Performance Analysis of BER Reduction in BPSK & QPSK Modulation Using V-Blast Algorithms for MIMO System

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Abstract

Wireless communication system with multi-antenna arrays has been a field of intensive research on the last years. The emergence of multiple antenna system has opened another very resourceful dimension – space, for information transmission in the air. It has been demonstrated that multiple antenna system provides better BER and it can be further improved by using different modulation techniques. Since then, multiple-input multiple-output (MIMO) system has become one of the major focuses in the research community of wireless communications and information theory. There are many modulation techniques that can be applied to MIMO systems such as BPSK, QPSK, and the Vertical Bell Labs Space-Time Architecture (V-BLAST). In this paper, we study the performance of general MIMO system, the general V-BLAST architecture with Zero-Forcing (ZF), in fading Rayleigh channels. It achieves a higher spectral efficiency. Spatial multiplexing increases the capacity and link reliability of the MIMO systems. The BER performance of BPSK, QPSK MIMO systems in fading (Rayleigh multipath) channel is analyzed. V-Blast is used as a detection technique. A comparison of these modulations is also done in Rayleigh fading channel. The performance has been concluded based on BER (Bit Error Rate) Versus SNR (Signal to Noise Ratio).

Keywords: V-Blast, Rayleigh channel, MIMO, Zero Forcing, Minimum Mean Square Error.

1. INTRODUCTION

Wireless communication is the transfer of information between two or more points that are not connected by an electrical conductor. Wireless operations permit services, such as long-range communications, that are impossible or impractical to implement with the use of wires. Information is transferred in this manner over both short and long distances. Wireless communication is reliable, robust and secure. Foschini has proposed two types of Bell Labs Space-Time architecture (BLAST), namely diagonal BLAST (D-BLAST) and Vertical BLAST (V-BLAST), for MIMO system [1] to achieve high capacity. Compared with the D-BLAST detector, the V-BLAST detector has lower decoder complexity. The V-BLAST algorithms apply iterative nulling and canceling to the received signal to determine the transmitted data symbols. It has been found that the order of detection becomes important to the overall system performance. In [1], the ordering based on the post-processing SNR has been proved to be the optimal method. In addition to the optimal ordering, other detection orderings have also been proposed and analysis for MIMO systems.

2. MODEL OF V-BLAST SYSTEM

Wireless communication using Multiple Input Multiple Output MIMO has recently emerged as one of the most significant technical breakthroughs in modern communications technology. MIMO systems establish an arbitrary wireless communication a link for which the transmitting end as well as the receiving end is equipped with multiple antenna elements as illustrated in Fig. 1. V-BLAST (Vertical-Bell Laboratories Layered Space-Time) is a detection algorithm to the receipt of multi-antenna MIMO systems [2], available for the first time in 1996 at Bell Laboratories in New Jersey in the United States by Gerard J. Foschini. He proceeded simply to eliminate interference caused successively issuers.

Fig -1: Block Diagram of V-BLAST

The complete detection algorithm can be summarized as recursive as follows: Initialize:
\[ w_k = \left( G_i \right)_k \]  
\[ y_k = w_k^T \times r_i \]  
\[ \hat{s}_k = \text{sign}(y_k) \]  
\[ r_{i+1} = r_i - \hat{s}_k (H)_{ki} \]  
\[ G_{i+1} = \left( (H_i^H + \sigma^2 I_{N_r})^{-1} \right) H_i^H \]  
\[ k_{i+1} = \arg \min \| (G_{i+1})_j \|^2 \]  
\[ i \leftarrow i + 1 \]  

4. MIMO SYSTEM

MIMO systems are an extension of smart antennas systems. Traditional smart antenna systems employ multiple antennas at the receiver, whereas in a MIMO system multiple antennas are employed both at the transmitter and the receiver. The addition of multiple antennas the transmitter combined the advanced signal processing algorithms at the transmitter and the receiver yield significant advantage over traditional smart antenna systems - both in terms of capacity and diversity advantage. A MIMO channel is a wireless link between M transmitting and N receiving antennas. It consists of MN elements that represent the MIMO channel coefficients. The multiple transmit and receive antennas could belong to a single user modem or it could be distributed among different users. The later configuration is called distributed MIMO and cooperative communications.

\[ \text{Fig -2: SISO, MISO, SIMO & MIMO system} \]

5. MODULATION TECHNOLOGY

Modulation is the process of facilitating the transfer of information over a medium. Sound transmission in air has limited range for the amount of power your lungs can generate. To extend the range your voice can reach, we need to transmit it through a medium other than air, such as a phone line or radio. The process of converting information (voice in the case) so that it can be successfully sent through a medium (wire or radio waves) is called modulation.

a. Binary Phase Shift Keying (BPSK): BPSK (also sometimes called PRK, Phase Reversal Keying, or 2-PSK) is the simplest form of phase shift keying (PSK). It uses two phases which are separated by 180° and so can also be termed 2-PSK. It does not particularly matter exactly where the constellation points are positioned, and in this figure they are shown on the real axis, at 0° and 180°.

b. Quadrature Phase Shift Keying (QPSK): This is also known as four-level PSK where each element represents more than one bit. Each symbol contains two bits and it uses the phase shift of π/2, means 90° instead of shifting the phase 180°.

