STUDY OF VARIOUS TRANSMISSION SCHEMES OF MIMO SYSTEMS

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Abstract A special MIMO transmission scheme with multiple active transmit antennas, named as Multiple Active Spatial Modulation (MA-SM) with antennae set detector is introduced and STBC-SM which combines Spatial Modulation (SM) and Space-Time Block Coding (STBC) ,it take advantages of the benefits of both the system is also introduced in this paper. A new approach called as minimum metric select is proposed in STBC-SM.A general technique is presented for the design of the STBC-SM scheme for any number of transmits antennas. By allowing multiple transmitting antennas in the SM system to transmit different symbols at the same time instant, MA-SM takes advantages of the low complexity of SM and high multiplexing gain of Vertical-Bell Lab Layered Space-Time (V-BLAST) system.

The BER using different types of modulation is analyzed for MA-SM and STBC-SM. Also the capacity is calculated for various numbers of active antennae in MA-SM to enhance the performance and reliability.

1. INTRODUCTION

In radio, multiple-input and multiple-output, or MIMO is the use of multiple antennas at both the transmitter and receiver to improve the communication performance, reliability and capacity compared to single antennae wireless system. MIMO systems require less transmission energy. Hence it is tempting to believe that MIMO systems are more energy efficient than single-input single-output (SISO) systems. It is one of several forms of smart antenna technology. Note that the terms input and output refer to the radio channel carrying the signal, not to the devices having antennas. MIMO systems can support higher data rates at the same transmission power and bit-error-rate (BER) requirements i.e. for the same throughput requirement, MIMO systems require less transmission energy. Hence it is tempting to believe that MIMO systems are more energy efficient than single-input single-output (SISO) systems.

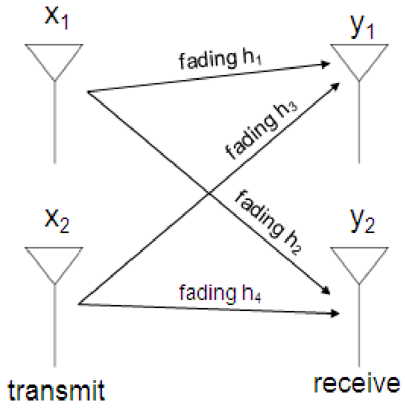

Fig 1. MIMO model

Several MIMO transmission schemes have been comprehensively studied recently, among which the time block code and spatial multiplexing are two general schemes achieving the reliability. The STBC under time block code offer an excellent way to exploit the spatial diversity gain because of the implementation simplicity as well as their low decoding complexity. In STBC it has been proven to be impossible to construct full-rate full-diversity code for more than two transmit antennas with linear complexity.

The family of spatial multiplexing, such as the V-BLAST schemes, can provide high multiplexing gain. The most widely used V-BLAST scheme by allowing simultaneous transmission over all antennas can achieve a maximum multiplexing gain. Besides, the Inter Channel Interference (ICI) and Inter Antenna Interference (IAI) make it extremely difficult to decode streams linearly with negligible system performance degradation. To avoid the drawbacks of V-BLAST the SSK is introduced. Space Shift Keying (SSK) Modulation is a novel digital modulation concept suitable for multiple-input multiple-output (MIMO) wireless communication systems. SSK modulation, which is a fundamental component of spatial modulation, inherently exploits fading in wireless communications to provide better performance over conventional amplitude/phase modulation (APM) techniques. In Space Shift Keying (SSK) Modulation, only the antenna indices relay information and not the amplitude and phase. Since only one antenna is permitted to be active during a time slot, the ICI and IAI are totally avoided, which results in further simplification in system design and the reduction in decoding complexity. The next MIMO transmission scheme approaching even higher capacity by combining the amplitude/phase modulation techniques with antenna index modulation, named Spatial Modulation (SM), here, the information is conveyed not only by the amplitude/phase modulation techniques, but also by the antenna indices. Since only one antenna is active all over the transmission the ICI and IAI in SM system will also be avoided. Hence the low complexity decoder is capable of prominent performance. To eliminate the ICI and IAI, Both the SM and SSK modulation systems allow for one active antenna which, however, limits the exploitation of spatial dimension and design flexibility. Recently, an extension of SM, named as Generalized SM (GSM), which allows several antennas to be active. In order to achieve high transmit rate, GSM requires a large number of transmit antenna but there is no proper detection scheme is available in GSM. Hence except SSK and SM, other transmission schemes belong to multi user MIMO. Both SSK and SM are single user MIMO
system.

