Performance Enhancement of V-Blast MIMO-OFDM System using ZF with Gaussian Filter and PSK Scheme

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Abstract - Wireless communication is an area which has all time favorite among researchers. The best thing about this technology is that it facilitates each and every device available for communication or for sharing of information of any kind (data, voice, images and video etc.). In this paper the same technology is being evaluated and enhanced its performance. Here the V-Blast detection technique taken into consideration because this is very efficient non-linear detection method, in addition of this we have considered the MIMO-OFDM system as basic infrastructure of communication system. Performance of the system is calculated under BER vs SNR for different data lengths and with PSK modulation scheme. The proposed technique to reduce the error probability we have used zero forcing (ZF) and minimum mean square error (MMSE) with V-Blast and Gaussian Filter.

Keywords: V-Blast, MIMO, OFDM, ZF, MMSE and Gaussian Filter.

I. INTRODUCTION

In the past few years, theoretical research on multiple-input multiple-output (MIMO) systems that use multiple transmit and receive antennas in a rich scattering communication channel have provided brilliant results. They have given a linear increase in system capacity and spectral efficiency with respect to the number of transmit antennas as long as the number of receive antennas is greater or equal to the number of transmit antennas. In a MIMO communication system, multiple transmission paths can be used to improve diversity and/or multiplexing gain. In the V-BLAST transmitter, every antenna transmits its own independently coded symbols and the V-BLAST receiver, uses a spatial domain decision feedback equalizer. The process involves each symbol is decoded and then fed back to cancel its interference with other symbols. This process repeats until all the symbols are decoded. The decoding order can be optimized by decoding the symbol with largest signal to noise ratio (SNR) first. Due to this decision feedback structure, the V-BLAST system with MIMO technology yields a very good spectral efficiency in a scattering rich environment. The benefits are achievable without increasing the transmission bandwidth or power.

Figure 1.1 Multiple Input Multiple Output (MIMO) channel model.
TX for transmitter and RX stand for receiver antennas.

Fig. 1.2 Earlier Technologies of Wireless Communication System
MIMO System:

Wireless communication System was developing continuously and during this advancement procedure it uses various technologies as per the demand and to provide quality of service in Wireless Communication System see figure 1.2. In this there were some earlier technologies which are as follows [8][9]:

a. SISO – Single Input Single Output System
b. SIMO – Single Input Multiple Output System
c. MISO – Multiple Input Single Output System

II. BELL LABORATORIES LAYERED SPACE-TIME

Bell Laboratories Layered Space-Time (BLAST) is a transceiver architecture for offering spatial multiplexing over multiple-antenna wireless communication systems. This type of system has multiple antennas at both the transmitter and the receiver in an effort to exploit the many different paths between the two in a highly-scattering wireless channel. BLAST was invented by G. Foschini at Bell Laboratories. Proper antenna allocation of the data being transmitted, many data streams can be transmitted simultaneously within a single frequency band the data capacity of the system then grows directly in line with the number of antennas. BLAST algorithm was first developed as Diagonal Blast and due to implementation complexity it is modified and introduced Vertical-Blast Technique.

a. D-Blast : Diagonal Bell Labs Layered Space Time
b. V-Blast : Vertical Bell Labs Layered Space Time

D-BLAST:

The diagonally-layered space-time architecture proposed by Foschini, now known as diagonal BLAST (Bell Laboratories Layered Space-Time) or D-BLAST is one that approach. D-BLAST uses multi element antenna structure at both transmitter and receiver and an elegant diagonally layered coding structure in which code blocks are dispersed across diagonals in time and space. In an free Rayleigh scattering model, this processing structure leads to theoretical rates which grow linearly with the number of antennas (assuming equal numbers of transmit and receive antennas) with these rates approaching 90% of Shannon capacity [16].

\[ \text{Fig. 2.1 D-Blast System} \]

V-BLAST:

The diagonal approach suffers from certain implementation complexities which make it inappropriate for initial implementation. In this thesis, we describe a simplified version of BLAST known as vertical BLAST or V-BLAST, which has been implemented in real time in the laboratory.

We have demonstrated spectral efficiencies of 20 - 40 bps/Hz at average SNRs ranging from 24 to 34 dB. Although these results were obtained in a relatively benign indoor environment, we believe that spectral efficiencies of this magnitude are unprecedented, regardless of propagation environment or SNR, and are simply unattainable using traditional techniques.

\[ \text{Fig. 2.2 V-Blast System} \]
The essential difference between D-BLAST and VBLAST lies in the vector encoding process. In DBLAST, redundancy between the substreams is introduced through the use of specialized inter substream block coding. The D-BLAST code blocks are organized along diagonals in space-time.

It is this coding that leads to D-BLAST’s higher spectral efficiencies for a given number of Tx and Rx. In V-BLAST, still, vector encoding process is simply a de-multiplex operation followed by independent bit-to-symbol mapping of each sub stream. No inter sub stream coding, or coding of any type, is needed, though conventional coding of the individual sub streams may certainly be applied[1].

Multipath refers to the phenomenon by which multiple copies of a transmitted signal are received at the receiver, due to the presence of multiple radio paths between the transmitter and receiver. These multiple paths arise due to reflections from objects in the radio channel. Multipath is manifested in several ways in communications receivers, depending on the degree of path difference relative to the wavelength of propagation, the degree of path difference relative to the rate of signaling, and the comparative motion among the transmitter and receiver. Multipath from scatterers that are spaced very close together will cause a random change in the amplitude of the received signal. Due to central-limit effects, the resulting received amplitude is often modeled as being a complex Gaussian random variable.