6. BLOCK DIAGRAM

In this paper idea is not the same as ideal communication channel where noise does not take place. A channel can be distorted or signal can be faded due to multipath communication or inter symbol interference. Now the basic idea of the project is that at the transmitter, random signal is generated and converted these bits into symbols so that modulation becomes easy. BPSK and QPSK modulation technique is used for modulation and to improve the data rate. Gain of the system can be improved by V-BLAST algorithm. Rayleigh fading channel with AWGN noise is considered as communication channel. At the receiver end, MIMO receives the no. of signals and V-BLAST null downs the ISI and receives the strong signal.

\[ \text{Fig -3: Block Diagram} \]
7. SIMULATION RESULTS

The BER performance of the equalizers is compared with respect to the variation in $E_b/N_0$(dB) as seen from the simulation scripts. The used modulation techniques are BPSK and QPSK and the considered channel is Rayleigh fading channel. The preferred technique for improving BER performance is V-BLAST. The data is sent through the no. of transmitting antennas and the no. of receiving antennas is used for reception. The above considered technologies have been combined using the MATLAB software (Version 7.10). Now for different cases for the performance evaluation, the selected range of SNR is 0 to 12.

Table 1: Parameters used in Dissertation Work

<table>
<thead>
<tr>
<th>S. NO.</th>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Technology</td>
<td>V-BLAST</td>
</tr>
<tr>
<td>2</td>
<td>Data Bits</td>
<td>$10^6$</td>
</tr>
<tr>
<td>3</td>
<td>Number of Transmitter</td>
<td>1-4</td>
</tr>
<tr>
<td>4</td>
<td>Number of Receiver</td>
<td>1-4</td>
</tr>
<tr>
<td>5</td>
<td>Algorithm</td>
<td>ZF, MMSE, ML</td>
</tr>
<tr>
<td>6</td>
<td>Modulation Techniques</td>
<td>BPSK, QPSK</td>
</tr>
<tr>
<td>7</td>
<td>Channel</td>
<td>Rayleigh AWGN</td>
</tr>
<tr>
<td>8</td>
<td>Data Substream Length</td>
<td>1-4</td>
</tr>
<tr>
<td>9</td>
<td>SNR</td>
<td>0-12</td>
</tr>
</tbody>
</table>

7.1 Simulation and Results for BPSK and QPSK Modulation without V-BLAST

Consider the case of Single Input Single Output first. In this scheme single transmitter is selected to transmit the whole data while a single receiver is selected for the reception. In the Graph-1 for BPSK modulation technique, the minimum and the maximum values of bit error rate for all the equalizers (ZF, MMSE and ML) are 0.05848 and 0.1913 respectively. In case of QPSK modulation technique, the minimum and the maximum values of bit error rate for all the equalizers (ZF, MMSE and ML) are 0.05568 and 0.1915 respectively. From the given graph it is seen that each equalizer performs in the same manner for QPSK modulation technique. And for BPSK modulation technique, each equalizer also performs in the same manner but gives better results than QPSK modulation technique.
Graph 4: Performance Evaluation Of Different Equalizers & 4x4 MIMO System Without V-BLAST

7.2 Simulation and Results for BPSK and QPSK Modulation with V-BLAST

Graph 5: Performance Evaluation of Different Equalizers & 1x1 MIMO System with V-BLAST

Graph 6: Performance Evaluation of Different Equalizers & 2x2 MIMO System with V-BLAST

Graph 7: Performance Evaluation of Different Equalizers & 3x3 MIMO System with V-BLAST

Graph 8: Performance Evaluation of Different Equalizers & 4x4 MIMO System with V-BLAST

8. CONCLUSIONS

The performance of the equalizers increases in terms of BER, as the number of transmitting and receiving antenna increases, when BPSK and QPSK modulation technique is used with V-BLAST. From the simulated results it has been found that the performance of BPSK modulation technique with different MIMO system is better than the performance of QPSK modulation technique in terms of bit error rate. V-BLAST technique with equalizers gives better performance then Equalizers without the V-BLAST technique.

9. REFERENCES


