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Multi-User Detection for FEC-Coded Massive Trellis Coded Modulation MIMO: An Iterative Interference Rejection Approach

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***Abstract*—In this paper we analyze the issues and applications of multi user detection in a massive spatial modulation multiple input multiple-output (MUD SM MIMO) system, In this system base station is equipped with a large no. of antennas and each user equipment UE uses a single carrier Spatial modulation (SC SM) for the uplink transmission. Unlike the traditional multi user detection for massive SM MIMO systems the use of forward error correction coding (FEC) method is explored in the design, which is utilized to combat the impact of multi-user interference (MUI).particularly we propose to utilize the soft information from the forward error correction decoder to repeatly improve the multi user interference rejection procedure and deliver high accuracy estimation of the transmitted signals. Then the decoder and the MUI cancellation units are exchange the soft information, which constitutes a turbo structure and leads to simultaneous improvement of the mean square error (MSE), bit error ratio (BER) performance. The performance gain is substantiated by theoretical analysis as well as numerical simulations. In the above method, we use trellis coded modulation to improve the output efficiency and provide improved mean square error (MSE) and the bit error ratio (BER) performance than the existing method.**

***Index Terms*: Spatial modulation, MIMO, multi user detection, single carrier, forward error correction coding.**

I.INTRODUCTION

The Next decade cellular communication networks are Predicted to equip the base station BS with a large number of antennas to help to serve multiple user equipments (UEs) simultaneously which is referred to as the MIMO (massive multiple input multiple output). To harnessing the multiplexing diversity gain are brought by the more than hundreds of antennas, a significant improvement in energy, spectral efficiency can be reached. Nowadays the method of spatial modulation have been proposed to be combine with massive Multi Input Multi Output to get the multi-user SM-MIMO (MU SM-MIMO) techniques where each User Equipment manage SM for uplink transmission.

Thanks to the single radio frequency chain property of Spatial Modulation, the Power dissipation and power of each User Equipment is same as a single antenna User Equipment, when the uplink transmission rate can be boosted by conveying additional information via the active antennas indices. One of the other most challenging tasks in uplink transmission of MU SM-MIMO is how the Base Station combats the multi user interference and performs multi user detection. However as indicated the single carrier SM (SC-SM) operating in frequency selective fading channels is a more practical broadband SM transmission choice due to its low complexity. In the authors proposed a FEC-Coded Massive Trellis Coded Modulation for SC-SM by utilizing the sparsity of the SM signals.

II.MULTI INPUT MULTI OUTPUT

The MIMO stands for multiple input and multiple output antennas, which is used can achieve higher traffic data rates in the communication systems. MIMO techniques also open up a whole new spatial dimension for exploitation, keeping in mind the limitations surrounding frequency and time dimensions. By using the multiple transmit and multiple receive antennas, it is possible to transmit multiple data streams at the same time, and within the same frequency band, hence increasing the data rate with the number of transmit antennas and thereby improving system performance through diversity**Error! Reference source not found.** below depicts a wireless transmission system using MIMO. By exploiting the structure of the channel matrix, independent paths can be obtained via which independent data streams can be transmitted, that is multiplexing.

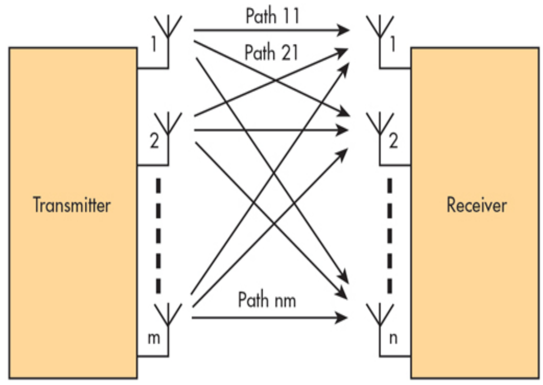

Figure 1. wireless transmission system using MIMO Using

the above diagram, the MIMO system model can be derived as below.

$$\begin{bmatrix} y1 \\ \vdots \\ yMr \end{bmatrix} = \begin{bmatrix} h11 & \cdots & h1Mt \\ \vdots & \ddots & \vdots \\ h1Mr & \cdots & hMrMt \end{bmatrix} \begin{bmatrix} x1 \\ \vdots \\ xMt \end{bmatrix} + \begin{bmatrix} n1 \\ \vdots \\ nMr \end{bmatrix}$$

Equation above can alternatively be written as

$$y = Hx + n$$

where, y is the received, Mr x 1, symbol column vector, x is the Mt x 1, column vector of the transmitted symbols, H is the channel matrix of dimension Mr x Mt, and n the Mt x 1 noise vector. Mt and Mr are the total number of transmit and receive antennas respectively.

III.SPATIAL MODULATION

Spatial Modulation Scheme is used to increase the Spectral efficiency of wireless communication system. Its Connect the digital modulation and multiple-antenna transmission to systems.

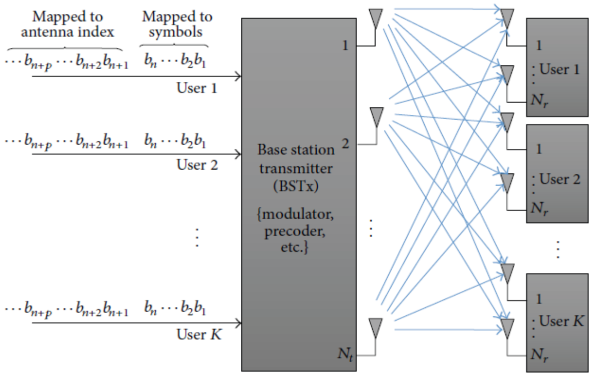

Figure 2. Spatial Modulation for MIMO System.

In the Spatial Modulation technique only one the antenna is active for transmission at a time. So the Spatial Modulation is very energy efficient as compare to the Spatial Multiplexing. Spatial Modulation works on the concept of Modulating symbol with phase or amplitude of the carrier and selection of antenna for transmission of the carrier signal. The main disadvantages are also there so a new idea of using multiple active transmits antennas with the spatial modulation are considered and this technique is called as Generalized Spatial Modulation (GSM). We can say that GSM is a hybrid of Spatial Multiplexing and Spatial Modulation. It transmits the same symbol over the active antennas and uses a set of active antenna combinations as an information source to increase spectral efficiency.

a)Advantages of SM

SM totally avoids inter channel interference need no synchronization between the transmit antennas, No constraints on the no. of receive antennas or transmit antennas.

It achieves spatial multiplexing gains even for a single receiver antenna and only a single RF chain is required at the transmitter side. It achieves better robustness to channel estimation errors .it achieves better robustness to channel correlation. The computational complexity is independent of the no. of transmit antennas.

b) Issues of spatial multiplexing MIMO

The spatial multiplexing MIMO can improves spectral efficiency, but affects from inter channel interference output in high computational complex algorithms .That requires inter antenna synchronization. It needs multiple Radio Frequency Suffers from error propagation.

IV.EXISTING SYSTEM

In the coded MU SM-MIMO uplink model, the BS is equipped with N_r receive antennas (RAs) and serves K UEs simultaneously. Each UE has N_t transmit antennas (TAs), while only one of them is randomly activated in each symbol period, according to the SM principle. For the k-th UE, a bit-interleaved coded modulation (BICM) scheme is concatenated with an SM mapper to generate the SM signals, as depicted. More specifically, the source bit stream $b_{s,k}$ is firstly encoded by a convolutional encoder with coding rate R to yield $b_{e,k}$. After interleaving, $b_{c,k}$ is obtained and then grouped by every m bits to yield $b^n{}_{g,k} \in x\{0,1\}^m$, in which n denotes the symbol index and m denotes the maximal transmitted bits per symbol. The first $m1 = \log_2 N_t$ bits of $b^n{}_{g,k}$ are used for antenna selection, while the last $m2 = m - m1$ bits are used to select a complex symbol from a 2^{m_2}-ary quadrature amplitude modulation (QAM) alphabet. Gray labeling is adopted for the mapping of QAM symbols. Therefore every $b^n{}_{g,k}$ is mapped to an SM symbol $s_{n,k} \in C_{N_t \times 1}$ which can be denoted by:

$$s_{n,k} = q_{n,k} 1$$

where $q_{n,k}$ is taken from the QAM alphabet. The limitations are Pilot contamination due to limited orthogonal pilot subcarriers as of bounded coherent interval and bandwidth. High signal processing complexity due to utilization of large number of antennas and multiplexing of UEs (or Mobile subscribers).Sensitive to beam alignment, as extremely narrower beam is used which is sensitive to movement of MS or swaying of antenna array channel reciprocity assumption is used in TDD mode.

V.PROPOSED METHOD

As the large-scale SM–MIMO implementations may incur in a non negligible training overhead for channel estimation. Some TA elements remain inactive in every channel use, SM–MIMO offers a lower throughput than SMX–MIMO. This implies that SM–MIMO requires a larger number of TA elements for achieving the same SE as capacity achieving SMX–MIMO communications. Due to its specific encoding mechanism in SM–MIMO, the active TA changes in every channel use.

