:

$$X_1 = \begin{matrix} x_1 & -x_2{}^* \\ x_2 & x_1{}^* \end{matrix}$$

In the coding matrix X1, the subscript index gives the transmit fee compared to a SISO gadget. For Alamouti's scheme, the transmission we used 2 transmitting and two receiving antennae. The rows of the coding matrix constitute the transmit antennas while it columns correspond to single time instances.

Table 4.1: Alamouti's Scheme



In alternative way, the channel coefficients used are given from the first antenna to the j^{th}receiver antenna $h_{j,1}$ and those from the second antenna to the j^{th}receiver antenna $h_{j,2}$ must satisfy the following equations:

$$h_{j,1} = h_{j,1}(t) = h_{j,1}(t+T) = h_{j,1}(t_1) = h_{j,1}(t_2)$$

$$h_{j,2} = h_{j,2}(t) = h_{j,2}(t+T) = h_{j,2}(t_1) = h_{j,2}(t_2)$$

Finally, the received signals obtained at receiver antenna j during the two-time instances are $r_{j,1}$and $r_{j,2}$. The received signals satisfy following equations,

$$r_j{}^1 = h_{j,1}.x_1 + h_{j,2}.x_2 + n_j{}^1$$

$$r_j{}^2 = h_{j,2}.x_2{}^* + h_{j,2}.x_1{}^* + n_j{}^2$$

In the above Equation, the Additive White Gaussian Noise (AWGN) fading channel components are added at each receiver antenna element j while during the transmission time instances serially *t*1 and *t*2, are denoted *nj*1 and *nj*2, respectively.

b) Maximal Ratio Combining

Maximum ratio combining is one of the well-known linear combining methods. In a well-known linear combining process, many sign inputs are in my opinion weighted and delivered together to get an output signal. The weighting elements may be preferred in frequent approaches. The output sign is a linear aggregate of a weighted replica of all the obtained alerts. The received signal is given below,

$$r = \sum_{i=0}^{n_R} \alpha_i . r_i$$

Where, r is the obtained signal at acquiring antenna i, and αi is the weighting factor for receiver antenna 1. In most ratio combining, the weighting issue of every get hold of the antenna is selected to be in percentage with its very own signal voltage to noise power ratio. Let Ai and φi be the amplitude and segment of the acquired signal, respectively. If every obtain antenna has the equal average noise electricity, the weighting vector can be represented as,

$$\alpha_i = A_i e^{-j\varphi_i}$$

This method is referred to as superior combining due to the fact it can maximize the output SNR. This scheme requires the information of channel fading amplitude and sign phases. So, it could be used at the side of coherent detection, but it isn't realistic for non-coherent detection.

V. Simulation Results

In this implementation, MATLAB is used to check the overall channel performance using different modulation technique primarily based on BPSK modulation scheme. By making use of Alamouti's STBC and Maximum ratio combining approach, it's miles feasible to make channel reaction from Rayleigh fading channel to AWGN channel. However, from the subsequent figures, it is visible that the performance doesn't appear to improve in the case of no range and it considerably recovers using applying the diversity techniques like 2x2 Alamouti and 2x4 Alamouti case. Also, we can see from the graphs that the BER performance of the gadget increases for multimedia statistics and because the information rate increases, we need additional diversity as an example for the case of 4x4 Alamouti methods and it works extensively quality with low records price programs. The two varieties of statistics which it's miles examined for are the actual time audio and photo statistics.

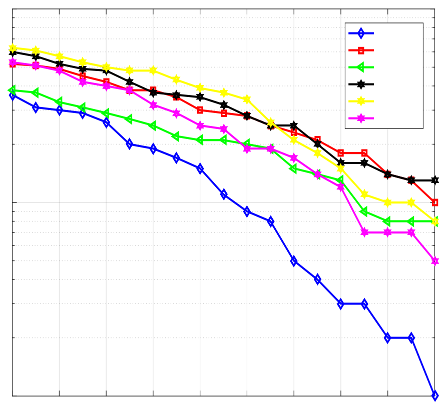


Fig.5.1: BER analysis for different modulations in Alamoutis STBC with ZF equalizer (Rician channel)

