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PERFORMANCE ENHANCEMENT OF MIMO SYSTEMS USING ANTENNA SELECTION ALGORITHM

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Abstract

Multiple-input multiple-output (MIMO) systems are anticipated to be widely employed to address the ever increasing capacity demands for wireless communication systems. MIMO technology is one solution to attain this by transmitting multiple data streams from multiple antennas. Increasing the number of transmit and receive antennas enables to improve system performance , but the multiple RF chains associated with multiple antennas are costly in terms of size, power and hardware.Therefore,an efficient scheme is required for the systems with large antennas to reduce the hardware and computational costs. An efficient approach to achieve this goal is the fast transmit antenna. For low-rank channels, transmit antenna selection can increase the capacity compared to a full-complexity system. In this paper we have studied different antenna selection schemes and the performances are compared in an analytical manner.

Keywords-- MIMO, Antenna Selection, Channel Capacity, SNR

I. INTRODUCTION

Multiple-input multiple-output (MIMO) systems, which employ multiple antennas at both transmitter and receiver, can significantly increase system capacity and improve performance of wireless communication channel.A major drawback of MIMO systems comes from the increased hardware cost due to multiple RF chains. Due to the high cost, an alternative technique called antenna selection algorithm is investigated. Spatial Multiplexing is a transmission technique in MIMO wireless communication system to transmit independent and separately encoded data signals. Streams from each of the multiple transmit antennas are transmitted simultaneously to all antennas in the receiver.

Spatial multiplexing allows increasing the bit rate without consuming more time or frequency resources and without increasing the total transmit power.Spatial multiplexing can only be fully exploited if the number of antennas, at both sides is equal to or greater than the number of parallel streams. The main drawbacks of spatial multiplexing scheme are interring channel interference,Inter–Antenna Synchronization (IAS), Multiple Radio Frequency (RF) chains. Also, the spatial multiplexing transceiver designs require a number of receive–antenna greater than the number of transmit–antenna, which may limit, due to economical reasons [6]. To overcome the disadvantage of the spatial multiplexing, detailed above the new technique called spatial modulation is used.

Spatial Modulation is an entirely new modulation concept that exploits the uniqueness and randomness properties of the wireless channel for communication, which aims at reducing the complexity and cost of multiple–antenna schemes without deteriorating the end–to–end system performance and still guaranteeing good data rates. The low– complexity transceiver design and high spectral efficiency are simultaneously achieved in spatial modulation by adopting the simple modulation and coding mechanisms. In the proposed system one transmit-antenna is activated for data transmission at any signalingtime instance, this entirely avoids inter channel interference and only one RF chain is needed for data transmission.

Spatial modulation can efficiently work if number of receiver antenna is less than that of transmitter antennas,since the receive–antenna are used to get only a diversity gain. In addition to eliminating inter channel interference at the receiver, no mutual coupling is produced by spatial modulation between the transmit antennas and also it requires no synchronization between them. Also the symbol duration is unchanged in spatial modulation even though the transmitted symbol carries different number of information bits due to the described working mechanism. Because of this, the bandwidth occupied is unchanged which effectively results in the desired increase in spectral efficiency.

The spatialposition of each transmit–antenna in the antenna–array is used as a source of information, this is obtained by establishing a one–to–one mapping between eachantenna index and a block of information bits to be transmitted, and it results in acoding mechanism called transmit–antenna index coded modulation [1]. Due to the above mechanisms, spatial modulation is called new physical layer transmission technique which combines, in a unique fashion, digital modulation, coding, and multiple–antenna to achieve high data rates and low–complexity implementations.

II. ANTENNA OVERVIEW

The use of diversity or spatial multiplexing in the system, the main drawback of any MIMOsystem is the increased complexity, and thus cost.

