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A comparison analysis for AF, DCF, DTF relaying techniques in distributed QO-STBC

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Abstract

STBC (Space Time Block Code) schemes are widely used in MIMO-OFDM systems for communicational link or antenna link performance enhancements. For more than two transmit antenna systems, QOSTBC (Quasi Orthogonal STBC) is found to be very effective. In general QO-STBC lowers decoding complexity and higher BER performance is achieved. In this paper the output for the bit-error-rate (BER) performance of quasi-orthogonal space time block code (QOSTBC) with L=4 and M=1 antennas over the frequency flat Rayleigh block fading channel has been analyzed. For encoding and decoding processes, Alamouti scheme and (ML) maximum likelihood decoding scheme has been used simultaneously. Also we consider the throughput problem of a wireless fading network with relaying scheme, where n single antenna source-destination pairs communicate through a set of single antenna relays using detect-and-forward, decode- and-forward along with amplify-and-forward strategies. Finally the performance of all has been evaluated along with AWGN, Rayleigh fading channels with MRC with two sender strategy.

Keywords: Alamouti Code, STBC, OSTBC, QOSTBC, BER, Decode and Forward (DF), Amplify and Forward (AF), MATLAB

1. Introduction

The efficiency of a wireless communication system is achieved by three basic parameters viz. bandwidth, transmit power and wireless channel environment. As the system has limited bandwidth, the available spectrum can be utilized only by limited number of users. As the system has limited bandwidth, the available spectrum can be utilized only by limited number of users. The characteristics of a wireless channel are dynamic and unpredictable, which makes the system analysis difficult. Here huge amounts of data can be transferred to longer and longer distances without any cables which lead to fading. Fading is the variation of signal amplitude over time and frequency. It may either be due to multipath propagation, scattering, diffraction or non LOS-communication. It causes signal degradation and reduced performance. To overcome this drawback, diversity techniques are adopted.

Diversity is a method of improving reliability of a message signal using multiple communication channels. There are many diversity techniques such as transmit diversity, receive diversity, time diversity, space diversity, frequency diversity etc. Here transmit diversity and spatial diversity techniques are adopted. In transmit diversity technique, signals originating from two or more independent sources have been modulated with the same information bearing signal. In space diversity, signals are transmitted over multiple propagation paths. Space time block codes provide spatial diversity using multiple transmit antennas. Hence a system can perform better even in a fading environment.

Some motivational factors that best suits towards choosing STBC for solving diversity problems.

- Mobile devices are small in general and could not be efficient for being optimal receiver satisfying diversity
- Receiver Decoding complexity is limited for the devices
- Requirement of effective system with open loop configuration
- Efficient Data Encoding and Data Decoding Schemes
- Low Power Requirements
- Requirement of low complex transmit and receive diversity at the BS.

Space–time block coding is a technique used in wireless communications to transmit multiple copies of a data stream across a number of antennas and to exploit the various received versions of the data to improve the reliability of data-transfer.

The Space-Time Codes (STCs) have been implemented in cellular communications as well as in wireless local area networks. Space time coding is performed in both spatial and temporal domain introducing redundancy between signals transmitted from various antennas at various time periods. It can achieve transmit diversity and antenna gain over spatially uncoded systems without sacrificing bandwidth.

The research on STC focuses on improving the system performance by employing extra transmit antennas. In general, the design of STC amounts to finding transmit matrices that satisfy certain optimality criteria. Constructing STC, researcher have to trade-off between three goals: simple decoding, minimizing the error probabilIty, and maximizing the information rate.

There are two types of space time block codes. They are as following:

a. Orthogonal Space time block codes.

b. Non-Orthogonal space time block codes.

Different types of orthogonally

Orthogonal if the inner product of any distinct rows of the matrix is 0.

Quasi Orthogonal matrix in which the columns are divided into groups. The columns within each group are not orthogonal to each other but different groups are orthogonal to each other.

This has been used in coding theory by Zafarkhani

Encoding Scheme

Alamouti Codes

To demonstrate STBC (Space Time Block Codes), the Alamouti code, the very basic and commonly used space time code is explained in details.

Below figure represents an Alamouti code for two transmitters and one receiver system (2x1)

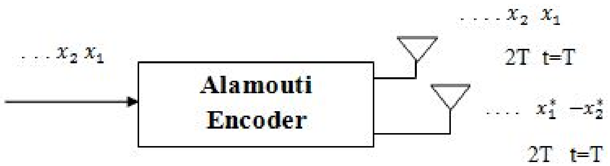

Fig 1: Alamouti encoder

h1 and h2 are impulse responses of the two channels whose envelopes follow Rayleigh distribution.

	Transmitter1	**Transmitter2**
Time t	x1	x2
Time t+T	-x2*	x1*

Where x1, x2 are the modulated symbols.

The received vectors are

y1= h1(x1) + h2(x2) +n1 (first time slot)

y2= h1 (-x2*) + h2(x1*) +n2 (second time slot)

where n1,n2 denote AWGN noise and y1,y2 denote the received vectors

These equations may be written as

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} h_1 & h_2 \\ h_2^* & -h_1^* \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} n_1 \\ n_2 \end{bmatrix}$$

$$H = \begin{bmatrix} h_1 & h_2 \\ h_2^* & -h_1^* \end{bmatrix}$$

Is an 2×2 channel matrix or

y=hx + n and h is an orthogonal matrix

Decoding Scheme

Decoding is the process of converting received messages into code words of a given code. There have been many methods of mapping messages into code words.

