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WCDMA: TOWARDS IP MOBILITY AND MOBILE INTERNET



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WCDMA: Towards IP Mobility and Mobile Internet

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Books are the joy of life, and learning is a never-ending experience.

*To my wife Tiina and to our sons Eerik and Elias
—Tero Ojanperä*

*To my wife Jyoti, to our daughter Neeli,
and to our sons Anand and Rajeev
—Ramjee Prasad*

PREFACE

Since the first edition of this book *Wideband CDMA for Third Generation Mobile Communications* was published two years ago, enormous progress has been made in the development of third generation mobile networks. After the selection of WCDMA as a main approach in Japan and Europe in 1998, and cdma2000 and EDGE in the United States, there have been two direct sequence wideband CDMA proposals: asynchronous WCDMA and synchronous cdma2000. In 1999, however, the two proposals were harmonized, resulting in three modes: direct sequence based on WCDMA, multicarrier based on cdma2000, and time division duplex. These standards—as well as EDGE—have been now finalized and are termed release'99 standards.

Meanwhile, regulatory hurdles to third-generation implementation have been cleared. In many countries, the third-generation licenses have already been awarded using either “beauty contents” or an auction process. In WARC'2000, extension bands for third-generation networks were identified.

In addition, the standardization environment has changed dramatically. A new standardization body, the Third Generation Partnership Project (3GPP), was formed at the end of 1998 with a focus on the WCDMA air interface and GSM core network. Following the establishment of 3GPP, another partnership project, 3GPP2, was founded to develop specifications for cdma2000-based networks. In 2000, the EDGE standardization was transferred from ETSI to 3GPP. In addition, several new industrial interest groups have emerged. 3G.IP and the Mobile Wireless Internet Forum (MWIF) were initiated to drive development of Internet Protocol (IP)-based third-generation networks.

While waiting for the deployment of third-generation networks technology, second-generation networks have also developed further and the Internet has continued to develop at an unanticipated speed. Today there are more than 600 million mobile subscribers; this number may rise to one billion by 2002. Wireless Application Protocol (WAP) and i-Mode in Japan have already brought the Internet into pocket. The mobile Internet has become known to most of us—if not in practice, then from the wide media coverage.

As a result of the success of the Internet and developments in the mobile Internet, the

third-generation network has now been focused on IP based networks, termed all-IP networks or IP mobility networks. The goal is to specify a single, unified IP based core network to which different radio access networks can be connected. An all-IP approach is expected to result in increased flexibility and cost savings.

In addition to the core network development, the WCDMA, EDGE and cdma2000 air interfaces are developed further to provide higher data rates and better spectrum efficiency.

The changes in the standardization environment, the mobile Internet and all-IP networks are shaping the direction of development of third-generation networks and the whole wireless communications. This led us to the idea of revising the book and renaming it in order to better reflect the direction in which the industry is heading, *WCDMA: Towards IP Mobility and Mobile Internet*.

This book provides a comprehensive introduction to wideband CDMA and third-generation networks. It provides the technical background necessary to understand how wideband CDMA air interfaces are designed, starting from system requirements, applications, and radio environments, combined with a detailed treatment of technical solutions for spreading codes, coding, modulation, RAKE receiver, and soft handover. It also provides a review of WCDMA and cdma2000. Radio network planning is a key competence for network operators. This book gives an introduction to the art of network planning with problems and solutions specific to CDMA. The standardization and regulation environment for development of third-generation networks is very complex. This book provides insight into the structure and operations of different standardization bodies, industry interest groups, and regulatory bodies.

Recently, mobile Internet and all-IP (Internet Protocol)-based networks have emerged as cornerstones for the future growth of mobile communications. This book provides an introduction to both schemes with insight into the development of wireless communications concepts.

Figure P.1 illustrates the coverage of the book. Chapter 1 introduces basic definitions and the background of third-generation systems development. Chapter 2 explains the basic principles of CDMA. Chapter 3 introduces mobile Internet, IMT-2000 service targets and applications. Chapter 4 presents radio environments and their characteristics. Chapter 5 covers all the main aspects of wideband CDMA air interface design, including frame structures and physical channel design, spreading codes and their properties, and radio resource management aspects such as handover and power control. Chapters 6, 7, and 8 review WCDMA, WCDMA TDD, and cdma2000 air interfaces and their future evolution. In Chapter 9, radio performance of wideband CDMA, including spectrum efficiency and range, is discussed. Hierarchical cell structures (HCS) are discussed in Chapter 10. Chapter 11 describes the implementation of wideband CDMA mobiles and base stations. CDMA network planning is discussed in Chapter 12. Chapter 13 introduces the basic principles of IP. Chapter 14 presents network architectures, interfaces, and protocols for 3GPP, IS-41, and all-IP networks. Chapter 15 describes the

standardization and regulation environment of third-generation networks. Finally, the future directions of the wireless multimedia communications networks are discussed in Chapter 16.

