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Advancement of MIMO-OFDM System with Proficient Coding Technique

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abstract: However, wireless devices are range and data rate limited. The research community has spent a great deal of effort on finding ways to overcome these limitations. One method is to use Multiple-Input Multiple-Output (MIMO) links. The multiple antennas allow MIMO systems to perform precoding (multi-layer beamforming), diversity coding (space-time coding), and spatial multiplexing. Beamforming consists of transmitting the same signal with different gain and phase (called wights) over all transmits antennas such that the receiver signal is maximized. Diversity consists of transmitting a single space-time coded stream through all antennas. Spatial multiplexing increases network capacity by splitting a high rate signal into multiple lower rate streams and transmitting them through the different antennas. High bit error rates of the wireless communication system require employing forward error correction (FEC) methods on the data transferred to reducing the error in transmission. This paper we analyze the performance of MIMO-OFDM system under 16 QAM and 64 QAM system by using forward error correcting codes (Convolutional codes) under AWGN channel and compare with OSTBC code.

Keyword: MIMO-OFDM, Forward Error Correction (FEC), OSTBC Coding, Convolution coding, Puncturing, Interleaving

I. INTRODUCTION:

Multicarrier modulation techniques, including OFDM modulation are considered as the most promising technique to combat this problem [1]. OFDM technique is a multi-carrier transmission technique which is being recognized as an excellent method for high speed bi-directional wireless data communication. Orthogonal Frequency Division Multiplexing (OFDM) is mainly used in the standards for high speed data communications in wireless LAN and MAN such as Worldwide Interoperability for Microwave Access (WiMAX) [2]. One of the fastest growing areas of consumer electronics is multimedia applications based on Wireless communications for Metropolitan Area Network (MAN) [3]-[5]. It is a rapidly evolving field with ever increasing data rates to support consumer's demands for new features, advanced functionality, and services for multimedia content provision. Orthogonal frequency division multiplexing (OFDM) with multiple-input multiple-output (MIMO) feature is mainly used in the standard for high speed data communications Worldwide Interoperability for Microwave Access (WiMAX). The forward error correction (FEC) mechanisms play an important role in the performance of MIMO-OFDM systems. The forward error correction (FEC) mechanism in the standard plays a very important role in its performance. A number of techniques are being used to achieve highly effective error-control coding. Interleaving also plays a major role in the FEC mechanism. The aim of interleaving is to reorder the incoming data and make the adjacent bits non-adjacent by a factor, to cope with the burst errors occurring during the transmission of data over the channel. We have divided the paper in different section, in second section we describe the system description in which we describe the convolution coding puncturing and interleaving, third section contain the system simulation parameters and finally we conclude the result and its contingencies in last section.

II. SYSTEM DESCRIPTION:

A. Multiple Input Multiple Output Systems:

The key challenge faced by wireless communication systems is developing of very high speed wireless communication links that allow good quality-of-service (QoS) and coverage capability in non-line-of-sight (NLOS) environments. As we know that bandwidth spectrum is a limited source and propagation conditions are hostile due to multipath component at receiving side and interference from other users, this requirement calls for means to genuinely enhance spectral efficiency and to improve link reliability. Multiple-input Multiple-output (MIMO) wireless technology achieve these demands by offering increased spectral efficiency through spatial multiplexing gain, and improved link reliability due to antenna diversity gain without additional bandwidth or increased transmit power [6].

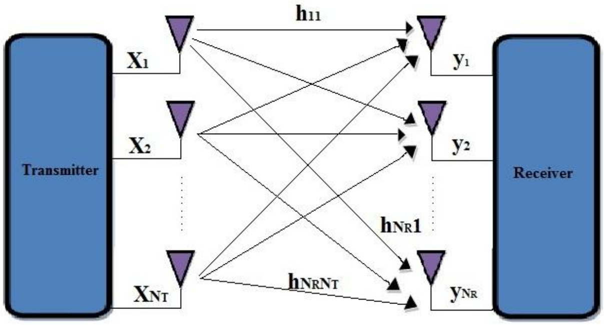

Fig 1: $N_R \times N_T$ MIMO System

We can write MIMO system in matrix form as follows:

$$\begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_r \end{bmatrix} = \begin{bmatrix} h_{1,1} & h_{1,2} & \cdots & h_{1,t} \\ h_{2,1} & h_{2,2} & \cdots & h_{2,t} \\ \vdots & \vdots & \ddots & \vdots \\ h_{r,1} & h_{r,2} & \cdots & h_{r,t} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_t \end{bmatrix} + \begin{bmatrix} n_1 \\ n_2 \\ \vdots \\ n_r \end{bmatrix} \quad \text{...(1)}$$

