Performance Analysis of the KPI parameters for MIMO –OFDM system using V-Blast Algorithm

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Abstract: This paper gives an introduction of various linear and non-linear detection techniques and about V-BLAST algorithm which is applied to improve the performance of the MIMO_OFDM system .

Keywords: MIMO, OFDM, Algorithm, Detection Techniques

I. INTRODUCTION

In OFDM systems the data is divided into several parallel channels, one for each sub-carrier. Each sub-carrier is modulated with a conventional modulation scheme (such as Quadrature amplitude modulation or phase shift modulation) at a low symbol rate maintaining total data rates similar to single carrier modulation scheme in the same bandwidth. The main concept in OFDM is Orthogonality of the sub-carriers. Since the carriers areall either sin or cosine waves, we know that thearea under the sine wave or cosine wave is zero as shown in Figure 1.1.

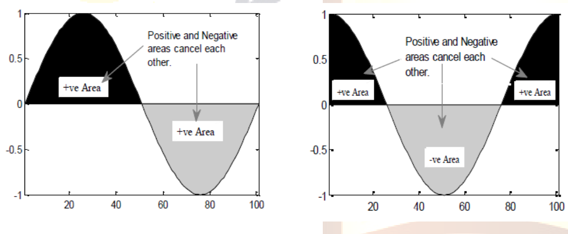

Figure 1.1: Thearea under a sineand a cosine wave over one period.

The main aim of the present research is to develop an algorithm that can improve the KPI parameters. The rest of the paper has been organized as follows section 2 describes OFDM basic principle, Section 3 describes the multipath environment and MIMO techniques. Section 4 describes various detection techniques and also V-BLAST algorithm which is used to improve the performance of the system. Results are given in section 5 and the paper is concluded in section 6.

II. OFDM PRINCIPLE

A high data transmission supposes very short symbol duration, conducing at a large spectrum of the modulation symbol. Theenergy from one symbol interferes with theenergy of the next ones, in such a way that the received signal has a high probability of being incorrectly interpreted. This provides a flat frequency response for each channel. This is represented in Figure 2.1.

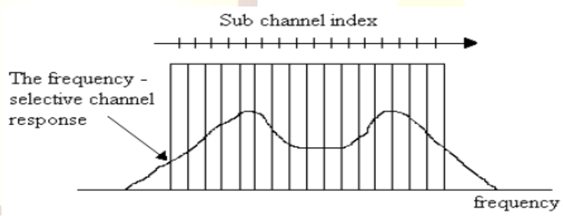

Figure 2.1: The frequency selective channel responseand relatively flat response on each sub channel

"Frequency Division Multiplexing" (FDM), means transmitting the data among a large number of closely spaced subcarriers. This is due to the fact that in OFDM the spectra of individual subcarriers are allowed to overlap.

2.1 OFDM SYSTEM BLOCK DIAGRAM

Figure 2.2 presents a classical OFDM transmission scheme that uses Fast Fourier Transform (FFT). The input data sequence is baseband modulated, using a digital modulation scheme. The modulation is performed on each parallel sub stream that is on the symbols belonging to theadjacent DFT frames. The data symbols are parallelized in N different sub streams. Each sub stream will modulatea separate carrier through the IFFT modulation block, which is the key element of the OFDM scheme. A cyclic prefix is inserted in order to eliminate the Inter symbol Interference (ISI) and Inter Block Interference (IBI)

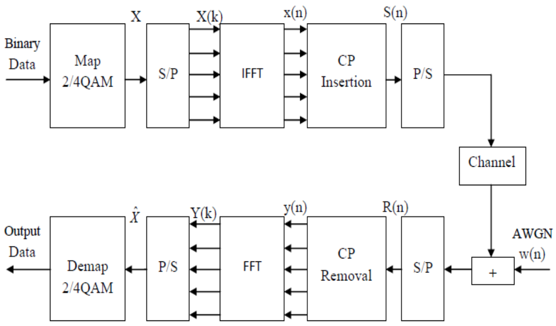

Figure 2.2: The block diagram of an OFDM system

The cyclic prefix of length L is a circular extension of the IFFT-modulated symbol, obtained by copying the last L samples of the symbol in front of it. The data is back-serial converted, forming an OFDM symbol that modulates a high-frequency carrier before transmitting through the channel. To the receiver, the inverse operations are performed; the data is down converted to the baseband and the cyclic prefix is removed. The coherent FFT demodulator will ideally retrieve theexact form of transmitted symbols. The data is serial converted and theappropriated demodulation scheme is used to estimate the transmitted symbols.

