

国外电子信息精品著作(影印版)

3G无线网络和 无线局域网的设计与性能

**Design and Performance of 3G
Wireless Networks and Wireless LANs**

**Mooi Choo chuah
Qinqing Zhang**



科学出版社

www.sciencepress.com

3G无线网络和无线局域网的设计与性能

Design and Performance of 3G Wireless Networks and Wireless LANs

- Overview of core principles of wireless communications (e.g., FDMA, TDMA, CDMA), airlink capacity analysis, and evaluation.
- Traffic model descriptions and illustrations for circuit-switched and packet-switched services.
- In-depth coverage of how base station and radio network controller can be designed to meet capacity requirements.
- Discussion of unique design issues in 3G networks, innovative solutions, and possible new 3G features.

国外电子信息精品著作 (影印版)

片上系统设计
模拟/射频集成电路设计的晶体管级建模
宽带高动态范围DAC
可重构片上系统的系统级设计
ADC的动态特性
嵌入式系统设计
 $\Sigma\Delta$ A/D转换技术在信号调理中的应用
超高频多速开关电容电路设计
CMOS锁相环: 分析和设计
3G无线网络和无线局域网的设计与性能
视觉感知的模拟超大规模集成电路实现
Delta-Sigma数据转换器
系统集成: 从晶体管设计到大规模集成电路
无线网络RF工程: 硬件、天线和传播

传感器和通信中的CMOS级联式 $\Sigma\Delta$ 调制器
射频功率放大器的高级设计技术
混合信号片上系统的适应性技术
VLSI的统计分析和优化: 时序和功耗
片上系统的设计和描述语言
奈奎斯特ADC的校准技术
时钟发生器在片上系统处理器中的应用
用于4G的CMOS锁相环和压控振荡器
运算电路综合: FPGA, ASIC和嵌入式系统
功耗管理: 基于VLSI及DSP的计算机系统
CMOS电子学: 失效分析与诊断
半导体制造和工艺控制基础

ISBN 978-7-03-018251-7



9 787030 182517 >

销售分类建议: 电子信息

定价: 50.00 元

国外电子
信息
精品著作
（影印版）

无线网络和无线局域网的设计与性能

社



国外电子信息精品著作（影印版）

**Design and Performance of 3G
Wireless Networks and Wireless LANs**

3G 无线网络和无线局域网 的设计与性能

Mooi Choo Chuah
Qinqing Zhang

科学出版社

北京

图字：01-2006-7413

内 容 简 介

全书对 3G 无线系统的原理、部件、系统构成、网络运行等作了系统而翔实的论述，站在设计的角度来讲述技术的应用，让读者容易理解。

本书对从事无线通信的工程师、大学教师、研究生、高年级本科生均有参考价值。

Mooi Choo Chuah, Qinqing Zhang : Design and Performance of 3G Wireless Networks and Wireless LANs

Copyright © 2006 Springer

This reprint has been authorized by Springer-Verlag (Berlin/Heidelberg/New York) for sale in the People's Republic of China only and not for export therefrom.

图书在版编目(CIP)数据

3G 无线网络和无线局域网的设计与性能 = Design and Performance of 3G Wireless Networks and Wireless LANs; 英文/ (美) 莫伊 (Chuah, C. C.) 编著. —影印版. —北京: 科学出版社, 2007. 1

(国外电子信息精品著作)

ISBN 978-7-03-018251-7

I. 3… II. 莫… III. ①无线电通信-通信网-英文②无线电通信-局部网络-英文 IV. TN92

中国版本图书馆 CIP 数据核字(2006)第 149507 号

责任编辑：余 丁/责任印制：安春生/封面设计：陈 敬

科学出版社出版

北京东黄城根北街 16 号

邮政编码：100717

<http://www.sciencep.com>

天时彩色印刷有限公司印刷

科学出版社发行 各地新华书店经销

2007 年 1 月第 一 版 开本：B5(720×1000)

2007 年 1 月第一次印刷 印张：23

印数：1—3 000 字数：573 000

定价：50.00 元

(如有印装质量问题,我社负责调换〈双青〉)

《国外电子信息精品著作》序

20世纪90年代以来,信息科学技术成为世界经济的中坚力量。随着经济全球化的进一步发展,以微电子、计算机、通信和网络技术为代表的信息技术,成为人类社会进步过程中发展最快、渗透性最强、应用面最广的关键技术。信息技术的发展带动了微电子、计算机、通信、网络、超导等产业的发展,促进了生命科学、新材料、能源、航空航天等高新技术产业的成长。信息产业的发展水平不仅是社会物质生产、文化进步的基本要素和必备条件,也是衡量一个国家的综合国力、国际竞争力和发展水平的重要标志。在中国,信息产业在国民经济发展中占有举足轻重的地位,成为国民经济重要支柱产业。然而,中国的信息科学支持技术发展的力度不够,信息技术还处于比较落后的水平,因此,快速发展信息科学技术成为我国迫在眉睫的大事。

