Performance Verification of Successive Interference Cancellation for STBC MIMO-OFDM System with Channel Correlation

Jing-Jyun You · Shyue-Win Wei

Published online: 26 October 2008
© Springer Science+Business Media, LLC. 2008

Abstract Multiple-input multiple-output orthogonal frequency division multiplexing (MIMO-OFDM) transmission can improve both the transmission capacity and performance due to diversity gain. However, when the antennas are close to each other in a MIMO-OFDM system, the diversity order will be decreased because of channel correlation. In the paper performance of various detection methods for space–time block code (STBC) MIMO-OFDM with channel correlation are evaluated, including the conventional Alamouti full matrix detection, the modified diagonal matrix detection, the least square-zero forcing (LS-ZF) detection, and the successive interference cancellation (SIC). The paper also verify that the SIC detection can still keep excellent detection performance under large channel correlation.

Keywords MIMO · OFDM · Channel correlation · Signal detection · Successive interference cancellation · STBC

1 Introduction

Systematic research to develop reliable communication systems in a linear channel dates back to about six decades ago with the pioneering work accomplished by Shannon [1]. Then, Brandenburg and Wyner derived the expressions for the information capacity of a multiple-input multiple-output (MIMO) channel with memory in 1974 [2]. The MIMO system is a system with multiple antennas at its transmitting and receiving units. Although traditional smart antennas can improve the performance of single data flow, the MIMO system can provide more independent propagation channels. Simulations conducted in the late 80s indicate that under certain conditions the channel capacity would increase linearly with the number of antennas [3]. However, when the antennas are close to each other, the diversity order of MIMO will be decreased due to channel correlation. Orthogonal frequency division multiplexing (OFDM) is well known as a high spectral efficiency modulation in wireless
communications [4]. The basic idea of OFDM modulation is to partition a wideband signal bandwidth into a set of orthogonal subcarriers, and to induce a symbol period that is much longer than the bit duration. The long period of OFDM symbol provides good protection against multi-path interference of channel. However, channel response might change within a long symbol period for a fast fading channel. For OFDM, orthogonality among subcarriers would no longer maintain and inter-subcarrier interference (ICI) is induced [5].

Recently, the combination of MIMO and OFDM transmission has initiated a great deal of research activities. The MIMO-OFDM is a broadband transmission combining the MIMO system and the OFDM modulation technique. In a non-line-of-sight multipath transmission environment, MIMO-OFDM can provide excellent service capacity, reliable transmission, very high data rate, and nearly perfect frequency spectrum efficiency. Several architectures have been proposed for MIMO system to improve transmission performance and or increase the throughput, such as the vertical Bell laboratories layered space time (V-BLAST), space–time block code (STBC), space–frequency block code (SFBC), etc. The detailed performance analyses of the Alamouti-like MIMO or the V-BLAST MIMO schemes for Wideband-Code Division Multiple Access (W-CDMA) systems can be found in [6]. In the paper STBC combined with two-input two-output antennas are majorly considered which is also optionally considered in the WiMAX transmission [7].

Conventionally, ICI cancellation in an OFDM system can be performed by inverting the frequency domain channel matrix $H$ at the receiver, and is denoted as the zero-forcing (ZF) method [8]. Besides to the ZF, the V-BLAST detection presented for MIMO system can also be used for OFDM signal detection and is also referred to as the successive interference cancellation (SIC) since it is an iterative detection method [9–12]. Several SIC algorithms were presented for OFDM signal detection [9–12]. In the paper performance of various detection methods for MIMO-OFDM are evaluated, including the conventional Alamouti full matrix detection, the modified Alamouti diagonal matrix detection, the least square-zero forcing (LS-ZF) detection, and the SIC.

The rest of this paper is organized as follows. Section 2 briefly describes the OFDM principle and the MIMO-OFDM signal model over time-varying channel. In Sect. 3, several conventional detection methods for STBC MIMO-OFDM are summarized. Performance degradation due to channel correlation is also verified. The algorithms of ZF-SIC and MMSE-SIC are presented in Sect. 4. The performance gain of SIC compared to other detection methods is given. Section 5 gives our conclusions.

## 2 MIMO-OFDM Signal Model

The basic OFDM modulation concept is to partition a wideband signal into a set of orthogonal sub-carriers [4]. To maintain orthogonality among the subcarriers, it is necessary to add in a cyclic prefix (CP), also called guard period, to every symbol. The length of CP should cover the channel response duration. For hardware implementation, an inverse fast Fourier transform (IFFT) can be used as the modulator while a fast Fourier transform (FFT) is used as the demodulator in an OFDM system [4]. The size of the FFT/IFFT equals the number of subcarriers for wireless transmission. A transmitted time-domain OFDM symbol without CP that observed at the IFFT’s output can be expressed as:

$$x = [x(0)x(1)\ldots x(N - 1)]^T$$

in which $N$ is the number of subcarriers. The transmitted OFDM symbol will be passed through a multi-path time-varying fading channel. For a wideband transmission, the multi-path fading channel can be modeled as tapped delay line: