Book Recommendation: Advanced MIMO Systems

Kosai Raoof and Huaibei Zhou

1. Background

During recent years, MIMO communication systems become an important research and development subject. Many papers are already published in the fields of channel capacity, synchronization, space time coding, etc.
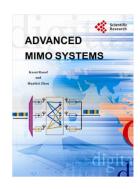
The idea of this book was born during the Wicom Conference in 2007, where many sessions have dedicated to MIMO systems, dealing with physical channel layer as well as protocol aware MIMO networks. Speaking with Professor Huaibei Zhou the steering committee chair of this outstanding international conference and Dr. Ruoshan Kong the conference organizer, we decided to edit and publish a book by exploiting the opportunity of having direct contacts with the authors during the conference. The proposition was to introduce recent advances in MIMO systems such as polarized MIMO systems and smart antenna selection systems, to the researchers and graduate students in academic and industry communities.

2. Introduction of Chapters

This book covers the main fields of MIMO systems with 10 chapters, each chapter covers either base-band signal processing aspect or application. I will introduce each chapter with few lines in order to give a global idea to the reader.

Chapter 1 reviews most known multiple antenna MIMO techniques for single-user point-to point systems and multiuser systems, from how multiple antennas help provide diversity and multiplexing to the detection techniques. The space time – code is also detailed for different structures. Finally many performance curves are also provided to give the reader an idea about the benefits of MIMO systems.

Chapter 2 deals with the modeling, analysis, and simulation of multiple-input multiple-output (MIMO) narrowband fading channels for mobile-to-mobile com-munications. Using the wave propagation model, the complex channel gains are derived and their statistical properties are studied. General analytical solutions are provided for the three-dimensional (3-D) space-time cross-correlation function (CCF). The proposed procedure provides an important framework for designers of future mobile-to-mobile communication systems to verify new transmission concepts employing MIMO techniques under realistic propagation conditions.

The purpose of chapter 3, is to introduce the capacity of multiple antenna systems in Rayleigh fading channels. The information theory is applied to characterize the capacity of multi-antenna systems. Different structures of multi-antenna systems are studied such as systems employing multiple antennas at reception, systems employing multiple antennas at transmission and systems employing multiple antennas at both transmitter and receiver sides. Two classic MIMO systems will be examined: spatial multiplexing systems and space-time coding systems. The capacity of these MIMO systems is investigated in the case that the MIMO channel is perfectly known at receivers but known or unknown at transmitters.

Chapter 4 has focused on the synchronization framework and algorithms for MIMO systems, especially for frequency synchronization. Due to the application of distributed MIMO or separated oscillators at transmit/receive antennas in MIMO systems, multi-dimensional frequency offset combined with unknown channel should be considered with some signal processing approaches. Maximum likelihood estimation as well as expectation maximization algorithm provide the current algorithm development in this area. The receive signal models, schemes and algorithms along with performances for synchronization in MIMO-CDMA, MIMO-UWB, MIMO-OFDM systems are also introduced.

Chapter 5 presents antenna selection technique in MIMO systems. Although the performance of a wireless communication system can be substantially improved by

implementing multiple antennas, such a system incurs high hardware complexity. Since antennas are generally cheaper than electronic devices, antenna selection is a promising approach to reduce hardware complexity while maintaining benefits of MIMO systems. In this chapter, the application of antenna selection in MIMO systems over fading channels is studied. The performance analysis of such MIMO system is provided with simulation results.

Chapter 6 describes the MIMO-OFDM channel estimation in multi-user systems. A generic MIMO-OFDM channel estimator is developed for which the number of channel estimation parameters is less dependent on the maximum delay spread of the multi-path channel. It is shown that the vectorization of the fading channel model presents a preferable solution, where the CSI in the MIMO-OFDM system can be represented in a reduced parameter sense using an arbitrary basis.

In chapter 7, a successive interference cancellation (SIC) based signal detector is introduced. The SIC detector is very effective in signal recovery with a complexity close to the MMSE for varying channels. In addition, this approach can be applied to space-frequency block codes, time-reversal space-time block codes, and V-BLAST.

Chapter 8 presents a new concept for exploiting polarization diversity in MIMO systems. This subject is recently introduced where theoretical results are so promising to boost channel capacity. In this chapter, we briefly present spatial multiplexing MIMO communication systems. Two MIMO channels modeling are presented for multi-elements dual-polarized MIMO systems. These models are based on Kronecker and geometry-based stochastic channel models. After modeling the MIMO channel propagation, we then proceed to the study of the channel capacity in both cases where the MIMO channel is perfectly known and unknown at transmitter.

Finally, we proposed a method to determine approximately which system (uni-polarized or dual-polarized systems) corresponds better to a propagation environment. The Cooperative Systems for Sensor Networks is introduced in chapter 9; this is one of the direct applications of MIMO systems in the near future.

Cooperative MIMO (C-MIMO) scheme can deploy the energy-efficiency of MIMO technique which plays an important role in long range transmission where transmit energy is dominant in the total consumption. In various applications, such as area surveillance for military operations, monitoring of agriculture related farm duties or intelligent transportation systems, middle and long range transmissions are indeed often required because of the large covered area of the wireless sensor networks. An illustrative example of this cooperative principle to MIMO systems with 3 to 8 antennas is presented, in which, an energy-efficient antenna subset selection is performed followed by an iterative rate selection algorithm that selects the transmission rate for uniform cluster energy consumption.

In the same context, chapter 10 discusses the impact of using MIMO physical channel on the MAC and network layers. MIMO Aware Mobile Ad hoc NETwork (MANET) presents a radical way to improve the performance of wireless communications. Such systems can be utilized in wireless ad hoc networks for improved network throughput. The MIMO-aware MAC layer has also capabilities to track the directional position of neighboring mobile network elements of MANET and coordinating the neighbors for concurrent transmission and reception to reduce interference.

<div align="right">

Kosai Raoof
Grenoble, France

</div>