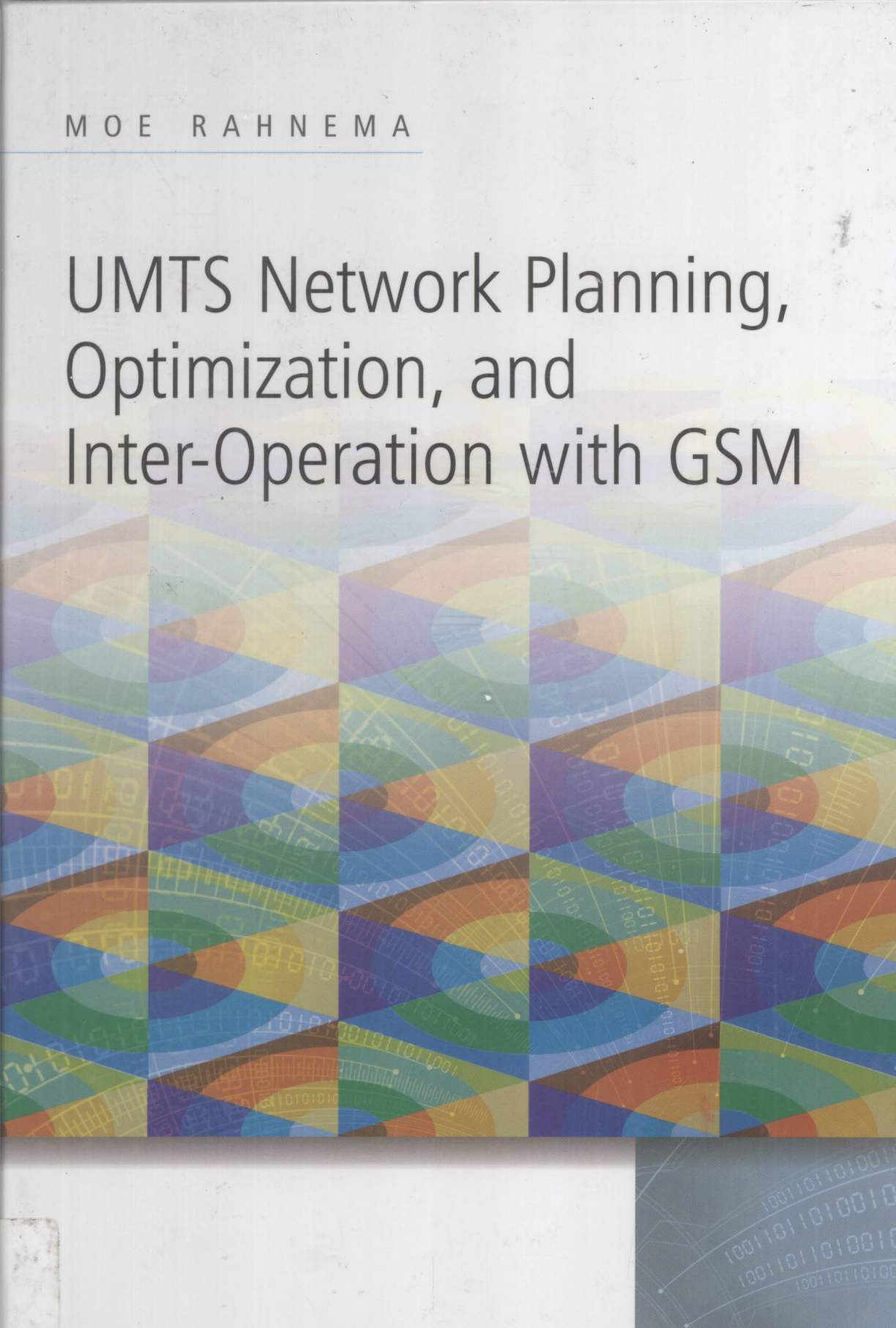
MOE RAHNEMA

UMTS Network Planning, Optimization, and Inter-Operation with GSM



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Moe Rahnema

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UMTS NETWORK PLANNING, OPTIMIZATION, AND INTER-OPERATION WITH GSM

Preface

The continuing explosive growth in mobile communication is demanding more spectrally efficient radio access technologies than the prevalent second generation (2G) systems such as GSM to handle just the voice traffic. We are already witnessing high levels of mobile penetration exceeding 70% in some countries. It is anticipated that by 2010 more than half of all communications will be carried out by mobile cellular networks. On the other hand, the information revolution and changing life habits are bringing the requirement of communicating on a multimedia level to the mobile environment. But the data handling capabilities and flexibility of the 2G cellular systems are limited. The third generation (3G) systems based on the more spectrally efficient wideband CDMA and a more flexible radio channel structure are needed to provide the high bit rate services such as image, video, and access to the web with the necessary quality and bandwidth. This has promoted the inception of a global 3G standard that will bring higher capacities and spectral efficiencies for supporting high data rate services, and the flexibility for mixed media communication. The 3G mobile communication network referred to here as UMTS (Universal Mobile Telecommunication System) is based on the Wideband Code Division Multiple Access (WCDMA) and is the main 3G radio access standard in the world. UMTS has been deployed in Europe, and is being deployed in the USA, Japan, Korea, and in many other parts of Asia around the same frequency band of 2 GHz. The present book provides a detailed description of the WCDMA air interface, the detailed radio planning, and the optimization and capacity improvement mechanisms for the FDD-mode, the QoS classes, and the end-to-end parameter interworking mechanisms, as well as an adequate coverage of the terrestrial and the core network design, dimensioning, and end-to-end data transfer optimization mechanisms based on the TCP protocol.

Chapter 1 provides a snapshot description of the evolution of the UMTS releases, highlights the main features introduced in each release, and then briefly discusses the challenges facing the network operators in the planning and optimization of 3G networks, their inter-operation with existing GSM networks, and the trends of future network evolutions.

Chapter 2 provides a detailed and comprehensive overview of the UMTS architecture, network elements, interfaces, and code division multiple access spread spectrum concepts and issues. The chapter also covers the UMTS air interface channel organization and protocols, contains an overview of specific mechanisms that impact 3G radio performance such as power control and handovers, and ends with a description of the key WCDMA link performance indicators used in radio network planning and optimization.