The main contributions of this paper are as follow:

1) A novel scheme of multi-antenna transmission for spatial multiplexing, named MA-SM, is proposed, in which several transmit antennas carrying different information symbols are active during each time slot. Similar to traditional SM, information bits in MA-SM are mapped into both spatial dimension and traditional complex dimension. A new approach we consider here is Antenna Set Detector; it consists of matched filter and CSI (Channel State Information)

2) The proposed MA-SM scheme employs both amplitude and phase and also antenna indices to convey information.

3) The another transmission scheme named as STBC-SM is proposed in this paper. It combines spatial modulation (SM) and space-time block coding (STBC) to take advantage of the benefits of both the system. A new approach, we consider here is minimum metric select.

II. MULTIPLE-ACTIVE SPATIAL MODULATION

The general system model consists of a MIMO wireless link with *NT* transmit antennas and *NR* receive antennas, which is illustrated in Figure2. The source information bits are transmitted from *NP* of the transmit antennas after being mapped through an *M* order Quadrature Amplitude Modulation (*M*-QAM) the information is passed through the channel and Additive White Gaussian Noise is added. After demapping the information the received signal is given by

$$y = \sqrt{\frac{\rho}{N_P}} H X + w$$

where ρ is the average signal to noise ratio (SNR) at each receive antenna, $\boldsymbol{H}$ and $\boldsymbol{w}$ are the channel and noise respectively. They are independent and identically distributed (i.i.d).

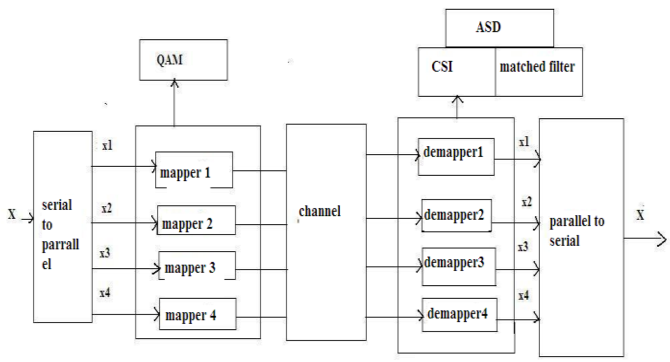

Fig 2. MA-SM block diagram

Here the information is passed serially and using the serial to parallel converter, the information is converted in to parallel form.The modulation used here is QAM during the mapping process. QAM is both an analog and a digital modulation scheme. It conveys two analog message signals, or two digital bit streams, by changing (modulating) the amplitudes of two carrier waves, using the amplitude-shift keying (ASK) digital modulation scheme or amplitude modulation (AM) analog modulation scheme. The two carrier waves, usually sinusoids, are out of phase with each other by 90° and are thus called quadrature carriers or quadrature components hence the name of this scheme. The modulated waves are summed, and the resulting waveform is a combination of both phase-shift keying (PSK) and amplitude-shift keying (ASK), or (in the analog case) of phase modulation (PM) and amplitude modulation. QAM is used extensively as a modulation scheme for digital telecommunication systems. QAM is a combination of simple AM and simple Phase Modulation. This allows for more data to be transmitted over roughly the same bandwidth. The mapping process is done in the transmitter side and after mapping of information those messages is passed through the channel. In the receiver side the demapping process takes place. The ASD (Antennae Set Detector) is present in the receiver side. The Antennae Set Detector consists of CSI (Channel State Information) and matched filter. The CSI is of two types a) CSI at the transmitter and b) CSI at the transmitter and receiver. The CSI at transmitter conveys only transmitter information because the antenna indices at the transmitter and receiver side are same. The CSI at transmitter and receiver conveys both transmitter and receiver information because, the antennae indices at the transmitter and receiver side is different. Thus at the receiver side, the decoder estimates both the indices of active antennas and symbols conveyed by them from the received *NR*-dim signal vector with the knowledge of channel state information (CSI). The matched filter is the optimal linear filter for maximizing the signal to noise ratio (SNR) in the presence of additive stochastic noise. All the information is retrieved serially by using parallel to serial converter, and the original information is recovered with less BER. .We are calculating the bit error rate using QAM modulation and the channel capacity in implementation part with increase in SNR to increase the reliability and the performance of the system.

