CAPACITY AND PERFORMANCE ANALYSIS OF MIMO-SPACE TIME BLOCK CODE SYSTEM

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Abstract

Spectrum is a limited resource in wireless communication and thus it limits the data rate for transmission. But the emergence of multiple antenna system i.e MIMO (Multi Input Multi Output) has explored the space dimension for information transmission. MIMO system provides a solution for increase in gain of capacity without increasing the use of spectrum. Thus, the MIMO is an attractive scheme in the evolution of fourth generation broadband wireless communication. The MIMO system is mainly attractive for increasing the efficiency with multiple antennas. The MIMO scheme had been simulated and evaluated in terms of Bit Error Rate (BER) versus the Signal to Noise Ratio (SNR) .

Keywords MIMO Systems, Space-time Block Codes, BER, SNR, Capacity.

I. Introduction

MIMO systems are considered to provide high data rate and are robust to multipath delay in wireless communication [1]. Channel parameters are needful for decoding, detection and diversity combining. Whereas MIMO scheme offers the lager system capacity and diversity in mobile wireless links. Mobile communication starting from 2G,3G and now 4G with data rates varying from 12kbps in 2G to 2Mbps in 3G and 100Mbps in 4G [2]. Increase in the capacity is responsible for increase in data rates. MIMO system help us to increase the data rate by using spatial multiplexing and It also utilize the multipath components to increase the diversity order or received SNR. We can increase capacity by precoding at the transmitter which is nothing but transmitting the symbol in the desired direction and beamforming at the receiver. This precoding and beamforming process can increase the capacity by min(r, t) where r and t are number of antenna at receiver and transmitter respectively.

II. MIMO System

Multiple-Input Multiple-Output (MIMO), is a radio communication technology which mainly focus on the spatial diversity and spatial multiplexing. In MIMO system the capacity of the channel is increased linearly with the increase in number of receive and transmit antennas [3-4]. Spatial diversity technology under MIMO is regarded to improve the signal to noise ratio and thus the reliability of the system against various forms of fading. Researchers, Paulraj and Kailath (1998) introduced the spatial multiplexing feature of MIMO to provide additional capacity using different paths.

Let's consider some central concepts for flat fading MIMO signal model defined as:

$$y = Hs + n \quad (1)$$

where 's' is the received signal vector, s is the transmitted signal vector , 'n' is the noise, H is the channel response and is assumed as i.i.d zero mean and unit variance complex Gaussian channel. A typical MIMO system with the signal processing subsystem is shown in the Fig.1 below:

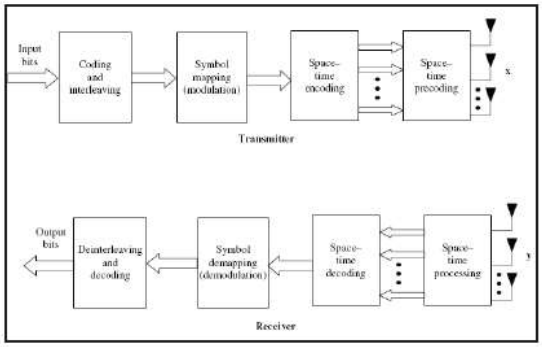

Fig. 1: A typical MIMO System with STBC

A. Space Time Block Codes

MIMO exploits multipath environment for increasing data rate which is possible with space time coding techniques. Space-Time codes make it possible to achieve coding gain as well as diversity benefit without expanding bandwidth. Space-time block coding scheme in MIMO systems enable the transmission of multiple copies of a data stream across a number of antennas and exploit the various received versions of the data for reliable data transfer. In [3] Tarokh et al has introduced the Space-time coding using multiple transmit and receive antennas. A space time block code is usually represented by a matrix. Each row represents a time slot and each column represents one antenna's transmissions over time.

$$H = \begin{pmatrix} h_{1,1} & \cdots & h_{1,N_t} \\ \vdots & \ddots & \vdots \\ h_{N_r,1} & \cdots & h_{N_r,N_t} \end{pmatrix} \quad (2)$$

Within this matrix, Sij is the modulated symbol to be transmitted
in time slot i from antenna j. There are to be T time slots and
transmit antennas as well as receive antennas. This block is
usually considered to be of 'length' T.
space–time coding combines all the copies of the received signal
in an optimal way to extract as much information from each of them as possible.

B. Alamouti Space-Time Code

Alamouti in [5] has proposed a simple diversity concept for achieving transmit diversity.