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Chapter 3 is a detailed and comprehensive overview of multipath radio channel statistical parameters that impact communication system and network design and a description of 3GPP and ITU multipath channel models. It also presents the numerous path loss channel models and parameters for various environments, and discusses in fair detail guidelines for path loss model tuning based on RF measurements and obtaining adequate path loss prediction model resolutions, which is of particular importance in 3G network planning. This chapter is also a general useful reference for RF path loss prediction and RF channel model development for RF professionals concerned with mobile communication.

Chapter 4 presents the key 3G radio network parameters modeling the multi-user load and the interference geometries. It also derives the theoretical formulation for base station power, the uplink and downlink load factors, and the pole capacities, as well as presenting sample numerical results to illustrate the concepts and deriving conclusions and implications to guide optimal radio network planning in WCDMA. This chapter provides the necessary theoretical background and concepts for the next chapter, which focuses on the detailed practical radio network planning.

Chapter 5 presents the detailed processes and formulations for radio network planning and dimensioning. This chapter presents the guidelines for selecting radio base station sites based on the results of the latest research activities, derives the link budget formulas for the traffic, the pilot, and the HSDPA channels, presents a detailed iterative link budgeting static analysis approach, and provides sample link budgeting templates and examples. Then follows a presentation of flowcharts for the iterative Monte Carlo simulation processes for detailed radio capacity and coverage verification. The chapter also presents engineering design guidelines for site sectorisation and engineering, antenna selections, pilot and control channel power settings, traffic requirements analysis, and radio dimensioning and site placement coordination with other operators to mitigate inter-operator interferences.

Chapter 6 presents further guidelines for optimal radio network planning based on layered radio architectures. The layered radio architectures implemented on single and/or multiple frequency carriers are a necessity mechanism to provide optimum capacity and service coverage in the multi-service scenarios of 3G networks. This chapter discusses how this is achieved and provides practical guidelines for designing layered multi-carrier radio architectures.

Chapter 7 presents the cost-effective and realistic 3G planning models and strategies for incumbent GSM operators. It discusses how the existing GSM operators can utilize RF path loss measurements collected by their GSM networks to obtain site re-engineering guidelines, and realistic path loss models for 3G site co-location scenarios to minimize interference geometries.

Chapter 8 discusses and presents the various power control and handover mechanisms and related measurements and parameters for WCDMA. Power control and handover (soft handover) are two very important and basic mechanisms in 3G networks, and understanding them and the impact of related parameters, and their optimization on network performance, are critical to proper radio network planning and optimization. This chapter provides the detailed guidelines for tuning these mechanisms where possible.

