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A Novel Spatial Modulation Scheme Using Trellis Code

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ABSTRACT:In this fast growing modern era of wireless communication we need modulation schemes that have minimum power and bandwidth requirements but has high efficiency. There was a great boost in spectral efficiency with the advent of Multiple-input-multiple output systems (MIMO).This system still had certain drawbacks like high complexity and hardware cost. So we needed an even more efficient scheme and hence came to the concept of Spatial modulation. In this modulation scheme multiple antennas are considered as additional constellation points that carry information bits. Only one antenna is active at a time and the antenna index is also transmitted along with the information bits. This antenna index is encoded using trellis code which is a new concept. Hence this modulation scheme is termed as Trellis coded spatial modulation. The performance of TCSM is compared with other modulation schemes to show that it is better efficiency.

KEYWORDS: spatial modulation, trellis coded modulation, MIMO
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I.INTRODUCTION

Due to increasing data rates in modern era wireless communication systems is now a very challenging field. The spectrum or bandwidth available to the service providers is often limited. The power requirements are also to be cut down to as low as possible to achieve better energy efficiency. Thus, the designers for wireless systems face a two-part challenge, increased data rates and performance improvement with little or no increase in bandwidth and power. The main disadvantage with error correcting codes is bandwidth expansion. So for a band limited system such as a telephone system, use of error correcting codes is difficult. In order to use bandwidth efficiently without increasing power, a new method called trellis coded modulation can be used. It is a method which combines the error correction and modulation functions of the communication system, to achieve better gains in system performance. In TCM, the bandwidth expansion is not required because it uses the same symbol rate and power spectrum. The main differences are the introduction of a redundancy bit and the use of a constellation with double points. The main idea of TCM modulation is to partition the symbols into different sets of same size and in each set the distance between the symbols should be maximized. When the signals are transmitted over the wireless communication channel the main problem is that it experiences fading and so the error performance of the system degrades. In order to achieve high capacity and to avoid fading, multiple antenna elements can be used at both the transmitter and receiver of a wireless system. This leads to the development of a multiple transmit-receive architecture called Bell Labs Layered Space-Time Architecture (BLAST). One main type of BLAST is V-BLAST (vertical BLAST). In this the information bit stream is divided into many sub streams and then it is modulated and transmitted through the channel using same bandwidth. At the receiver the reverse operation is performed. When the number of transmit antenna increases then the data rate also increases. The function of the receiver is to nullify the effect of inter channel interference between the transmitted symbols. In MIMO system all the antennas will be active at both the transmitter and the receiver of a wireless system. In MIMO system the complexity, power and the cost of hardware is increased.

In order to combat these problems a new modulation scheme i.e. spatial modulation is used. In the normal case two dimensional modulations are used. But in the case of SM it uses a third dimensional modulation. By this it means that the index of the antenna is transmitted along with the symbol. In the basic form of SM, the transmitter has access to all antennas, but only one out of these antennas is active and is used to transmit data in any given symbol interval. The receiver must determine which of the antennas was selected for transmission. In this paper TCM is concatenated with

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SM. This novel method is known as Trellis Coded Spatial Modulation (TCSM).By using these method antennas is partitioned into different sets of equal size and in each set the distance between the antenna pair is maximized. Different modulation schemes like BPSK,4-QAM and 16-QAM are tested to know which one has better performance. The performance of TCSM is then evaluated in AWGN and kronecker channels. The BER curve for TCSM model, VBLAST, SM and Alamouti are then evaluated for different modulation schemes.

II.TRELLIS CODE AND SPATIAL MODULATION

When data is transmitted through a wireless channel, errors are introduced in it and channel coding is used to remove these errors and recover the actual data that is transmitted perfectly at the receiver. Channel coding is performed by adding redundant parity bits to the data to be transmitted. Using simple channel coding schemes, only error detection is possible while error correction is also possible using more advanced channel coding schemes. Thus, the need for retransmission is eliminated as well as higher reliability is also achieved. In the proposed system, TCM is applied to the antenna index of the input and the remaining input bits are modulated and transmitted through the channel. At the receiver Viterbi decoding is performed and evaluated its error performance.

