SPACE-TIME MEDIA-BASED MODULATION

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Abstract: MBM, or media-based modulation, is an intriguing index modulation (IM) approach for networks beyond 5G that makes use of the radiation patterns of a reconfigurable antenna to transmit data. In this research, we provide a space-time coding-based general framework for MBM and develop a new idea of space-time coded IM, space-time media-based modulation (ST-MBM). Using the one-of-a-kind RF mirror activation concept of MBM, the suggested strategy builds on space shift keying, a well-known IM solution, and the Hurwitz-Radon family of matrices to accomplish transmit diversity gain using a single RF chain. Our goal is to find the average bit error probability and theoretical pair wise error probabilities for both correlated and uncorrelated channel states using the ST-MBM technique. The suggested ST-MBM scheme's information theoretical constraints are further illuminated by deriving a lower bound for its mutual information.

Keywords: MBM, ST-MBM, RF, IM, error probability, RF mirror, Space Time.

I. INTRODUCTION

The growing need for wireless devices with high data rates has resulted in a congested electromagnetic spectrum. This desire has led to the creation of microwave and millimeter-wave integrated components that are adaptable, highly selective, multifunctional, and more efficient. These components need a category of structures that are not reciprocal and possess additional capabilities, such as frequency production, wave amplification, and full-duplex communication. Space-time (ST) modulation has shown its suitability for high data transfer due to its exceptional capacity for electromagnetic wave manipulation. Space time-modulated (STM) media are electromagnetic structures that exhibit dynamic and directional properties, with their constitutive parameters varying both spatially and temporally. STM media have recently garnered significant interest in the scientific and technical fields. The distinctive and unusual characteristics of STM media have resulted in the creation of innovative physics principles and revolutionary devices in the fields of acoustics, microwave, terahertz, and optics.

Currently, scholars worldwide are very interested in OFDM. In Orthogonal Frequency Division Multiplexing (OFDM), the channel is divided into many narrow parallel subchannels. This increases the length of each signal and reduces or eliminates the interference between symbols caused by multipath situations. OFDM enables the transmission of high data rate traffic by dividing the incoming serial data stream into parallel low-rate streams that are delivered concurrently on orthogonal sub-carriers [1]. The spectrum in an OFDM system is split into many subcarriers, and all of these subcarriers are orthogonal to each other [3]. OFDM has been standardized for several applications, including digital audio broadcasting (DAB), digital television broadcasting, wireless local area networks (WLANs), and asymmetric digital subscriber lines (ADSLs).The performance of the OFDM system is enhanced by using the MIMO technology, which allows for the simultaneous transmission of several data streams utilizing multiple antennas. MIMO-OFDM, which combines OFDM and MIMO technologies, is actively being researched and is considered one of the most promising options for future communication systems, including wireless LAN and broadband access. MIMO communication systems use multiple broadcast and receive antennas to enhance data throughput without the need for more capacity. They also enhance diversity and improve performance against fading channels via the utilization of space-time codes [4]. The performance of MIMO-OFDM systems increases in a linear manner as the number of antennas increases, assuming that the receiver has optimum knowledge of the wireless channel. Employing several antennas at both the transmitting and receiving ends may greatly improve the capacity and dependability of wireless connections [5]. Nevertheless, the operation of multiple antennas encounters considerable obstacles due to the intricate nature and high expense of the hardware, which is necessitated by the need for synchronizing the antennas and maintaining numerous radiofrequency (RF) chains. Spatial modulation (SM) is an emerging modulation technology designed for multiple antenna systems to tackle these concerns. This modulation approach was first introduced in [4] and subsequently enhanced. Space shift keying (SSK) is a signalling method that may be seen as a specific instance of SM.

