Design and BER Performance of MIMO-OFDM for Wireless Broadband Communications

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Abstract: *To achieve high data rates, speed and simultaneous increase in range and reliability without consuming extra radio frequency requires MIMO-OFDM for wireless broadband communication.*

This paper investigates the performance of MIMO-OFDM using different modulation schemes are used to encode and decode the data stream in wireless communication over AWGN channel for unknown transmitter and known receiver. In this paper first we integrate OFDM to MIMO. In particular; we apply MIMO detection methods based on VBLAST (Vertical Bells Lab Layered Space Time) architecture to improve spectral efficiency.

Keywords: *Orthogonal Frequency Division Multiplexing (OFDM); (Vertical Bells Lab Layered Space Time) VBLAST; Multiple Input Multiple Output (MIMO); Bit Error Rate (BER).*

I. Introduction

Now-a-days, wireless communication systems are playing crucial role. Initially, wireless systems were mainly designed to support voice. Later these are used to transfer the data, they gain popularity because of their ease of use and mobility .All wireless technology face the challenges of signal fading, multipath, increasing interference and limited spectrum. Orthogonal Frequency Division Multiplexing (OFDM) plays a crucial role and reduce receiver complexity in wireless broadband systems but in this case synchronization and channel estimation are very important, and it is replaced by Multiple Input Multiple output-Orthogonal Frequency Division Multiplexing (MIMO-OFDM) which is a multi-user OFDM that allows multiple accesses that scheme that combines TDM and FDM on the same channel, widely for the next generation wireless communication systems such as WLAN,WMAN, WiMAX and 3G-LTE standard in order to accommodate many users in the same channel at the same time. The use of MIMO technology in combination with OFDM, i.e., MIMO-OFDM is therefore seems to be an attractive solution for future broadband wireless systems. But this MIMO system having fast framing rate of the order of 1–2 µs will be polluted by ISI when operational in an environment having a typical time delay Spread of 200 µs. Thus an ISI value of 200/2 = 100 is an undesirable multi-path effect for the real MIMO system. Therefore MIMO cannot achieve zero ISI and hence cannot be utilized alone. OFDM based multi-carrier approach may be enabler for the MIMO broadband operation So the fast frames are slowed down first and converted to several slow sub frames and modulated to multiple carriers of OFDM. OFDM-MIMO is, therefore, useful technology which can be explored both for communication and remote sensing (radar).

MIMO concept was first introduced by Jack Winters in 1987 for two basic communication systems. The first was for communication between multiple mobiles and a base station with multiple antennas and the second for communication between two mobiles each with multiple antennas.MIMO systems in spatial multiplexing have two architectures namely Diagonal BLAST (D-BLAST) and Vertical BLAST (V-BLAST). D-BLAST uses diagonal approach which suffers from certain implementation complexities which make it inappropriate for initial implementation. Its main motivation is to increase diversity, and thus improve the robustness of the communication link. V-BLAST uses vector encoding process. Its main objective is to increase the capacity data rate in a constrained spectrum and spectral efficiency of the communication link.

Recently, IEEE 802.11n task group was formed with goal of increasing the application throughput by making changes in the PHY and MAC layer. The major challenge in the physical layer is the uses of multiple transmit and receive antennas and OFDM modulation, which comprises of OFDM modulation as well as subcarrier allocation. Therefore, it is significant to focus more attention on wireless communication technology. OFDM typically uses a higher FFT size, and divides the available sub-carriers into logical groups called sub-channels. Unlike OFDM that transmits the same amount of energy in each subcarrier, OFDM may transmit different amounts of energy in each sub-channel i.e., users may also occupy more than one sub channel depending upon their Quality of Service (QoS).

The rest of the paper is organized as follows: Section-II details V-BLAST Architecture. Section-III illustrates the overall design of OFDM-MIMO (V-BLAST). The implementation and simulation will be detailed in section-IV. Finally, section-V gives the main conclusions of the work.

II. V-Blast Architecture

The structure of the V-BLAST systems is described in fig.1Notation: Vector symbol a: $(a_1, a2, a3, a4_{......} a_{M)})^T$, No. of Tx = M_T, No. of Rx = M_R.

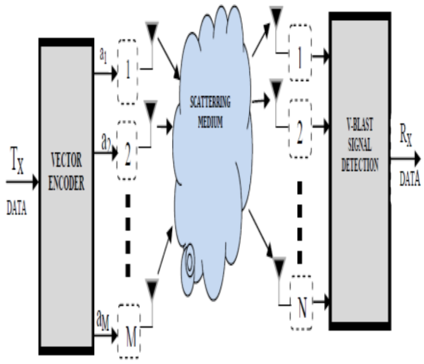

Fig.1. V-BLAST Architecture

A single data stream is demultiplexed into M sub streams, and each sub stream is then encoded into symbols and fed to its respective transmitter. Transmitters *1-*M_T operate co-channel at symbol rate *1/T* symbols/sec, with synchronized symbol timing. Each transmitter is itself an ordinary QAM transmitter. The collection of transmitters comprises, in effect, a vector –valued transmitter, where components of each transmitted M_T -vector are symbols drawn from a QAM constellation. We assume that same constellation is used for each sub stream, and that transmissions are organized into bursts of *L* symbols. The power launched by each transmitter is proportional to $1/M_T$ *so* that the total radiated power is constant and independent of M_T.

