Chapter 7
The Impact of MIMO Communication on Non-Frequency Selective Channels Performance

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ABSTRACT

This chapter reviews the basic concepts of multiple-input multiple-output (MIMO) communication systems and analyses their performance within non-frequency selective channels. The MIMO system model is established and by applying the singular value decomposition (SVD) to the channel matrix, the whole MIMO system can be transformed into multiple single-input single-output (SISO) channels having unequal gains. In order to analyze the system performance, the quality criteria needed to calculate the error probability of M-ary QAM (Quadrature Amplitude Modulation) are briefly reviewed and used as reference to measure the improvements when applying different signal processing techniques. Bit and power allocation is a well-known technique that allows improvement in the bit-error rate (BER) by managing appropriately the different properties of the multiple SISO channels. It can be used to balance the BER's in the multiple SISO channels when minimizing the overall BER. In order to compare the various results, the efficiency of fixed transmission modes is studied in this work regardless of the channel quality. It is demonstrated that only an appropriate number of MIMO layers should be activated when minimizing the overall BER under the constraints of a given fixed date rate.

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INTRODUCTION

The need for high data rate communication systems has remarkable increased in the last years due to the rising demand of wideband services like video and TV especially in mobile applications. Nevertheless, several barriers must be broken to fulfill the requirements of future communication systems. A lot of efforts and research activity has been developed in order to give answers to the challenge of increasing the spectral efficiency and improving the bit-error rate (BER) with the constraint of finding a moderate complexity implementation. Various technologies, techniques and algorithms have been developed in the last decades and researchers are working at the definition of new standards and future communication systems.

Adaptive modulation (AM) is a promising technique to increase the spectral efficiency of wireless transmission systems by adapting the signal parameters, such as modulation constellation or transmit power, dynamically to changing channel conditions (Zhou et al., 2005). However, in order to comply with the demand on increasing available data rates in particular in wireless technologies, systems with multiple transmit and receive antennas, also called MIMO systems (multiple-input multiple-output), have become indispensable and can be considered as an essential part of increasing both the achievable capacity and integrity of future generations of wireless systems (Kühn, 2006; Zheng and Tse, 2003).

The well-known water-filling technique is virtually synonymous with adaptive modulation and it is used for maximizing the overall data rate. However, delay-critical applications, such as voice or streaming video transmissions, may require a certain fixed data rate. For these fixed-rate applications it is desirable to design algorithms, which minimize the overall BER at a given fixed data rate.

Against this background, the novel contribution of this chapter is that we demonstrate the benefits of amalgamating a suitable choice of activated MIMO layers and number of bits per symbol along with the appropriate allocation of the transmit power under the constraint of a given data throughput.

BACKGROUND

There is no doubt about the key role that communication systems have in the information society. The various available technologies allow users to share, store and transmit information to others.

The rising demands of new services especially broadband ones like video require the appropriate technologies to transmit and receive information with the expected quality. The demand for higher network capacity and for higher performance of wireless networks is enormous.

There are two major challenges in the design of future wireless communication systems (i.e. in LTE, Long Term Evolution): increasing the spectral efficiency (channel capacity) and improving the link reliability (BER). MIMO Systems are able to improve the spectral efficiency significantly, and consequently MIMO plays a key role in many future wireless communication systems.

MIMO technology has attracted a lot of attention in wireless communications, since it offers significant increases in data throughput and link range without additional bandwidth or transmit power. It achieves this by higher spectral efficiency (more bits per second per hertz of bandwidth) and link reliability or diversity (reduced fading). Because of these properties, MIMO is a hot topic in international wireless research.

Multiple antennas techniques can be used for different objectives and the most common are beamforming and transmit/receive diversity. Diversity techniques provide some protection against channel fading and increase the system range. MIMO techniques are a different way in which multiple antennas are used in a communication system.