II LITERATURE SURVEY

The multiplexing gain of wireless networks, Author: A. Host-Madsen and A. Nosratinia

The Wireless Network Cloud (WNC) is a novel network architecture where wireless base stations are implemented as software modules and multiple base-stations are consolidated to a single centralized computing platform. Due to the time-varying and random nature of base station traffic, consolidation leads to multiplexing of statistically-varying base station loads on a common hardware platform. In turn, this can lead to significant hardware reduction in the consolidated platform as compared to the distributed network. This paper represents the first analysis of this consolidation gain. Through traffic simulation experiments, we quantify the extent and variation of this multiplexing gain in a WiMAX base- station network in different traffic conditions. We show experimentally, that the obtained gain increases linearly with network size (number of base-stations). Further, we also show that the consolidation gain is higher when the consolidated base-stations face higher traffic intensity.

Interference alignment and degrees of freedom of the K-user interference channel, Author: V. Cadambe and S. Jafar,

For the fully connected K user wireless interference channel where the channel coefficients are time-varying and are drawn from a continuous distribution, the sum capacity is characterized as C(SNR) = K 2 log(SNR) + o(log(SNR)). Thus, the K user time-varying interference channel almost surely has K=2 degrees of freedom. Achievability is based on the idea of interference alignment. Examples are also provided of fully connected K user interference channels with constant (not time-varying) coefficients where the capacity is exactly achieved by interference alignment at all SNR values.

Interference alignment in MIMO cellular networks, Author: B. Zhuang, R. Berry, and M. Honig,

We explore the feasibility of linear interference alignment (IA) in MIMO cellular networks. Each base station (BTS) has Nt transmit antennas, each mobile has Nr receive antennas, and a BTS transmits a single beam to each active user. We present a necessary Zero-Forcing (ZF) condition for zero interference in terms of the number of users, the number of cells, Nt and Nr. We then examine the performance of iterative (forward-backward) algorithms for jointly optimizing the transmit precoders with linear receivers. Modifications of the max-SINR and minimum leakage algorithms are presented, which are observed to converge to a ZF solution whenever the necessary conditions are satisfied. In contrast, convergence of the (original) max-SINR algorithm is problematic when the necessary conditions are satisfied with (near) equality. A more restrictive ZF condition is presented, which predicts when these convergence problems are unlikely to occur.

Interference alignment with limited feedback, Author: H. Bolcskei and I. Thukral.

A limited feedback-based interference alignment (IA) scheme is proposed for the interfering multi-access channel (IMAC). By employing a novel performance-oriented quantization strategy, the proposed scheme is able to achieve the minimum overall residual inter-cell interference (ICI) with the optimized transceivers under limited feedback. Consequently, the scheme outperforms the existing counterparts in terms o f system throughput. In addition, the proposed scheme can be implemented with flexible antenna configurations.

EXISTING SYSTEM

Space-time block codes (STBC) are a generalized version of Alamouti scheme, but have the same key features. These codes are orthogonal and can achieve full transmit diversity specified by the number of transmit antennas. In other words, space-time block codes are a complex version of Alamouti's space-time code, where the encoding and decoding schemes are the same as there in the Alamouti space-time code on both the transmitter and receiver sides. The data are constructed as a matrix which has its columns equal to the number of the transmit antennas and its rows equal to the number of the time slots required to transmit the data. At the receiver side, the signals received are first combined and then sent to the maximum likelihood detector where the decision rules are applied. Space-time block codes were designed to achieve the maximum diversity order for the given number of transmit and receive antennas subject to the constraint of having a simple linear decoding algorithm. This has made space-time block codes a very popular and most widely used scheme. In the decoder, the received signal is fed to the channel estimator. The estimated coefficients of the channel together with the combiner are given as the input to the maximum likelihood detector. The detected signal is then fed to the demodulator. The demodulator gives the original information which is transmitted.