III. Space Time Block Code Spatial Modulation

A new MIMO transmission scheme, called STBC-SM, is proposed. The basic idea of SM is an extension of two dimensional signal constellations (such as M-ary phase shift keying (M-PSK) and M-ary quadrature amplitude modulation (M-QAM), where M is the constellation size) to a third dimension, which is the spatial (antenna) dimension. Therefore, the information is conveyed not only by the amplitude/phase modulation (APM) techniques, but also by the antenna indices. The Alamouti code is chosen as the
target STBC to exploit. As a source of information, we consider not only the two complex information symbols embedded in Alamouti STBC, but also the indices of the transmit antennas employed for the transmission of the Alamouti STBC. A general technique is presented for constructing the STBC-SM scheme for any number of transmit antennas. Since our scheme relies on STBC, by considering the general STBC performance criteria. A low complexity ML decoder is derived for the proposed STBC-SM system, to decide on the transmitted symbols as well as on the indices of the two transmit antennas that are used in the STBC transmission. It is shown by computer simulations that the proposed STBC-SM scheme has significant performance advantages over the SM with an optimal decoder, due to its diversity advantage. A general technique is presented in STBC-SM transmitter and receiver for constructing the STBC-SM scheme for any number of transmitting antennas. A low complexity Maximum Likelihood ML decoder is used for the STBC-SM system, to decide on the transmitted symbols as well as on the indices of the transmit antennas.

In the transmitter block the antennae selection selects the no of antennas to transmit the data in the transmitter. The symbol pair selection pairs the two separate set of information

.The antennae and paired information is stored in minimum metric selection in receiver. The mapper maps those paired information to the corresponding antennae and those information is also stored in min metric select. The information is passed through the channel. L is the antennae no and x1, x2…are the set of information sent from transmitter.

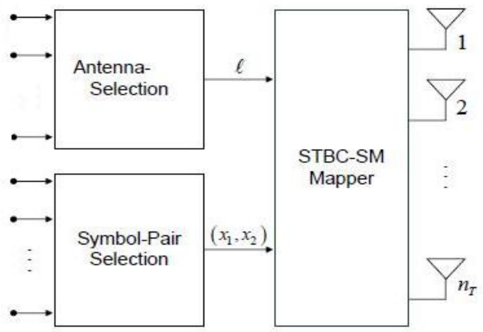

Fig 3.STBC-SM transmitter

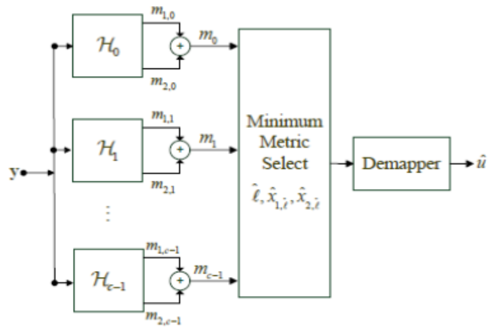

Fig 4. STBC-SM receiver

After the information is passed through the channel, the two separate set of information is added and passed through the minimum metric select .It stores the information about which antennae is active and which two set of information is paired and added .The min metric select calculates the least weighted set of information and based on the weight, the information is passed to demapper. In demapper the two set of information is removed from antennae and is received. The Maximum Likelihood ML decoder is used in the receiver. The main difference between MA-SM and STBC-SM is, in STBC-SM the information is paired and added and the least weighted information is retrieved first .We are calculating the bit error rate in implementation part to increase the reliability and the performance of the system. Three types of modulation are used to calculate the BER, they are

- BPSK
- QPSK
- QAM

Based on the constellation size of different types of modulation the BER varies. BPSK uses two phases which are separated by 180° and so can also be termed 2-PSK. BPSK is functionally equivalent to 2-QAM modulation. The constellation size of BPSK is 2. QPSK uses four points on the constellation diagram. Hence the constellation size of QPSK is 4.

Quadrature amplitude modulation (QAM) is both an analog and a digital modulation scheme. The number of points in the grid is usually a power of 2 (2, 4, 8,). Since QAM is usually square, some of these are the most common forms are 8-QAM, 16-QAM, 64-QAM and 256-QAM.

IV. SIMULATION RESULTS

A.MA-SM

In this section, we present the simulation results for the MA-SM system for the Bit Error Rate with four transmit antennas and receiver antennas. The BER decreases linearly with increase in SNR. The BER decreases when compared to other MIMO transmission scheme named STBC, V-BLAST, SSK, SM and GSM. For these schemes the BER achieved is 10^{-1} for the signal to the noise ratio of 4db. But for MA-SM the BER produced is 10^{-2} to 10^{-3} for the same SNR value of 4db.