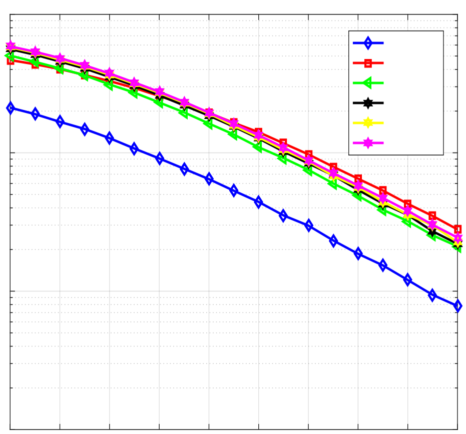


Fig.5.2: BER analysis for different modulations in Alamoutis STBC with ZF equalizer (AWGN channel)

Below there is an analysis of Alamouti STBC for Rayleigh channel using BPSK modulation. By BER performance analysis we get the better results for proposed work with Alamouti STBC with 2 T-X antennae and 2 R-X antennae than the existing techniques like without diversity.

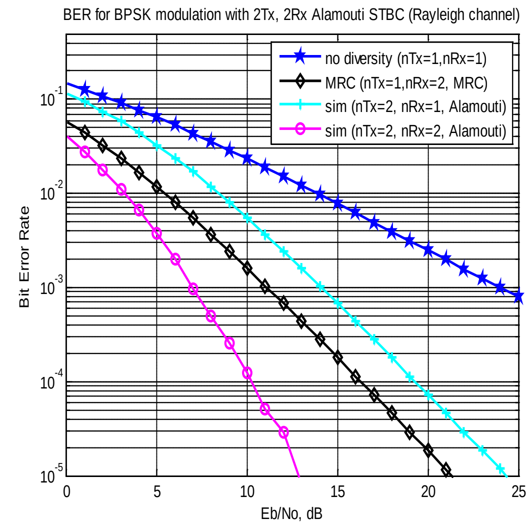


Fig.5.3: BER for BPSK modulation with Alamouti STBC (Rayleigh channel)

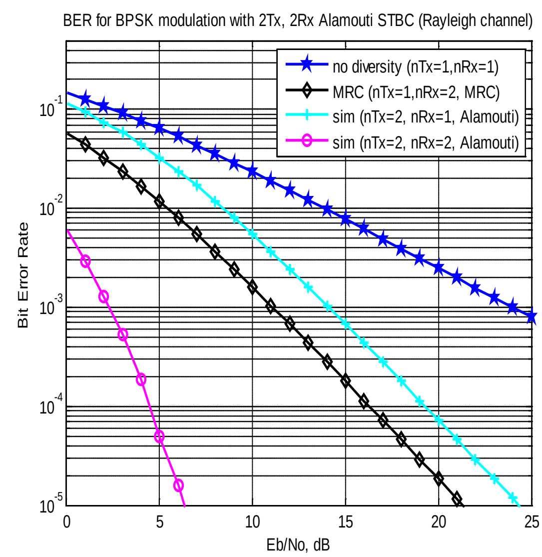


Fig.5.4: BER for BPSK modulation with Alamouti STBC (Rayleigh channel)

VI. Conclusion

With implementation execution using MATLAB software, we can go for analysis of wireless fading channel environment, as the nature of fading increases to the certain extent and the data rate is also increased to the great extent, one of the ways to get good BER performance of the system is increasing the spatial diversity. We analyzed the working of Almouti STBC under the different modulations and under different fading channel. From this analysis, we get to know that as modulation index is increases, there is increased in BER that means degraded the performance of a system. With the help of increasing the number transmitter or receiver, we can achieve better performance of the proposed implementation. The future work can be extended to real-time signals like the high-resolution images, video streams, and live videos or live broadcasting signals like the DVB-2 to check the efficiency of the diversity-based systems to crisscross its robustness and improvement for multimedia applications. Finally, with the subjective and objective quality assessment of the data, we can prove that the implemented system is having improved performance.

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