BER Performance of Different Modulation Schemes for MIMO Systems

Madan Lal[†] and Hamneet Arora[††],

Department of Electronics and Communication Engineering, Bhai Gurdas Institute of Engineering and Technology, Sangrur -148001, Punjab PTU, Jalandhar, India

Summary
In this paper we have discussed Multiple Input Multiple Output(MIMO) in Wireless medium by using Spatial Multiplexing technique for the calculation of the Bit Error Rate (BER). MIMO improve the throughput in wireless medium. It achieves a higher spectral efficiency. Spatial multiplexing increases the capacity and link reliability of the MIMO systems. The BER performance of BPSK, QPSK and QAM in MIMO systems in Rayleigh multipath channel is analyzed. V-Blast is used as a detection technique. A comparision of these modulations is also done in Rayleigh fading channel.

Key words:
BER, Mimo, Modulation, Qam, Qpsk

1. Introduction

Wireless channel modeling has always been the area to active research. It is related to the spectrum. Marconi pioneered the wireless industry 100 years ago. Today life is impossible without wireless in some form or the other. The demands on bandwidth and spectral availability are endless. Currently wireless finds its widest expression in fixed and mobile roles.
The ever-increasing populations of wireless technology consumers demand faster and more convenient communications, progressively saturating the radio frequency (RF) bands. However, there is limit to the data throughput of the wireless channel. This is termed the channel capacity, the maximum data rate for reliable (error-free) data communication, assuming an involved coding scheme. In 1948, Shannon defined this capacity in terms of the available bandwidth and signal power [1]. In a digital system, the capacity for a channel of bandwidth *W* perturbed by white thermal noise of power *N*, with an average transmits power of *P*, is given by

$$C=B \log_2 (1+ S/N) \qquad (1)$$

The gradual evolution of mobile communication systems follows the quest for high data rates, measured in bits/sec (bps) and with a high spectral efficiency, measured in bps/Hz.

Multiple-Input-Multiple-Output (MIMO) wireless systems characterized by multiple antenna elements at the transmitter and receiver operate by exploiting the spatial properties of the multipath channel, thereby offering a new dimension which can be used to enable enhanced communication performance. Such systems have demonstrated the potential for increased capacity in rich multipath environments. [2]
The Multi-Input and Multi-Output (MIMO) communication systems provide very high data rates with low error probabilities. In communication, multiple-input and multiple-output, or MIMO, is the use of multiple antennas at both the transmitter and receiver to improve communication performance. It is one of several forms of smart antenna technology.
MIMO technology has attracted attention in wireless communications, since it offers significant increases in data throughput and link range without additional bandwidth or transmit power. It achieves this by higher spectral efficiency (more bits per second per hertz of bandwidth) and link reliability or diversity (reduced fading). Because of these properties, MIMO is a current theme of international wireless research.
In this paper, we describe a wireless transmission in which we have used the concept of MIMO .Spatial multiplexing technique has been used to increase the channel capacity significantly. BPSK, QPSK, 16 QAM &64 QAM are the modulation techniques in the Rayleigh channel. So Vblast is the detection technique. A comparative study of various modulation schemes for MIMOs and results are shown in the next sections .BER is calculated and analyzed for comparison.

2. Channel Model

Rayleigh channel is used as medium for data transmission in wireless communication. Rayleigh distribution is used to describe the stastical time varying nature of the received envelope of a flat fading signal, or the envelope of an individual multipath component. It is well known as the envelope of the sum of the two quadrature Guassian noise signals obeys a Rayleigh distribution. It has the probability

Manuscript received March 5, 2011
Manuscript revised March 20, 2011

density fuction(pdf) given by

$$P(r) = (r/\sigma^2)\exp(-r^2/2\sigma^2) \text{ for } (0 \le r \le \infty) \qquad (2)$$

Where σ is the rms is value of the received signal voltage before envelope detection and σ^2 is the time average power of the received signal before envelope detection. [3]

