AN ARCHITECTURE FOR REALIZING TRANSMISSION FOR 2×2 MIMO CHANNEL

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Abstract-*The idea of using multiple receive and multiple transmit antennas has emerged as one of the most significant technical breakthroughs in modern wireless communications. Theoretical studies and initial prototyping of these MIMO systems have shown order of magnitude spectral efficiency improvements in communications. As a result, MIMO is considered a key technology for improving the throughput of future wireless broadband data systems MIMO is the use of multiple antennas at both the transmitter and receiver to improve communication performance. It is one of several forms of smart antenna technology. MIMO technology has attracted attention in wireless communications, because it offers significant increases in data throughput and link range without requiring additional bandwidth or transmit power. This is achieved by higher spectral efficiency and link reliability or diversity (reduced fading).Spatial multiplexing is a transmission technique in MIMO wireless communication to transmit independent and separately encoded data signals, so called streams, from each of the multiple transmit antennas. Therefore, the space dimension is reused, or multiplexed, more than one time. What mainly makes MIMO systems interesting is their potential ability to achieve an increase in system capacity or in link reliability without requiring additional transmission power or bandwidth (Goldsmith, 2005). In this paper, we focus on different receivers for 2x2 MIMO channel*

Keywords-*MIMO systems, wireless communications, Spatial multiplexing.*

I INTRODUCTION

(a) Spatial multiplexing

Spatial multiplexing is a transmission technique in MIMO wireless communication to transmit independent and separately encoded data signals, so-called *streams*, from each of the multiple transmit antennas. Therefore, the space dimension is reused, or multiplexed, more than one time.If the transmitter is equipped with Nt antennas and the receiver has Nr antennas, the maximum spatial multiplexing order (the number of streams) is

$$Ns = \min(Nt, Nr)$$

if a linear receiver is used. This means that N_s streams can be transmitted in parallel, ideally leading to an N_s increase of the spectral efficiency (the number of bits per second and per Hz that can be transmitted over the wireless channel). The practical multiplexing gain can be limited by spatial correlation, which means that some of the parallel streams may have very weak channel gains.

In the SM strategy (Tse & Viswanath, 2006), a single symbol stream is first demultiplexed and encoded into two separate and independent substreams. Each substream is then transmitted simultaneously over each transmit antenna and, at the receiver, an optimal joint decoder is employed for retrieving the original symbol stream. Since this strategy requires one single symbol stream, it can only be used for the transmission of a SD representation of the source.

(b) Types of MIMO

- ***Space Time Transmit Diversity (STTD)*** **-** The same data is coded and transmitted through different antennas, which effectively doubles the power in the channel. This improves Signal Noise Ratio (SNR) for cell edge performance.
- ***Spatial Multiplexing (SM)*** **-** the “Secret Sauce” of MIMO. SM delivers parallel streams of data to CPE by exploiting multi-path. It can double (2x2 MIMO) or quadruple (4x4) capacity and throughput. SM gives higher capacity when RF conditions are favorable and users are closer to the BTS.
- ***Uplink Collaborative MIMO Link*** **-** Leverages conventional single Power Amplifier (PA) at device. Two devices can collaboratively transmit on the same sub-channel which can also double uplink capacity.

(c) Benefits of MIMO Technology

MIMO channels provide a number of advantages over conventional SISO channels such as the array gain, the diversity gain, and the multiplexing gain. While the array and diversity gains are not exclusive of MIMO channels and also exist in single-input multiple-output (SIMO) and multiple-input single-output (MISO) channels, the multiplexing gain is a unique characteristic of MIMO channels. These gains are described in brief below.

(d) Array Gain

Array gain denotes the improvement in receive signal-to-noise ratio (SNR) that results from a coherent combining effect of the information signals. The coherent combining may be realized through spatial processing at the receive antenna array and/or spatial pre-processing at the transmit antenna array. Formally, the array gain characterizes the horizontal shift of the error probability versus transmitted or received power curve (in a log-log scale), due to the gain in SNR.

(e) Spatial Diversity Gain

Diversity gain is the improvement in link reliability obtained by receiving replicas of the information signal through (ideally independent) fading links. With an increasing number of independent copies, the probability that at least one of the signals is not experiencing a deep fade increases, thereby improving the quality and reliability of reception. A MIMO channel with nT transmit and nR receive antennas offers potentially nTnR independently fading links and, hence, a spatial diversity order of nTnR. Formally, the diversity gain characterizes the slope of the error probability versus transmitted or received power curve (in a log-log scale) in the high-SNR regime.