The lack of scattering in the propagation environment may result in a poor error probability and EE.An encoding mechanism based on TCM is proposed for reducing the impact of channel correlation on the system's performance. The main advantage of this encoding is that it offers better performance in correlated channels. . TCM is used in conjunction with SM to partition the TAs into subsets by maximizing the spacing between TAs of the same subset. It provides better SINR and BER when compared with the spatial modulation.

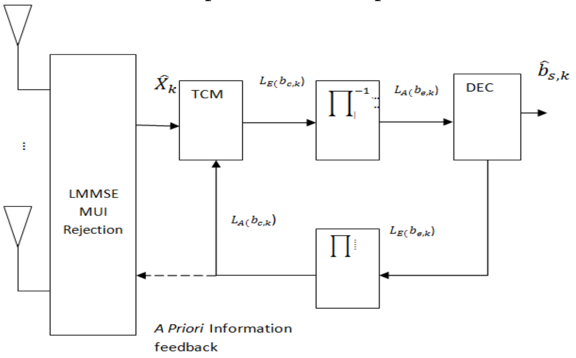

Figure 3 proposed scheme

In the proposed system as showed in the below, a two-stage processing strategy is employed to decode the data bits. In the first stage, a linear MMSE (LMMSE) estimation is performed to eliminate the MUI of other UEs. In this way, the extrinsic information from the decoder improves the MUI cancellation results, which in turn provides enhanced demodulation output to the decoder. This turbo structure, according to, has the potential of significantly improving the system performance. The soft-input soft-output (SISO) decoder calculates the extrinsic information $L_E(b_{e,k}$ using the Bahl-Cocke-Jelinek-Raviv (BCJR) algorithm, which is then interleaved to yield $L_A(b_{c,k})L_A(b^n{}_{c,k})$ can hence be obtained from $L_A(b_{c,k})$ by simple re-arrangements.

VI.TRELLIS CODED MODULATION SCHEME

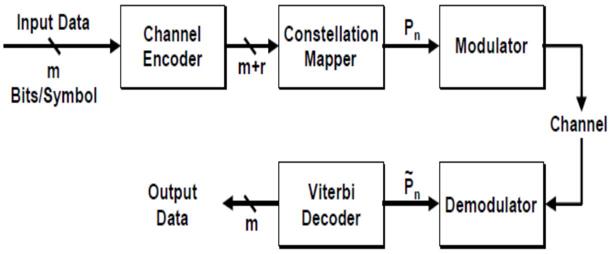

Figure 4. Trellis Coded Modulation

A systems approach towards a combined coding and modulation scheme is meaningful in order to obtain better system performance. Significant progress has taken place over the last two decades on the concepts of combined coding and modulation (also referred as coded modulation schemes).

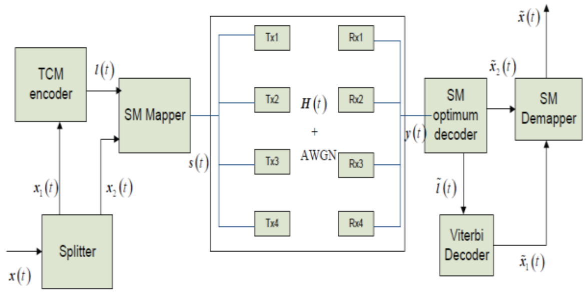

Figure 5. Trellis coded spatial system model

Several schemes have been suggested in the literature and advanced modems have been successfully developed exploiting the new concepts. Amongst the several strategies, which have been popular, trellis coded modulation (TCM) is a prominent one.

$$\rho_e \sim e^{d^2{}_{min}/2\sigma^2}$$

A trellis coded modulation scheme improves the reliability of a digital transmission system without bandwidth expansion or reduction of data rate when compared to an uncoded transmission scheme using the same transmission bandwidth. A TCM scheme uses the concept of tree or trellis coding and hence is the name 'Trellis Coded Modulation'. The **a**dvantages are the proposed method yields better SINR and BER compared with the existing spatial modulation methods.

a)Key features of Trellis Coded Modulation

- The operations of (baseband) modulation and coding are combined.

- The bandwidth is not expanded: same symbol rate, but redundancy is introduced by using a constellation with more points than would be required without coding.
the number of points is doubled

- The symbol rate and power spectrum is unchanged Since there are more possible points per symbol, it may appear that the error probability would increase for a given signal to noise.