要使我国的信息技术更好地发展起来,需要科学工作者和工程技术人员付出艰辛的努力。此外,我们要从客观上为科学工作者和工程技术人员创造更有利于发展的环境,加强对信息技术的支持与投资力度,其中也包括与信息技术相关的图书出版工作。

从出版的角度考虑,除了较好较快地出版具有自主知识产权的成果外,引进国外的优秀出版物是大有裨益的。洋为中用,将国外的优秀著作引进到国内,促进最新的科技成就迅速转化为我们自己的智力成果,无疑是值得高度重视的。科学出版社引进一批国外知名出版社的优秀著作,使我国从事信息技术的广大科学工作者和工程技术人员能以较低的价格购买,对于推动我国信息技术领域的科研与教学是十分有益的事。

此次科学出版社在广泛征求专家意见的基础上,经过反复论证、仔细遴选,共引进了接近30本外版书,大体上可以分为两类,第一类是基础理论著作,第二类是工程应用方面的著作。所有的著作都涉及信息领域的最新成果,大多数是2005年后出版的,力求“层次高、内

容新、参考性强”。在内容和形式上都体现了科学出版社一贯奉行的严谨作风。

当然，这批书只能涵盖信息科学技术的一部分，所以这项工作还应该继续下去。对于一些读者面较广、观点新颖、国内缺乏的好书还应该翻译成中文出版，这有利于知识更好更快地传播。同时，我也希望广大读者提出好的建议，以改进和完善丛书的出版工作。

总之，我对科学出版社引进外版书这一举措表示热烈的支持，并盼望这一工作取得更大的成绩。

中国科学院院士
中国工程院院士
2006年12月

Preface

Cellular phones, especially those enabled by second-generation telecommunication systems, have had tremendous impacts on our daily lives. In some countries such as India, the number of cellular phone subscribers has far exceeded the number of wired phone subscribers. Meanwhile, the Internet has also significantly changed our daily lives. More and more e-commerce applications have been introduced while the number of Internet users has skyrocketed over the recent five years. The mobile workforce has also tremendously increased in size. Mobile workers expect to be able to use the Internet while on the move. However, the data handling capabilities of second-generation systems are limited. Thus, third-generation (3G) cellular systems such as UMTS (Universal Mobile Telecommunication Systems) and CDMA2000 (Code-Division Multiple Access) Systems are designed to provide high bit rate data services that enable multimedia communications. Such third-generation cellular systems allow high-quality images and video to be transmitted and received. The third-generation cellular systems also provide open-access capabilities where value-added services, e.g., location-based services, can be introduced by third-party providers. While the 3G standards are being drafted, and equipment for third-generation cellular systems is being designed, wireless LAN systems are introduced into our daily lives to meet our demand for wireless data services while on the move. This book describes the network architectures of UMTS and CDMA2000 systems and how major network elements within the 3G networks can be designed. In addition, this book provides discussions on how the end-to-end performance for voice and data services can be determined. It also provides guidelines on how the radio access networks and core networks can be engineered. Last but not least, this book describes the various wireless LAN standards and how voice and data services can be offered in wireless LAN systems.

The book is organized as follows: Chapter 1 provides an introduction to wireless communication concepts. It briefly discusses the first- and second-generation systems that are based on Frequency Division Multiple Access (FDMA) and Time Division Multiple Access (TDMA) technologies, and the spread spectrum-based communication systems. Then, it briefly discusses common techniques used in spread-spectrum communications, e.g., power control, soft handoff, adaptive modulation and coding, and multiuser diversity. Chapter 2 provides an introduction to wireless systems. It discusses generic wireless system architecture and how the system operates, e.g., the registration of mobile phones, how mobile phones initiate calls, how calls are delivered, what happens when mobile phone users move, and how intra/inter-system handoffs are carried out. Chapter 3 provides an introduction to traffic engineering issues. Service providers are interested in maximizing their revenue via offerings of high-value services while maintaining high utilization of their installed infrastructure. Thus, traffic engineering is required since different applications have different quality of service requirements. Traffic models for different applications need to be developed. Chapter 3 discusses techniques that one can use to determine the traffic models for different applications, e.g., WWW-browsing and emails. It also discusses the different parameters used to describe circuit-switched and packet-switched services. Chapter 4 describes the network architectures for UMTS and CDMA2000 systems. Chapter 5 analyzes the airlink interface capacity and performance for UMTS/CDMA2000 systems. Chapter 6 describes how the 3G base station can be designed to meet certain performance requirements. Chapter 7 describes how the 3G base station controller can be designed and how the radio access networks can be engineered. Techniques that can be used to reduce the OPEX of the radio access networks are also discussed. Chapter 8 describes how the core network elements can be designed. Chapter 9 describes the end-to-end performance of voice and data services in 3G systems. Chapter 10 provides a high-level description of the various 802.11-based wireless LAN systems. Chapter 11 describes the medium access control (MAC) and quality of service (QoS) features in 802.11-based wireless LAN systems. Chapter 12 discusses the upcoming 3G features.