(g) Spatial Multiplexing Gain

MIMO systems offer a linear increase in data rate through spatial multiplexing , i.e., transmitting multiple, independent data streams within the bandwidth of operation. Under suitable channel conditions, such as rich scattering in the environment, the receiver can separate the data streams. Furthermore, each data stream experiences at least the same channel quality that would be experienced by a SISO system, effectively enhancing the capacity by a multiplicative factor equal to the number of substreams. In general, the number of data streams that can be reliably supported by a MIMO channel coincides with the minimum of the number of transmit antennas nT and the number of receive antennas nR, , min{nT; nR}.

II LITERATURE REVIEW

Because of its extra ordinary increase in data throughput and link reliability without expending additional bandwidth and transmit power, MIMO systems have attracted a wide research attentions in wireless communications since the last decade. Some of the researches conducted on the area of MIMO systems are reviewed below.

The first breakthrough to MIMO systems was made by Gerard J. Foschini and M. J. Gant in [1], where they used information theoretic approach to investigate the ultimate limits of the spectral efficiency achievable when using MIMO systems. Besides, they have hinted the need of inventing a new MIMO detection scheme to realize a hefty portion of the great capacity promised.

In [2], Gerard J. Foschini showed that enormous spectral efficiency up to 42 bps/Hz can be achieved when using MIMO systems with 8 antennas both at the transmitter and receiver, which is more than 40 times that of the SISO systems. However, he used D,BLAST (diagonal_BLAST) architecture which suffers from certain implementation complexities which make it inappropriate to realize in hardware.

P. W. Wolkiansky et al in [3] introduced V_BLAST (Vertical BLAST) which uses ordered successive interference cancellation (OSIC) as MIMO detection technique. In their laboratory test bed, they achieved spectral efficiency up to 40 bps/Hz at practical SNRs.

In [4, 5] the Zero Forcing (ZF) based V_BLAST of [3] was extended to MMSE based V_BLAST to improve system performance. However, the main drawback of MMSE V_BLAST is that it requires accurate estimate of the noise level in the system which is practically difficult to obtain. In [4] D. W_bben et al obtained the same performance as MMSE V_BLAST using MMSE_SQRD which has lower complexity compared to MMSE V_BLAST. This also requires knowledge of statistical information of noise level within a system to maintain high performance.

The work of A. V. Zelst in [5] revised the above MIMO detection schemes and compared the performance results of these schemes with the Maximum Likelihood Detection (MLD) scheme. In this paper it was shown that MLD outperforms the other detection methods. Furthermore, the performances of these detection algorithms for broadband MIMO systems were analyzed in [7] where OFDM is coupled with MIMO systems to combat the ISI resulting from high data rate. In either case, the performance of the traditional MIMO detection schemes is far inferior to that of maximum likelihood detection method especially for higher MIMO sizes. However, the MLD scheme has a complexity which increases exponentially with the number of antennas and/or the constellation orders. Moreover, the performances of the traditional MIMO detection schemes deteriorates under ill,conditioned channels resulting from spatial correlations and fall below acceptable threshold for certain applications requiring significant transmission accuracy [19].

The works reported in [8, 10] try to reduce the complexity of MLD by using approximations, but the complexity reduction they achieved is not satisfactory for higher modulation orders and large MIMO sizes. Sphere decoding algorithms introduced in [8,9,10] are the state_of_the art MIMO detection techniques which can substitute the MLD algorithm. These algorithms use iterative search based on a tree structure, either breadth first search or depth first search, to perform MIMO signal detection. In [8] B. Hassibi and H. Vikalo used sphere decoding to obtain MLD performance and Low Complexity MIMO_OFDM Receivers For Achieving Near Optimal Performance 5 reported that SDAs have, in general, variable complexity under different channel conditions and SNRs and hence, have variable computational throughput.

There are a lot of works done to improve the performance of k, best SD with negligible additional complexity as in [12,13]. In general, the performance of the k, best SD is poor especially when the k value is small. Even though there are plenty of works done in the literature to reduce the complexity and/or improve the performance of the two SD schemes separately, little attention has been paid to the combination schemes which can take the advantage of both schemes. To this end, authors in [15] introduced staggered SD where the search is simultaneously performed along the depth and breadth of the tree. However, this requires a number of independent processing units to perform the search along the different dimensions of the tree. Nevertheless, they claimed that they achieved better throughput than the pure depth first SD.