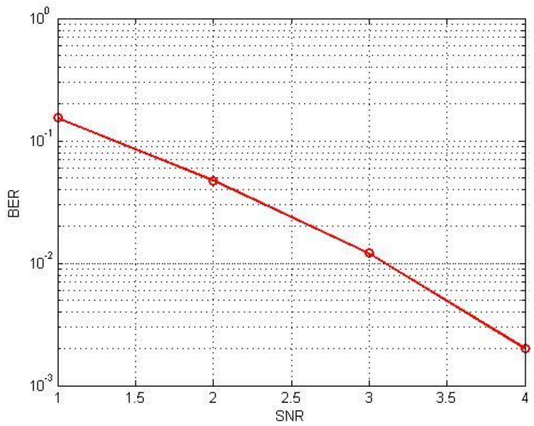

Fig 5. SNR vs. Bit Error Rate performance for MA-SM

The second simulation result for MA-SM is the channel capacity with increase in SNR. Channel capacity is the tightest upper bound on the amount of information that can be reliably transmitted over a communications channel. By the noisy-channel coding theorem, the channel capacity of a given channel is the limiting information rate (in units of information per unit

$$C = B\log_2\left(1+\frac{S}{N}\right)$$

Where

C is the channel capacity in bits per second;
B is the bandwidth of the channel in hertz
S is the average received signal power over the bandwidth
N is the average noise or interference power over the bandwidth, measured in watts (or volts squared) and
S/N is the signal-to-noise ratio (SNR).

The capacity increases as the number of transmitter antennae increases. The Shannon capacity is the minimum capacity is also plotted. The results indicate that the capacity gain obtained from multiple antennas heavily depends on the available channel information at the receiver or transmitter, the channel signal-to-noise ratio, and the correlation between the channel gains on each antenna element. The capacity increases with increase in SNR with perfect knowledge of CSIT and CSIR in the absence of correlation. As the no of transmitter and receiver antennae increases the channel capacity also increases. In presence of correlation in channel there is degradation in capacity performance. Here the channel capacity is calculated with number of active transmitter antennas two, three and four.

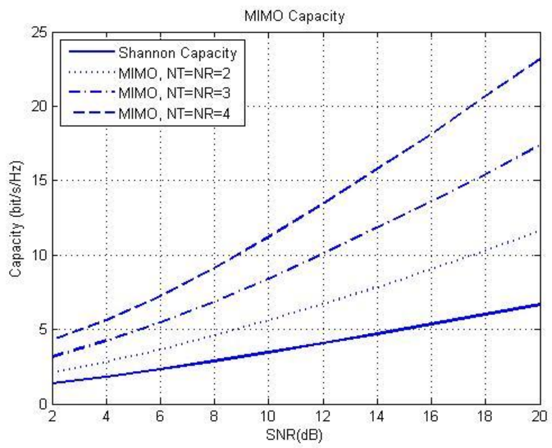

Fig 6. SNR vs. channel capacity for various no of transmitter antennas for MA-SM

B.STBC-SM

Based on the constellation size of different types of modulation like BPSK, QPSK, QAM and the number of transmitter antennae, the BER varies for STBS-SM. The BPSK produces less BER than using QPSK and QAM modulation. The BER using 16-QAM is 10^{-1} for the SNR of 4db and the BER is between 10^{-1} to 10^{-2} if 8-QAM is used for the same SNR. The BER is 10^{-2} if QPSK modulation with constellation size 4 is used for the same 4db SNR. BPSK with constellation size 2 produces less BER of 10^{-3} for same 4 db SNR.