In V-BLAST, however, the vector encoding process is simply a demultiplex operation followed by independent bit-to-symbol mapping of each sub stream.

III. Exper Imental Setup for Ofdm- Mimo (V-Blast) Systems

The experiment is simulated as shown in fig.2. Assuming a AWGN channel with a maximum delay spread of 75ns, perfect channel knowledge at the receiver and perfect synchronization, no knowledge of the channel at the transmitter and employ interleaving. The modulation schemes employed are BPSK, QPSK and 16 QAM. The bandwidth of an IEEE 802.11a system is 20MHz.There are 256 sub-carriers in each OFDM symbol. These mark for an inter-carrier spacing Δf of $20X10^6$ /256 = 781.25 KHz.

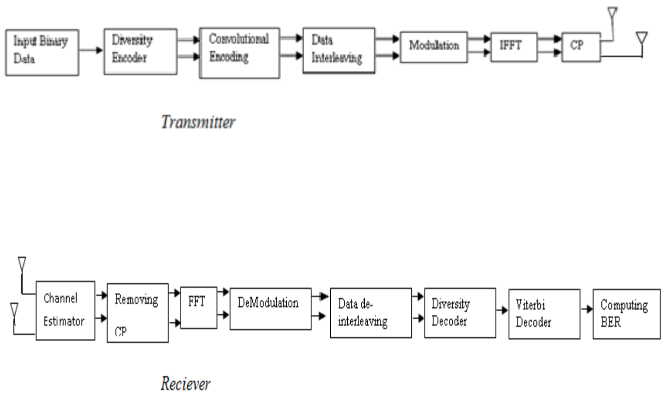

Fig.2. Block Diagram of OFDM-MIMO (V-Blast) System

The binary input data is initially sent to the diversity encoder. In diversity encoder spatial multiplexing is applied it prevents from long sequence of 0's and 1's .This splits the data into orthogonal streams. In the figure we are considering 2x2, 2x3, 2x4, 4x4 systems. The first stream is to the top, second stream to the second and it is continued to other streams likewise respectively. Here they are converted from serial to parallel. Thus the subcarriers are obtained. The subcarriers are then given to the convolution encoder. It is used for real time error correction. It is done by combining the fixed number of inputs. The input bits are stored in a fixed length shift registers and they are combined with the help of mod-2 adders. An input sequence and contents of shift registers perform modulo-two addition after information sequence is sent to shift registers, so that an output sequence is obtained. It is used to improve BER and to reduce high peak to average power ratio which is present in OFDM. . The de facto standard for this encoder is (2, 1, 7). The other rate ½ is achieved by puncturing the output if this encoder. Puncturing involves deleting coded bits from output data sequence, such that ratio of un-coded bits to coded bits is greater the mother code. The signal is then sent to the data interleaving. The idea of interleaving is to disperse a block of data in frequency so that the entire block does experience the deep fade in the channel. This prevents the burst errors at the receiver .Otherwise the convolution decoder will not perform very well in presence of burst errors. The interleaved are grouped together to form symbols. The symbols are then modulated using BPSK, QPSK and 16QAM schemes. They are given to IFFT and append to the CP. Hence the information is transmitted in packets. The receiver is the exact inverse process after the incoming packets are received. Diversity decoder converts parallel sub streams to serial form. The serial form is given to Viterbi decoder and is mostly applied to convolution encoder and it uses maximum likelihood decoding technique. Noisy channels cause bit errors at the receiver. Viterbi algorithm estimates actual bit sequence using trellis diagram. Then the BER is computed.