3. MIMO Model

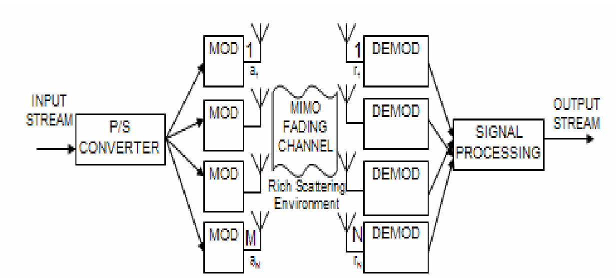

Figure-1 MIMO Link Model

We have shown the model of MIMO in fig-1.At first, the incoming data streams travels through serial to parallel converter and then all the streams are modulated by using BPSK,QPSK,16 QAM,64QAM. After that spatial multiplexing comes into picture. Now all the modulated streams travel through the turbulent environment and then collected by antennas at receiver end. After that all the streams are demodulated and detected by V-BLAST detection technique. Brief introduction of all the techniques and channel model is given below

3.1 Modulation Techniques

In this an M message bits are encoded by transmitting a single pulse in one of 2*M* possible time-shifts. This is repeated every T seconds, such that the transmitted bit rate is M/T bits per second. There are four modulation techniques used for it that are Binary phase shift modulation (BPSK),Quadrature phase shift modulation(QPSK), 16-Quadrature Amplitude modulation(16- QAM) and 64-Quadrature Amplitude modulation (64QAM)The no. of points on constellation is related to the no. of QAM.

3.2 Spatial Multiplexing

Spatial multiplexing offers a linear (in the number of transmit-receive antenna pairs or min (M_R, M_T) increase in the transmission rate (or capacity) for the same bandwidth and with no additional power expenditure. It is only possible in MIMO channels. The bit stream is split into two half-rate bit streams, modulated and transmitted simultaneously from both the antennas. The receiver, having complete knowledge of the channel, recovers these individual bit streams and combines them so as to recover the original bit stream. Since the receiver has knowledge of the channel it provides receive diversity, but the system has no transmit diversity since the bit streams are completely different from each other in that they carry totally different data. Thus spatial multiplexing increases the transmission rates proportionally with the number of transmit-receive antenna pairs.

This concept can be extended to MIMO-MU. In such a case, two users transmit their respective information simultaneously to the base station equipped with two antennas. The base station can separate the two signals and can likewise transmit two signals with spatial filtering so that each user can decode his own signal correctly. This allows capacity to increase proportionally to the number of antennas at the base station and the number of users [4].

3.3 V- Blast –the Detection Algorithm

V-BLAST is a layered space time detection scheme for detection or combining of MIMO signals at the receiver side. It works on the principle that transmitters operate co-channel and symbol synchronized using same modulation schemes for transmitting independent data sub streams. The channel information being known only at the receiver, there is no power adaptation at the transmitter side, i.e. equal power levels are radiated at each transmitter in a scaled manner so that the total power remains constant irrespective of the number of transmitters. V-BLAST is a recursive procedure in which we decode the “strongest” signal first, then subtracting this strongest signal from the received signal, proceed to decode the strongest signal of the remaining transmit signals, and so on. The optimum detection order in such a *nulling and cancellation* strategy is from the strongest to the weakest signal. The VBLAST/ZF algorithm [5] is:

Initialization

$W_1 = H^+$

$i = 1$

Recursions:

$k_i = \operatorname{argmin} \|(W_i)_j\|^2$

$j \notin \{k_1 \dots k_{i-1}\}$

$y_{k_i} = [(W)_i]_{k_i} Y_i$

$\hat{X}_{k_i} = Q(y_{k_i})$

$y_{i+1} = y_i - \hat{X}_{k_i}(H)_{k_i}$

$W_{i+1} = H_{k_i}{}^+$

$i = i + 1$ (3)