III. MIMO-OFDM DETECTION TECHNIQUES

In this section, the MIMO-OFDM transmitter model is proposed. A typical receiver structure for the proposed transmitter has been analyzed and discussed, and the signal model at each receive antenna is also derived.

3.1Transmitter model

The incoming data bits are randomized using a scrambler in order to avoid the occurrence of long zeros and ones. The output of the scrambler block ensures that the bits areequally likely to satisfy the theoretical assumptions. The scrambled bits are passed into an encoder sparser where it is de-multiplexed across the N_{ES} forward error correction (FEC) encoders in a round robin fashion. The total power transmitted is normalized across the N_t transmit antennas and is given as $\sum_{q=1}^{N_t} E\left[\left|x_q(n)\right|^2\right] = 1$, where $x_q(n)$ is the transmitted signal from the $q^{th}TX$ antenna.

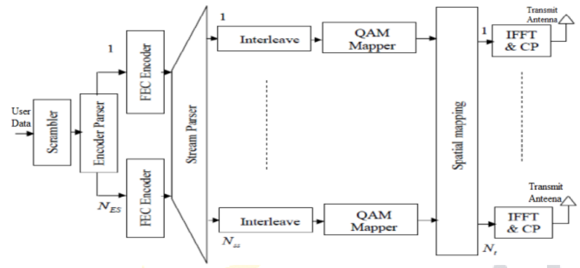

Fig 3.1 The 802.11n MIMO-OFDM Baseband Transmitter

3.2 Receiver model

At the receiver, N_r antennas are used to receive the signal. The signals in each RX antennaare down converted to baseband and sampled with a maximum sampling duration of 50ns. Assuming that the receiver is perfect timeand frequency synchronized, and theexact channel knowledge is availableat the receiver,

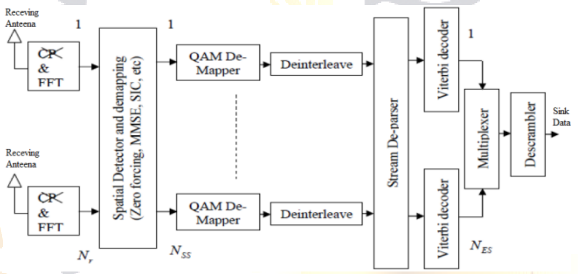

Fig 3.2 802.11n MIMO OFDM Baseband Receiver

IV. IMPLEMENTATION OF V-BLAST ALGORITHM

V-BLAST stands for Vertical Bell Laboratories Layered Space Time. V-BLAST is a wireless communication technique used with MIMO-OFDM systems. It is an extra ordinarily bandwidth efficient approach for wireless networks. Its spectral efficiency ranges from 20 to 40 bps/Hz whileefficiency of traditional wireless communication techniques ranges from 1 to 5 bps/Hz(mobile cellular) to around 10 to 12 bps/Hz (point to point fixed microwave system)[45]. In a wireless system, radio wave does not simply propagate from transmit antenna to receiveantenna, but bounceand scatter randomly off objects in theenvironment.

Thealgorithm for thewhole process can be categorized into three steps as follows,

Step1: Nullifying

Nullifying the solution,

$$\boldsymbol{G} = \begin{pmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{pmatrix}$$

Ordering,

$$\rho = \{\|(\boldsymbol{G})_1\|^2, \|(\boldsymbol{G})_2\|^2\}$$

$$k = min(\rho)$$

Finding nullified matrix,

$$\boldsymbol{g} = \begin{pmatrix} g_{21} \\ g_{22} \end{pmatrix}$$

Nullifying theeffect of signal,

$$y_2 = \boldsymbol{g}^T \boldsymbol{r}$$

Step2: Quantizing

$$x_2 = Quant(y_2)$$

Cancelling theeffect of detected stream from signal,

$$\boldsymbol{r} = \boldsymbol{r} - \begin{pmatrix} h_{21} \\ h_{22} \end{pmatrix} x_2$$

Step3: New channel matrix formation

$$\boldsymbol{H} = \begin{pmatrix} h_{11} & 0 \\ h_{12} & 0 \end{pmatrix}$$

Now the step1 will be repeated to get the first stream.

To implement V-Blast on ZF,

$$\boldsymbol{G} = \left(\boldsymbol{H}^H \boldsymbol{H}\right)^{-1} \boldsymbol{H}^H$$

Now the V-Blast algorithm will beapplied over G.

And to implement V-Blast on MMSE,

$$G = \left(H^H H + \frac{N_t}{SNR} I_{N_r} \right)^{-1} H^H$$

Now the V-Blast algorithm is applied over G.

V. RESULTS AND DISCUSSIONS

In this section the performance of various detection techniques are discussed on the basis of BER/SNR and compared with each other. The performance of V-BLAST based detection techniques arealso shown and compared with other detection techniques and hence the performance of V-BLAST based system is evaluated.