In this paper, MIMO is implemented using Alamouti algorithm with 2 antennas at the transmitter and 2 antennas at the receiver side and it is shown in figure 2. A orthogonal space-time block code [7] for two transmit antennas was developed by Alamouti [8]. In the Alamouti encoder, two consecutive symbols x_1 and x_2 are encoded with the following space-time code word matrix:

$$X = \begin{pmatrix} x_1 & -x_2^* \\ x_2 & x_1^* \end{pmatrix}$$

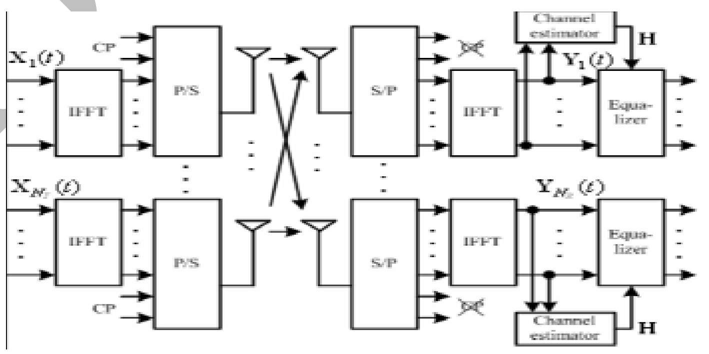

Fig. 2 MIMO OFDM system with Alamouti

Alamouti encoded signal is transmitted from the two transmit antennas over two symbol periods. During the first symbol period, first transmitter transmits x_1 and the second transmitter transmits x_2 simultaneously. During the second symbol period, these symbols are transmitted again, where $-x_2^*$ is transmitted from the first transmit antenna and x_1^* transmitted from the second transmit antenna.

III. CONVOLUTION CODING:

Convolutional codes were first introduced by Elias in 1955 as an alternative to block codes. Convolution encoder contains memory while block encoder are memory less. A convolutional code is generated by passing the information sequence to be transmitted through a linear finite-state shift register. In general the shift register consists of *K* (*k*-bit) stages and n linear algebraic function generators.

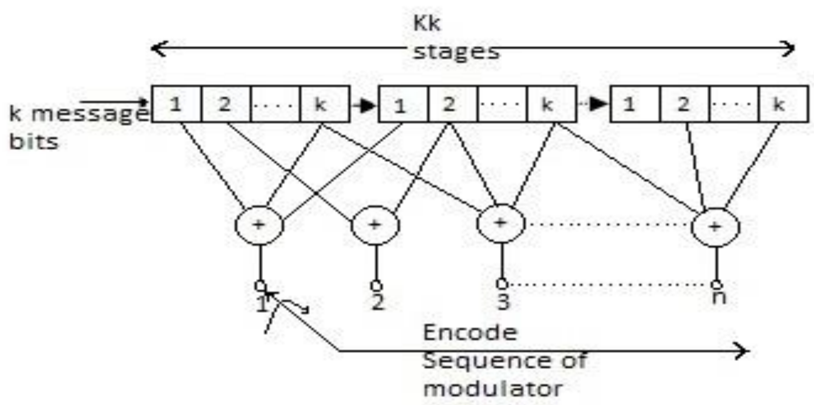

Fig. 3: Convolutional Encoder

Where, *k* = number of bits shifted into the encoder at one time
n = number of encoder output bits corresponding to the *k* information bits
Code rate =*k*/*n,"* The quantity *k/n* called the code rate, is a measure of the efficiency of the code. Commonly *k* and *n* parameters range from 1 to 8, *m* from 2 to 10 and the code rate from 1/8 to 7/8 except for deep space applications where code rates as low as 1/100 or even longer have been employed.*"*
Puncturing techniques can be easily applied to convolutional codes. This allows generating a set of punctured codes out of one mother code. The advantage is that to decode them all only one decoder is needed and adaptive coding scheme can be thus implemented. One of the most important decoding algorithms is the Viterbi algorithm that uses the principle of maximum likelihood decoding.