1. Trellis coded modulation

Trellis coding is an error correcting technology in modern digital communication system. The word trellis denotes the use of trellis (also called convolutional) codes. With TCM it can be said that there is no bandwidth expansion but signal set expansion. For conventional systems with convolutional codes, the free Hamming distance is an important figure of merit, but with TCM the free Euclidean distance between signal points is more important. Generally, the choices of coding and signal constellation do not take place separately.TCM combines the functions of a convolutional coder of rate R = k / k + 1 and a M-ary signal mapper that maps $M = 2^{\wedge k}$input points into a larger constellation of $M = 2^{\wedge k+1}$ constellation points. The bits given to the convolution encoder is used to select the subset and the bits uncoded are used to select the signals from subsets. First, the trellis diagram of the convolutional code must be found. Distance properties of the TCM system can be analyzed through the trellis diagram. The Viterbi algorithm is used for decoding. The Viterbi algorithm decodes the convolutional code by selecting the most likely path through the trellis, which represents the received code sequence and is associated with given received information sequence.

2. Spatial Modulation

Spatial modulation (SM) is a new transmission technique that uses multiple antennas. In SM the symbol is modulated not only by phase and amplitude but also by the position of the antenna. In SM the information is conveyed both by the signal space and the antenna space. The basic idea is to map the block of information bits to two information carrying units, a symbol chosen from a constellation diagram and a unique transmit antenna number that is chosen from a set of transmit antennas. In this case, only one antenna will be active at a particular time instant. The location of the activated antenna in spatial domain is used as an information source for transmission of the data and thus spectral efficiency is increased. The use of the transmit antenna number as an information-bearing unit increases the overall spectral efficiency.SM is different from other MIMO techniques. Each unique antenna position can be denoted by a binary data. According to the incoming information, active antenna will be selected and that will transmit the remaining information bits. This helps to improve the data rate without increasing the band width. Apart from the active transmit antenna, the other antennas will transmit zero power. And this will remove ICI at the receiver and the need to synchronize the transmit antennas. At the receiver, maximum receive ratio combining (MRRC) is used. It can be used to estimate the transmit antenna number, and after this the transmitted symbol l is estimated. These two estimates are used by the spatial demodulator to get back the original block of information bit.

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III.PROPOSED SCHEME

The proposed scheme combines trellis coded modulation and spatial modulation, and forms new system models i.e. trellis coded spatial modulation. The main idea is to apply a bandwidth efficient modulation technique to the antenna constellation points of spatial modulation (SM). The aim is to improve SM performance in various channel conditions. In this mainly AWGN and Kronecker channels are used. Also the performance of TCSM for various modulation schemes is evaluated. In this mainly BPSK and 4-QAM are used currently. As a future extension 16-QAM is also to be compared.

