A VERTICAL LAYERED SPACE-TIME CODE AND ITS CLOSED-FORM BLIND SYMBOL DETECTION

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Abstract  Vertical layered space-time codes have demonstrated the enormous potential to accommodate rapid flow data. Thus far, vertical layered space-time codes assumed that perfect estimates of current channel fading conditions are available at the receiver. However, increasing the number of transmit antennas increases the required training interval and reduces the available time in which data may be transmitted before the fading coefficients change. In this paper, a vertical layered space-time code is proposed. By applying the subspace method to the layered space-time code, the symbols can be detected without training symbols and channel estimates at the transmitter or the receiver. Monte Carlo simulations show that performance can approach that of the detection method with the knowledge of the channel.

Key words  Layered space-time code; Array signal processing; Subspace method; Blind symbol detection

I. Introduction

Due to the limited band, transmitted power and multipath fading, the wireless channels are the narrow data pipes that do not accommodate rapid flow data. Deploying space-time code can broaden this data pipe and increase the capacity of wireless communication. G. J. Forschini have shown that the capacity grows at least linearly with the reduction of the number of transmit and receive antennas\(^1\)\(^-\)\(^2\).

Space-time codes include layered space-time codes proposed by G. J. Forschini in Lucent's Bell Lab., space-time trellis codes and space-time block codes proposed by AT&T academe. The vertical layered space-time code is of limited detection complexity regarding the spatial processing required and can demonstrate robust high capacity. This paper discusses the coding and symbol detection of vertical layered space-time code.

Thus far, vertical layered space-time codes assumed that perfect estimates of current channel fading conditions are available at the receiver. However, learning the fading coefficients becomes increasingly difficult as either the fading rate or number of transmit antennas increase. Increasing the number of antennas increases the required training interval and reduces the available time in which data may be transmitted before the fading coefficients change. For example, if five training symbols were used per antenna pair, a system with four transmitter and one receiver antenna would require 20 training symbols—a significant overhead. But in some case the coherence time of the third-generation European cellular standards would be less than 20 symbols, in which case it is not clear whether accurate channel estimation is possible\(^3\).

Motivated by these considerations, we propose a vertical layered space-time code and

\(^1\)Manuscript received date: April 11, 2002; revised date: December 9, 2002.
Partially supported by the National Natural Sciences Foundation (No.69872029) and the Research Fund for Doctoral Program of Higher Education (No.1999069808) of China
by applying one subspace method, the symbols can be detected without the training symbols and the channel estimates at the transmitter and receiver. The subspace method, an array signal processing method, has been applied to mobile communication systems for only a little more than 10 years\cite{4-5}. It exploits the eigen-structure of the correlation matrix of the received signal to extract the channel or symbol information directly.

It needs the thorough knowledge of subspace method and space-time codes to combine these two into integrity. Ref.[6] combines subtly the special structure of space-time block code in OFDM system with the subspace method to accomplish the (semi-) blind channel estimation with the help of precoder. However, the layered space-time codes do not have the special structure of space-time block codes, so Ref.[6] can not be applied to layered space-time codes. In this paper, with the flexibility of vertical layered space-time codes and the character of DOA-MATRIX\cite{7} that provides both the eigen-values and eigen-vectors, we realize the symbol detection without channel state information and training symbols. From Monte Carlo simulations, we show that the performance can approach that of the detection method with the knowledge of the channel.

In this paper, we use the following convention: \{·\}∗ for conjugate, \{·\}T for transpose, \{·\}H for conjugate transpose.

II. System Model and Vertical Layered Space-Time Code

Vertical layered space-time code has been proposed for wireless local loop applications (Lucent's BLAST project\cite{8}) and wireless LAN's\cite{9}, the consideration of which is to demultiplex the rapid flow data into slow flow data. Assume the system has N transmit antennas and M receive antennas. The block diagram of a vertical layered space-time system is shown in Fig.1. A signal symbol stream is demultiplexed into N substreams, and each substream is then encoded and modulated into symbols by the layered mod/code and fed into its respective transmitter.

![Fig.1 Vertical layered space-time code block diagram](image)

Different vertical layered space-time code has different layered mod/code. In this paper, we propose a vertical layered space-time code. And based on it, by applying the subspace method, the symbols can be detected without the channel estimates and training symbols. The layered mod/code is shown in Fig.2. After the input data s1, s2, …, sN are demultiplexed and fed into the N layered mod/codes, the input of layered mod/code i is si. In the successive two symbol periods, the outputs of layered mod/code i are si and bisi, respectively, and then in the following symbol periods, it encodes and modulates for the next output block of the series-parallel transformation. Generally, after the j-th series-parallel transformation, the j-th output block of layered mod/code i is (si+(j-1)N, bisi+(j-1)N),