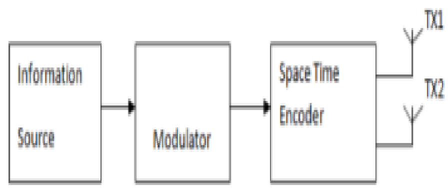


Fig.1. space-time encoder

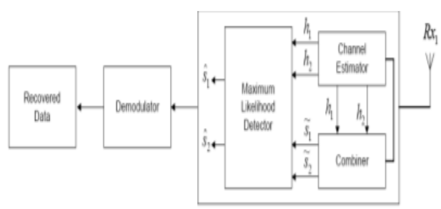


Fig.2. space-time decoder

III PROPOSED SYSTEM

In this paper, an innovative concept based on the framework of SSK and MBM schemes, called space-time media-based modulation (ST-MBM), is proposed by cleverly combining the Hurwitz-Radon family of matrices with the MBM transmission approach. The proposed ST-MBM scheme is the first STBC-based scheme that achieves transmits diversity gains by using a single RF chain with a significantly lower receiver complexity. Theoretical error performance analysis of the proposed ST-MBM scheme is performed and its exact average bit error probability (ABEP) is derived for correlated and uncorrelated channel states. Furthermore, a lower bound is obtained for the mutual information of the ST-MBM scheme. Through comprehensive computer simulations, bit error rate (BER) performance of ST-MBM scheme is compared with the existing state-of-the-art MIMO concepts in the literature.

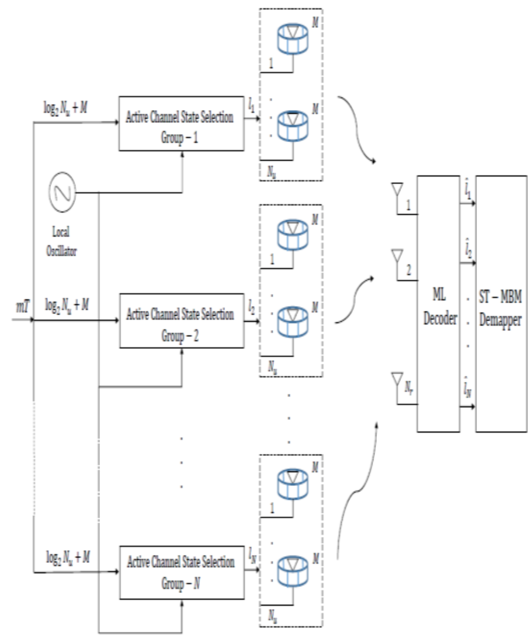


Fig.3. Block diagram of the ST-MBM scheme.

IV IMPLEMENTATION

MULTILEVEL INVERTER

An efficient way to compensate the inherently low spectral efficiency of STBC-based systems is to carry as much information as possible via the indices of the building blocks of the target transmission system. For a MIMO-MBM transmission scheme, the available building blocks for indexing are transmit antennas and RF mirrors. Beside these, in the proposed STMBM scheme, in order to further improve the spectral efficiency, information bits are subdivided into N transmission groups and space-time coding principle is independently applied to these transmission groups.In this project, an innovative concept based on the framework of SSK and

MBM schemes, called space-time media-based modulation (ST-MBM), is proposed by cleverly combining the Hurwitz-Radon family of matrices with the MBM transmission approach. Multi-user MIMO (MU-MIMO) can leverage multiple users as spatially distributed transmission resources, at the cost of somewhat more expensive signal processing. In comparison, conventional, or single-user MIMO considers only local device multiple antenna dimensions. Multi-user MIMO algorithms are developed to enhance MIMO systems when the number of users or connections is greater than one. Multi-user MIMO can be generalized into two categories: MIMO broadcast channels (MIMO BC) and MIMO multiple access channels (MIMO MAC) for downlink and uplink situations, respectively. Single-user MIMO can be represented as point-to-point, pair wise MIMO.