These are mostly used to regain messages sent over a noisy channel.

ML (Maximum Likelihood Decoding) algorithm is always assumed to be a low complex method for OSTBC(Orthogonal space-time block codes (OSTBCs) based on the real-valued lattice representation.

IV. Different Relaying Schemes

In communication systems, a relay channel is a probability model of the interlinking between a transmitter and a receiver aided by one or more intermediate relay nodes.

Decode and Forward Scheme (DCF)

Decode-and-Forward (DF): In this relaying scheme, the relay decodes the source message in one block and transmits the re-encoded message in the following block.

The achievable rate of DF is known as

$$\max_{p(x_1,x_2)} \min\left(I\left(x_1;y_1|x_2\right), I\left(x_1,x_2;y\right)\right)$$

Amplify and Forward Scheme (A-F)

Amplify-and-Forward (AF): In this relaying scheme, the relay sends an amplified version of the received signal in the last time-slot. Comparing with DF and CF, AF requires much less delay as the relay node operates time-slot by time-slot. Also, AF requires much less computing power as no decoding or quantizing operation is performed at the relay side.

MRC

In telecommunications, maximal-ratio combining (MRC) is a method of diversity combining in which:

1. The signals from each channel are added together,
2. The gain of each channel is made proportional to the rms signal level and inversely proportional to the mean square noise level in that channel.
3. Different proportionality constants are used for each channel.

It is also known as ratio-squared combining and pre detection combining. Maximal-ratio combining is the optimum combiner for independent AWGN channels.

MRC can restore a signal to its original shape.

V. Experimental Results

The virtual tool simulation is supported by the following tools:

- MATLAB version 7.7 (R2008b);

Below figure shows simulated output for the bit-error-rate (BER) performance of quasi-orthogonal space time block code (QOSTBC) with L=4 and M=1 antennas over the frequency flat Rayleigh block fading channel.

The costellation used: QPSK for s1 and s2.

Rotated Pi/4 QPSK for s3 and s4.

Such design yields to full rate code and 2 bis/sec/Hz.

QPSK constellation

x_q = [1 1-1-1];

y_q = [1 -1 1-1];

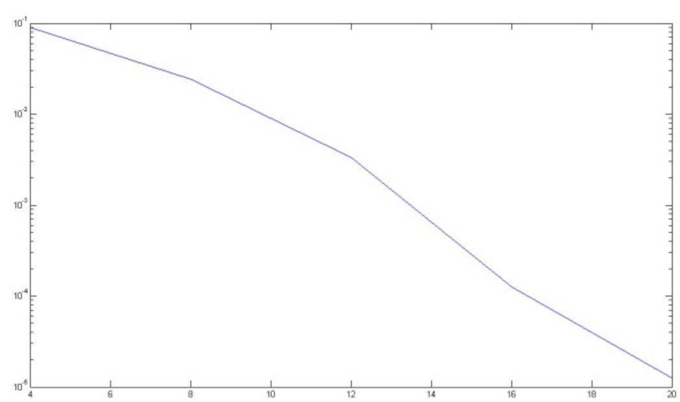

Fig 5: BER Performance for QO- STBC

Comparison of Decode and F, Detect and F and Amplify and Forward Methods in flat fading with WGN

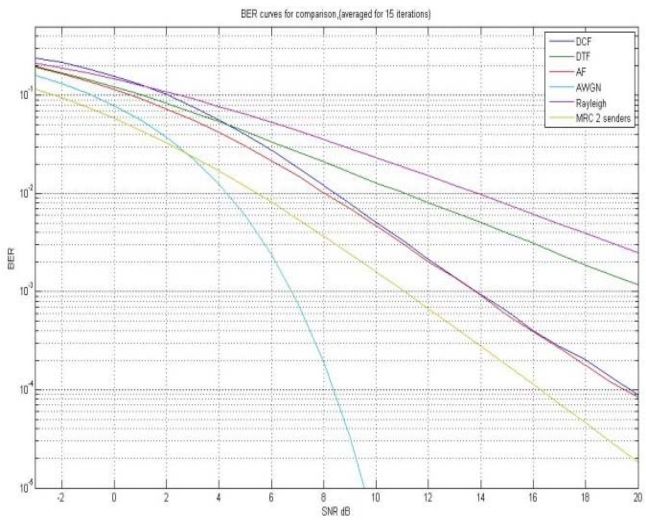

Fig 6: BER Performance for QO- STBC with DCF, DTF, A-F, MRC, AWGN, Rayleigh schemes

The above results shows A-F (Amplify and forward) Relaying scheme has greater BER performance as compared to the Decode and Forward Scheme (DCF) and Detect and Forward(DTF) Schemes.

VI. Conclusion

With reference to the current scenario and considering the performance of a wireless communication system in various fading environment, linking between transmitter and receiver has been very essential and in this study we have implemented a BER performance for the most effective antenna linking scheme QO-STBC and analyzed its performance for various relaying schemes. considering Decode-and –Forward (DCF), Detect-and-Forward (DTF), Amplify-Forward and MRC scheme for 2 senders and compared the result with AWGN and Rayleigh channels. We found A-F method is very effective as compared to the DCF and DTF Schemes and can be suitably used for optimizing the diversity problems.

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