Efficient Wireless Communication System using MIMO-OFDM and Advanced Detection Schemes

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Abstract - Modern communication technology is the subset of wireless communication and the day by day innovations are somewhere, somehow connected to the wireless technology. The innovations are mostly belongs to this area of technological research which is all time favorite with researchers. The most excellent thing about wireless technology is that it facilitates every device able to connect to the world in seconds and share information or retrieve information as quick as possible of any kind (images, video, data, and voice etc.). this paper discuss about the technology is being worked and possible enhancements can be done without losing its performance, and to achieve such improvement a non-linear detection technique V-Blast, integrated with the basic wireless system with the linear detection technique because these techniques are very efficient. To maintain the quality of service additional technology MIMO-OFDM is also integrated in the infrastructure of proposed communication system. Outcomes of the system are analysed under BER vs SNR graphs for different data lengths, different number of transmitter and receiver antennas by adopting 2-PSK modulation scheme. From the simulation Results to reduce the error probability Zero Forcing(ZF) and Minimum mean square error(MMSE) with V-Blast and Gaussian Filter made an extremely good combination.

Keywords: Non-Linear, Linear Detection Techniques, MIMO-OFDM 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.

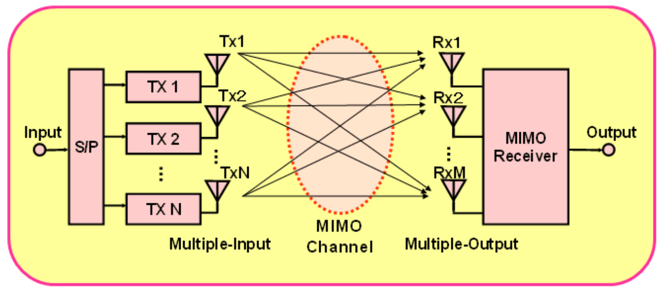

Figure 1.1 MIMO channel model. TxM for transmitter and RxM stand for receiver antennas.

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].

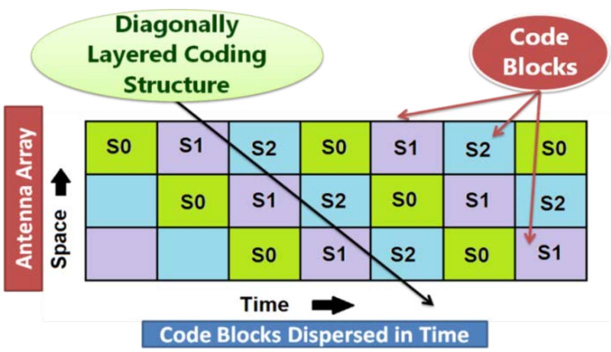

Fig. 2.1 D-Blast System

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.

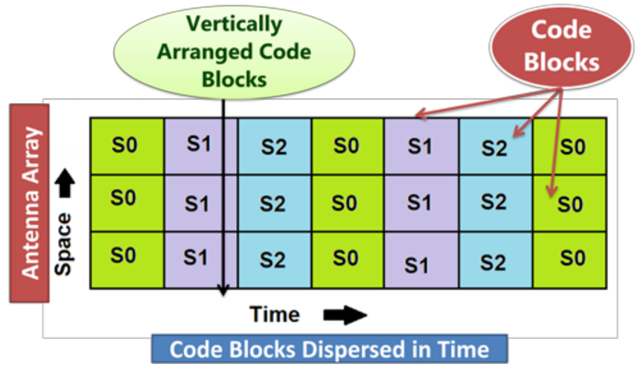

Fig. 2.2 V-Blast System

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 signalling, and the comparative motion among the transmitter and receiver.

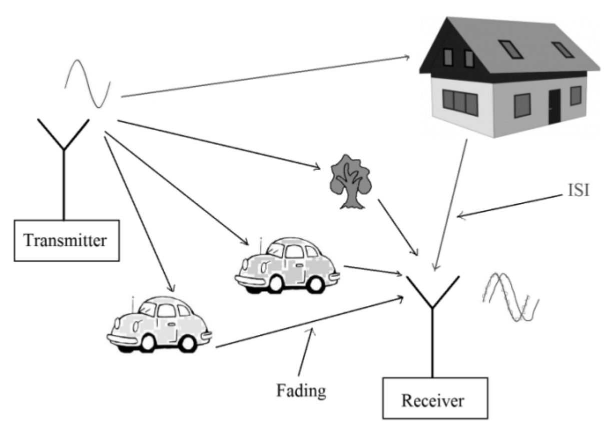

Fig.1.3 Wireless Channel Model

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 working block diagram of the Proposed MIMO-OFDM system with 2-PSK modulation using Gaussian Filtering Methodology is shown in Fig. 3.1. Here the proposed methodology utilizes 2-PSK modulation with Gaussian Filter and Different MIMO Antenna Configurations has been used to reduce the Bit Error Rate which is analysed with different levels of SNR.