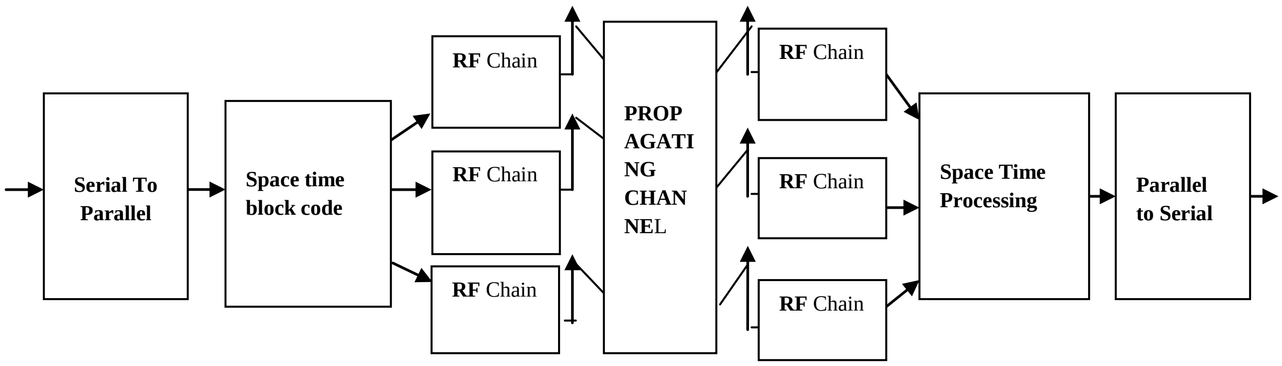

Fig.1 Principles of spatial multiplexing

To reduce the complexity, antenna selection has been introduced. In the antennaselection only the best set of antennas out of all antennas are used, but gives almost the same capacity as the conventional systems, as the remaining antennas are not employed, thus the number of required RF chains are reduced The principle of this can be seen from the fig. [1], shown below, in this different data streams are transmitted (in parallel) from the different transmit antennas.

The multiple receive antenna elements are used for separating the different data streams coming from transmitter to the receiver.The advantage of this method is that the data rate can be increased by a factor $N_t$without requiring more spectrum.In this paper, information –theoretic capacity is discussed mostly i.e., the data rate that can be transmitted over a channel without errors if ideal coding isused. MIMO systems with N_t transmit and N_r receive antennas require $_{Nt}$ (Nr) complete RF chains at the transmitter, and the receiver.. Due to this reason the "best" L out of N antenna signals are chosen (either at one or at both link ends) and processed [2].This reduces the number of required RF chains from N to L, and thus reduces the cost of the hardware.

In this paper, the performance that can be achieved with such a system,and how the "best" antennas out of all sets of antennas can be selected in an efficient manner are discussed.

III. SPACE-TIME CODED SYSTEMS

Space–time block coding is a technique used in wireless communication to transmit multiple copies of a data stream across a number of antennas and to exploit the various received versions of the data to improve the reliability of data transfer. Space- time coded systems with transmit and receive antenna selection in correlated channels are discussed. It is assumed that the transmitter has knowledge about the statistics of the fading, i.e., it knows the correlation of the fading at the different antenna elements.

Space time block coding technique involves the transmission of multiple redundant copies of data to compensate for fading and thermal noise in the hope that some of them may arrive at the receiver in a better state than others. The data streams to be transmitted are encoded in blocks, in the case of STBC in particular.This block is distributed among spaced antennas and across time.

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Also the space time block coding technique requires to have multiple transmit antennas, but it is not necessary to have multiple receive antennas, the above said condition is achieved to improve the performance.This process of receiving diverse copies of the data is known as diversity reception.

STTD is one of numerous open loop transmit diversity schemes which also include Phase Switched Transmit Diversity (PSTD), Time Switched Diversity TSTD, Orthogonal Transmit Diversity (OTD) and Space Time Spreading (STS), out of all these maximal combining ratio with transmit antenna selection technique is used in the proposed scheme. The aim of all of these schemes is to smooth the Rayleigh fading and drop out effects observed when using only a single antenna at both ends of a radio link in a multipath environment.Link reliability for each user overtime,especially near cell edges (in the absence of soft handoff), and also the average performance of an ensemble of users at any particular instant can be achieved by diversity.

IV. Antenna Selection Algorithms

The only mechanism for a truly optimum selection of the antenna elements is an exhaustive search of all possible combinations for the one that gives the best SNR or capacity. However, for H-S/MIMO, this requires some (N_{tLt}) and (N_rLr) computations of determinants for each channel realizations, which quickly becomes impractical. For this reason, various simplified selection algorithms have been proposed. The simplest selectionalgorithm is the one based on the power of the received signals [3].This is quite effective in diversity case the goal of the receiver is to separate the different data streams. Thus it is not good to use the signals from two antennas that are highly correlated, even ifboth have high SNR. The transmitter, the receiver, or both use only the signals from a subset of the available antennas. This allows considerable reductions in the hardware expense.

The diversity degree for both linear diversity systems with complete channel knowledge and space-time coded systems can be retained by antenna selection. Antenna selection is an extremely attractive scheme for reducing the hardware complexity in MIMO systems. There are two main approaches for antenna selection: norm-based selection and successive selection.

The former approach is more suitable when SNR is low, whereas the latter suits the high SNR regime. The above said two can be applied for either transmit or receive antenna selection.

Antenna selection has certain inherent limitations one of the most important limitations arises whenever the system bandwidth is larger than the coherence bandwidth of the channel. However, in moderately frequency-selective channels; antenna selection still provides significant gains.

A.Transmit Antenna Selection with MRC

Transmit antenna selection can increase the capacity compared to a full-complexity Transmit antenna selection, unlike receive selection, requires a feedback path from the receiver to the transmitter This feedback rate is rather small, especially for single antenna selection. Transmit antenna selection is very similar to receive antenna selection; the antennais selected that provides the highest equivalent receive SNR Selection diversity techniques require knowledge of channel conditions at the receiver for receive selection and at the transmitter for transmit selection. The estimation and feedback of channel state information takes some time, and the channel state must remain constant over that period. Transmit antenna selection hasmany similarities with receive antenna selection.

