

移动通信前沿技术丛书

CDMA

网络规划与优化(英文版)

CDMA Network Planning and Optimization

中兴通讯《CDMA网络规划与优化》编写组 编著

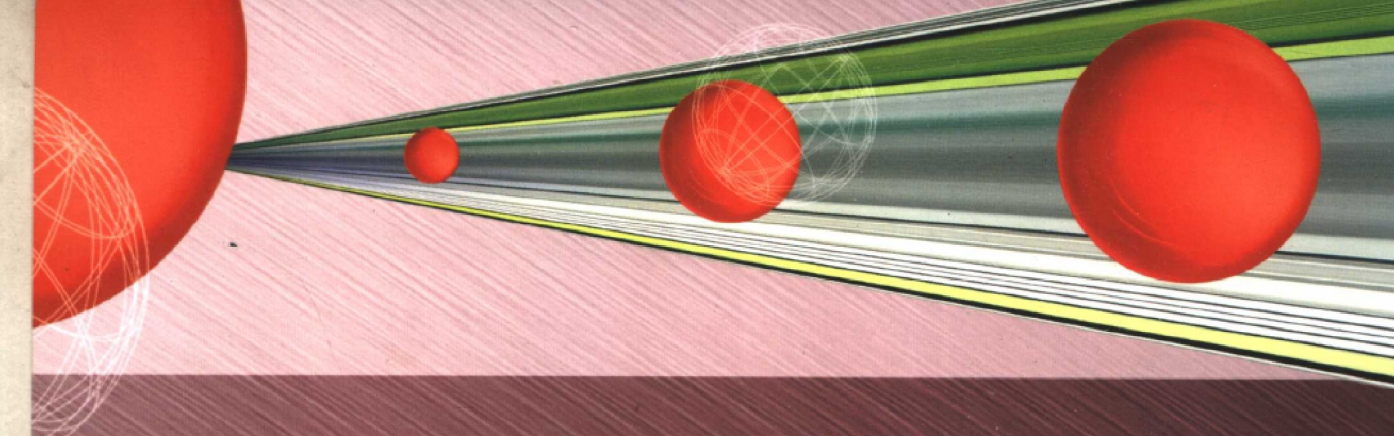
Editing Team of CDMA Network Planning and Optimization, ZTE Corporation



电子工业出版社

PUBLISHING HOUSE OF ELECTRONICS INDUSTRY

<http://www.phei.com.cn>



Beginning from fundamentals of the wireless communications technology and then introducing CDMA basic theories, procedures of CDMA network planning and optimization, the effect of the interference to wireless communications networks, and so on, this book presents readers a complete knowledge system about CDMA network planning and optimization. The contents of this book mainly include: fundamentals of cellular mobile communications, introduction to CDMA technology, CDMA network planning, special topics on CDMA network planning, CDMA network optimization, special topics on CDMA network optimization, CDMA network simulation, interference, and introduction to ZTE's ZXPOS series software tools for network planning and optimization.

This book contains rich information on CDMA network planning and optimization, with plenty of practical cases, tables, figures and pictures for clear explanation and easy reading.

This book can be referred to by CDMA network planning and optimization engineers, it can also serve as the reference for the professionals working in related fields.



责任编辑：奚昊

责任美编：孙焱津



本书贴有激光防伪标志，凡没有防伪标志者，属盗版图书。

ISBN 978-7-121-04115-0



9 787121 041150 >

定价：69.00 元

移动通信前沿技术丛书

CDMA 网络规划与优化

(英文版)

CDMA Network Planning and Optimization

中兴通讯《CDMA 网络规划与优化》编写组 编著

Editing Team of *CDMA Network Planning and Optimization*, ZTE Corporation

電子工業出版社

Publishing House of Electronics Industry

北京 • BEIJING

内 容 简 介

Beginning from fundamentals of the wireless communications technology and then introducing CDMA basic theories, procedures of CDMA network planning and optimization, the effect of the interference to wireless communications networks, and so on, this book presents readers a complete knowledge system about CDMA network planning and optimization. The contents of this book mainly include: fundamentals of cellular mobile communications, introduction to CDMA technology, CDMA network planning, special topics on CDMA network planning, CDMA network optimization, special topics on CDMA network optimization, CDMA network simulation, interference, and introduction to ZTE's ZXPOS series software tools for network planning and optimization.