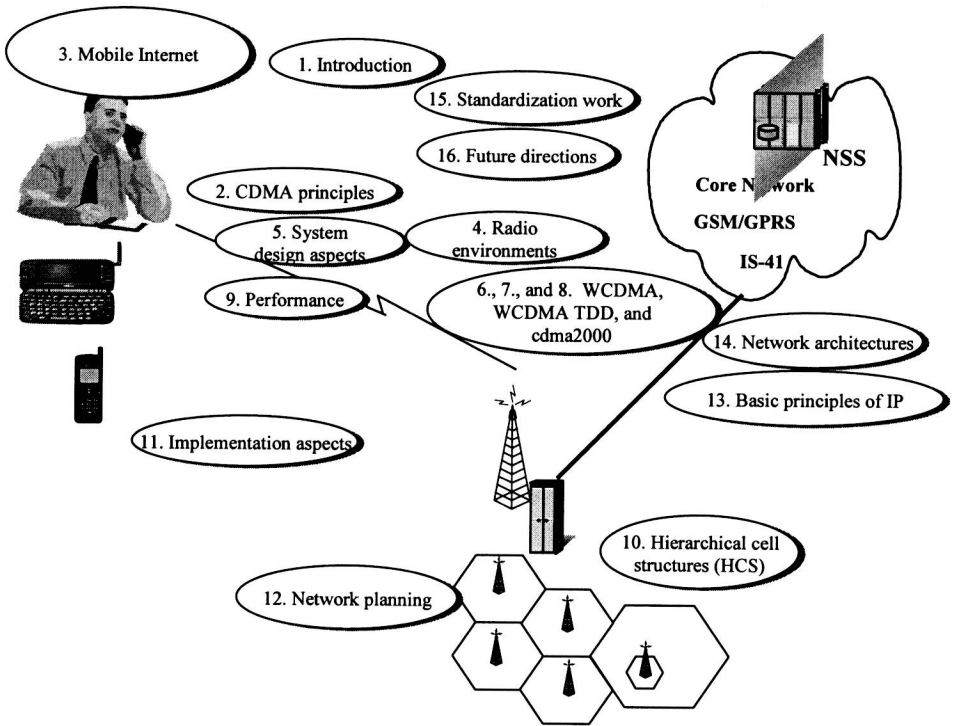


Figure P.1 Illustration of the coverage of this book.

This book is intended for everybody involved in the field of mobile radio systems. It provides different levels of material suitable for managers, researchers, system designers, and graduate students. The structure of the book facilitates two reading approaches. A general overview of wideband CDMA, third-generation systems, and IP, suitable for managers, can be obtained by reading Chapter 1; Chapter 2; Sections 3.1 to 3.6; Sections 4.1 to 4.3; Chapters 6, 7, and 8 (overview parts); Chapter 13; Chapter 14 selectively; and Chapters 15 and 16. A more thorough reader interested in technical details should read all sections. Section 3.11 provides a more mathematical view of applications covering traffic models. Sections 4.4–4.7 provide detailed propagation and mobility models. Chapter 5 contains an in-depth treatment of wideband CDMA system design aspects.

The views expressed in this book are those of the authors and do not represent the views of their employers.

ACKNOWLEDGMENTS

The material in this book originates from several projects at Nokia, Delft University of Technology (DUT), and Aalborg University (AAU) with a common goal of defining the third-generation of mobile communications. The research program to produce wideband CDMA specifications within Nokia dates back to the early 1990s when an experimental wideband CDMA testbed project was started. Tero was intensively involved with the start of CDMA system studies in 1993. Based on these studies, a project called CSS2000 was launched in 1994. Tero had the pleasure of being a project leader with an ambitious—at that time almost overwhelming—goal of producing a wideband CDMA air interface for UMTS. Later the research was expanded to a research program investigating several aspects such as 2-Mbps transmission, radio resource management, and packet aspects for UMTS. The book *CDMA for Wireless Personal Communications* (Artech House, 1996) by Ramjee proved to be a good starting point for this book. Ramjee initiated the CDMA research activities in DUT in 1989 and currently the Center for PersonKommunikation (CPK) of AAU is very active in the research and development of wireless IP-based CDMA systems.

In 1995, the FRAMES project brought together a number of talented individuals from several companies, laboratories, and universities, namely CNET, CSEM, Chalmers University of Technology, Ericsson, ETHZ, Instituto Superior Técnico, Nokia, Siemens, Roke Manor Research, The Royal Institute of Technology, DUT, the University of Kaiserslautern, and University of Oulu. The goal of FRAMES was to study and define a proposal for the UMTS air interface. FRAMES also created the seeds for this book by getting us acquainted with each other. We decided to put the results of various CDMA and third-generation related projects into a book format.

Several individuals contributed to the research and writing of this book. The efforts of the other contributors to this book—Timo Eriksson, Harri Holma, Seppo Hämäläinen, Martijn Kuipers, Harri Lilja, Carl Wijting, and Antti Toskala—are especially appreciated.

António Trindade from DUT helped to prepare the complete manuscript of the first edition. He also provided very constructive suggestions to improve the book and corrected numerous mistakes. Without his strong dedication it would not have been possible to complete the first edition of the book. Rajeev Prasad and Albená Mihovska of CPK helped to prepare the second edition manuscript, freeing us from an enormous editorial task.

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We hope this book will help to explain the rationale behind UMTS wideband CDMA and the other wideband CDMA air interfaces, and third-generation systems in general, including all-IP-based mobile networks.

*Tero Ojanperä
Ramjee Prasad
January 2001*

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