Massive MIMO: Concepts, Practical Issues and Future Prospects

Alister G Burr, Manijeh Bashar, and Qinhui Huang
Dept of Electronics, University of York, York YO10 5DD, UK

1. Introduction

Massive MIMO was introduced in [1], and has since become one of the most favoured technologies under consideration for fifth generation (5G) mobile wireless systems. The fundamental concept is essentially multi-user multiple-input, multiple output (MU-MIMO) wireless transmission on a massive scale, in which the number of antenna elements at a base station greatly exceeds the number of user terminal antennas, and both numbers tend to infinity. [1] showed under these conditions that according to a "channel hardening" effect it is possible to separate users increasingly well as the number of antennas increases, using a very simple algorithm based on conjugate beamforming, and hence in principle serve an effectively unlimited user density by increasing the number of antennas with little signal processing overhead.

This paper falls into two parts. The first introduces the fundamental concepts of massive MIMO, and discusses some of the practical issues involved in its implementation. The second then looks forward to future prospects for the technology.

2. Part I: Concepts and Practical Issues

In this section we first introduce the fundamental concept of massive MIMO from [1], giving the results that show how user separation is achieved and the concept of "channel hardening". Since correct operation requires channel state information at the base station the question of how that is obtained is also discussed.

However the concept as presented in [1] makes assumptions about the nature of the system and the channel. In particular, the assumption that the number of antennas tends to infinity is of course not realized in practice, which means that we cannot rely on channel hardening to completely separate users in practice. Thus other algorithms such as zero-forcing must be applied in practice. In addition the channel hardening concept as presented in [1] assumes an independent Rayleigh fading channel, while in practice the channel fading is not independent. We address the detection and propagation issues making use of the COST 2100 propagation model [2] to give realistic results in a clustered multipath channel.

3. Part II: Future Prospects

The second part of the paper then considers the future prospects for massive MIMO, especially in the 5G context. These are two-fold. One arises from the considerable interest in millimetre-wave systems for 5G, in order to provide the bandwidth necessary to achieve the peak data rates required. We argue that millimetre-wave systems in fact require massive MIMO for their implementation, and discuss the developments required to achieve this, with particular reference once again to channel modelling issues.

The second is the concept of distributed massive MIMO. A similar concept has also been termed "cell-free massive MIMO" [3], so-called because it avoids cell-edge effects which otherwise limit coverage of cellular systems, including those based on massive MIMO. [3] does not however address the problem of fronthaul connections between the distributed antennas: we describe our recent work which overcomes this problem.

4. References

1. T. L. Marzetta, “Noncooperative cellular wireless with unlimited numbers of base station antennas,” IEEE Trans. Commun., vol. 9, no. 11, pp. 3590-3600, Nov. 2010

2. R. Verdone and A. Zanella, Eds., Pervasive Mobile and Ambient Wireless Communications: COST Action 2100, Springer, 2012

3. H. Q. Ngo, A. Ashikhmin, H. Yang, E. G. Larsson and T. L. Marzetta, "Cell-Free Massive MIMO: Uniformly great service for everyone," *2015 IEEE 16th International Workshop on Signal Processing Advances in Wireless Communications (SPAWC)*, Stockholm, 2015, pp. 201-205.