This book contains rich information on CDMA network planning and optimization, with plenty of practical cases, tables, figures and pictures for clear explanation and easy reading.

This book can be referred to by CDMA network planning and optimization engineers, it can also serve as the reference for the professionals working in related fields.

Copyright © 2007 by Publishing House of Electronics Industry.

No part of this publication may be reproduced or distributed in any means, or stored in a database or retrieval system, without the prior written permission of the publisher.

未经许可, 不得以任何方式复制或抄袭本书之部分或全部内容。

版权所有, 侵权必究。

图书在版编目(CIP)数据

CDMA 网络规划与优化(英文版)/中兴通讯《CDMA 网络规划与优化》编写组/编著. —北京: 电子工业出版社, 2007.4

(移动通信前沿技术丛书)

ISBN 978-7-121-04115-0

I. C… II. 中… III. 码分多址—宽带通信系统—英文 IV. TN929.533

中国版本图书馆 CIP 数据核字(2007)第 038793 号

责任编辑: 窦 昊

印 刷: 北京市顺义兴华印刷厂

装 订: 三河市双峰印刷装订有限公司

出版发行: 电子工业出版社

北京市海淀区万寿路 173 信箱 邮编 100036

开 本: 787×980 1/16 印张: 21.5 字数: 481.6 千字

印 次: 2007 年 4 月第 1 次印刷

定 价: 69.00 元

凡所购买电子工业出版社图书有缺损问题, 请向购买书店调换。若书店售缺, 请与本社发行部联系, 联系及邮购电话: (010) 88254888。

质量投诉请发邮件至 zltz@phei.com.cn, 盗版侵权举报请发邮件至 dbqq@phei.com.cn。

服务热线: (010) 88258888。

Preface 1

It is commonly known that the development of the modern telecommunications technology is unimaginable. As one of the greatest technical achievements in the 20th century, it continues to evolve to the third generation (3G) technology at a solid pace at the very beginning of the new 21st century. With the advantages such as sufficient system capacity and high-quality multimedia services, the third generation mobile telecommunications is becoming the objective pursued by almost all major mobile operators and telecommunications equipment suppliers around the globe.

With the rapid growth of the telecommunications technology, the planning and optimization of the mobile networks has gradually become one of the most important research focuses in the telecommunications field. Being one of the largest and most famous telecommunications equipment providers in China, ZTE Corporation has been engaged in the research and practice in mobile network planning and optimization for many years. Particularly since the year 2001 when the world's largest commercial CDMA network launched by China Unicom, hundreds of ZTE's engineers who are involved in the design, research & development and test participated in the planning and optimization of this large-scale CDMA network in China. During the few years since then, the engineers from ZTE have served for more than several tens of countries around the world. With their outstanding professional skills in CDMA network planning and optimization, they delivered the people in those countries high-quality mobile telecommunications services.

"Let wireless communication extremely smooth", just such faith makes these intelligent and passionate young technical experts constantly accumulate and summary the knowledge and experiences and keep track with the latest development trend in CDMA network planning and optimization, and write this *CDMA Network Planning and Optimization*. We hope that the publication of this book can contribute to show the readers a more splendid and attractive picture of the fastest-growing mobile telecommunications technology.

Xie Daxiong
Senior Vice President of ZTE Corporation
January 2007

Preface 2

In the past several decades, the mobile telecommunications underwent very fast growth and wide application. In China, by June 2006, the number of mobile subscribers has reached 430 million. From the year 2001 to now, China Unicom has built the largest CDMA network in the world, and China has become the world's largest mobile telecommunications market. With extensive and deep application of mobile networks, the issues concerned by the mobile operators and equipment suppliers have transferred from the scale of the networks to the network performance optimization, that is, how to further improve the network performance over the existing spectrum and infrastructure in order to provide better services to the customers.

During the network building process, network planning is an essential step. A reasonably planned network can achieve the coverage to the maximum extent, and meanwhile minimize the system equipment units and capital costs under satisfying the requirements of system capacity and service quality. With the change of network structure, radio environment, subscriber distribution and habits in which subscribers enjoy services, the network needs to be optimized in time by constantly monitoring network performance and comprehensively analyzing the collected test data, OMC data and subscribers' complaints to eliminate network problems and obtain the best network performance and perfect the service quality.