In [16], H. L. Chiang and S. G. Chen, incorporated DF SD into k, best SD to reduce its complexity. They also used MMSE, SQRD based layer reordering and obtained performance similar to the layer reordered k, best SD with reduced complexity. However, they used S, E enumeration of [6], which requires specific ordering of the tree branches according to their distance. In this thesis, the hybrid SD scheme, which collects the desirable features of the two SDAs, k, best and DF SDAs, is proposed to achieve performance very close to that of MLD. Moreover, initial radius setting technique, which can reduce the complexity without using any enumeration technique, is introduced.

III METHODOLOGY

In this paper we simulated the algorithms of the receivers for 2x2 MIMO channel using MATLAB.

Transmission for 2×2 MIMO channel

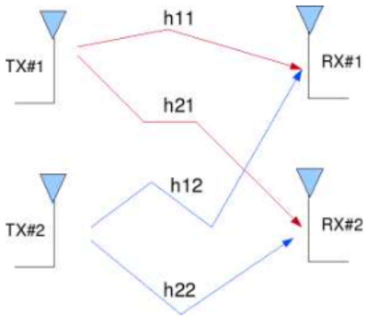

Figure 1: Ttransmit 2 receive MIMO channel

In a 2×2 MIMO channel, probable usage of the available 2 transmit antennas can be as follows:

- Consider that we have a transmission sequence, for example X1 , X2 ,X3,....,Xn
- In normal transmission, we will be sending X1 in the first time slot, X2 in the second time slot, X3and so on.
- However, as we now have 2 transmit antennas, we may group the symbols into groups of two. In the first time slot, send X1 and X2from the first and second antenna. In second time slot, send X3 and X4 from the first and second antenna, send X5 and X6 in the third time slot and so on.
- we are grouping two symbols and sending them in one time slot, we need only n/2 time slots to complete the transmission
- This forms the simple explanation of a probable MIMO transmission scheme with 2 transmit antennas and 2 receive antennas.

IV IVRESULT AND DISCUSSION

There a multiple transmit antennas and multiple receive antennas resulting in the formation of a Multiple Input Multiple Output (MIMO) channel. In our paper, We will restrict my discussion to a 2 transmit 2 receive antenna case (resulting in a **2×2 MIMO** channel). We will assume that the channel is a flat fading Rayleigh multipath channel and the modulation is BPSK. In this paper I have discussed six receivers for 2X2 MIMO channels and simulated the result using MATLAB.