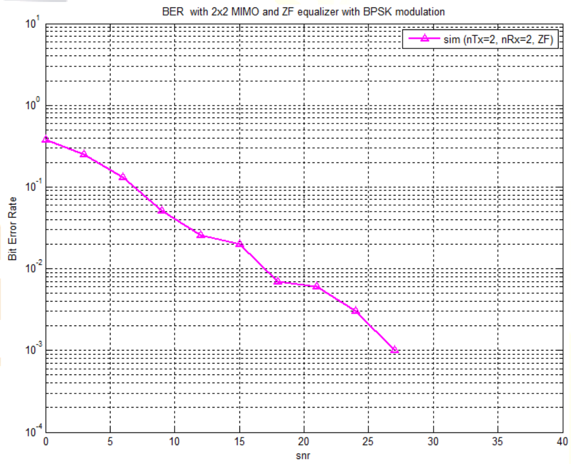

Fig 5.1 BER/SNR plot for ZF equalizer with BPSK modulation

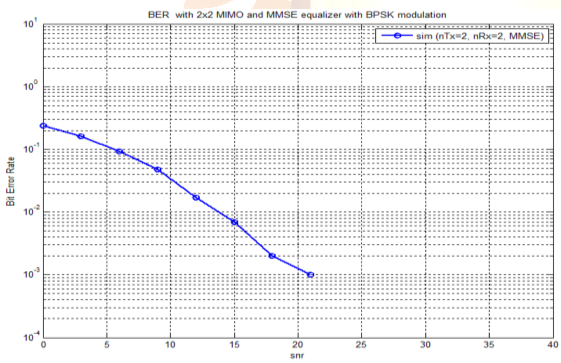

Fig 5.2 BER/SNR plot for MMSEequalizer with BPSK modulation

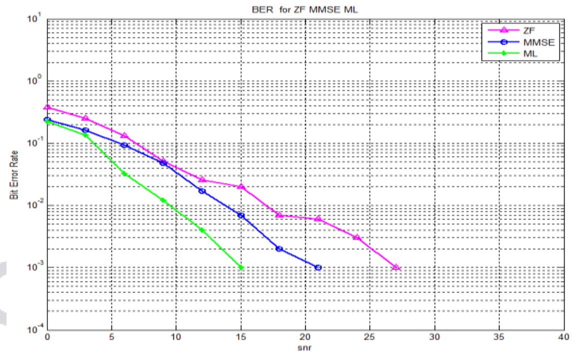

Fig 5.3 BER/SNR plot for ZF, MMSEand ML equalizers with BPSK modulation

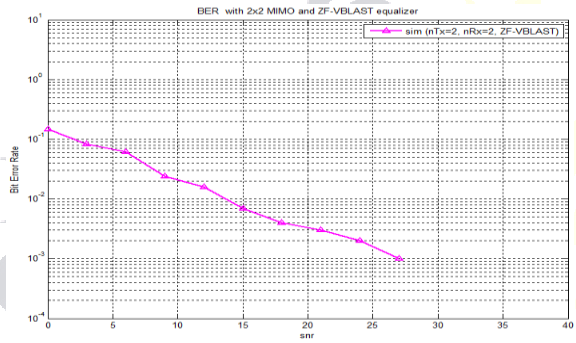

Fig 5.4 BER/SNR plot for V-BLAST based ZF equalizer with BPSK modulation.

The performance of all of these techniques is compared which clearly shows that the performance of MMSE shows better performanceas compared to ZF, but ML shows best performanceamong the three but it is very complex as compared to MMSEand ZF. That's why there was a need to discover a technique which shows better performance without the cost of complexity. Therefore V-BLAST algorithm is applied over ZF and MMSE with a view to find a technique which would show better performanceand it should be less complex as compared to ML.

VI. CONCLUSION

In this paper a 2X2 MIMO-OFDM system is analyzed using various detection techniques and BER/SNRparameters were found out. These parameters arecompared suchthataless complex system with higher accuracy and efficiency can be designed. On the basis of its results various parameters of a MIMO-OFDM system can be found out for a particular requirement. Hence this paper can be used as a reference for choosing a best suited MIMO-OFDM system for a particular task. In this paper, the performance of MIMO-OFDM system is also analyzed with various modulation techniques which are the basic building blocks of modern digital communication. Hence this paper can also be used to compare between various modulations techniques in MIMO-OFDM communication. One can also makeappropriate choice of a modulation technique which will best suit his requirements and also the favourable conditions for the system to work efficiently, on the basis of the given comparison.

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