The author team of this book consists of professional engineers of ZTE Corporation all of whom have been engaged in CDMA network planning and optimization for many years and have a deep understanding on this field. In this book, a plenty of practical cases related to the CDMA network planning and optimization are presented and deeply analyzed. Particularly, for some network environments with special coverage requirements, we offer our effective and flexible solutions.

Beginning with the fundamentals of the wireless communications technology and then introducing the CDMA basic theories, procedures of CDMA network planning and optimization, the effect of the interference to the mobile communications network, etc., this book present the readers a complete knowledge system about the CDMA network planning and optimization process. The following is a synopsis of the subjects covered in each chapter.

- **Chapter 1.** Fundamentals of mobile cellular telecommunications systems, mainly including the evolution of mobile telecommunications technology, the basic theory

about radio wave propagation, capacity theory, and basic knowledge about antennas used in mobile telecommunications systems.

- **Chapter 2.** The basic theory about spread spectrum. Some key techniques used by CDMA systems are introduced including power control, soft handoff, diversity technique and multi-user detection. The structure of various channels in CDMA2000 1X and CDMA2000 1xEV-DO systems are also introduced in this chapter.
- **Chapter 3.** Present the complete procedures of network design which includes network topology design, site location and antenna selection, PN planning, networking with different equipment units, etc.
- **Chapter 4.** Introduce two common scenarios in network planning: repeaters and indoor distribution systems. Discuss the major influencing factors in multi-sector networking and multi-carrier networking. Provide feasible solutions for several special network environments such as for ultra-far distance coverage, dense residential areas coverage, high-rise building coverage, crossroad coverage and emergency communication.
- **Chapter 5.** Present the optimization procedures and detailed contents in each stage of network building process. Introduce the types of data required by network optimization and data collecting methods, as well as the methods of exploring valuable information from collected data to locate network problems. These analysis methods are not independent, instead, in practical applications, they are often combined for searching out the origins of the network problems.
- **Chapter 6.** Deal with the commonly seen problems during network operation such as dropped calls, difficult accessing, poor voice quality, and low data transmission rate. Discuss the reasons of these problems and present processing proposals by describing practical cases.
- **Chapter 7.** Introduce the network simulation and its roles and applications in network planning and optimization.
- **Chapter 8.** Analyze the interference, a key factor in wireless networks. Discuss the classification of the interference, and the effect that interference exerts on network coverage and capacity. Offer the troubleshooting methods on external interference together with introducing some practical cases and listing common external interference.
- **Chapter 9.** Introduce the ZXPOS series software tools for network planning and optimization which are designed by ZTE Corporation itself. This series software tools include ZXPOS CNP1, ZXPOS CNT1, ZXPOS CNA1 and ZXPOS CNO1. This

chapter introduces their respective features and major functions.

Appendix introduces two typical ZTE CDMA BTS products, and the development and achievements of CDMA network planning and optimization services ZTE Corporation in recent years.

The materials in this book are extracted from the network planning and optimization practice of ZTE's CDMA network planning and optimization team. It is the wisdom summary of practical experiences of the network planning and optimization engineers of ZTE Corporation and China Unicom. We hope it can provide useful reference to the professionals associated with CDMA network planning and optimization.

This book was written by the author team of CDMA Research Institute of ZTE Corporation. The whole work was edited by Xie Daxiong and Zhang Xudong. Among the chapters of the Chinese edition, Chai Wenye wrote the chapters 1 and 7, Jiang Minggang and Wang Peng wrote the chapters 2, 3 and 4, Su Xingming and Wu Yun wrote the chapters 5, 6 and 8, and Li Wei and Yu Shengbing wrote the chapter 9. In addition, Yan Han, Yang Tao, Zhang Xifeng, Zhao Ping, Chen Jian, Duan Xueping, Li Sheng, Zhang Sanxi, Pan Guodong, Ye Renzhao and Zhang Zhenhua also participated in the writing on some contents of the book. Dong Wenbin revised the entire book of Chinese edition.

