

# Chapter 4

## Recent Trends for Interference Mitigation in Multi-Antenna Wireless Systems

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### ABSTRACT

*In this chapter we discuss the general techniques of multi-antenna systems. Then, we delve to describe four recent trends in interference mitigation technologies that will change the design of the future 4G and beyond (5G) of mobile and wireless communication systems. Particularly, we consider the coordinated multi-point MIMO systems, smart terminal devices techniques, millimeter-wave communications and massive MIMO systems. We discuss the fundamental concepts of those new approaches, along with their advantages, and the challenges facing such technologies. Even though the references list of this chapter is not anticipated to be exhaustive, the cited articles and also the references therein should be good sources of further reading to start with.*

### INTRODUCTION

In the whole world wide the strategy of the leading mobile communication companies is to improve their operations and enhance their quality of service, all together with their aiming towards better customer confidence. Thus, they are actively seeking for new ways and technologies to spread those services everywhere and to make them available to everyone at any time. This accelerates the

expansion of wireless communication and speed up the move towards the next-generation of information and communication technology (ICT). Motivated by that, researchers continuously try to create new promising developments in the field of communication systems to realize peak bit rate of multi-gigabit per second. Achieving such rate is predicted to be facilitated by the deployment of distributed broadband wireless communication (BWC) systems, where interference arises

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everywhere. Therefore, the new communication systems required to work reliably in the interference environment which will dominate most of future wireless communication systems.

Inspired by this vision, we aim in this chapter to discuss the new trends of interference mitigation strategies which can be adopted in multi-antenna systems. Particularly, we focus on four new communication technologies that can potentially lead to the achievement of higher spectral efficiency with more flexible mobility wireless communication for the Next-Generation Networks (NGN). Technically speaking, this chapter should be significant in the sense that it introduces and expands the insight of the crucial role of these technologies as promising key strategies for the broadband wireless communication networks to resolve the challenges facing the next-generation networks beyond 4G (B4G) towards 5G. In addition, this chapter will discuss also the challenges associated with the practical implementation and deployment of these technologies in the current or future communication networks.

## **Multiple Antenna Techniques**

The all-time question faces the researchers in the field of wireless communication is *how to design high speed systems with reliable connection?* In other words, how can we establish a wireless system that grants not only a high speed bit rate but with an acceptable low bit error rate performance? Conventionally, single antenna systems try to utilize the time and frequency domains to optimize the system performance to overcome the wireless channel multipath effects. However, the rapidly increase of the wireless services and the pressing demand for higher bit rates and better error performance, have motivated the researcher to look for other new ways to utilize the available resources in communication system. Interestingly the solution came by exploiting the multipath environment which was a part of the problem. This can be achieved by utilizing the antenna system to

open a new era of wireless systems to be extended into another processing space, represented as the spatial domain by using the multiple antennas.

This great opportunity of utilizing the multi-antenna system started in the end of the 1990's, where it was shown to be an opening for new technologies that can substantially improve the quality of services of the wireless systems (Mietzner et al., 2009).

The general aspects of the benefits of utilizing the multiple antennas in wireless communication system shown in figure 1, as presented by (Mietzner et al., 2009), can be categorized into the following main points:

### **Higher Data Rates Using Spatial Multiplexing**

Spatial multiplexing means transmitting independent sequence (layer) of information simultaneously through the individual elements of the multiple antenna system. Spatial multiplexing using  $N$ -element transmit antenna can roughly increase the data rate by factor of  $N$  comparing with the single antenna system, and interestingly without any increase of the allocated power. The first spatial multiplexing schemes were published in (Paulraj, 1994; Weitzen, Member, Kilpatrick, & Mui, 1992). Then, the well-known spatial multiplexing scheme of Bell-Labs Layered Space-Time Architecture (BLAST) was introduced in (Foschini, 1996). The main steps of all the spatial multiplexing techniques are: splitting the data bits into  $N$  layers at the transmitter (demultiplexing). Then, those bits are modulated into symbols and transmitted simultaneously over the  $N$  antenna elements. At the receiver side, interference cancellation algorithms are employed to separate the different data sequences from the received signal. There are various types of detection algorithms. The designers of those algorithms try to keep the balance between the performance and complexity trade-offs. For instance, good examples for the low complexity detection algorithms based on

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