Mobile Wireless Communications

Wireless communication has become a ubiquitous part of modern life, from global cellular telephone systems to local and even personal-area networks. This book provides a tutorial introduction to digital mobile wireless networks, illustrating theoretical underpinnings with a wide range of real-world examples. The book begins with a review of propagation phenomena, and goes on to examine channel allocation, modulation techniques, multiple access schemes, and coding techniques. GSM and IS-95 systems are reviewed and 2.5G and 3G packet-switched systems are discussed in detail. Performance analysis and accessing and scheduling techniques are covered, and the book closes with a chapter on wireless LANs and personal-area networks. Many worked examples and homework exercises are provided and a solutions manual is available for instructors. The book is an ideal text for electrical engineering and computer science students taking courses in wireless communications. It will also be an invaluable reference for practicing engineers.

Mischa Schwartz joined the faculty of Electrical Engineering at Columbia University in 1974 and is now Charles Batchelor Professor Emeritus. He is the author and co-author of ten books, including best-selling books on communication systems and computer networks. His current research focuses on wireless networks. He is a Fellow and former Director of the IEEE, past President of the IEEE Communications Society, and past Chairman of the IEEE Group on Information Theory. He was the 1983 recipient of the IEEE Education Medal and was listed among the top ten all-time EE educators, IEEE survey, 1984. He also received the 2003 Japanese Okawa Prize for contributions to Telecommunications and Engineering Education and the New York City Mayor's Award in 1994 for contributions to computer communications.

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To my wife Charlotte

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Preface

It is apparent, even to the most casual observer, that a veritable revolution in telecommunications has taken place within recent years. The use of wireless communications has expanded dramatically worldwide. Cell phones are ubiquitous. Although most such mobile terminals still carry voice principally, more and more users are sending and receiving data and image applications. Wi-Fi, an example of a wireless local area network (LAN), has caught on spectacularly, joining the major cellular networks deployed throughout the world.

This book, designed as an introductory textbook in wireless communication for courses at the Senior and first-year graduate level, as well as a self-study text for engineers, computer scientists, and other technical personnel, provides a basic introduction to this booming field. A student or reader of the book should come away with a thorough grounding in the fundamental aspects of mobile wireless communication, as well as an understanding of the principles of operation of second- and third-generation cellular systems and wireless LANs. To enhance an understanding of the various concepts introduced, numerical and quantitative examples are provided throughout the book. Problems associated with each chapter provide a further means of enhancing knowledge of the field. There are many references to the current technical literature appearing throughout the book as well. The author considers these references an integral part of the discussion, providing the reader with an opportunity to delve more deeply into technical aspects of the field where desired.

After the introductory Chapter 1, which provides a history of mobile communications, followed by a detailed description of the book, chapter by chapter, the book breaks down roughly into two parts, the first part containing Chapters 2 to 8, the second part Chapters 9 to 12. Chapters 2 to 7 provide an introduction to the fundamental elements of wireless mobile communications, with Chapter 8 then providing a detailed discussion of the second-generation systems, GSM, IS-95, and IS-136 or D-AMPS, in which these basic concepts are applied. Specifically, Chapter 2 treats the propagation phenomena encountered in communicating over the wireless medium, while Chapter 3 introduces the cellular concept. Power control, channel assignment, modulation, coding, and access techniques are then discussed in the six chapters following. This material in the first part of the book is covered in the first semester of a full-year course on wireless communication at Columbia

University. The second-semester course following this first course then covers material from the second part of the book, as well as additional material based on current reading and research.

The second part of the book provides more advanced material. It begins in Chapter 9 with a thorough discussion of the performance analysis of wireless systems, building on some of the items touched on only briefly in earlier chapters. Chapter 10 then describes the third-generation systems W-CDMA, cdma2000, and GPRS in depth, again building on the earlier discussion of second-generation systems in Chapter 8. The focus of this chapter is on data and multimedia wireless communication using packet-switched technology. A brief review of the concept of layered architectures is included, showing, in particular, how GPRS interfaces with Internet-based packet networks. Chapter 11 then discusses the access and scheduling techniques used or proposed for use in cellular systems. The book concludes with a discussion of wireless LANs (WLANs) and Personal-Area Networks (PANs). The WLAN discussion focuses on Wi-Fi and extensions thereof to much higher bit-rate wireless LANs; the PAN discussion deals with the Bluetooth system.

The book can, therefore, be used for either a single-semester course on wireless systems or for a full-year course. A single-semester course might cover the first eight chapters, as has been the case at Columbia, or might use as examples of current wireless systems material drawn from sections of Chapters 8, 10, and 12. A full-year course would cover the entire book. The material in the book could also be used in conjunction with a course on communication systems, providing the application of communication technology to the wireless area.

The only prerequisites for the book, aside from a certain technical maturity commonly available at the Senior or first-year graduate level, are a knowledge of basic probability and linear algebra. There is no prior knowledge of communication theory and communication systems assumed on the part of the reader, and the material in the first part of the book dealing with modulation and coding, for example, is meant to be self-contained. Those readers with some prior knowledge of communication systems should find the tutorial discussion in the coding and modulation chapters a useful review, with the specific application of the material to wireless systems further solidifying their knowledge of the area.

The author would like to acknowledge the help of a number of individuals with whom he worked during the writing of this book. In particular, the author is indebted to the students who took the wireless course at Columbia, using the preliminary notes covering the material, and to the instructors with whom he shared the teaching of the course. He would like to particularly acknowledge the help and co-teaching support of Professor Andrew Campbell of the Electrical Engineering department at Columbia; Professor Tom LaPorta, formerly of Bell Labs and currently with the Computer Science department of Pennsylvania State University; and Dr. Mahmoud Naghshineh of IBM. The author has, at various times, carried out research in the wireless area with each of these colleagues as well. The questions raised and answered while teaching the course, as well as conducting research in the area, were invaluable in writing this book.

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