Dong Wenbin, Ma Yue, Chen Jian, Li Bin, Zheng Jianfeng, Su Xingming, Pan Chunjin, Wei Anfeng, Wu Wei, Lin Shengzhou, Wu Lianhao, Zhang Lijie, Wang Butang, Xue Ao, Li Sheng, Ma Huiyu, Wu Feng, Wu Yun, Liu Wei, Li Wei, Chen Jun, Fu Xinbo, Sun Jiyong, Wang Lei, Muhammad Abbas Ali Khan and Muhammad Umair Yasir took part in the revising of the English edition of this book, and Fan Yufei revised the entire book of English edition.

During the production of this book, we cited some documents that have been published publicly or unpublished yet written by the ZTE's and China Unicom's CDMA network planning and optimization engineers, in here we acknowledge the authors of these references. We also would like to thank Ph. D. Zhao Xianming, Ph. D. Pang Shengqing, Ph. D. Lu Kexue, Ph. D. Wu Yanwei, and experts of Mr. Xu Xinyong, Mr. Xu Ming and Mr. Wang Yaping, without their great assistance, this book would not have been completed smoothly.

Contents

1	Fundamentals of Cellular Mobile Communications	1
1.1	Evolution of Cellular Mobile Communications Technology	1
1.2	Concept of Cellular Network	3
1.2.1	Common and Cellular Communications Systems	4
1.2.2	Cell Characteristics	4
1.2.3	Cell Classification	6
1.3	Radio Propagation Basics	8
1.3.1	Large-scale Fading and Small-scale Fading	9
1.3.2	Propagation Mechanisms	9
1.3.3	Free Space Propagation and Line-of-sight Propagation	15
1.3.4	Path Loss Prediction Theory	18
1.4	Radio Propagation Models	20
1.4.1	Macro Cell Propagation Model	21
1.4.2	Micro Cell Propagation Model	25
1.4.3	Indoor Propagation Models	27
1.5	Antennas in Cellular Mobile Communications Systems	30
1.5.1	Major Antenna Parameters	31
1.5.2	Base Station Antennas	38
1.5.3	Mobile Terminal Antennas	42
1.5.4	Antenna Diversity	43
1.6	References	49
2	Introduction to CDMA Technology	50
2.1	Evolution of CDMA Technology	50
2.2	Spread Spectrum System	51
2.2.1	Fundamentals	51
2.2.2	Major Performance Indexes	52
2.2.3	Mechanism	53
2.2.4	Modulation Modes	53
2.2.5	Features of Spread Spectrum Communication	55
2.3	Key Techniques in CDMA	56

2.3.1	Power Control	56
2.3.2	Soft Handoff	60
2.3.3	Diversity	63
2.3.4	Multi-User Detection (MUD)	66
2.4	CDMA System Channel Structure	68
2.4.1	Channel Structure in CDMA2000 1X	68
2.4.2	Channel Structure in EV-DO	74
2.5	CDMA Spread Spectrum Sequence	77
2.5.1	Walsh Code	77
2.5.2	Pseudorandom Noise Sequence	78
2.6	References	79
3	CDMA Network Planning	80
3.1	Network Planning Flow	80
3.1.1	Requirements and Basic Information Collection	81
3.1.2	Available Site Survey	81
3.1.3	Field Strength Test and Spectrum Scanning	82
3.1.4	Network Topology Design	83
3.1.5	Planned Site Survey and Validation	83
3.1.6	RF Parameters Setting	84
3.2	Coverage Planning	84
3.2.1	Coverage of the CDMA System	84
3.2.2	Coverage Planning Procedures	89
3.2.3	Comparison of Coverage between GSM and CDMA Systems	89
3.3	Capacity Planning	90
3.3.1	Capacity Prediction	90
3.3.2	Traffic Model	92
3.3.3	Capacity Calculation in CDMA2000 1X System	95
3.3.4	Capacity Planning Process	101
3.4	Network Topology Design	103
3.5	Selection of Networking Elements	105
3.5.1	Macro BTS	105
3.5.2	Micro BTS	106
3.5.3	Remote Radio Unit (RRU)	106
3.5.4	Repeater	107