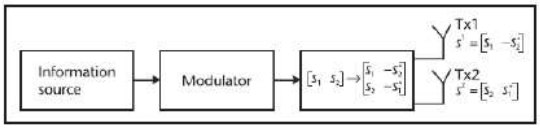

Fig. 2: Block Diagram of the Alamouti Space-Time Encoder

The information bits are first modulated using an M-ary modulation scheme. The encoder then takes a block of two modulated symbols S1andS2 in each encoding operation and gives it to the transmit antennas according to the code matrix [6],

IV. Simulated Results

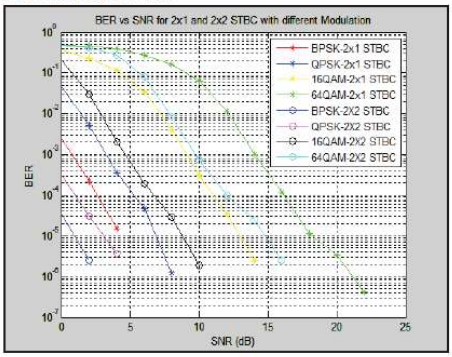

Fig. 3: BER Vs SNR Plot Alamouti STBC System

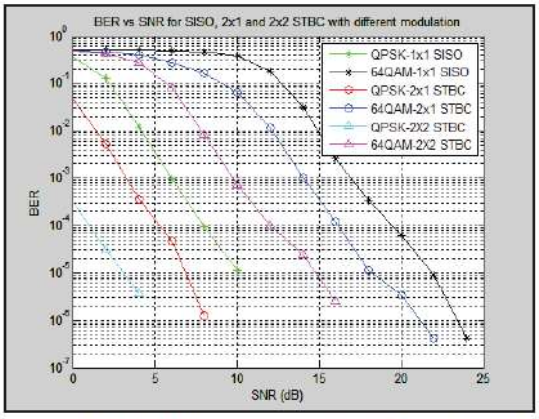

Fig. 4: BER Vs SNR Plot for SISO, 2X1 STBC and 2X2 STBC system

With the increase number of antennas, the BER performance improves.

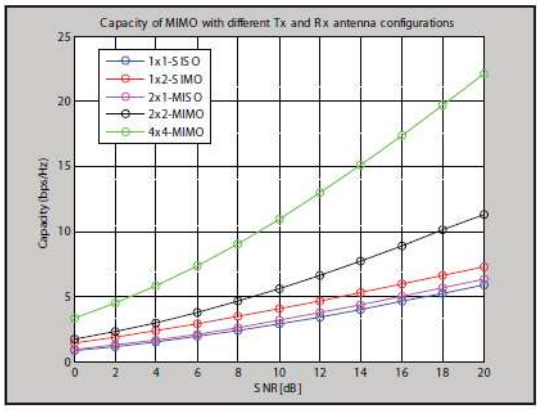

Fig .5: Capacity Plot for SISO Vs SIMO Vs MISO Vs MIMO

The capacity of MIMO systems is better than SISO and other systems. Due to the spatial diversity by reducing fading and improving SNR, there is an increase in the capacity of the system. However, the improvement in SNR is limited, as it is increasing inside the log function. Multiple antennas increases the capacity but the significant improvement in capacity is achieved with equal or higher number of receive antennas compare to transmit antennas.

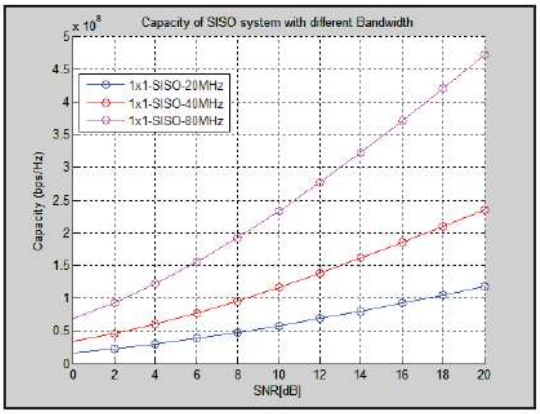

Fig. 6: Capacity Plot for SISO With Different Bandwidth

It is clear from the Fig. 6 that capacity increases as the bandwidth is increased. The capacity increases 1bps/Hz for every 3dB of SNR values.

V. Conclusion

The Alamouti scheme has been simulated for various modulation in Rayleigh channel. The better BER curve produced by a system which uses more number of antennas at both sides of the communication link. Space-time block codes with lower modulation order always provide low bit-error-rate than the space-time block codes with higher order modulation scheme. Moreover for improving wireless communication it is beneficial to transmit data using many different low-powered channels than using one single, high-powered channel. Furthermore, future scope can be seen as the MIMO – OFDM combination as the best way to exploit the spatial diversity, time diversity and frequency diversity. This can improves the overall system performance.

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