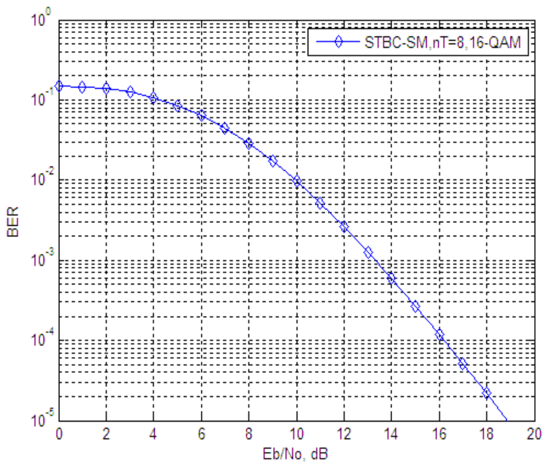

Fig 7.SNR vs. Bit Error Rate for 16 QAM

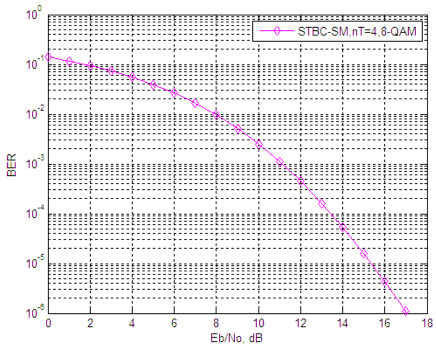

Fig 8.SNR vs. Bit Error Rate for 8 QAM

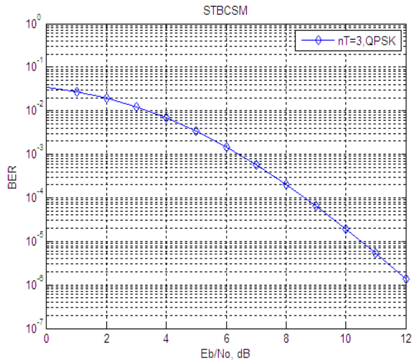

Fig 9. SNR vs. Bit Error Rate for QPSK

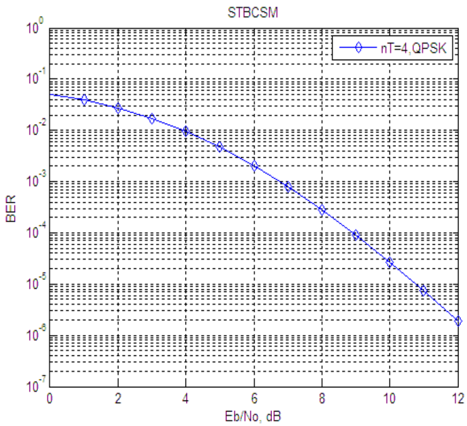

Fig10. SNR vs. Bit Error Rate for QPSK

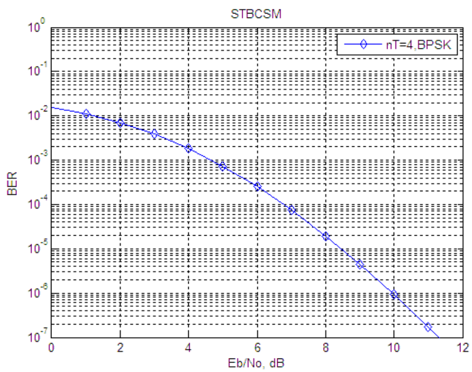

Fig 11.SNR vs. Bit Error Rate for BPSK

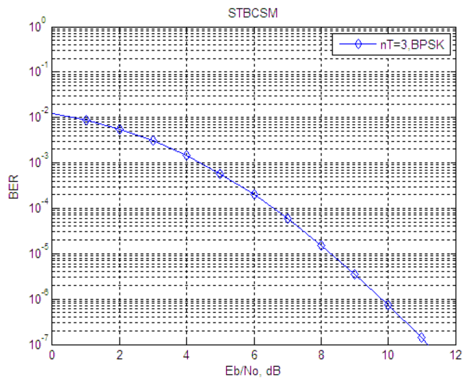

Fig 12. SNR vs. Bit Error Rate for BPSK

V. CONCLUSIONS

We introduced a low complexity MIMO transmission schemes, called MA-SM and STBC_SM as an alternative to existing MIMO transmission schemes such as STBC, VBLAST, SSK, SM, and GSM. Here several transmit antennas carrying different information symbols are active during each time slot. The antenna set detector with arbitrary number of active antennas rather than a single antenna index in spatial dimension is considered. By using MA_SM error rate is reduced than other transmission schemes. And also the capacity increases as the number of transmitter antennae increases. Hence MA-SM produces high reliability, consumes time and energy and increase the performance of the system. It has been shown via computer simulations that MA-SM offers significant improvement of the system compared to other MIMO transmission schemes. In STBC-SM transmitter and receiver, a general technique has been presented for constructing the STBC-SM scheme for any number of transmitting antennas. Here the BER is analyzed using three different types of modulation. The main difference between MA-SM and STBC-SM is, in STBC-SM the information is paired and added and the least weighted information is retrieved first.

VI. REFERENCES

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