SPACE DIVISION MULTIPLE ACCESS:

MIMO broadcast represents a MIMO downlink case in a single sender to multiple receiver wireless networks. Examples of advanced transmit processing for MIMO BS are interference aware precoding and SDMA-based downlink user scheduling. For advanced transmit processing, the channel state information has to be known at the transmitter (CSIT). That is, knowledge of CSIT allows throughput improvement, and methods to obtain CSIT become of significant importance. MIMO BS systems have an outstanding advantage over point-to-point MIMO systems, especially when the number of transmit antennas at the transmitter, or AP, is larger than the number of receiver antennas at each receiver (user) as shown in below fig. Two categories of coding techniques for the MIMO BC include those using dirty paper coding and linear techniques.

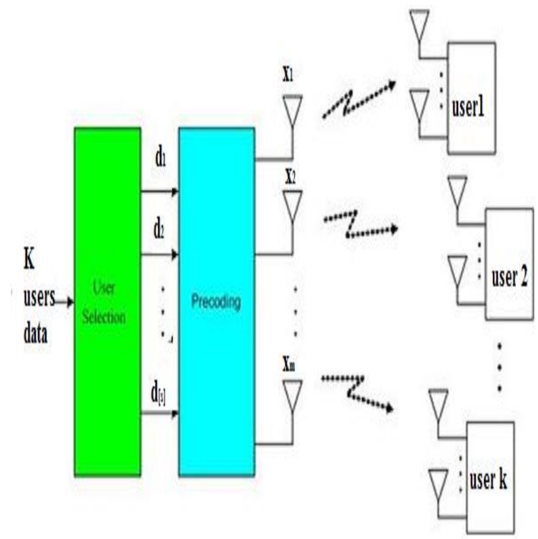
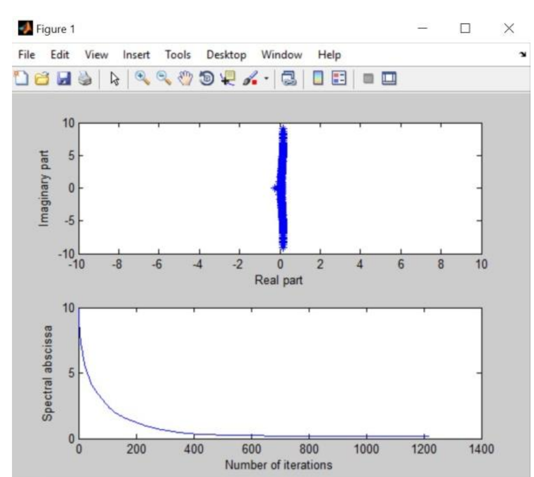


Fig.4. Space Division Multiple Access.

SIMULATION RESULTS:

In this section, BER performance of the ST-MBM scheme is investigated through comprehensive computer simulations. For different spectral efficiency values and transmit diversity gains, the BER performance and mutual information analysis of the ST-MBM scheme are evaluated and its superior error performance over existing systems are shown. All computer simulations are depicted as a function of the received energy per bit to noise ratio (Eb=N0) for Nr = 4.



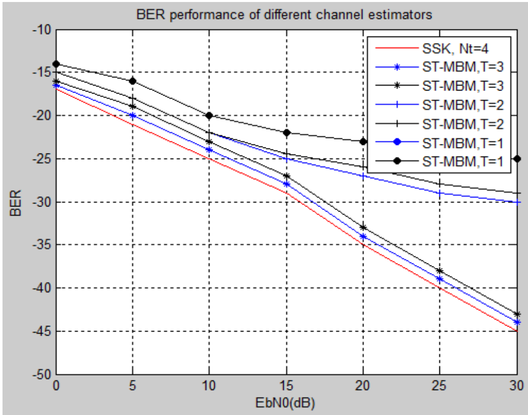


Fig.5. BER performance of different channel estimators.