Chapter 9 focuses on the typical strategies and algorithms that are implemented by vendors for the management and control of traffic load and the allocation of radio resources to achieve coverage and quality for each service category. These strategies are based on

measurements defined in the 3GPP Standards and include admission and load/congestion control functions, allocation of radio resources to different services, and the related measurements used in the process. The chapter also discusses guidelines for setting the decision thresholds for measurements used in the control and admission of each traffic category into the network, so that the overall desired coverage and quality can be achieved for the multi-service environment of 3G.

Chapter 10 introduces and discusses various additional coverage and capacity improvement techniques beyond what is discussed in Chapter 5 on radio site planning and optimization. The mechanisms introduced here include antenna receive and transmit diversities, use of mast head amplifiers, repeaters, optimal site configurations, etc. The chapter includes practical examples and case studies.

Chapter 11 introduces the reader to issues involved in co-planning WCDMA with existing GSM networks and their optimal inter-operation. The issues addressed include inter-system interference and avoidance guidelines, antenna sharing configuration examples, and inter-system handover parameter tuning for resource pooling and overall network capacity and coverage optimization.

In Chapter 12, the AMR speech codecs for GSM and 3G networks are introduced. The various implementation options and performance under varying background noise conditions are discussed, and the tradeoffs in the AMR source coding rate and capacity in WCDMA are quantitatively evaluated and presented along with the associated control parameters for guiding the radio optimization process. The chapter also discusses the wideband AMR, which uses higher sampling rates to achieve superior voice quality.

Chapter 13 covers the guidelines for the design and dimensioning of the terrestrial access network in 3G. Strategies for dimensioning the Iub and Iu links, and sharing access links with existing GSM networks using alternative transport technologies, are also discussed.

Chapter 14 introduces the reader to the core networks in WCDMA, with a detailed discussion of the protocols and transport technologies involved. The chapter also presents dimensioning guidelines for various core network elements, links based on practical traffic models, and protocol overhead accounts. Furthermore, the chapter discusses some of the recent trends for distributed core network elements based on the separation of call and mobility control from the actual user information transport as paving the way to an all-IP core. It discusses soft switching and presents practical migration strategies for migration to soft switching core architectures. The chapter also discusses the IMS service platform and the flexibility for multimedia traffic handling and service support.

Chapter 15 presents the WCDMA end-to-end Quality of Service (QoS) architecture, signaling flows, QoS service classification, and parameters/attributes. The chapter also discusses key QoS implementation mechanisms in the core and the mapping of QoS related attributes and parameters across the radio access, the Iu, and the core network to achieve end-to-end performance.

Chapter 16 provides the reader with a thorough detailed discussion of the important TCP (transmission control protocol) and its adaptation to the wireless links, particularly for UMTS and GPRS networks. The chapter presents and discusses the issues involved in using the conventional TCP in the mobile communication environment and presents the appropriate variations of the protocol and complementary measures such as tuning relevant

parameters within TCP and the underlying radio link control protocol to adapt the performance for achieving optimal data throughputs and reduced delays.

Finally in Chapter 17, the reader is introduced to efficient time saving and practical methodologies for measuring and monitoring the network performance and finding the root cause problems for quick troubleshooting in the perplexing multi-service and highly interactive 3G radio environment. The performance trending and troubleshooting techniques discussed in this chapter are equally applicable to GSM and other network technologies.

This book is an outgrowth of the author's years of experience and consulting in the wireless telecommunication field starting from low earth orbit satellites at Motorola to GSM, to GPRS planning in the USA and Asia, and to extensive investigation, studies, and development of radio and core network planning for 3G in the USA and Europe. The book has a heavy focus on the radio/RF planning aspects of 3G networks, but is also intended to benefit significantly professionals involved in core network planning, dimensioning, and end-to-end optimization aspects, RF propagation channel modeling professionals, university students, and new researchers to the field, as well as provide insight for advanced developments in equipment manufacturing.

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The author would like to thank the many pioneering researchers in the industry, and in academia, whose efforts have helped to create the groundwork for this book. Without this work, it would never have been possible to put together such a publication. I would also like to thank the many clients who have provided consulting opportunities to me in this industry. This has helped me gather the knowledge, experience, and insight to be able to put together a book of this scope.

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The author welcomes any comments and suggestions for improvement or changes that could be implemented in possible future editions of this book. The email address for gathering such information is mroi_us@yahoo.com.

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