IV. PUNCTURING:

To ensure high reliability, however, convolutional codes tend to occupy a large bandwidth. This is due to the fact that convolutional codes add redundancy to each transmitted bit, producing a code rate of smaller than 1. The larger number of redundancy bits added to each transmitted bit, the stronger the protection given to the said bit against transmission errors [9]. One way to reduce the occupied bandwidth is by using punctured convolutional codes [10] [11]. Puncturing is the process of deleting some parity bits from the codeword according to a puncturing matrix. Puncturing is the trade-off between rate and performance. Puncturing increases code rate without increasing complexity for code rate from 1/3 to ½ or more and decreases free distance of code. The redundant bits in coding decrease the bandwidth efficiency. The bandwidth efficiency decreases with increase in redundant bits in coding. The puncturing pattern adjust code rate to achieve system requirement, the puncturing pattern adjust code rate.

V. INTERLEAVING:

It is a way to arrange data in a non- contiguous way to increase performance. It is typically used in error correction coding, particularly within data transmission, for multiplexing of several input data over shared media. The interleaving technique is to reorder the encoded data such that the adjacent bits can now become nonadjacent which can help handling the burst error occurring in those channels. Many papers in the literature have addressed the issue about how to interleave the data in order to reduce the decoding errors [12] [13] [14]. To reorder a long sequence of data, there are two fundamental approaches being popularly used. The first approach is to divide the sequence into separate blocks, and the orders of data in each block are permutated according to some predetermined function. This type of interleaving is referred as block interleaving. The other type of interleaving is called convolutional interleaving which shuffles the sequence in a regular sliding-window approach. Usually the selection of interleaving type has to be matched with the type of error control code being adopted.

VI. PROPOSED MODEL & SIMULATION RESULTS:

I. Proposed model:

In the proposed model of OFDM OSTBC Encoder is used as forward error correction code in place of Convolution encoder and time interleaved data passes through the different modulation (16 QAM, 64 QAM). Following block diagram represent the proposed model.

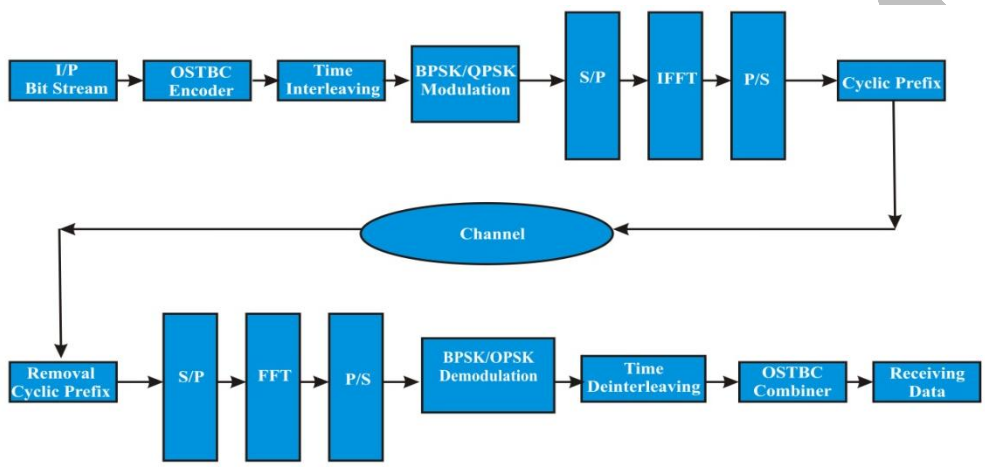

Fig. 4: Proposed OFDM Model

II. Simulation Parameters

The simulation parameters used in this thesis are given in the following Table.