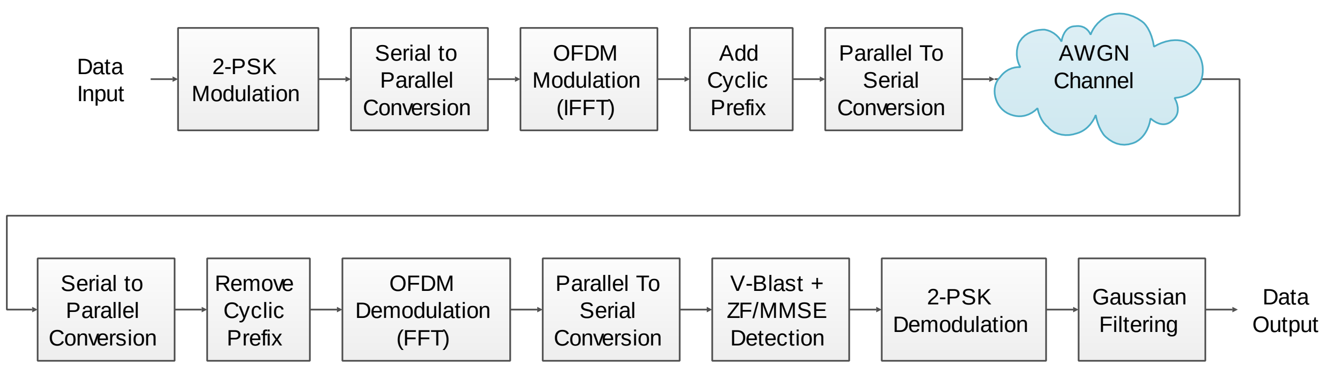

Fig. 3.1 Block Diagram of Proposed Methodology

The Block Diagram in the transmitter section very firstly the data is modulated by 2-PSK modulator and then OFDM Modulation i.e. Inverse Fast Fourier Transform (IFFT) is applied for multiplexing then after addition of cyclic prefix is data signal transfer 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 2-PSK Demodulation has been done then after V-BLAST with MMSE and ZF linear detection methods have been adopted and in final stage the Gaussian Filter is adopted to reduce the BER.

As the flow graph shows the whole simulation flow of Proposed Methodology in this firstly, the environmental variables initialized then the data is generated, PSK Modulates then IFFT Technique is used after that addition of cyclic prefix then noise mixed with data signal during transmission. 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.

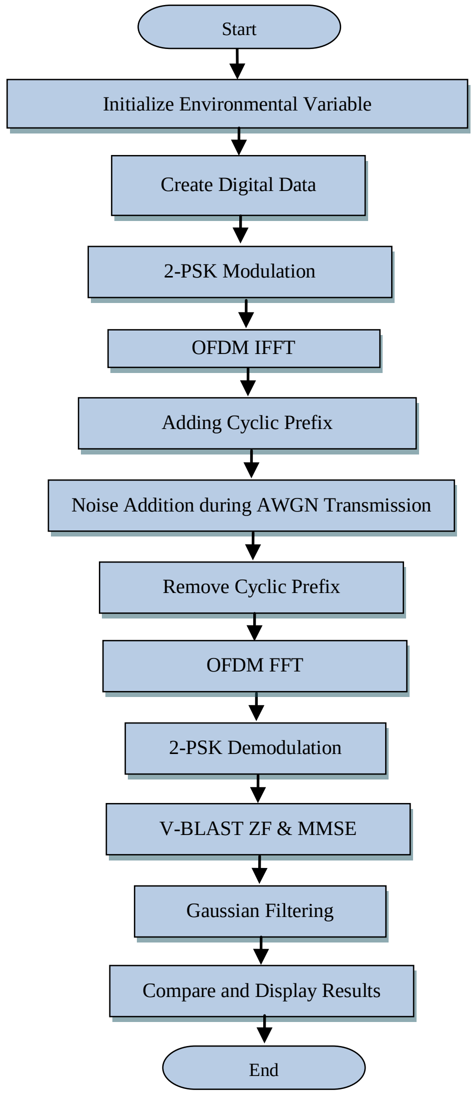

Fig. 3.2 Flow Chart of Proposed Methodology

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 2x2 antenna system 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.

