Analysis of Spreading Technique for MIMO-CDMA based on Space Time Block Codes with Independent Channel coefficients

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Abstract:

The future of communication system is changing towards high capacity and faster data transmission with error less environment. Wireless and efficient Communication Systems follows the Improvement in the Bit error rate (BER) over fading channel with decrease in the system level complexity. Multiple Input multiple output (MIMO) generally improves spectral efficiency and link reliability. And CDMA is a simple technique that has many advantages, spread spectrum gives best results in CDMA technique, for the improvement in signal quality, the combination of both techniques rise to give a simple solution. For better Bit error rate (BER) there is permutation spreading technique runs on space time block code (STBC) matrices. Here the crucial part is spreading strategy that follows frequency of data bits and each transmit antenna uses different spreading sequences gives fewer errors in symbols. The assignment of spreading sequence allotment follows some permutation designs that should have required squared Euclidean distance from message to another message for better spatial diversity, orthogonality and code symmetry. Permutation spreading development can be achieved by changing the pattern of space time block code environment. The results indicate that, there is an improvement in Bit Error rate.

Keywords: MIMO, CDMA, STBC, BER, Spreading.

I. Introduction

Code-division multiple access (CDMA) users are identified at the base station by their unique spreading code. The signal that is transmitted that modulates its spreading code. Such modulation schemes are Binary phase shift keying (BPSK), Quadrature phase shift keying (QPSK). Direct-sequence code-division multiple access (DS-CDMA) comprises of the narrowband message signal is multiplied by a large bandwidth signal, which is called the spreading of a signal. The spreading signal is generated by convolution of sequence code with a waveform whose duration is much smaller than the symbol duration. The receiver performs a correlation operation to detect the message addressed to a given user and the signals from other users appear as noise due to decorrelation.In order to spread the bandwidth of the transmitting signals, a sequence is used. Multiple Input Multiple Output (MIMO) is a technology that uses multiple antennas to transmit and receive signals.

MIMO-CDMA system can be designed with Nt transmit antennas and the parity bits select Nt different spreading sequences from a set of N mutually orthogonal spreading sequences; and each transmit antenna uses at most the best one of the selected spreading sequences. A different approach of permutation of Nt spreading sequences is assigned to different sequences of parity bits, hence the technique is referred to as permutation spreading. And it can be analysed for single user environment by considering a nominal channel path gains with unknown channel coefficients at the receiver. So in this paper we investigated the effect of imperfect channel state information on the receiver performance. We compare the performance of the two techniques for MIMO-CDMA systems operating on frequency-flat slowly Rayleigh fading channels. In section II, we provide a block diagram of the MIMO-CDMA system employing permutation spreading. In section III, we provide the STBC-based spreading code permutation design with a new approach for a system of 4 transmit antennas without knowledge of Channel state information and unknown path gains. In section IV, we provide a union bound for the BER. The simulated BER performance for the MIMO-CDMA case considered in this paper The block diagram of a MIMO-CDMA transmitter receiver pair employing permutation spreading is shown in Figure.

II. LITERATURE SURVEY

To fulfill the objectives of the thesis, understanding the fundamentals of CDMA is essential. Several standard books were referred to get clear idea about the CDMA technology and its importance in communication applications (Spread Spectrum and CDMA Principles and Applications by valery.P.Ipatov). Many technical papers and books were referred to understand the significance of spreading process, various types of spreading codes. Several papers were referred to understand the characteristics of MIMO (MIMO system technology for wireless communications edited by George tsoulos).

1.1 MIMO- CDMA SYSTEM EMPLOYING PERMUTATION SPREADING WITH UNKNOWN PATH GAINS

The block diagram of a MIMO-CDMA transmitter receiver pair employing permutation spreading is shown in Figure.