Where H^+ denotes the Moore-Penrose Pseudoinverse of H, $(W_i)_j$ is the jth row of W_i ,Q(.) is a quantizer to the nearest constellation point, H_{k_i} denotes the matrix obtained by zeroing the columns k_1, $k_{2,\dots,}$ k_i of H and $H_{k_i}^{+}$ denoted the pseudoinverse of H_{k_i}. The ZF ru;e creates a set of subchannels by forming $\hat{X}_{ZF} = (H^{+}H) + H^{+}N_o$. The jth such subchannel has noise variance $\|(H^{+})_j\|^2 N_o$ .The order selection rule priorities the sub channel with the smallest noise variance. [6]

4. Simulations and Results

We have simulated the MIMO channel with channel state information known only at the receiver Performance evaluation in terms of BER with respect to SNR was carried out using VBLAST-ZF in MATLAB environment by transmitting modulated data streams in blocks of 10,000 bits each using Rayleigh channel model. Figure 2,3,4,5 shows the performance of BPSK, QPSK, 16 QAM and 64 QAM modulation schemes respectively.M denotes the no. transmitter antennas and N denotes the no. of receiver antennas. With the change in M and N the BER V/S SNR is calculated for BPSK, QPSK, 16 QAM and 64 QAM modulation schemes. When M=N=1, it is a single input single output system (SISO). So SISO is also compared with the MIMO and with the increase of no. of antennas the performance also increases.

In figure 6 the graph is plotted between different modulation schemes. BPSK and QPSK show better response at lower SNR but 16 QAM and 64 QAM show better results at higher SNR