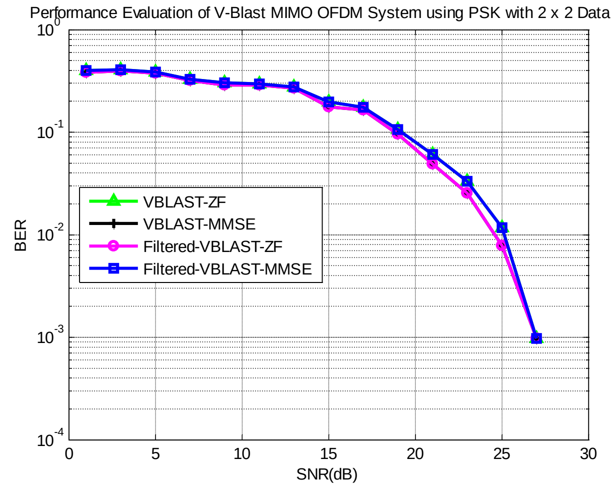

Fig. 4.1 Performance of V-Blast MIMO-OFDM System using ZF and MMSE detection with Gaussian Filter and 2x2 Antennas

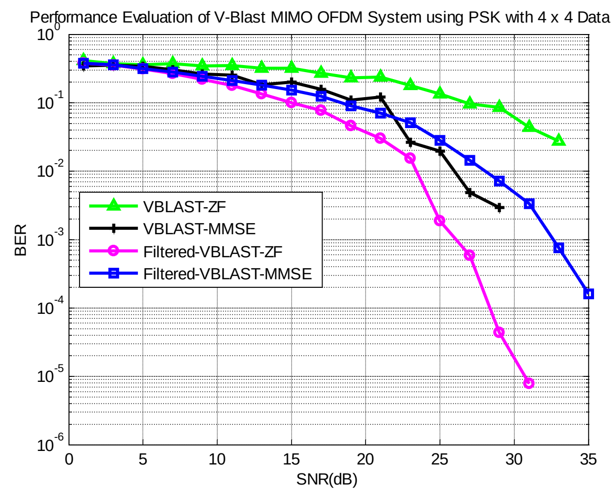

Fig. 4.2 Performance of V-Blast MIMO-OFDM System using ZF and MMSE detection with Gaussian Filter and 4x4 Antennas

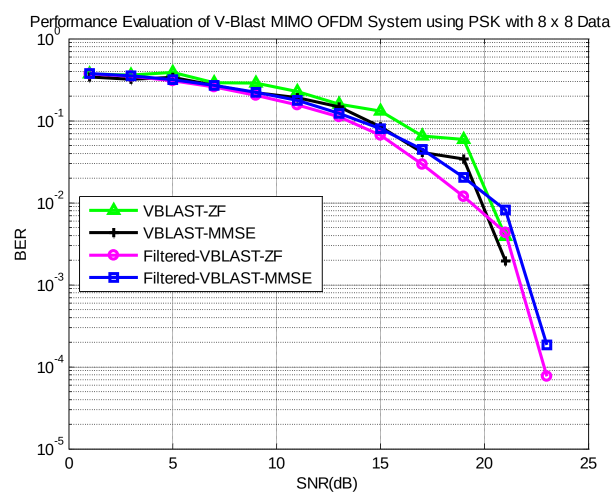

Fig. 4.3 Performance of V-Blast MIMO-OFDM System using ZF and MMSE detection with Gaussian Filter and 8x8 Antennas

In Fig. 4.2 the simulation results with 4x4 antenna system 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.

In Fig. 4.3 the simulation results with 8x8 antenna system 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.

V. CONCLUSION AND FUTURE SCOPE

The outcomes of the simulation of proposed system are shown in the last section. In the outcomes it is clearly shown that the minimum mean square(MMSE) and zero forcing (ZF) with V-blast performs better with 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 large data over narrow bandwidth wireless media, as a result proposed work has added better BER performance to the system. In future improvements the OFDM base wireless systems more sophisticated modulation techniques with definitely perform better and gives as low as possible error than existing systems, in addition with the system efficient detection techniques will help to reduce the noises presents in the signal at the receiver.

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