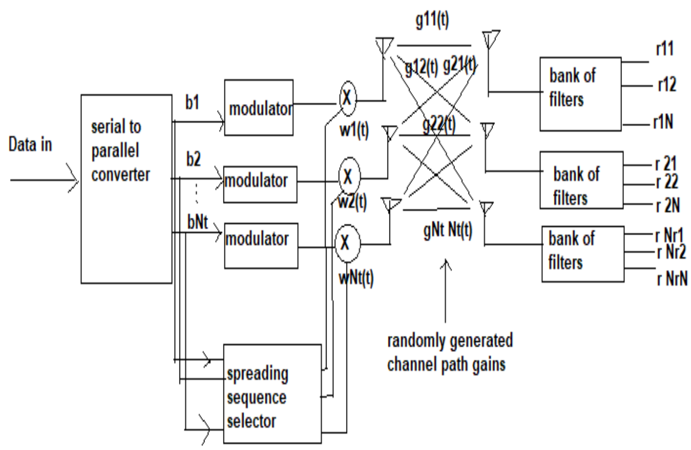

Figure. 1. Block diagram of MIMO-CDMA system employing permutation spreading with channel path gains

The input data is converted into Nt parallel streams. On one signalling interval, the bits to be transmitted are used to select Nt spreading sequences from a set of N mutually orthogonal spreading sequences, where $N>$. The message bits are then modulated using binary phase shift keying (BPSK) or Quadrature phase shift keying (QPSK) and each bit is spread using the spreading sequence selected in the previous step. The spreading sequences employed on a given signalling interval $\{w\ 1\ (t)$..., $wNt\ (t)\}$ are chosen from a set of N orthogonal spreading sequences $\{c\ 1\ (t)$,$c\ 2\ (t)$,,$cN\ (t)\}$.At the channel, Unknown and randomly generated path gains {g11(t),g12(t)…g1N(t),g21(t),g22(t…g2Nr1(t)……..gNrN(t) } are attacked on the modulated signals.At the receiver, the output of each antenna is connected to a bank of matched filters. There is one matched filter for each of the spreading codes in the user's set $\{c\ 1\ (t),\ 2\ (t),,\ (t)\}$. We can estimate the transmitted data sequence based on the received vector, which is given by:

$$r = [r\ 11, r\ 12, \ldots, r\ 1N, r\ 21, \ldots, rNr\ 1, \ldots, rNrN]\ T$$

1.2 Space- Time Block Code Based Permutation With Unknown Channel Path Gains

$$\begin{bmatrix} S1 & S2 & S3 & S4 \\ -S2 & S4 & S1 & -S3 \\ -S3 & S4 & S1 & -S2 \\ -S4 & S3 & S2 & S1 \end{bmatrix} \quad (2)$$

TABLE I

BPSK SIGNALING STBC PERMUTATION SPREADING

coset	Message vectors	$W_1(t)$	$W_2(t)$
M_1	00 11	$C_1(t)$	$C_3(t)$
M_2	01 10	$C_2(t)$	$C_4(t)$
M_3	10 01	$C_3(t)$	$C_1(t)$
M4	11 00	$C_4(t)$	$C_2(t)$

TABLE . 2. TRANSMIT ANTENNAS

the channel path gain matrix G is defined as

$$G = \begin{bmatrix} g11 & g12 \\ g21 & g22 \end{bmatrix}$$

This channel path gains are randomly generated pseudo random noise coefficients.

The STBC-based spreading code permutation is given in Table I. Columns 1 and 3 in (2) are respectively assigned to columns 1 and 2 of Table I.

The output from the kth matched filter of the jth receive antenna would be given as

$$r_{jk} = \{bi\sqrt{Eb/Nr}\ g_{ji} + n_{jk} \quad \text{if } w_i(t) = c_k(t), \quad , \quad \text{otherwise} \quad (3)$$

where g ji is the complex channel gain for the ith transmit-jth receive antenna link; Eb is the average received energy per bit; and nkj is the sampled noise from the kth matched filter of the jth receive antenna. The received vector, r = u b + n where u b is the received data vector that is dependent on the transmitted data vector,

$b = [b\ 1, b\ 2, \ldots, bNt]^T$ and $n = [n\ 11, \ldots, n\ 1N, n\ 21, \ldots, n\ 2N, \ldots, nNr\ 1, \ldots, nNrN]^T$

is a vector made up of noise samples. For example, if the transmitted message

m = [0,0], then b = [−1,−1] and u b =[−g 11 ,0,−g 12 ,0,−g 21 ,0,−g 22 ,..,−g Nr 1 ,0,0,0,−g Nr 2 ,−g Nr 4 ,0] ^{T}.