IV. Simulation

The above system was simulated in the MATLAB.As we know that the system is known receiver and unknown transmitter the information from transmitter to receiver was received in the form of packet or frame. The received packets may be lost or include errors because of noisy channel. Performance analysis is done for different Modulation schemes and for different transmit and receive elements. We transmit our data by using OFDM technique in which large number of closely spaced orthogonal subcarriers is used to carry data. Each Carrier is modulated and demodulated with a modulation schemes. The encoded data is passed through Gaussian where Additive White Gaussian noise (AWGN) is added. There are some restrictions and disadvantages in digital wireless communication systems between transmitter and receiver where received signals arrive at receiver with different power and time delay due to reflection, diffraction and scattering effects. For this reasons Bit Error Rate (BER) value is relatively high. In this condition the digital wireless communication systems will not perform well.BER is the fundamental parameter to access the quality.BER is simply defined as: Number of error bits/Number of total bits. Noise in transmission medium disturbs the signal and causes data corruptions. Relation between signal and noise is described with SNR (signal-to-noise ratio).SNR is defined as: signal power/Noise power. SNR is inversely proportional with BER. The less the BER result is higher the SNR and the better communication quality. We note that as the diversity order increases the performance of V-Blast improves, which is to be expected. The diversity order at the receiver is more than $M_R – M_T+1$ and less than M_R. By using FFT approach as the number of subcarrier increases the better is accuracy due to high number of points. The data rate will also increase.

i) In comparison with three modulation schemes QPSK, BPSK and 16 QAM with keeping the transmitting elements fixed and varying receiving elements are shown in fig 3, 4, 5. BER is varied slightly due to its receiving diversity technique.
ii) Performance of BPSK can improve BER and data rate, at small value of SNR. It operates between 4 and 6dB.
iii) Performance of QPSK is better than BPSK for the same bandwidth but the data rate will be doubled. It operates between 8 and 10dB
iv) Performance of 16QAM has better SNR when compared with QPSK; BPSK .It operates between 10 and 14dB.

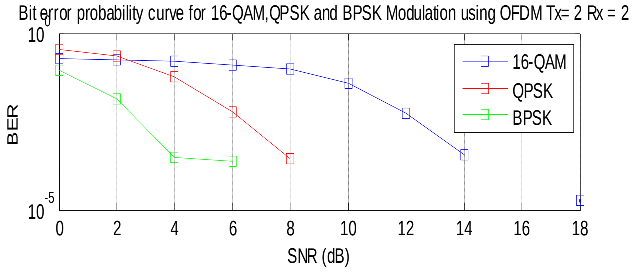

Fig.3. Performance of 2x2.Parameters: No. of FFT points=256; Channel=AWGN; Number of Data Carriers=256.

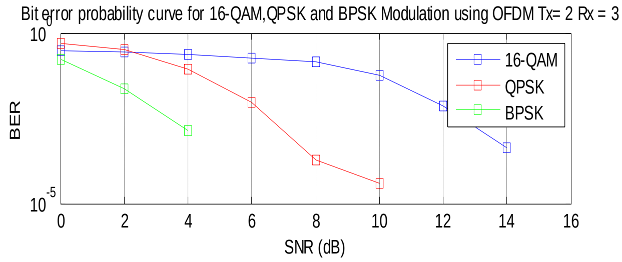

Fig.4. Performance of 2x3.Parameters: No. of FFT points=256; Channel=AWGN; Number of Data Carriers=256.

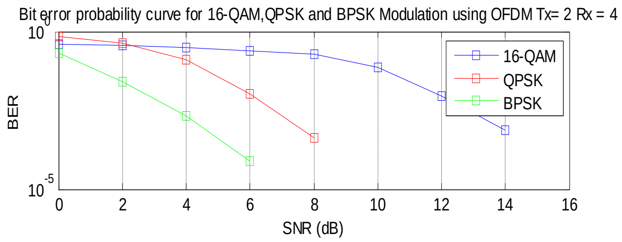

Fig.5. Performance of 2x4.Parameters: No. of FFT points=256; Channel=AWGN; Number of Data Carriers=256.

V) The 4x4 transmit and receiving elements as shown in fig 6 has better SNR in 16QAM when compared to other SNR.

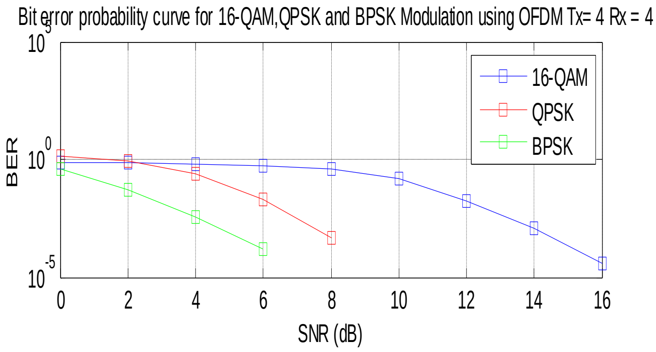

Fig.6. Performance of 4x4.Parameters: No. of FFTpoints=256; Channel=AWGN; Number of Data Carriers=256.

V. Conclusion

In this paper, we compare the performance of OFDM-MIMO (V-BLAST) in terms of BER using different modulation schemes by varying both transmitting and receiving elements on AWGN channel. It is found that by using VBLAST technique we can improve spectral efficiency.

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