Chapter 8
A Massive MIMO Channel Estimation Using Circulant Jacket Matrices

Moon Ho Lee
Chonbuk National University, Korea

Md. Abdul Latif Sarker
Chonbuk National University, Korea

Kyeong Jin Kim
Mitsubishi Electronic Research Lab, USA

ABSTRACT

In this chapter, the authors investigate several fundamental issues that arise in wireless Multiple-Input and Multiple-Output (MIMO) communication over fading channels. Wireless channels are usually recognized as multipath fading channels. There are two basic aspects in wireless communication that practice the problem. Firstly, the matter of fading and secondly the disparity in the wired world. The special kinds of circulant matrices are called circulant Jacket matrices. In this chapter, the authors investigate circulant Jacket matrices in a massive MIMO channel that uses the eigenvector and the eigenvalues of this channel. In summary, they assume a perfect multipath channel with random sequences. For this system, a significant improvement in channel estimation can be seen compared to Maximum Ratio Combining (MRC), Least Squares (LS), and Minimum Mean Square Error (MMSE)-based linear channel estimations.

1. INTRODUCTION

The use of multiple antennas in the system is the principal feature of all advanced cellular wireless broadband standards in MIMO technology such as LTE in (Dahlman et al, 2008) and massive MIMO in (Toskala et al, 2012, Marzetta et al, 2010, Rusek et al, 2013 and Hoydis et al, 2013). For example, in LTE standards, up to eight antennas can be employed in the BS, whereas an unlimited numbers of BS antennas are allowed in massive MIMO. Recently, the massive MIMO becomes a new research field. A variable point-to-point MIMO system is a multi-user (MU) MIMO system in (Marzetta et al, 2006 and Vishwanath et al, 2003) in which an antenna array simultaneously distributes a multiplicity of independent terminals. A MU-MIMO system is more
passive in the propagation environment than a point-to-point system such that under line of sight propagation states multiplexing gain vanishes for a point-to-point system, while it is retained in the MU-system. By means of a time division duplex (TDD) a channel reciprocity can be used to obtain the downlink channel from the uplink channel in (Vishwanath et al, 2003). To obtain an exact knowledge of channel state information (CSI) at the transmitter, feedback is required from the receiver in fast fading. Thus, a prohibitively large bandwidth is required for this feedback. In such a strategy, the transmitter relies on channel statistics instead of on an actual channel realization. The receiver then estimates the channel statistics and feeds them back to the transmitter or in a TDD setting the estimation may be performed at the transmitter based on uplink data. The CSI plays a key feature in the MU-MIMO system. In the forward link data transmission, the BS is required to know the forward CSI, while in the reverse link data transmission, it is required that the BS knows the reversed CSI. Multi-user MIMO operation with a large number of antennas in the BS compared with terminals was advocated in (Caire et al, 2003) which considers a single-cell TDD. The pilot symbols, through reciprocity, provide the BS with an estimate of the forward CSI, which in turn generates a linear precoder for data transmission. The time required in transmission of pilot symbols is proportional to the number of terminals served and is independent of the number of antennas in the BS as shown in (Gesbert et al, 2007). Thus, the number of terminals that can be served by the BS is limited by the channel coherence time, which itself depends on the mobility of the terminals. Even with a very noisy channel estimate, use of a more BS antennas has been always beneficial, and in the limit of an infinite number of antennas, the effects of fast fading and uncorrelated noise vanish. Thus, we can always recover the multiplicative matrix ambiguity from low SNR conditions by adding a sufficient number of antennas. A wireless network is considered in (Marzetta et al, 2006) employing a large number of pilot symbols. The propagation medium is modeled as two-dimensional object whose wavelength spaced regular rectangular array can access a number of degrees-of-freedom and its performance becomes better proportional to the square-root of the number of antennas. If the number of BS antenna arrays grows large, the channel between the users and the BS becomes very long random vectors, which becomes pair wisely orthogonal according to fair propagation. As a result, assuming that the BS has perfect CSI, a simple MRC can remove interference from the other users without using more frequency resources. If the number of BS antennas grows large, then the channel can be estimated from the eigenvector of the covariance matrix (Werner et al, 2009) obtained from a set of received samples. In obtaining the covariance matrix, uplink pilot symbols are used in the conventional approach. However, since the channel coherence time is limited, the numbers of possible orthogonal pilot symbols being used are limited. Thus, pilot symbols have to be reused in other cells, which results in the estimates obtained in a given cell will be contaminated by pilots transmitted by the users in other cells. This is called the pilot contamination in (Jose et al, 2009 and Marzetta et al, 1999). In the proposed system, we assume that the BS comprising $M$ antennas serves $K$ terminals equipped with a single antenna. The terminals are located uniformly and randomly in the cell area of the BS. The propagation is assumed to be a combination of fast fading (which changes over a scale of the wavelength) and slow fading (log-normal and geometric decay). If the BS does not have perfect CSI, it estimates the channels according to the approaches proposed in (Franceschetti et al, 2009, Yin et al, 2013 and Hien et al, 2012).

In this chapter, we briefly overview the massive MIMO system in section 2. The channel estimation for massive MIMO system is described in section 3. The conclusions and future research directions are investigated in Section 4.