This book is aimed at operators, network manufacturers, service providers, engineers, university students, and academicians who are interested in understanding how 3G and wireless LAN systems should be designed and engineered.

Mooi Choo Chuah
Qinqing Zhang

Acknowledgments

The authors would like to acknowledge many colleagues who are or were from Bell Laboratories, Lucent Technologies for their contributions to the research work done with the authors that are reported in this book. The authors would like to thank the anonymous reviewers and Dr. D. Wong from Malaysian University of Science and Technology for providing useful suggestions to improve the content and presentations in the book.

The authors would also like to thank Springer's supporting staff members for answering numerous questions during the book writing process.

We are extremely grateful to our families for their patience and support, especially during the late night and weekend writing sessions.

Special thanks are due to our employers, Lucent Technologies and Lehigh University, for supporting and encouraging such an effort. Specifically, the authors would like to thank Dr. Victor B. Lawrence, the former Vice President of Advanced Communications Technologies, for his support and encouragement during the initial phase of our book writing process. Special thanks are due to Lucent Technologies, IEEE, 3GPP for giving us permission to use diagrams and illustrations for which they own the copyrights.

The authors welcome any comments and suggestions for improvements or changes that could be implemented in forthcoming editions of this book. The email address for gathering such information is 3gbook@cse.lehigh.edu.

Mooi Choo Chuah
Qinqing Zhang

Author Biographies

Mooi Choo Chuah is currently an associate professor at Lehigh University. She received her B. Eng. with Honors from the University of Malaya, and MS and Ph.D. degrees in electrical engineering from the University of California, San Diego. She joined Bell Laboratories, Holmdel, New Jersey in 1991. She was promoted to be Distinguished Member of Technical Staff in 1999 and was made a technical manager in 2001. While at Bell Laboratories, she worked on wireless communications, IP/MPLS protocol designs, and has been a key technical contributor to various business units and product teams at Lucent. She has been awarded 34 patents and has 25 more pending. Her current research interests include heterogeneous network system and protocol design, network/computer system security, disruption tolerant networking, and ad-hoc/sensor network design.

Qinqing Zhang is a Member of Technical Staff at Bell Labs, Lucent Technologies. She received her B.S. and M.S.E. degrees in Electronics Engineering from Tsinghua University, Beijing, China, M.S. and Ph.D. degrees in Electrical Engineering from the University of Pennsylvania, Philadelphia. Since joining Bell Labs in 1998, she has been working on the design and performance analysis of wireline and wireless communication systems and networks, radio resource management, algorithms and protocol designs, and traffic engineering. She has been awarded 6 patents and has 14 patent applications pending. She is an adjunct assistant professor at the University of Pennsylvania. She is a senior member of IEEE. She serves on the editorial board of IEEE Transactions on Wireless Communications and technical program committees of various IEEE conferences.

Contents

Preface

Acknowledgments

Author Biographies

Chapter 1 INTRODUCTION TO WIRELESS COMMUNICATIONS 1

1. INTRODUCTION.....	1
1.1 Technology Evolution	1
1.1.1 Basic Principles	2
1.1.2 Multiple Access Technique	2
1.1.3 System Implementations	3
1.2 Techniques in Wireless Communications	6
1.2.1 Power Control.....	6
1.2.2 Soft Handoff.....	8
1.2.3 Adaptive Modulation and Coding	9
1.2.4 Space–Time Coding and Multiuser Diversity	10
1.3 Summary	10
1.4 References	11