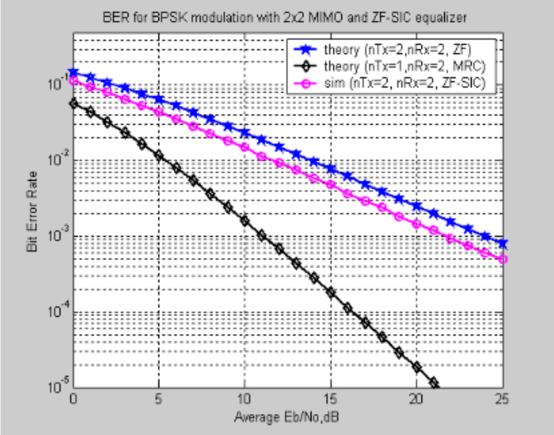

Figure 1: MIMO with Zero Forcing Successive Interference Cancellation equalizer

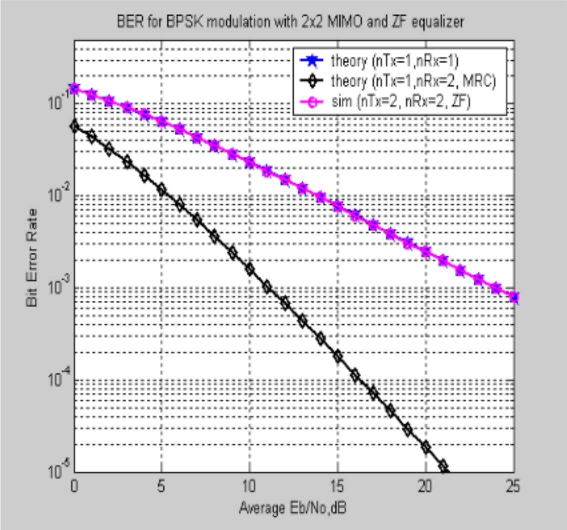

Figure 2: MIMO with Zero Forcing equalizer

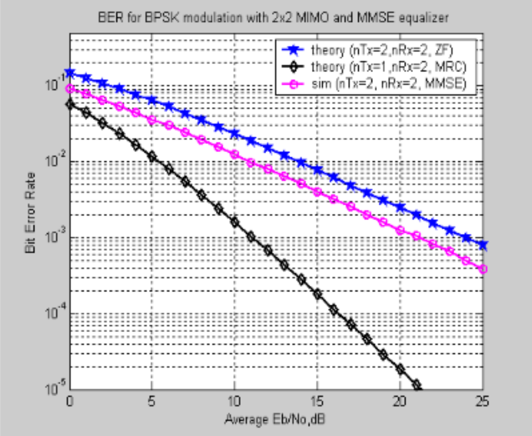

Figure 3: MIMO with MMSE equalizer

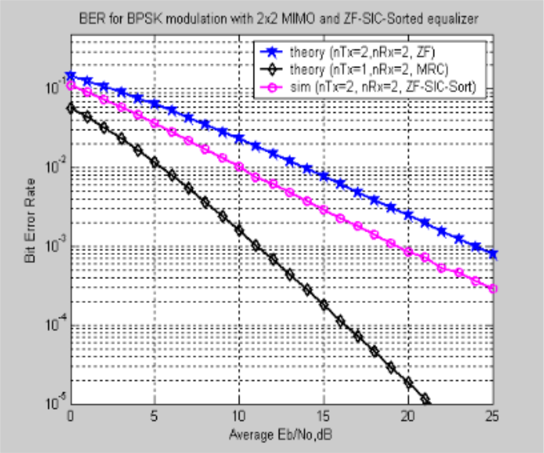

Figure 4:MIMO with ZF SIC and optimal ordering

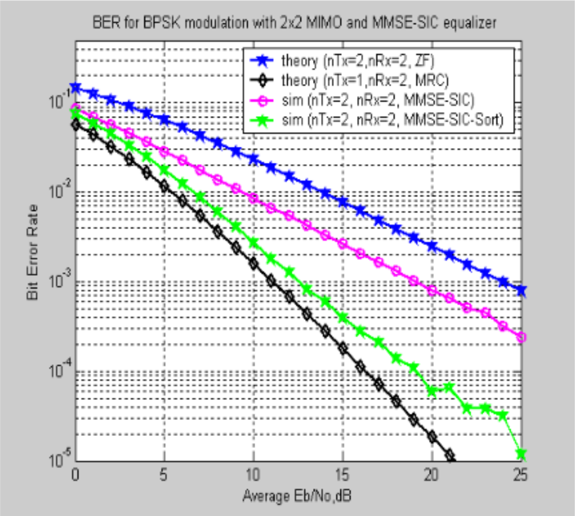

Figure 5: MIMO with MMSE SIC and optimal ordering

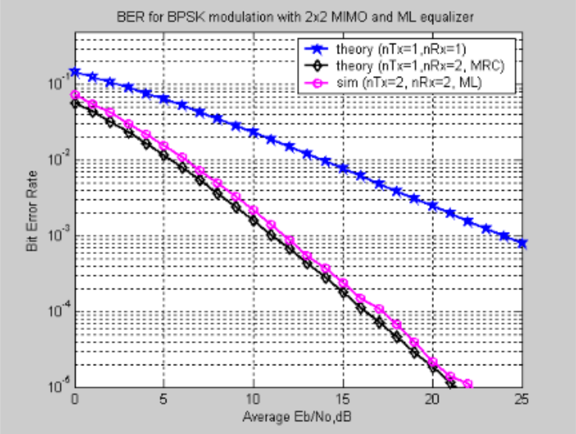

Figure 6: MIMO with ML equalization

V CONCLUSION

Several different diversity modes are used to make radio communications more robust, even with varying channels. These include time diversity (different timeslots and channel coding), frequency diversity (different channels, spread spectrum, and OFDM), and also spatial diversity. Spatial diversity requires the use of multiple antennas at the transmitter or the receiver end. Multiple antenna systems are typically known as Multiple Input, Multiple Output systems (MIMO). Multiple antenna technology can also be used to increase the data rate (spatial multiplexing) instead of improving robustness. In future, we can make a single integrated circuit that uses both methods combination.

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