LDPC based SFBC-OFDM: Performance Analysis

Hyun hee Kim and Woon Kyung M. Kim
Department of Radio Science and Engineering
College of Information and Communications, Korea University
e-mail: hyunkim@korea.ac.kr, mwkim@korea.ac.kr

Abstract

LDPC codes are re-emerged error correcting codes of which performance is very close to the Shannon limit with practical decoding complexity. A previous reported thesis has shown that LDPC coding significantly improves performance of the Space Time Block coded OFDM systems [7]. However, there are no theses about system improvement of the Space Frequency coded OFDM systems using LDPC coding. In this paper, we will show that we can make further improvement of the conventional Space-Frequency Block coded OFDM system performance with LDPC coding.

1. Introduction

Nowadays, Orthogonal Frequency Division Multiplexing (OFDM) method is well-known modulation scheme for high data rate digital communications, especially for channels with large delay spreads.

The combination of transmit diversity technique and OFDM results in an enhanced system performance in mobile wireless channel to combat fading [9]. A Space Frequency Block Coded (SFBC) OFDM among other schemes is an effective transmit diversity technique for application where the normalized Doppler frequency is large [5]. For the sake of further improving the performance, Forward-Error-Correction (FEC) schemes such as Turbo code can provide diversity improvement.

In recent years, the family of Low Density Parity Check (LDPC) codes has re-emerged as an attractive alternative to Turbo coding. LDPC codes were originally proposed by Gallager [1] In 1962. Only after the advent of turbo codes were they rediscovered by MacKay and Neal [2] and others. Owing to the codes' capability of approaching Shannon s performance limits, it has been improved system performance to apply LDPC codes. LDPC codes have been applied to space time coding schemes, such as MIMO-OFDM systems and space time block coded OFDM systems based on Alamouti's scheme [4]. However the fundamental performance of the concatenation scheme of LDPC codes and SFBC has not been clarified.

In this paper, we propose a concatenation scheme of LDPC codes and Space Frequency Block codes for OFDM systems.

2. Low Density Parity Check (LDPC) Codes

A. Overview of LDPC Codes

LDPC codes are error-correcting codes with sparse parity-check matrices, which are amenable to decoding using the message passing algorithm. A binary LDPC code is a binary linear error-correcting code defined by a sparse matrix H with the number of 1 s per column and the number of 1 s per row, both of which are very small compared to the block length. If the matrix H has N columns and M rows, the codewords consist of sequences v of N bits that satisfy a set of M binary parity checks defined by the parity check equation $Hv = 0$. The number of message bits is $K = N - M$, and the rate of the code is K / N, assuming that the matrix is of full rank.

B. Graph representation

Linear codes can be represented by graphs in various ways. An useful graphical representation of linear block codes in the representation of a linear block code by a Tanner graph [10], which displays the incidence relationship between the code bits of the code and the parity-check sums that check on them. As shown in Figure 1, there is an edge in the graph in the graph connection the bit and check nodes exactly when there is a 1? in the parity check matrix, so that an association can be made between edge-variables and the non-zero entries of the parity check matrix. The edge-variables in the same row of the parity-check matrix H are connected to the same check node, and so satisfy a parity-check constraint.

$$\overset{N}{\longleftrightarrow}\quad \begin{bmatrix} 1 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 1 \end{bmatrix} \updownarrow N-K=M$$

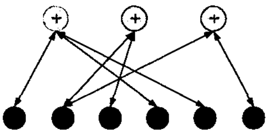

Fig.1 Parity check matrix and associated Tanner graph

C. Message Passing Algorithm

Using Tanner graph, we can represent decoding process of LDPC codes with the parity check matrix H of size $M \times N$ as shown in figure 2. B_i for $i = 1,2,...,N$, C_j for $j = 1,2,...,M$ and N_i $i = 1,2,...,N$ represent the bit nodes, the check nodes and external nodes connected B_i respectively. If an edge exists between the nodes B_i and C_j, then that edge is labeled by the variable e_{ji}. These are the internal edges of the graph for the LDPC code. In addition, an edge between the nodes B_i and N_i is labeled by variable v_i. These edges correspond to the external edges of the graph for the LDPC code. With this node N_i, then the intrinsic probability w.r.t. the LDPC decoder can be denoted as