Introduction

Technologies for wireless systems are always evolving. Standards and products adopt more and more quickly the latest innovations coming from industrial or academic laboratories.

TDMA and CDMA were the dominating technologies in the last few decades. However, the “historical” systems (GSM then UMTS, or the evolution of CDMA2000 and the evolution of WLAN and WMAN systems) all converge towards a next generation based on OFDM/OFDMA, the introduction of advanced antenna techniques, more aggressive frequency reuse schemes, flexible and scalable air interface, better support of QoS on the radio interface, etc.

Based on these advanced technologies, the wireless metropolitan network standard for WiMAX, IEEE 802.16, provides wireless last mile broadband access in metropolitan area networks (MANs) at a much lower cost than traditional cable, DSL or T1 technologies. One of the typical scenarios for the use of WiMAX is to enable various users to have broadband Internet access in one or more buildings via rooftop antennas. Nowadays, WiMAX also aims at providing ubiquitous and mobile access to broadband Internet, providing a very attractive alternative to the 3G/4G technology which is based on cellular networks. WiMAX is part of a global standardization effort of the IEEE that involves not only the well known local networks (WiFi, Ethernet) but also regional networks.

Moreover, WiMAX integration into IP networks is facilitated in the standard by the definition of five qualities of services classes covering the full range of foreseen applications, from best effort to delay and jitter-sensitive applications.

Using the flexibility provided by the advance radio access technologies embedded in the standard, WiMAX, as well as LTE, is expected to work at a much

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higher spectral efficiency compared to the previous mobile systems generations. Such gains can represent an opportunity for the operators, enabling higher capacity or better coverage, to bring high data rate wireless connections all over the world.

It is important to understand where these gains are coming from and to assess the theoretical limits of OFDM/MIMO systems for mobile communication. Moreover, to reach these limits, the system should behave perfectly, meaning a perfect coordination between all the mechanisms aiming at improving the capacity. Typically, power control, adaptive modulation and coding, intelligent multi-user scheduling, multi-antenna processing, etc., should be tightly and dynamically coordinated, adapted to a particular deployment as well as varying traffic and demand conditions.

Whilst this book does not provide an exhaustive description of WiMAX or LTE systems and it assumes that the reader already possesses a basic knowledge of these technologies, the different chapters offer in a stand-alone manner numerous facets related to the radio performance of OFDM-based systems. Indeed, the choices and the tuning of radio resource management strategies directly influence the system performance. Therefore, this book has the objective of collating references and answers to questions that can be raised when investigating OFDM such as the WiMAX system.

The book is organized into independent chapters, covering different aspects of the management of radio resources in an OFDM/OFDMA system. The drivers of the system performance are presented, from theoretical analysis to practical aspects, including examples of algorithms to perform radio resource allocation or information to help the reader understand how end-to-end QoS can be guaranteed.

The last two chapters of the book focus on the specific topic of relays. Actually, relays are predicted to play an important role in future wireless systems as they can represent a low cost solution to enhance coverage or capacity, especially in gray areas.

Chapter 1 presents a survey related to the information theoretic formulation of capacity in IEEE 802.16 WiMAX, focusing on the PHY layer. Many optimization problems can be stated due to the numerous possible choices in the optimization criterion (minimum sum power, maximal sum rate, fairness and all its variants, etc.) which come with related algorithms. The chapter comes from “WINEM”, a research program funded by the French National Research Agency, with recent results of a consortium comprised of universities and manufacturers.

From the same consortium, Chapter 2 presents another survey related to the WiMAX capacity, but this time from the networking perspective, and related radio

resource management issues. The bulk of scheduling and connection admission control (CAC) solutions proposed IEEE 802.16 research is presented. The chapter provides an overview of the main features proposed by the standard to support QoS and then outlines the challenges that should be addressed when designing a new scheduling or CAC solution. Along with the description of each proposal, a comparison outlining the advantages and limits of each solution is given. Next, emphasis is placed on the MAC layer, and an Erlangian approach of the system capacity optimization is presented.

Chapter 3 concludes the discussion related to the network-level mechanisms to support the QoS in a WiMAX network by providing an end-to-end QoS support. For this reason, the chapter recalls the well known mechanisms in IP networks and shows how these mechanisms work together with the native WiMAX QoS mechanisms.

Chapter 4 provides a detailed presentation of the coexistence mechanisms under consideration in the 80.16h standard amendment to support license-exempt operations of IEEE 802.16 systems. The proposed mechanisms cover both coexistence between IEEE 802.16 systems and between IEEE 802.16 and non-IEEE 802.16 systems. For this reason, the 802.16h group has proposed coordinated and uncoordinated coexistence mechanisms to meet the different regulatory rules and deployment scenarios. The 802.16h amendment is currently in its finalization phase. The authors of this chapter contributed directly to the 802.16h amendment definition.

In Chapter 5, key features for building efficient system simulation are exposed. The general concepts of system simulation (as opposed to link-level simulation) are introduced. After a brief reminder of air interface modeling, the focus of the chapter is on giving an accurate link layer abstraction model that can be used to accelerate system-level simulation. Hence, the modified Shannon limit model is given, followed by the exponential effective SNIR mapping (EESM) approach and enhancements. Since its recent introduction in standardization, this method is nowadays extensively used for modeling OFDM/OFDMA systems. Finally, the chapter concludes with a practical assessment that can be performed by system level simulations.

While classical scheduling approaches have been introduced in the illustration of Chapter 5, Chapter 6 presents a different approach, inspired by human behavior. Actually, system capacity depends on the system’s capability to manage inter-cell interference, with a minimum of signaling overhead. One possible approach is to use distributed heuristics. Chapter 6 presents the “Robin Hood” and “proactive donation” approaches and their performance, and discusses their applicability to the femto-cell environment, where distributed approaches are well suited.

Chapters 7 and 8 deal with relaying techniques. They come from the "FIREWORKS" project sponsored by the EU. This project specifically addressed the use of relay in OFDM systems. Chapter 7 first introduces the concept of traditional relaying, describing the various ways of using relays: with or without cooperation with the source, relaying in time or in frequency, as pure repeater or implementing digital processing such as decode and forward or compress or forward. The analytical performance of these relaying techniques is given and illustrated in typical scenarios.

Going further, Chapter 8 describes and evaluates radio resource management strategies suitable for relay systems. By exploiting the spatial-frequency-time domain, advanced forwarding and cooperative protocols are shown to substantially increase the capacity and traffic performance. Performance evaluations are given in the context of WiMAX.

We hope that this book will provide the reader with original and interesting views on the diverse aspects and triggers of the performance of OFDM/MIMO systems. Numerous references are proposed throughout the chapters for further reading. Obviously, it is quite impossible to give an extensive coverage in eight chapters, but this book gives hooks to understand some current hot topics in the design of WiMAX or LTE systems, from theoretical analysis to practical simulations set-up. It should become a good starting point for either students who wish to deepen their knowledge in emerging wireless systems or for engineers having the responsibility to design or operate such systems!