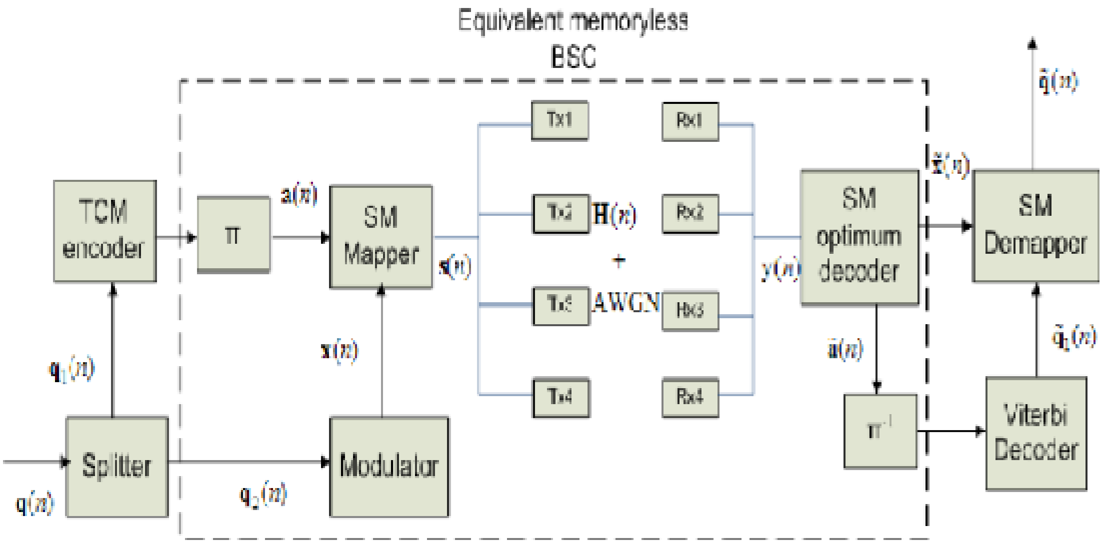

Figure 1: Block diagram for proposed TCSM system

The TCSM system model is shown in Fig 1.In this assume there are four transmit antennas (N_t=4) and four receive antennas (N_r=4).First the information bits are generated and the input bits at each time instant are grouped as the row vectors of the matrix x(t).The first step is to split the matrix into two matrixes i.e. q_1(n) and q_2(n) where q_1(n) represents the antenna index and q_2(n) represents the information bits. The first matrix q_1(n) maps the bits into antenna constellation points and the second matrix q_2(n) maps the bits into signal constellation points. In this modulation used is BPSK (phase shift keying) and 4-QAM (quadrature amplitude) and the second matrix is mapped into corresponding constellation points, where each element in this matrix corresponds to the symbol that is transmitted from one antenna at one time instant. The first matrix, q_1(n), is then used to select the transmit antenna which is active. Before mapping the bits in the first matrix to the spatial constellation points (the transmit antenna indexes), the bits are given to a TCM encoder. Consider the spacing between the antennas are equal and the output of the TCM encoder is used to select the antenna which is active. The first matrix q_1(n) is transformed into another matrix l(n) by giving the output to an encoder.
The SM mapper operates on both l(n) and q_2(n) matrices creating the output matrix. Each column of the output matrix is transmitted at a single time instant from the active transmit antennas over AWGN channel H(n). Then the signal transmitted will be received. Assume the channel and the noise are independent and identically distributed (iid) entries according to Gaussian distribution. In this AWGN channel model is considered along with many modulation types. At the receiver, the transmitted bits should be decoded. For that the optimum SM decoder is used to estimate the transmitted symbol ˜q_2(n) and the transmitted antenna index ˜l(n).The estimated antenna number is de-mapped to the corresponding bits and the incoming data sequence is given to a hard decision Viterbi decoder. The output from the Viterbi decoder together with the estimated symbols is used to retrieve the original information bits.

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IV. CHANNEL MODEL

A channel is mainly used for transmitting information. The capacity of the channel is measured by its bandwidth in Hz or its data rate in bits per second. The word channel refers to the medium between the transmitting antenna and the receiving antenna. When the signal is transmitted from the transmitter antenna to the receiver antenna, the characteristics of the wireless channel changes. These characteristics depend upon the distance between the two antennas, the path that the signal follows and the environment surrounding the path. At the receiver, the received sample vector on the receive antennas can be expressed as, y=Hx+n where channel matrix is denoted by H. One of the important models is AWGN channel model. In this noise will be added additively and the impairment to communication is a linear addition of wideband or white noise with a constant spectral density and a Gaussian distribution of amplitude.

MIMO (Multiple Inputs Multiple Outputs) system uses multiple antennas at the transmitters and receivers. By using this technique data rate can be increased. In this, corresponding to every antenna, there will be a RF chain and this will increase the complexity and power consumption. As the number of antenna increases numbers of RF chains will also increase. The main architectures of MIMO is VBLAST and Alamouti system model and is discussed below.

1. V-BLAST SYSTEM MODEL

To achieve high capacity, BLAST architecture can be used. Bell Laboratories Layered Space-Time (BLAST) is a transceiver architecture that contributes spatial multiplexing over multiple wireless communication systems. Such systems have multiple antennas at both the transmitter and the receiver in an effort to exploit the many different paths between the two in a highly-scattering wireless environment. The BLAST scheme de-multiplexes a user data stream into a number of sub streams that are equal to the number of transmission antennas. By implementing V-BLAST algorithm, the diversity gain is increased and the bit error rate (BER) performance is improved. The MIMO system is assumed to undergo flat fading channel.

5.2. ALAMOUTI SYSTEM MODEL

Alamouti introduced a new transmit diversity scheme, known as Alamouti scheme. In this scheme it uses two transmit antennas and any number of receiving antennas (N_r) and it has a maximum diversity order of $2N_r$.Since it transmits two symbols after every two time periods, Almaouti scheme has the rate of unity. In the Alamouti space-time encoder, information bits are grouped and in each group there will be m information units and then it is modulated, where m=log M .Then, the encoder takes a block of two modulated symbols x_1 and x_2 in their respective time intervals and maps them to the transmit antennas according to a code matrix. In the first time slot, the first and second antenna transmits the symbol x_1 and x_2. In second time slot $-x_2^*$and x_1^* will be transmitted from the first and second antenna. Here grouping two symbol s-means there will be two time slots to send two symbols. Hence, there is no change in the data rate. At the receiver maximal ratio receiver combining (MRRC) is used.