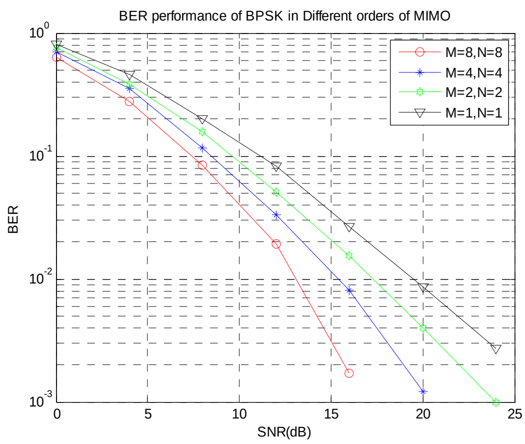

Figure 2- BER Performance of BPSK

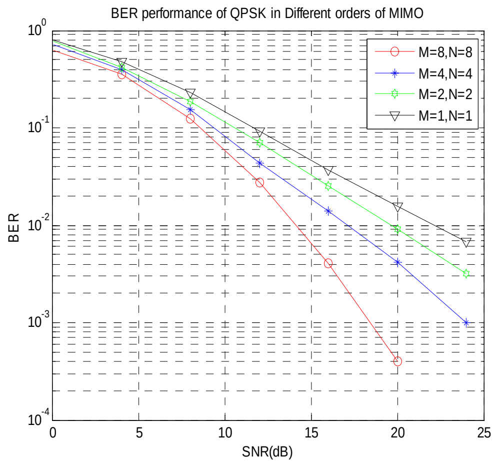

Figure 3-BER Performance of QPSK

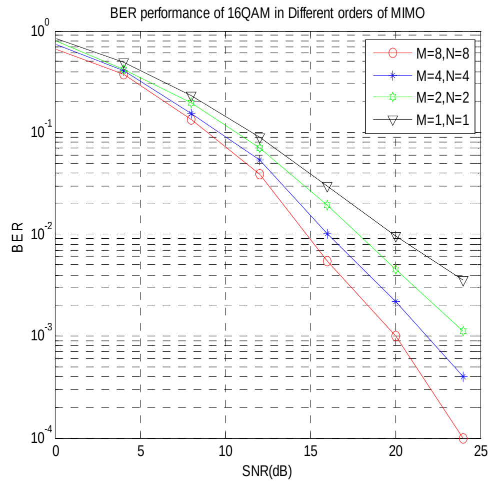

Figure 4-BER Performance of 16 QAM

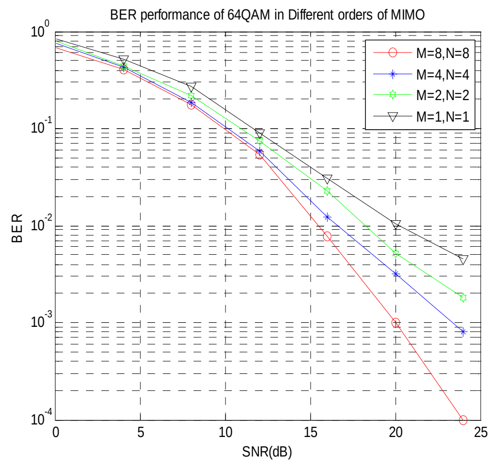

Figure 5-BER Performance of 64 QAM

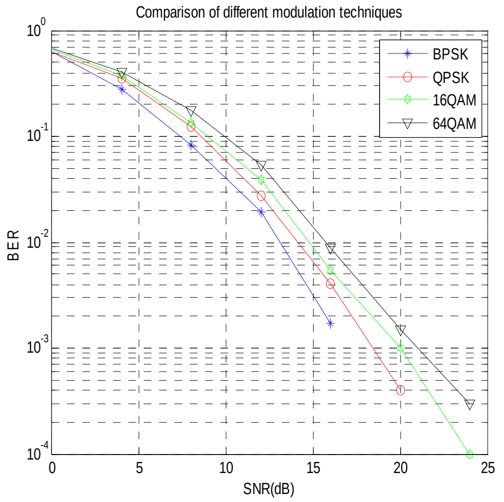

Figure 6-Comaprisons of different modulations

So we analyzed the BER in various moduations in Rayleigh channel taking M=N=8.BPSK has smaller BER than the other modulations.So BPSK has less errors.

Conclusion

From the above discussion, we can say that MIMO give better response and increased channel capacity in every modulation scheme as compared to SISO system. Various Modulations are compared with respect to BER and BPSK is the power efficient modulation technique as compared to other techniques. Its results are more satisfactory. V BLAST is a sub optimal detection technique which provides less complexity to the decoder.

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Madan Lal has received his three years Dipoma from the Department of Electronics and Communication Engineering of Board of Technical Education, New Delhi in 1990. He has received his B.Tech (AMIE) from Department of Electronics and Communication Engineering the Institution of Engineers (India) Kolkatta in 1996. He has received his Master of Technology from National Institute of Technology, Bhopal in1999.He is currently persuing his Ph.D degree from Department of Electronics and Telecommunication Engineering. He is a Chartered Engineer. He was the Principal of CRR Institute of Technology New Delhi from 2007 to 2008. He is presently Professor of Department of Electronics and Communication Engineering of Bhai Gurdas Institute of Engineering and Technology, Sangrur, Punjab, India. He is a life member of the Institution of Electronics and Telecommunication Engineers, New delhi. He is also a life member of the Institution of Engineers Kolkatta. His area of interest is wireless communication and circuit theory. He has contributed over 75 papers published in referred journals and presented in various international and national conferences. He has also qualified GATE.

Hamneet Arora has received her B.Tech from Department of Electronics and Instrumentation Engineering, Kurukshetra University; Kurukshetra in 2005.She is currently pursuing her M.Tech from Department of Electronics and Communication Engineering from Punjab Technical University, Jalandhar. She has worked as a Lecturer in various institutes. She is presently working at Manav Rachna University. She has more than five years of teaching experience. She has presented many papers in National and International Confrences. Her areas of interest are Wireless, Radio Frequency, Antennas and optics.