Table 1: OSTBC-OFDM Simulation parameters

Parameter	Value/Type
Error Correcting coding	Convolutional code, STBC
Modulation	16 QAM,64 QAM
Channel	AWGN
Interleaver	Time Interleaver
FFT size	256
Coding rate	1/2, ¾
Encoder	Trellis, OSTBC Encoder
Decoder	Viterbi, OSTBC Combiner

III. BER Analysis of 16 QAM

In this section BER analysis of MIMO-OFDM system using Convolutional code and OSTBC code structure is done for 16 QAM Modulations over AWGN channel.

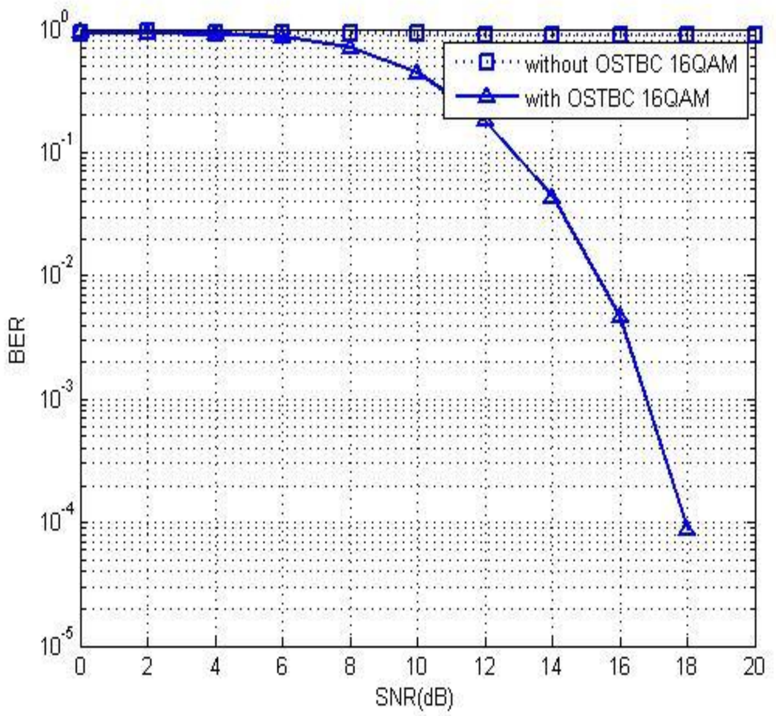

Fig. 5: BER comparison for16-QAM

Table 2: BER values for 16-QAM

SNR(dB) Value	BER without OSTBC	BER with OSTBC
0	0.934809	0.93342
2	0.93316	0.924219
4	0.932639	0.908681
6	0.925608	0.865104
8	0.917795	0.699306
10	0.911979	0.441406
12	0.901997	0.184201
14	0.897049	0.044965
16	0.898958	0.005208
18	0.894097	8.68E-05

IV. BER Analysis of 64 QAM

In this section BER analysis of MIMO-OFDM system using Convolutional code and OSTBC code structure is done for 64 QAM Modulations over AWGN channel.