V. RESULT AND DISCUSSION

The proposed method is tested on MATLAB R2014a, to justify the effectiveness of the proposed scheme. In order to simulate the proposed TCSM idea, the average BER is plotted versus the average SNR at each receiver input. The simulation settings are given below,

1) The number of transmitting and receiving antennas are selected and different modulation schemes such as BPSK and 4-QAM are used.

2) Then it is passed through different channels like AWGN and Kronecker channel with different values of SNR.

3) At the receiver end, they were demodulated, and decoded to extract the transmitted messages.

The number of bit errors between original message and decoded message were calculated. The performance of TCSM is compared with spatial modulation, V-BLAST, Alamouti system in AWGN and Kronecker channels. It is shown that spatial modulation with trellis coding has outperformed other conventional schemes. It also shows that Kronecker channel has better performance capabilities than AWGN channel. In this TCSM has better error performance. This is

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shown in figure 2 and figure 3.In figure 4, 4-QAM and BPSK modulation scheme comparison is shown and modulation order is increased for 4-QAM is better than BPSK.

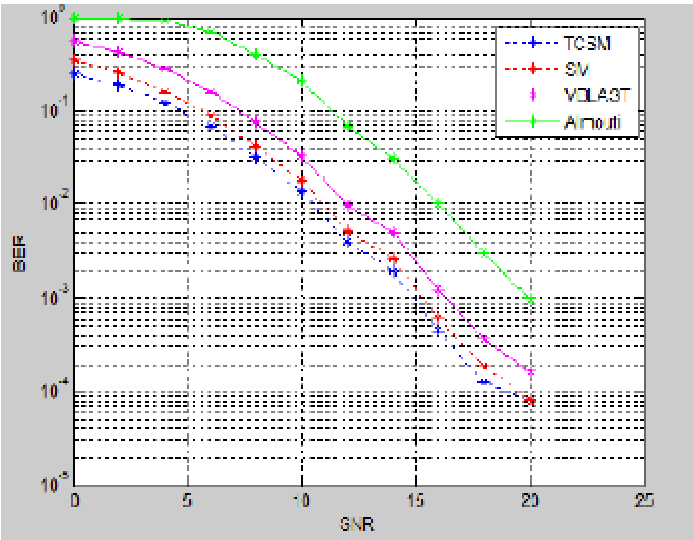

Figure 2: Performance comparison in AWGN channel

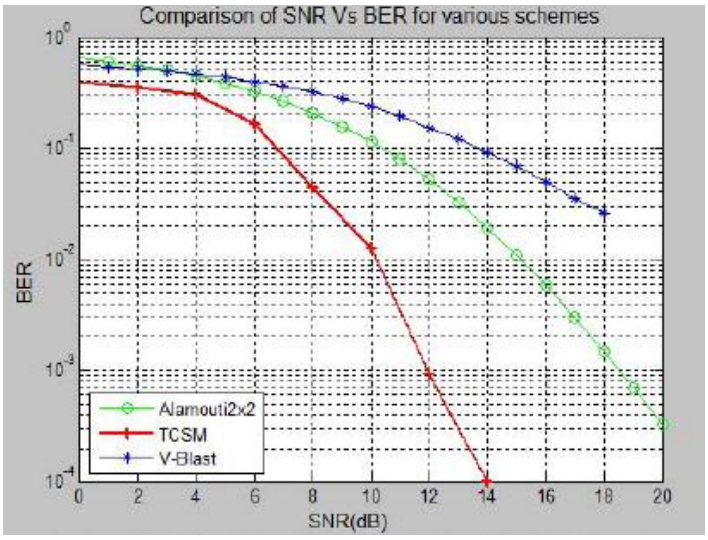

Figure 3: Performance comparison in Kronecker channel

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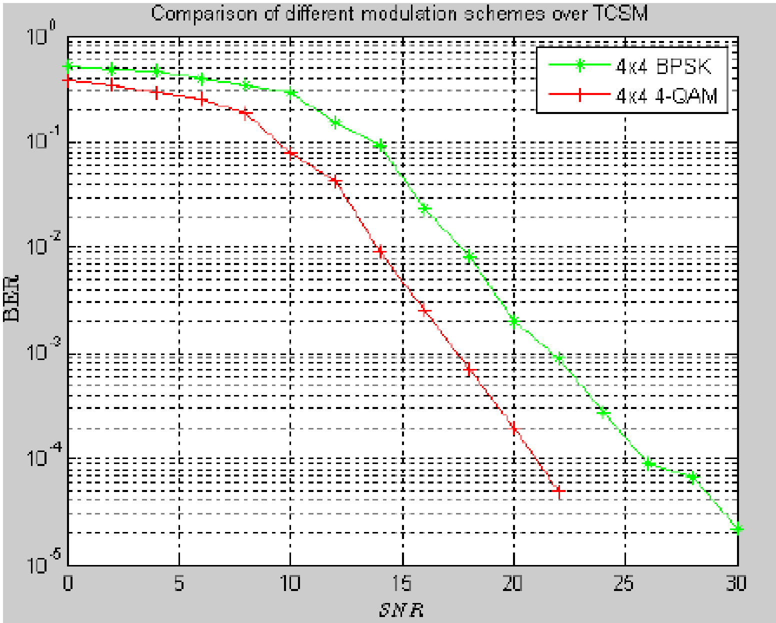

Figure 4: Performance comparison of various modulation schemes

VI. CONCLUSION

Here, a new bandwidth efficient coding technique for spatial modulation is implemented. This scheme consists of trellis coded modulation scheme that is applied to the antenna index of spatial modulation. Trellis coded modulation is a method which improves the noise immunity of digital transmission systems without expansion of bandwidth or reduction of data rate. Here we have a communication channel presented using the combination of convolution coding and one of the