This results in random amplitude whose envelope has a Rayleigh distribution, and this phenomenon is thus termed Rayleigh fading[14][19]. Other fading distributions also arise, depending on the physical configuration. When the scatterers are spaced so that the differences in their corresponding path lengths are significant relative to a wavelength of the carrier, the signals arriving at the receiver along different paths can add constructively or destructively. Which enhances fading that depends on the wavelength (or, equivalently, the frequency) of transmission, which is therefore called frequency selective fading. When there is relative motion between the transmitter and receiver, such type of fading also lay upon on time, since the path length is a function of the radio geometry. This results in time-selective fading. (Such motion also causes signal distortion due to Doppler effects.) A related phenomenon arises when the difference in path lengths is such that the time delay of arrival along different paths is significant relative to a symbol period. As a results in dispersion of the transmitted signal, and causes intersymbol interference (ISI); that is, contributions from multiple symbols arrive at the receiver at the same time.

Many of the advanced signal transmission and processing methods that have been developed for wireless systems are designed to contravene the effects of multipath. For example, wideband signaling techniques such as spread spectrum are often used as a countermeasure to frequency selective fading. These all minimizes the effect of deep frequency-localized fades and facilitates the resolvability and subsequent coherent combining of multiple copies of the same signal[17][20]. Similarly, by dividing a high-rate signal into many parallel signals with lower rate, OFDM reduces the effects of channel scattering on high-rate signals. Alternatively, high-data-rate single-carrier systems make use of channel equalization at the receiver to counteract this dispersion.

III. PROPOSED METHODOLOGY

The functional block diagram shows the Proposed Methodology for V-BLAST MIMO OFDM system with PSK modulation and Gaussian Filtration Methodology in Fig. 3.1. In our proposed methodology PSK modulation with Gaussian Filter has been used to minimize the Bit Error Rate is calculated with SNR.
Fig. 3.1 Block Diagram of Proposed Methodology

The Block Diagram in the transmitter section very firstly the data is modulated by PSK modulator and then Inverse Fast Fourier Transform (IFFT) is applied for multiplexing then after addition of cyclic prefix is done with data signal through the channel the noise is mixed in the receiver section then cyclic prefix is removed Fast Fourier Transform (FFT) is applied for de-multiplexing then PSK Demodulation has been then after V-BLAST with MMSE and ZF methods have been adopted and in final stage the Gaussian Filter is adopted to reduce the BER.

As the above flow graph shows the whole simulation flow of Proposed Methodology in this firstly, the environmental variables initialized the then data is generated, PSK Modulates then IFFT Technique is used after that addition of cyclic prefix done then noise mixed with data signal. Then Cyclic Prefix is removed FFT is adopted and PSK demodulator is implemented then V-BLAST ZF & MMSE with Gaussian Filter for minimizing the BER.

Fig. 3.2 Flow Chart of Proposed Methodology

IV. SIMULATION RESULTS

The proposed system is explained in the previous section. In this section the results of simulations performed on the proposed system is discussed. The system in evaluated under different data lengths and with PSK modulation. The results is compared for V-Blast with ZF, V-Blast with MMSE and both with and without filter. The results are shown in below figures.
In Fig. 4.1 the simulation results with 512 bits data is displayed, and the performance of the V-Blast with Zero Forcing using filter perform better than other techniques. So here Filtered V-blast ZF is optimum for system.

Fig. 4.1 Performance of V-Blast MIMO-OFDM System with ZF and MMSE detection using Gaussian Filter and 512 bits data

In Fig. 4.2 the simulation results with 1024 bits data is displayed, and the performance of the V-Blast with Zero Forcing using filter enhanced a little bit than previous configuration. So here Filtered V-blast ZF is again optimum for system.

Fig. 4.2 Performance of V-Blast MIMO-OFDM System with ZF and MMSE detection using Gaussian Filter and 1024 bits data

In Fig. 4.3 the simulation results with 2048 bits data is displayed, and the performance of the V-Blast with Zero Forcing using filter enhanced again a little bit than previous configuration. So here Filtered V-blast ZF is again optimum for system.

Fig. 4.3 Performance of V-Blast MIMO-OFDM System with ZF and MMSE detection using Gaussian Filter and 2048 bits data

In Fig. 4.4 the simulation results with 4096 bits data is displayed, and the performance of the V-Blast with Zero Forcing using filter enhanced again a little bit than previous configuration. So here Filtered V-blast ZF is again optimum for system.

Fig. 4.4 Performance of V-Blast MIMO-OFDM System with ZF and MMSE detection using Gaussian Filter and 4096 bits data
In Fig. 4.4 the simulation results with 4096 bits data is displayed, and the performance of the V-Blast with Zero Forcing using filter enhanced quite similar than previous configuration. So here Filtered V-blast ZF is again optimum for system but the performance will remain constant as we increase the data size.

V. CONCLUSION AND FUTURE SCOPE

The simulation results of proposed system is shown in the previous section. The results clearly shown that the zero forcing (ZF) with V-blast performs better in MIMO-OFDM system and it will be enhanced when gaussian filter is used with this technique. The OFDM technology is widely used technique to transfer data over wireless media, as a result proposed work has added performance to the system.

In future if advanced versions of MMSE and ZF is used with this system, it will perform better than existing.

REFERENCES


Author’s Profile

Sarita Sidam is a research scholar at Sagar Institute of Science and Technology Affiliated to RGPV, Bhopal. She is pursuing her Master in Technology in Digital Communication. She has keen interest in wireless communication systems and advancement in the performance of MIMO technology.

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