3.5.5	Indoor Distribution System	108
3.6	Practical Experiences in Engineering	109
3.6.1	Experiences in Site Location Selection	109
3.6.2	Experiences in Antenna Selection	112
3.6.3	Key RF Parameters to be Set	119
3.7	References	124
4	Special Topics on CDMA Network Planning	125
4.1	Repeater Planning and Design	125
4.1.1	Overview of the Repeater	125
4.1.2	Mechanism of the Repeater	127
4.1.3	Repeater Networking Planning	127
4.1.4	Parameters Adjustment after Repeater Introduction	142
4.2	Design of Indoor Distribution System	147
4.2.1	Application Environments	147
4.2.2	Introduction of Signals	149
4.2.3	Allocation of Indoor Signals	152
4.2.4	Designing Process	155
4.2.5	Objectives of Indoor Distribution System Design	158
4.3	Multi-sector Networking	159
4.3.1	Analysis of Six-sector Networking Coverage	159
4.3.2	Influence of Six-sector Networking on System Capacity	166
4.3.3	Antenna Selection in Multi-sector Networking	168
4.3.4	Hybrid Networking of Six-sector and Three-sector Cells	170
4.4	Solutions to Special Coverage Requirements	171
4.4.1	Solution to Ultra-far Distance Coverage	171
4.4.2	Solution to Dense Residential Areas Coverage	176
4.4.3	Solution to High-rise Building Coverage	179
4.4.4	Solution to Crossroad Coverage	182
4.4.5	Solution to Emergency Communication	184
4.5	Solutions to Multi-carrier Networks	193
4.5.1	Dual-carrier Networking	193
4.5.2	Handoff Solutions for Dual-carrier Networks	194
4.5.3	Parameter Setting in Dual-carrier Network	197
4.6	References	199

5	CDMA Network Optimization	200
5.1	Overview	200
5.2	Network Optimization Contents	200
5.2.1	RF Optimization	201
5.2.2	Maintenance Optimization	203
5.3	Data Sources of Network Optimization	206
5.3.1	DT Data	206
5.3.2	CQT Data	207
5.3.3	OMC Data	207
5.4	Analysis Methods on Network Optimization Data	214
5.4.1	Definition	214
5.4.2	Brief Introduction to Common Analysis Methods	214
5.4.3	Application of Data Analysis Methods	215
6	Special Topics on CDMA Network Optimization	219
6.1	Mobile Terminal Access Problems	219
6.1.1	Mechanisms of Access Problems	219
6.1.2	Practical Cases	223
6.1.3	Recommended Dealing Procedures on Terminal Access Problems	229
6.2	Voice Quality Problems	230
6.2.1	Monolog	230
6.2.2	Intermittent Voice	232
6.2.3	Cross-talking	233
6.2.4	Echo	234
6.2.5	Recommended Processing Procedures on Voice Quality Problems	236
6.3	Call Drop Problems	236
6.3.1	Mechanism of Dropped Calls	236
6.3.2	Causes and Cases	237
6.3.3	Recommended Processing Procedures on Call Drop Problems	244
6.4	Data Service Problems	245
6.4.1	Characteristics of Data Service Optimization	245
6.4.2	Low Data Rate on Forward Application Layer	246
6.4.3	Low Data Rate on Reverse Application Layer	248
6.4.4	Recommended Processing Procedures on Low Forward/Reverse Data Rate Problems	250
6.5	References	250

7	CDMA Network Simulation	251
7.1	Overview	251
7.2	Fundamentals	252
7.3	Propagation Model Calibration	258
7.3.1	Data Collection	258
7.3.2	Data Processing	260
7.3.3	Data Analysis	260
7.3.4	Assessment Precision	261
7.4	Wireless Network Simulation Flow	262
7.4.1	Data Preparation	263
7.4.2	Path Loss Prediction	264
7.4.3	Traffic Distribution Creation	264
7.4.4	Wireless Network Simulation Analysis	264
7.4.5	Outputting Network Simulation Design Report	266
7.5	Quality Assessment on Wireless Network Simulation Design	267
7.5.1	Acquiring Network Performance Data	268
7.5.2	Comparison Analysis	268
7.5.3	Deduction on Network Simulation Quality	269
7.6	Simulation in Network Planning and Optimization	271
7.6.1	Network Topology Design	271
7.6.2	PN Planning	273
7.6.3	Neighbor Cell Planning	276
7.6.4	Network KPI Prediction	279
7.6.5	Pilot Pollution and Overshooting	280
7.6.6	Capacity Expansion and Coverage Issue	283
7.7	References	283
8	Interference	284
8.1	Interference Classification	284
8.1.1	External Interference to CDMA System	285
8.1.2	Internal Interference to CDMA System	286
8.2	Effect of Interference on Network Coverage	291
8.2.1	Equivalent Calculation of External Interference	292
8.2.2	Calculation of the Equivalent Noise Figure	292
8.2.3	Effect of Noise Figure Increase on Coverage Radius and Area	293
8.2.4	Effect of Equivalent External Interference on Coverage Radius and Area	295

