Cooperative and Cognitive Networks:  
A Motivating Introduction
Towards the Age of Enlightenment in Wireless Communication Networks

All our knowledge begins with the senses, proceeds then to the understanding, and ends with reason. There is nothing higher than reason. Immanuel Kant

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Summary. In this introductory chapter, some key trends and emerging concepts for wireless communication networks are explored, highlighting chiefly those exploiting cooperative and cognitive principles. After discussing some key promising directions of development, a motivating overview of cooperative techniques in wireless networks is presented, followed by an overview of cognitive techniques and their use in wireless networks. The joint exploitation of these complementary principles are also considered in this chapter. Finally some visions on promising developments and possible evolutionary steps are included. The introductory discussions presented here serve as an initial motivation to the rest of the book, where many of the concepts and techniques discussed here are explained in detail.

1.1 Introduction

In the last two decades enormous efforts have been devoted to developing wireless communication technologies. Once affordable only to specific niche markets, these wireless communications are rapidly becoming everyone’s mainstream source of connectivity. Horizontal markets continue to grow in particular in developing regions of the globe, and it is expected that soon one third of the world population will use wireless devices for communication purposes. In many developed countries wireless voice-centric communications is replacing the well established wired counterpart. This trend is swiftly spreading into all regions of the world. Developments in the vertical markets are also significant, being propelled by the ever growing number of network access technologies as well as the incessant introduction of advanced terminals, mostly in developed countries. Behind schedule and with a currently
smaller business size, data-centric communications appear to follow a similar pattern than voice, particularly driven by the industry push and growing user acceptance of wireless Internet. Even though in recent years the concept of the fourth generation (4G) wireless and mobile communication system has been intensively discussed by industry and academia, even today a common, clear and widespread understanding of its meaning is missing. In the most general sense, the term 4G is used to loosely describe advanced future high-performance wireless communication systems. Often enough, 4G is used as a synonymous of very high data throughput communications systems. We advocate here the former interpretation of 4G, but in an integrative manner, encompassing an eclectic array of different wireless networks which cover virtually every possible communication scenario. This leads to the concept of converging networks where heterogeneous networks harmonically coexist. Convergence is taking place also in other domains, noticeably in terminal and service. It is not the purpose of this chapter to present in detail views and visions on 4G - the interested reader is referred to [2] for that purpose - but to identify and discuss some emerging trends and concepts likely to make a profound impact on future wireless communications.

Figure 1.1 illustrates the current mosaic of wireless communication networks from the service coverage (range) standpoint. Two main network components are clearly distinguished, namely wide area networks on one hand, and short-range networks on the other hand. Curiously, range-wise, the development of wireless communication networks follows an ordered evolution from large to small networks, starting with very large distribution networks of up to hundred of kilometers wide down to sub-meter short-range networks. Several reasons can be attributed to the development of increasingly smaller wireless networks, including the pressure to move towards unused (and typically higher) frequency bands of the spectrum and the need to support higher data throughputs. In general these two component networks were developed independently of each other but aiming, by design, to coexist. As discussed in [2], such a coexistence may inevitably lead to competing situations between some networks. Different networks are most commonly seen as complementary, where each network is used in a given scenario or for a particular application. Heterogeneity and convergence of networks, terminals and services are perhaps the most distinctive characteristics of future mobile and wireless networks. They will certainly bring challenges for the technical development but also new opportunities to exploit.

1.2 Ten Tenets Shaping Future Wireless Communications

In this section we identify and discuss some key emerging principles and trends likely to shape future wireless and mobile communication networks. We partic-