selected modulation schemes. The combined effect of Spatial Modulation and Trellis coding is compared with VBLAST, Alamouti and SM systems. It is found that the trellis coded spatial modulation offers significant advantages in BER compared to V-BLAST, Alamouti and SM systems. Also the BER curve of TCSM for different modulation schemes is obtained. This is an ongoing project and we need to compare it with many other modulation schemes to show that TCSM is the most efficient scheme in modern communication system.

REFERENCES

[1] Bernard Sklar, “Digital Communications: Fundamentals and Applications”, Prentice Hall.
[2] Shu Lin and Daniel J. Costello, Jr.,“Error control coding: Fundamentals and Applications”, Prentice Hall
[3] G. Ungerboeck, “Channel coding with multilevel/phase signals,”*IEEEJ.Inf.Technol.*, vol. 28, no. 1, pp. 55–67, 1982.
[4] Calderbank,R. and J.E.Mazo,”A New Description of Trellis Codes”,IEEE Transactions onInformationTheory,November1984,30(6),pp.784-791
[5] E. Biglieri et al., “Introduction to Trellis-coded modulation Application” McMillian Newyork,1991
[6] S. Benedetto et alii, “Performance Evaluation of Trellis Coded modulation Schemes”, *IEEE Proceedings*,2003
[7] E. Telatar, "Capacity of Multi-Antenna Gaussian Channels,"*European Transaction Telecommunication*, vol. 10, no. 6, pp.558-595, November/December 1999.
[8] S. Loyka and G. Tsoulos, "Estimating MIMO System Performance Using the Correlation Matrix Approach," *IEEE CommunicationsLetters*, vol. 6, no. 1, pp. 19-21, January 2002.
[9] By Marco Di Renzo, HaraldHaas,AliGhrayeb, Shinya Sugiura, Senior Member IEEE, “SpatialModulation for GeneralizedMIMO: Challenges, Opportunities,and Implementation”, *Proceedings of the IEEE*, Vol. 102,No. 1, January 2014.
[10] A.F. Molisch and M. Z. Win, “MIMO systems with antenna selection,"*IEEEMicrow. Mag.*, vol. 5, no. 1, pp. 46-56, Mar. 2004
[11] P. W. Wolniansky, G. J. Foschini, G. D. Golden, R. A. Valenzuela,” VBLAST:An Architecture for Realizing Very High Data RatesOver the Rich-Scattering Wireless Channel”, *Bell Laboratories, LucentTechnologies, Crawford Hill Laboratory,IEEE*1998.