VII.SIMULATIONS RESULTS

In this Section we provide several simulation results to substantiate the performance of the proposed system and the theoretical derivation results. MSE Performance Simulations firstly we examine the MSE performance yielded by scheme with K = 8. As can be seen from the figure, the theoretic bounds MSEub 1 and MSEub 2 provide tight upper bounds for the MSE asymptotically. With 10 iterations, the MSE of scheme II approaches that of the MUI-free case in a high-SNR region, which is the optimal MSE performance when the impact of MUI is perfectly cancelled. In order to compare the performance of the proposed system with state-of-the-art, we provide the uncoded bit error ratio (BER) of the proposed schemes and the trellis coded modulation. Note that the uncoded BER performance of the proposed scheme is counted based on the bit-errors of the demodulation outputs, which is given. It is also observed that the proposed scheme ensures its efficacy, even when Nr < KNt. Compared against , although a performance degradation is seen in extremely low SNR region, but the performance of scheme II is immediately improved with the increasing SNR, and exhibits a performance gain of approximately 0:5 dB over ,especially when K = 16. Note that this performance gain is achieved without sparsity pre-assumed for the uplink SM signals, which is different from the scheme.

The coded BER performance is depicted in Fig.4. Aided with the powerful turbo principle, a BER "waterfall" effect can be witnessed in 4 dB and 6:5 dB for MUD scheme II, when K = 8 and 16, respectively. Thanks to the application of iterative MUI suppression, scheme II shows a much lower BER than scheme I, while scheme I exhibits an extremely high error floor when many UEs are simultaneously scheduled. Besides, due to the successful convergence, the BER of scheme II is very close to the MUI-free case in a high-SNR region.

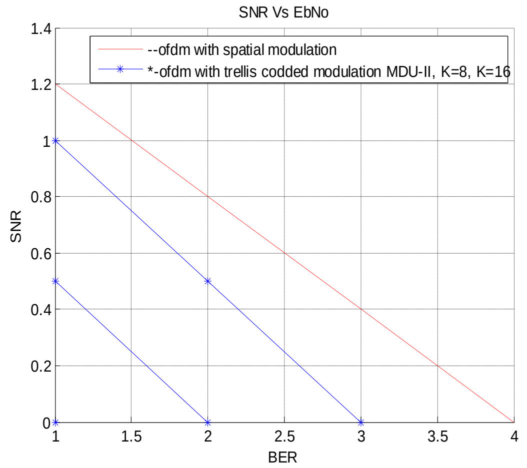

Figure 6. BER comparison of ofdm with spatial modulation vs trellis coded modulation

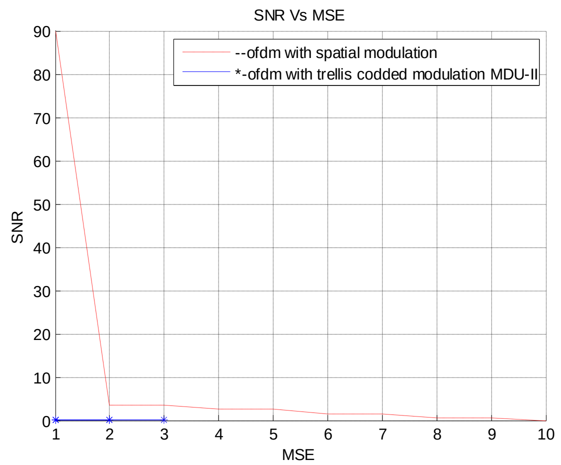

Figure 7.MSE comparison of ofdm with spatial modulation vs trellis coded modulation

VII .CONCLUSION

In this paper we present the design of spatial modulation (SM) scheme for massive multiuser MIMO (MU MIMO) system. In this scheme, the index of the receiving antenna which active of each user in a MU MIMO system is used to send additional information in addition to the transmitted symbols. The software Simulation results show that significant increase in the system throughput is achieved as the no of available receiver antennas per user is increased. There are two methods are proposed for implement the Spatial Modulation scheme for massive MU MIMO system the sub channel selection method ,zero padding method. BitErrorRate performance of proposed schemes are also studied and simulated.

Our simulation results show that for the sub channel selection method, the BitErrorRate performance degrades with increasing the no of users serviced by the BSTx or the no of receiving antennas per user. In the zero padding technique increasing the no of users does not affect the BitErrorRate performance since the multiuser interference is wholey removed by the mixing of zero padding and precoding operations applied at the BSTx.Trellis Coded Modulation is a bandwidth efficient transmission system that achieve high gain by integrating coding and modulation.

Trellis coded modulation is better to design in long sequences of messages. In this scheme, a group of information bits is first splited into two sequences, where the second sequence directly enters the Spatial Modulation mapper while the first sequence enters the Spatial Modulation mapper after passing through a four state convolution encoder and then go to random block interleaver.TCM modulation is used instead of SM to improve the channel correlation and achieve better system performance in terms of SINR and BER.

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