Maximum likelihood detection (MLD) is used to detect which message has been transmitted by finding the minimum squared Euclidean distance between the received vector and all the possible received vectors in the absence of noise. The expression is given asˆb = min b ||r − u b||

Figure.1.1 Block Diagram Transmission

Figure.1.2 Block Diagram of Reception

The receiver performs a time correlation operation to detect only the specific desired codeword. All other code words appear as noise due to decorrelation [12]. For detection of the message signal, the receiver needs to know the codeword used by the transmitter. Each user operates independently with no knowledge of the other users. CDMA is achieved by modulating the data signal by Space Time Block Code Improving the capacity of code-division-multiple access (CDMA) systems through advanced signal processing has been an area of intensive research for many years, with limited success. Multi antenna technologies called multiple-input multiple outputs (MIMO) are an obvious candidate to increase, particularly, downlink capacity

III. BIT ERROR PROBABILITY ANALYSIS

Let us consider the case when the transmitted message m = [0, 0], Here the channel can be non-selective and channel path gains are independent. We can determine bound on BER by finding squared Euclidian distance between signals corresponding to b= [-1 -1]. (4)
Distance between received vectors depends on random noise effecting and variable channel path gains. This can be approximated by multiplication and summation effect of corresponding path gains. That distance is called d

$$d=2Eb/Nr \sum\sum g_{jl}^2 \qquad (5)$$

probability that we transmit 00 but detect 11 is given by [4].
Therefore the union bound for the BER for a single user MIMO-CDMA system employing STBC-based permutation spreading is given by

$$P_b<P+(M-1)Pdiff$$

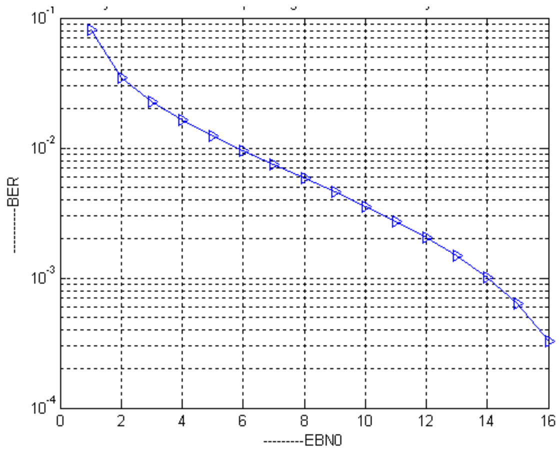

Fig.2 Performance analysis of MIMO-CDMA system employing permutation spreading based on STBC code while considering random channel path gains for 2x1 antenna system with BPSK modulation

IV. SIMULATION RESULTS

The simulation result for bit error rate (BER) performance is presented in this section. MIMO-CDMA system with 2 transmit antennas and 1 or 2 receive antennas are considered with independent channel path gains.

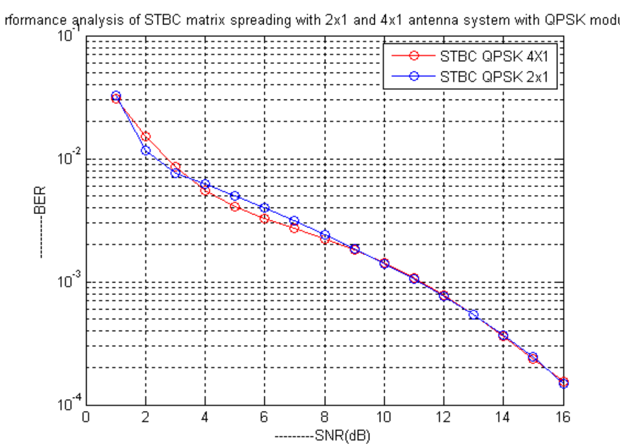

Figure.2.1 BER for STBC permutation for QPSK signaling for 4 transmit antennas, and 2 transmit antennas

Figure 2 shows the BER performances of MIMO-CDMA system employing STBC permutation considering channel path gains created randomly. The analysis results are given in Table II. From Figure 2, we see that spreading techniques provide significant gains and has a better BER performance achieved according to Table II.