8.3	Effect of Interference on System Capacity	295
8.3.1	Capacity under no External Interference	296
8.3.2	Capacity under with External Interference	298
8.3.3	Supplementary Explanations	301
8.4	Inter-system Interference Analysis	301
8.4.1	Mathematical Model for Mutual Interference Calculation	301
8.4.2	Interference on CDMA and GSM Networks	305
8.4.3	Mutual Interference between CDMA and Other Systems	307
8.5	Interference Troubleshooting	308
9	Introduction to ZTE's ZXPOS Series Software Tools for Network Planning and Optimization	311
9.1	Overview	311
9.2	Members of ZXPOS Series Software Tools	313
9.2.1	ZXPOS CNP1	313
9.2.2	ZXPOS CNT1	315
9.2.3	ZXPOS CNA1	317
9.2.4	ZXPOS CNO1	319
9.3	Services on ZXPOS Provided by ZTE	320
	Appendix Introduction to ZTE Typical CDMA BTS Products and CDMA Network Planning and Optimization Services	322
	Appendix A Two Typilal ZTE'S BTS Products	322
A.1	ZTE All-IP CDMA2000 BTS Series: Compact BTS	322
A.2	All-IP CDMA2000 BTS Series: Micro BTS (EV-DO Rev A Technology Offerings)	324
	Appendix B ZTE's CDMA Network Planning and Optimization Services	326
B.1	Overview	326
B.2	Development of ZTE's CDMA Network Planning and Optimization Services	327
B.3	Research Achievements and Project Management in CDMA Network Planning and Optimization Field	329
B.3.1	Research Achievements	329
B.3.2	Technical Knowledge Accumulation	329
B.3.3	Internal Journal	329
B.3.4	External Publication	330
B.3.5	Project Management	330

Fundamentals of Cellular Mobile Communications

1.1 Evolution of Cellular Mobile Communications Technology

The modern mobile communications technology emerged in the 1920s and until now it has gone through six stages.

The first stage was from 1920s to 1940s, which was marked by the application of early dedicated mobile communications system.

The second stage was from the middle 1940s to early 1960s when the initial public mobile communications system was applied. During this period, the mobile communications technology gradually entered the public communications areas. The mobile communications system adopted the manual connection mode and had a limited network capacity.

The third stage was experienced from the middle 1960s to middle 1970s when the United States developed the Improved Mobile Telephone System (IMTS), and Germany promoted the B network. The mobile communications system adopted the common base stations and the network capacity was greatly increased.

The fourth stage was from the middle 1970s through middle 1980s. In this stage, the cellular mobile communications technology received wide application. The system used the analog technology. During this period, Bell Labs (United States) developed the first generation (1G) cellular mobile communications system known as Advanced Mobile Phone System (AMPS). And North Europe, including Denmark, Norway, Sweden, Finland and U.K developed Nordic Mobile Telephone System (NMTS) and Total Access Communication System (TACS).

The fifth stage was from the middle 1980s to early 21st century. During this period, the digital mobile telecommunications systems were popularly applied, and the representative technologies were the GSM of Europe and CDMA of the United States, which were commonly mentioned as the second generation (2G) mobile communications technology. Compared with the analog cellular networks, digital cellular networks remarkably improve the spectrum utilization and system capacity.

The mobile telecommunications systems in this stage were capable of supporting diverse data services, hence making the service types greatly enriched.

The sixth stage began from the later 1990s and its representative technology was the third generation mobile telecommunications (3G). On the 18th session of ITU TG8/1 held in Helsinki, Finland on Nov.5, 1999, it was determined that five kinds of technologies belonging to three categories (TDMA, CDMA-FDD and CDMA-TDD) would be taken as the basis of the 3G mobile communications, among which WCDMA, CDMA2000 and TD-SCDMA are the three mainstreams of 3G standards. Currently, WCDMA and CDMA2000 have been put into commercial applications in some areas of the world. In this stage, the system capacity and spectral utilization were greatly improved, and the 3G mobile communications technology can provide high-speed data service as well as other enhanced services.