Chapter 2 INTRODUCTION TO WIRELESS SYSTEMS..... 13

2. INTRODUCTION.....	13
2.1 Generic Wireless System Architecture	14
2.1.1 Registration and Call Initiation	15

2.1.2	Mobility Management	16
2.1.3	Call Delivery	16
2.1.4	Handoff.....	17
2.2	Traffic Routing in Wireless Networks	17
2.3	First- and Second-Generation Cellular Radio Network.....	18
2.4	Deficiencies of First- and Second-Generation Wireless Systems	20
2.5	Second-Generation Cellular Networks Offering Wireless Data Services.....	21
2.6	Third-Generation Wireless Networks and Wireless LANs.....	22
2.7	Transport Choices for Wireless Backhaul Networks	24
2.8	End-to-End Protocol Stack.....	28
2.8.1	Circuit Switched Service	28
2.8.2	Packet Data Service.....	29
2.9	RLC/MAC Functions	30
2.10	Review Exercises.....	35
2.11	References.....	36
Chapter 3 INTRODUCTION TO TRAFFIC ENGINEERING.....		39
3.	INTRODUCTION.....	39
3.1	QoS Requirements of Internet Applications	40
3.2	UMTS QoS Classes	41
3.2.1	Conversational Class	43
3.2.2	Streaming Class.....	43
3.2.3	Interactive Class	43
3.2.4	Background Class.....	44
3.3	QoS Engineering	44
3.4	Traffic Modeling	47
3.4.1	Traffic Model Framework	50
3.4.2	Methodology for Traffic Characterization	52
3.5	Review Exercises	59
3.6	References.....	59
Chapter 4 OVERVIEW OF CDMA2000/UMTS ARCHITECTURE.....		61
4.	INTRODUCTION.....	61
4.1	Evolution of CDMA2000 Standards.....	62
4.2	Overview of CDMA2000 3G1x Network Architecture	63
4.3	Overview of CDMA2000 1xEV-DO Network	

Architecture.....	66
4.4 Overview of 3GPP Standards Evolution.....	67
4.5 Overview of UMTS R99/4 Network Architecture.....	68
4.5.1 UTRAN Components.....	70
4.5.2 General Protocol Model for UTRAN Terrestrial Interfaces.....	72
4.5.3 Core Network Components.....	80
4.5.4 General Protocol Model for CN Interfaces.....	83
4.6 Mobility Management.....	84
4.6.1 Circuit-Switched Services.....	85
4.6.2 Packet Services.....	86
4.7 Review Exercises.....	88
4.8 References.....	89

Chapter 5 AIR INTERFACE PERFORMANCE AND CAPACITY ANALYSIS.....91

5. CAPACITY ANALYSIS AND EVALUATION.....	91
5.1 Queuing Analysis in a Wireless Communication System.....	91
5.1.1 Call Arrival Process.....	91
5.1.2 Birth–Death Process.....	93
5.1.3 Lost Call Cleared and Lost Call Held.....	94
5.2 Erlang Capacity for Circuit-Switched Services.....	96
5.2.1 Capacity Analysis on Reverse Link.....	96
5.2.2 Capacity Analysis on Forward Link.....	105
5.3 Capacity for Packet Switched Services.....	111
5.4 Simulation Methodologies for Capacity Evaluation.....	112
5.4.1 System Level Simulation Assumptions for Forward Link.....	112
5.4.2 System Level Simulation Assumptions for Reverse Link.....	115
5.4.3 Performance Criteria and Output Metrics.....	118
5.5 Comparison of Analytical Models with Simulations.....	119
5.5.1 Comparison of Analytical and Simulation Results on Reverse Link.....	120
5.5.2 Comparison of Analytical and Simulation Results on Forward Link.....	124
5.6 Review Exercises.....	127
5.7 References.....	127

Chapter 6 DESIGN AND TRAFFIC ENGINEERING OF A BASE STATION.....	129
6. BASE STATION DESIGN.....	129
6.1 UMTS Base Station Design.....	130
6.1.1 CPU Budget for Various Component Cards in NodeB ..	130
6.1.2 Iub Interface Capacity	141
6.2 Capacity Evaluation and Resource Management of 1xEV-DO Base Stations	148
6.2.1 1xEV-DO Base Station Architecture.....	148
6.2.2 Processor Occupancy Analysis.....	149
6.2.3 Processor Performance Enhancements.....	155
6.3 Review Exercises	158
6.4 References.....	158
Chapter 7 RNC AND RADIO ACCESS NETWORKS DESIGN AND TRAFFIC ENGINEERING	159
7. INTRODUCTION.....	159
7.1 RNC Design.....	159
7.1.1 Overview of Generic RNC Hardware Architecture	160
7.1.2 RNC Capacity.....	160
7.1.3 Traffic Model Revisited	162
7.1.4 Impacts of RAB Inactivity Timer Value on Signaling Traffic and Power Consumption	172
7.1.5 Radio Resource Management.....	174
7.2 Techniques for Improving OPEX/CAPEX of UMTS RAN.....	181
7.3 Review Exercises	188
7.4 References.....	189
Chapter 8 CORE NETWORK DESIGN AND TRAFFIC ENGINEERING	191
8. INTRODUCTION.....	191
8.1 Registering and Activating the Circuit/Packet Switched Service	192
8.1.1 Routing Area Update.....	194
8.1.2 Activating a Packet Data Session	195
8.1.3 Receiving a CS Domain Call.....	196
8.2 SGSN	196
8.3 GGSN.....	200
8.4 GPRS/UMTS GTP Tunnel.....	200