Receive antennas	Permutation spreading Based on STBC designs without considering channel co efficient	Permutation spreading Based on STBC designs with channel gains
1	11 dB	11.6 dB
2	5.dB	4.3 dB

TABLE II : RESULTS FOR BPSK SIGNALING

II. CONCLUSION

The design of permutation spreading based on STBC (space time block code) matrix improves BER(bit error rate) performance in BPSK signaling while considering the random channel coefficients. This study leaves wide scope for future investigations. It can be extended to analysis of MIMO-CDMA for multi users instead of single user by perfect channel state information with asynchronous CDMA system.

REFERENCES

[1] Min Shi "Design of Spreading Permutations for MIMO-CDMA Based on Space-Time Block Codes" IEEE COMMUNICATIONS LETTERS, VOL. 14, NO. 1, JANUARY 2010

[2] C. D'Amours, "Parity bit selected spreading sequences: a block coding approach to spread spectrum," IEEE Commun. Lett., vol. 9, pp. 16-18, Jan. 2005.

[3] C. D'Amours and J.-Y. Chouinard, "Parity bit selected and permutation spreading for CDMA/MIMO systems," in Proc. IEEE Veh. Tech. Conf., pp. 1475-1479, Apr. 2007.

[4] V. Tarokh, H. Jafarkhani, and A. R. Calderbank, "Space-time block codes from orthogonal designs," IEEE Trans. Inf. Theory, vol. 45, pp. 1456- 1467, July 1999.

[5] Gordon L. Stuber, John R. Barry, Steve W. Mclaughlin, I. Mary Ann, AND Thomas G. Pratt, "Broadband MIMO-OFDM Wireless Communications", proceeding of the IEEE , Vol. 92, No. 2, February 2004.

[6] L. Zheng and D. Tse, "Diversity and multiplexing: A fundamental tradeoff in multiple antenna channels," IEEE Trans. Info. Theory, vol. 49, no. 5, pp. 1073-1096, May 2003.

[7] Jafarkhani H. "A quasi-orthogonal space-time block code" IEEE transaction on communications, vol-49, pp. 332-335, 2001.

[8] Wang Z., Giannakis GB, "Wirelees multi carrier communications: Where Fourier meets Shannon", IEEE signal processing magazine, vol-17, No-3, pp. 29-48, 2000.

[9] Ari H, olav T, Risto W., "Multi-antenna Transceiver techniques for 3G and beyond", Wiley: Newyork, NY, 2003

[10] Husnul Ajra, "Performance Evaluation of a QO-STBC Encoded OFDM Based MIMO CDMA Wireless Communication system With Various Channel Equalization Schemes", Rajshahi University, M.Sc Thesis - 2010.

[11] Theodore S. Rappaport, Wireless Communication principles and practice, 2nd Edition, Prentice Hall India.

[12] CDMA T&C Lesson 1, "http://wirelessresource.blogspot.com/2012/07/what-is-cdmaadvantage-disadvantage-and_4266.html".

[13] Qi Qu, Laurence B. Milstein, and Dhadesugoor R. Vaman, "Cognitive Radio Based Multi-User Resource Allocation in Mobile Ad Hoc Networks Using Multi-Carrier CDMA Modulation", IEEE journal on communications, vol. 26, No. 1, January, 2008.

[14] Wan Choi, Jeffrey G. Andrews, "Spatial multiplexing in cellular MIMO-CDMA systems with linear receivers: Outage probability and capacity," to appear (2004) Cached, Venue: IEEE Trans. Wireless Comm, Citations: 7 - 4 self.

[15] G. J. Foschini and M. J. Gans, "On limits of wireless communications in a fading environment when using multiple antennas," Wireless Personal Commun., vol. 6, pp. 311-335, March 1998.