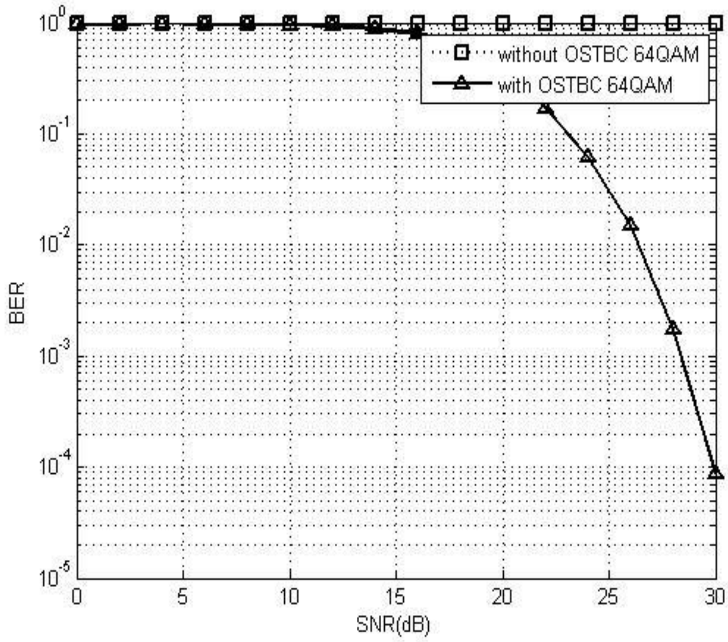

Fig. 6: BER comparison for 64-QAM

Table 3: BER values for 64-QAM

SNR(dB) Value	BER without OSTBC	BER with OSTBC
0	0.983767	0.98342
4	0.983333	0.981337
8	0.982552	0.973351
10	0.979253	0.967188
12	0.98099	0.943403
14	0.979774	0.895313
16	0.979601	0.798524
18	0.979774	0.605729
20	0.980035	0.370486
22	0.97908	0.170139
24	0.982118	0.059201
26	0.979601	0.015451
28	0.980035	0.001736
30	0.980382	8.68E-05

From graph 5.4 and 5.5 it was found that for high SNR values OSTBC 16-QAM and 64-QAM performs satisfying BER but it is perform for high SNR value and that are why to minimize the BER it's mandatory to increase the power of transmission signal.

E. BER Comparison of 16 QAM and 64 QAM with OSTBC coding

In this section BER performance comparison of 16-QAM and 64-QAM modulation using OSTBC code structure is done.

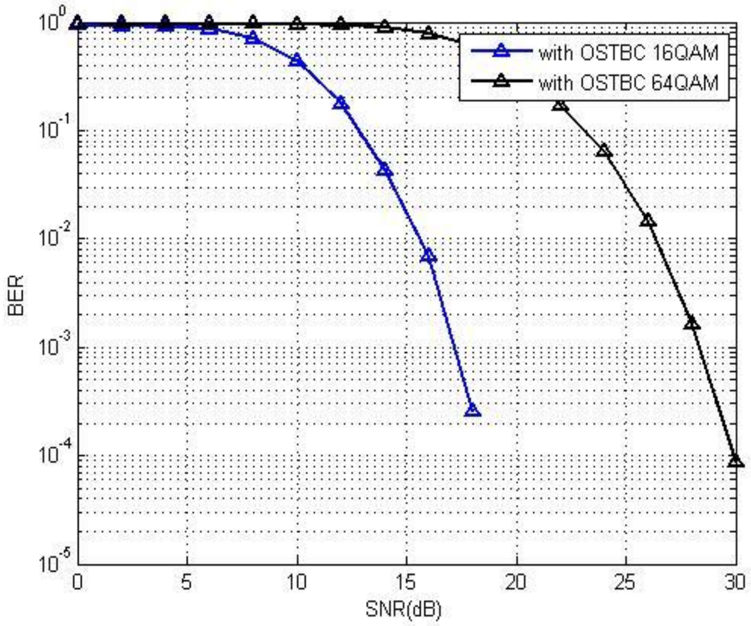

Fig.7: BER comparison of 16 QAM and 64 QAM for OSTBC

Table 4: BER values for OSTBC 16 QAM and 64 QAM

SNR(dB) Value	BER of 16-QAM	BER of 64-QAM
0	0.932639	0.980729
2	0.934983	0.983767
4	0.914931	0.98125
6	0.869531	0.977431
8	0.715885	0.973524
10	0.440365	0.959809
12	0.165799	0.94375
14	0.036806	0.904167
16	0.004774	0.811198
18	0.000174	0.613542

VII.CONCLUSION:

In this paper we compare the performance of MIMO-OFDM system in terms of BER using Forward Error Correction codes on AWGN channel. Here Convolutional codes are used as FEC codes. We evaluate Bit Error Rate of convolutional codes at different code rates for two modulation schemes and compare them with OSTBC code. Results show that BER performance is best for 16 QAM modulation schemes but we can use it only for low range communication system. For long range communication we have increase the SNR values so that transmission power must increase, hence high power may cause for interference. Therefore system needs another filtering of received signal.

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