The main difference, is that the transmit selection requires, a feedback path. The main function of the feedback is to inform the transmitter which antennas to select. When the transmitter is fully aware of the channel coefficients, the maximum capacity available in the channel will be attained [5]. The excess capacity provided by transmit antenna selection is Quantified and analyzed. The channel state information (CSI) is exactly known at the receiver and at the transmitter, the selection is available at the receiver or transmitter, and it is based on the instantaneous signal-to-noise ratio (SNR) at each receive antenna; Perfectknowledge of the channel correlation matrices at both transmitter and receiver sides.

B.Antenna Selection with OSTBC

In this antenna selection, Alamouti transmit diversity scheme is proposed. This OSTBC uses 2 transmit antennas and one receive antenna simultaneously. During the first symbol period, *x*1 and *x*2 are transmitted via the first and the second antenna respectively. While the next symbol cycle,-$x_2^*$and x_1^* are emitted respectively. The received signals, *y*1 and *y*2 for two considered time intervals are then obtained:

$$[y1\ y2] = [h1\ h2] \begin{bmatrix} X1 & -X2* \\ X2 & X1* \end{bmatrix} + [n1\ n2]$$

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The equivalent equation is given by

$$Y = Hv + N$$

All the transmit antennas are used without selection for transmission.In Transmitantenna selection with OSTBC (TAS/OSTBC):(NT ; 2;NR) scheme with Alamouti codecan also be considered. At any time, only two out of NT antennas are chosen for transmitting. The principle of the TAS/OSTBC is basically same as that of the RAS/OSTBC.

C.FAST TRANSMIT MIMO ANTENNA SELECTION ALGORITHM

A major drawback of MIMO systems comes from the increased hardware cost caused by Multiple analog/RF front ends, which motivated the investigation of antenna selection schemes Transmit antenna selection is very similar to receive antenna selection the antenna is selected that provides the highest equivalent receive SNR. With channel capacity as the performance criterion, the optimal selection can be obtained through the exhaustive search over all possible antenna subsets, on maximizing the channel capacity, a geometric approach called the G-circles algorithm is explored, based on either instantaneous channel state information.No CSI is available at the transmitter, so the selection is implemented at the receiver, and the selected antenna indices are fed back while the transmitter equally allocates its power among L selected antennas [3]. The channel capacity after antenna selection can be expressed as:

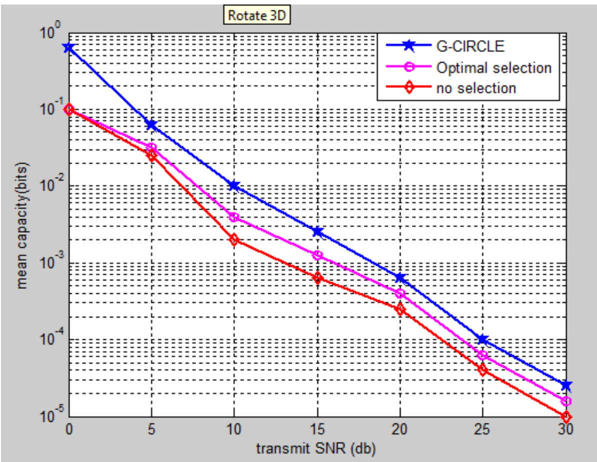
$$C = \log_2 \left| I_L + \rho / L\, H^H_{SL} H_{SL} \right|$$

Where $\mathbf{I}_L$is the $L\times L$ identity matrix, ρ is the average signal to noise ratio (SNR) at each receive antenna, and the operator ^{H}represents transpose conjugate [2].

V. ANALYTICAL ANALYSIS

In order to compare the performance of the proposed algorithm with that of the optimal antenna selection technique, the G-circle method, and the fast algorithm have been carried out.

The capacities achieved by antenna selection algorithms based on instantaneous CSI are investigated.It has found that the GSalgorithm perform near optimal for any channel conditioning situation.



The G-circles method yields uniformly better performances over the optimal .the G-circles method preserves the spatial multiplexing gain, and presents a reasonable performance loss.In this performance and capacity can be enhanced.

VI. CONCLUSION

In this paper, a new fast algorithm has been proposed for antenna selection in wireless MIMO systems. Our method achieves similar outage capacity as the optimal selection method and the fast algorithm at a much reduced computational costThe simple G-circles method reduces the complexity significantly with reasonable performance loss It can also be effectively deployed in correlation matrix-based antenna selections. Antenna selection is an extremely attractive scheme for reducing the hardware complexity in MIMO.Spatial modulation can be a promising candidate for low–complexity MIMO implementations. However, Spatial modulation is still a young–born research field and several issues need to be addressed to fully understand its potential and limitations in practical and realistic propagation environments.

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