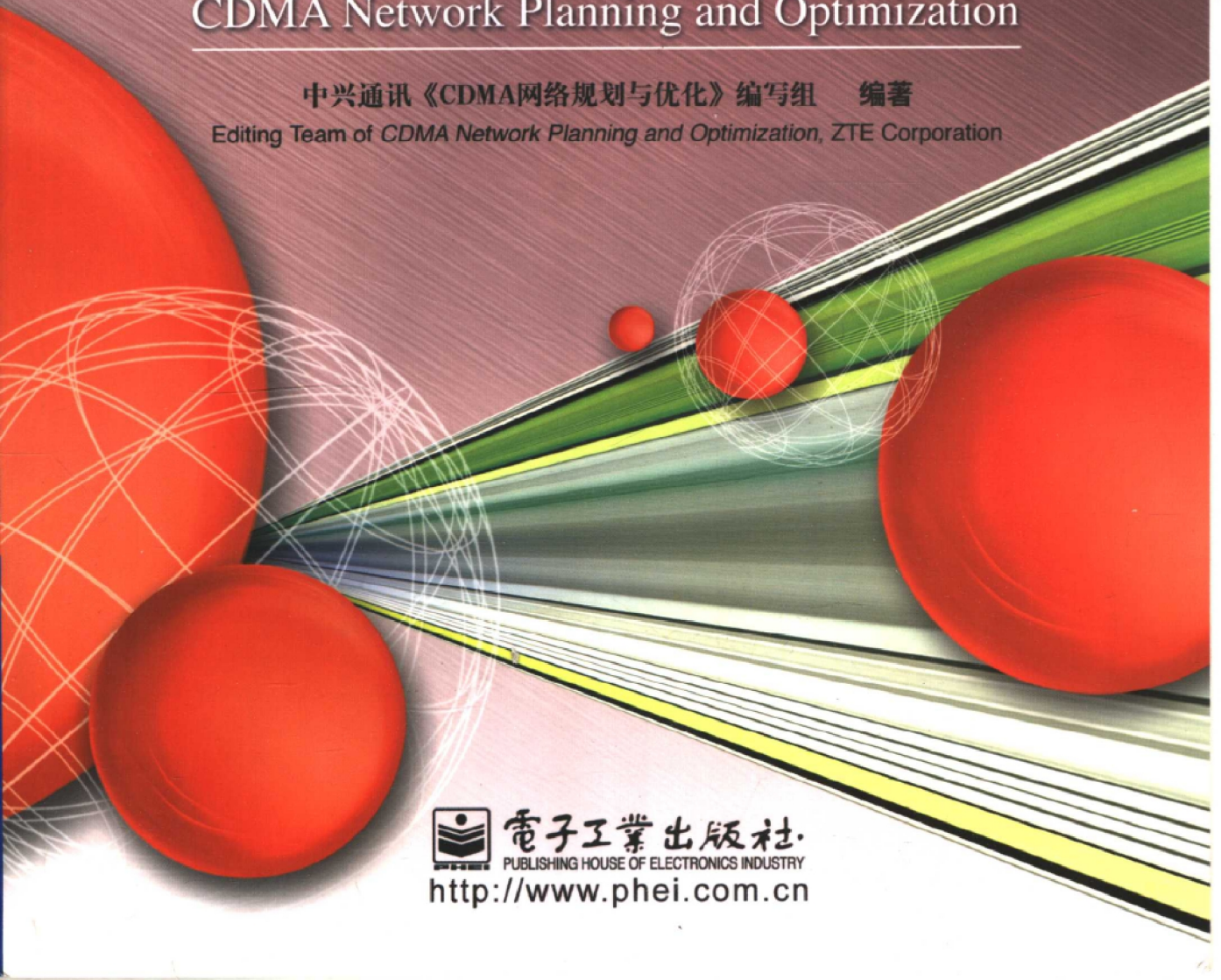
移动通信前沿技术丛书

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



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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.

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内 容 简 介

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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 inference 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

CHAPTER 1

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