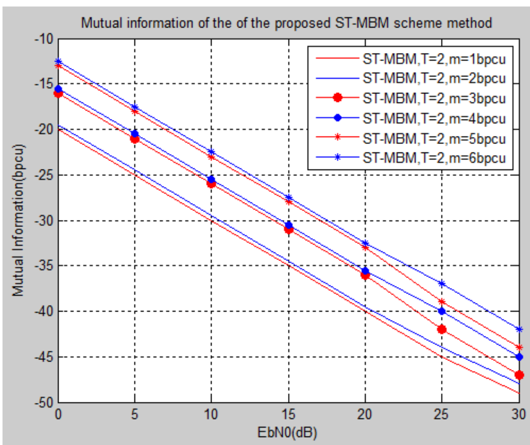


Fig.7.Mutual information of the of the proposed ST-MBM scheme method.

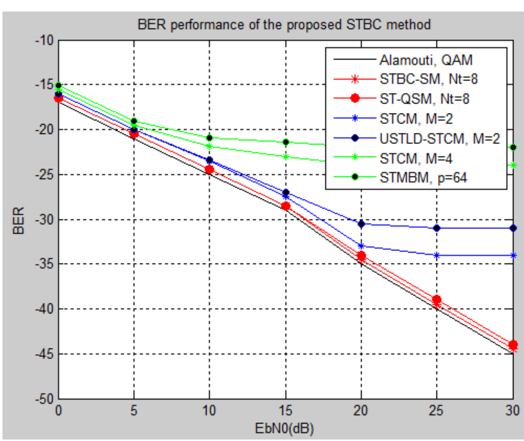


Fig.6.BER performance of the proposed STBC method.

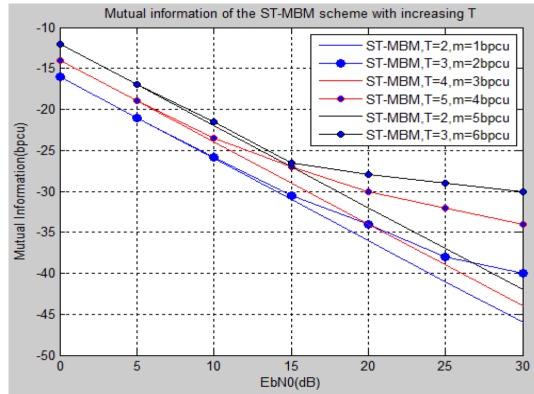


Fig.8. Mutual information of the ST-MBM scheme with increasing T.

In Fig. 6, the theoretical ABEP performance of ST-MBM schemes designed for T = 2 and T = 3 is depicted for correlated and uncorrelated fading conditions. The results show that the theoretical ABEP results of the ST-MBM scheme are consistent with the computer simulation results at high Eb=N0 values. Also, increasing correlation coefficients ra and rb apparently results in noticeable performance degradation and should be carefully monitored by the system designer. To show the effect of different transmit diversity gains at a certain spectral efficiency value, in Fig. 7, the BER performance of the ST-MBM scheme achieving a transmit diversity order of T with and without channel estimation errors, is provided. For each case, to achieve the same spectral efficiency value of m = 2 BPCU, a total of P = 2mT channel fade realizations are considered for N = 2 transmission groups, where P = NPu.

V CONCLUSION

In this paper, we have presented a general framework for space-time coded IM systems and introduced the ST-MBM scheme as the first STBC-based transmission scheme that uses a single RF chain at the transmitter while achieving various transmit diversity gains through MBM and time dispersion. Theoretical error performance analysis of the STMBM scheme for correlated and uncorrelated channel fadings has been investigated. Additionally, a lower bound has been derived for the mutual information of the ST-MBM scheme. Furthermore, through extensive computer simulations, the superior error performance of the proposed ST-MBM scheme with significantly lower decoding complexity over existing STBC-based transmission schemes has been demonstrated. The flexibility to achieve higher spectral efficiencies and various transmit diversity gains makes the ST-MBM scheme highly suitable for beyond 5G and ultra-reliable low latency communications (URLLC) applications. Our future work will focus on the enhancement of the proposed STMBM scheme through the use of multiple RF chains and/or ordinary modulations, low-complexity detection algorithms as well as performance analysis of the proposed system over poorly scattered millimeter wave (mm Wave) channels.

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