Table 1-1 shows the comparison of the three 3G mainstream standards.

Table 1-1 Comparison of Three 3G Mainstream Standards

Item	WCDMA	CDMA 2000	TD-SCDMA
Reuse mode	FDD	FDD/TDD	TDD
Basic bandwidth	5 MHz	1.25 MHz or 3.75 MHz	1.6 MHz
Chip rate	3.84 Mchip/s	1.2288/3.6864 Mchip/s	1.28 Mchip/s
Radio frame length	10 ms	10/5 ms	10 ms (Each 10-ms radio frame contains two 5-ms sub-frames.)
Channel encoding	Convolutional coding, Turbo code, etc.	Convolutional coding, Turbo code, etc.	Convolutional coding, Turbo code, etc.
Data modulation	QPSK (downlink), HPSK (uplink)	QPSK (downlink), BPSK (uplink)	QPSK and 8PSK
Spectrum spreading mode	QPSK	QPSK	QPSK
Power control	Open loop + closed loop. The control step length is 1dB, 2 dB or 3 dB	Open loop + closed loop. The control step length is 1 dB. 0.5/0.25 dB can also be selected	Open loop + closed loop. The control step length is 1dB, 2 dB or 3 dB
Synchronization relationship among BTSs	Synchronization or non-synchronization	GPS synchronization	Synchronization
Core network	GSM-MAP	ASNI-41	GSM-MAP

Note: The rate of 1 Mchip/s indicates that 1 M chips are transmitted per second.

In China, the research and application of mobile communications began relatively late, but it has been developing very quickly. China started to build its cellular mobile communications network in 1980s. In 1987, the first TACS analog mobile communications system was accomplished in Guangdong Province. Until 1990, the analog mobile communications networks had been established in 10 Chinese cities with subscribers reaching 20 thousand. In 1994, the China Ministry of Posts and Telecommunications decided to introduce the GSM technology, which speeded up the application of

mobile telecommunications technology in China. In 2001, China Unicom set to build CDMA networks, which made it a reality that both of the two 2G mainstream technologies had gone into commercial use in China. From 2002, the GSM and CDMA networks were gradually upgraded to 2.5G GPRS and CDMA2000 1X respectively. During the decade of 1987 to 1997, the mobile subscribers in China reached 10 million. In March 2001, this number reached 100 million. Until May 2004, this number exceeded over 300 million, with the penetration more than 20%. Among those subscribers, over 190 million belonged to the China Mobile and they were all GSM subscribers; China Unicom had over 100 million subscribers, among which about 80 million were GSM subscribers and more than 20 million were CDMA users.

With the coming of commercial use of 3G technology, China Ministry of Information Industry makes allocations on the available frequency bands adopted by various technical standards. The detailed allocation information is shown in Figure 1-1.

Technical mode	Frequency Range/MHz	Frequency														
		1880	1900	1920	1940	1960	1980	2000	2020	2040	2060	2080	2100	2120	2140	2160
Frequency division duplex	1920~1980 2110~2170															
Time division duplex	1880~1920 2010~2025															

(a) The Allocation of Main Frequency Bands for 3G Mobile Communication Systems

Technical mode	Frequency Range/MHz	Frequency														
		1760	1780	1800	1820	1840	1860	1880		2280	2300	2320	2340	2360	2380	2400
Frequency division duplex	1755~1785 1850~1880															
Time division duplex	2300~2400															

(b) The Allocation of Supplemental Frequency Bands for 3G Mobile Communications Systems

Figure 1-1 Frequency Band Allocation for 3G Mobile Communications Systems in China

1.2 Concept of Cellular Network

The early mobile communications technology was on the basis of common base stations. Because common base stations cannot reuse frequency, with the increasing popularity of the mobile communications technology, original systems began to fail to meet the requirement of increasing capacity.

To avoid the scarcity of frequency resource caused by the common base station mode, the specialists in the Bell laboratory began to employ the cellular concept in the mobile communications industry and proposed the concept of cellular mobile communications. Based on this concept, they set up an experimental cellular system. The original cellular system only consisted of one base station and multiple mobile terminals.

By rearranging the coverage area of radio communications system, the cellular system makes