A Blind Adaptive Projection Receiver for CDMA Systems

Shan Mo, Christian Schlegel and
V. John Mathews
Dept. of Electrical Engineering
University of Utah
E-mail: schlegel@ee.utah.edu

Abstract — **This paper presents a blind and adaptive CDMA receiver that does not require knowledge of the spreading codes associated with users other than the ones of interest. Receivers for synchronous as well as asynchronous transmission by multiple users with error control coding are developed. Simulation results demonstrating that the receivers suffer negligible performance loss over systems with complete knowledge of all the spreading codes are included in the paper.**

I. Introduction

The purpose of this paper is to develop a blind multiuser receiver based on the Projection Receiver (PR) principle [1] [2]. The projection receiver (PR) is a near-far resistant multiuser receiver that cancels the interference without explicitly detecting the transmitted data of the interfering users. As shown in Figure 1, the PR utilizes a metric generator to collect *soft* metric information for a forward error control (FEC) decoder. More details on the projection receiver is available in [1][2].

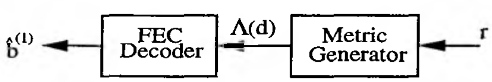

Figure 1: The projection receiver.

The projection receiver requires knowledge of the spreading codes of the interfering users (contained in a matrix $\mathbf{C}_u$) in order to determine the projection matrix M as

$$\mathbf{M} = \mathbf{I} - \mathbf{C}_u(\mathbf{C}_u^T\mathbf{C}_u)^{-1}\mathbf{C}_u^T \qquad (1)$$

In this paper, we will show that knowledge of the interfering spreading codes is not necessary since the subspace generated by the interfering signals can be estimated from the received signal.

II. Blind Subspace Tracking PR

Let $\mathbf{Q}$ be an orthonormal matrix with the same size of $\mathbf{C}_u$ such that $\mathbf{Q}^T\mathbf{Q} = \mathbf{I}$, and $\mathbf{C}_u = \mathbf{QV}$, where $\mathbf{V}$ is an upper triangular matrix. That is, $\mathbf{Q}$ performs an "economy size" QR decomposition of $\mathbf{C}_u$. Using the relationship $\mathbf{C}_u = \mathbf{QV}$ in (1), we can rewrite $\mathbf{M}$ as

$$\begin{aligned} \mathbf{M} &= \mathbf{I} - \mathbf{QV}(\mathbf{V}^T\mathbf{Q}^T\mathbf{QV})^{-1}\mathbf{V}^T\mathbf{Q}^T \\ &= \mathbf{I} - \mathbf{QQ}^T. \end{aligned} \qquad (2)$$

This result implies that $\mathbf{M}$ can be calculated without knowledge of the spreading codes of other users if an orthogonal basis set for the column vectors of $\mathbf{C}_u$ can be evaluated. One way of finding the orthogonal basis set of $\mathbf{C}_u$ is called subspace tracking. The algorithm for subspace tracking can be found in [3] [4].

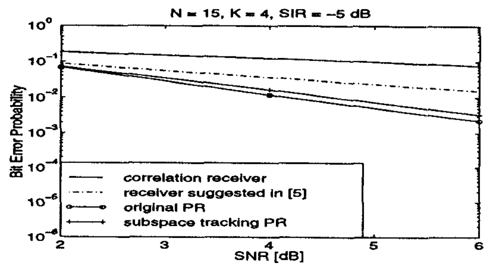

Figure 2: Bit error probability for different receivers.

III. Experimental Results

The probability of bit errors associated with a four-user synchronous CDMA system with spreading factor $N = 15$ were obtained using simulation experiments and the curves of the correlation receiver (which is merely a matched filter followed by the Viterbi decoder), the blind adaptive receiver suggested in [5] followed by the Viterbi decoder, the original PR proposed in [1] and the PR with subspace tracking are plotted with respect to the signal-to-noise-ratio. We can see from the results that the performance of the projection receiver that requires knowledge of the interfering users' spreading codes and the performance of the subspace tracking projection receiver that requires no knowledge of the spreading codes of the interfering users are no much different. Both the projection multiuser receivers perform significantly better than the correlation receiver and the blind receiver suggested in [5]. Further extensive simulation results for asynchronous CDMA can be seen in [6].

References

[1] C. Schlegel, S. Roy, P. Alexander, and Z. Xiang, "Multiuser projection receivers," *IEEE J. Selected Areas on Communications*, Vol. 14, No. 8, pp. 1610-1618, October 1996.

[2] C. Schlegel, P. Alexander, and S. Roy, "Coded Asynchronous CDMA and its Efficient Detection," *IEEE Trans. on Information Theory*, in press.

[3] B. Yang, "Projection approximation subspace tracking," *IEEE Trans. on Signal Processing*, Vol. 43, No. 1, pp. 95-107, January 1995.

[4] S. Roy, "Subspace blind adaptive detection for multiuser CDMA," unpublished manuscript.

[5] M. Honig, U. Madhow, and S. Verdu, "Blind adaptive multiuser detection," *IEEE Trans. on Information Theory*, Vol. 41, pp. 944-960, July 1995.

[6] Shan Mo, Christian Schlegel and V. John Mathews, "A Blind Adaptive Projection Receiver for CDMA Systems". unpublished manuscript, to be sent to *IEEE Transaction*.