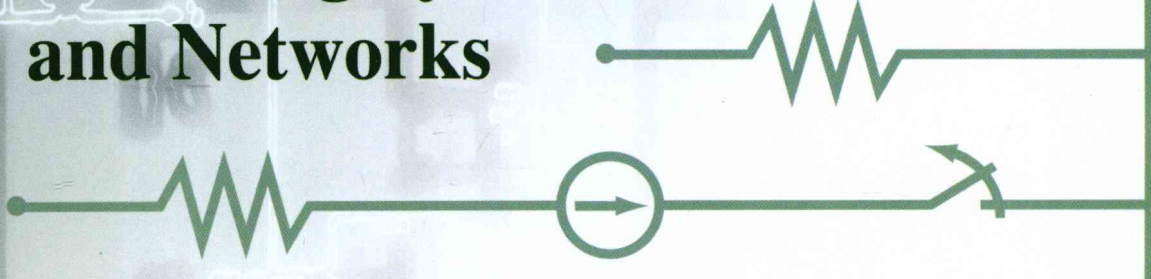
国外电子与通信教材系列

英文版

现代电信交换与网络

Telecommunication Switching Systems and Networks



[印] Thiagarajan Viswanathan 著

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Publishing House of Electronics Industry
北京 · BEIJING

内容简介

本书全面介绍了电信交换与网络的基本内容。全书分为13章，内容涉及基础知识、史特鲁乔式交换系统、纵横制交换、电子空分交换、语音数码化和传输、时分交换、光纤系统、流量管理、电话网络、数据网络、集成服务与数字网络（ISDN）、异步传输模式（ATM）、软交换以及下一代网络等，是一本关于电信交换技术与网络的全景式总结。

全书语言简洁，图形及示例清楚，可作为高校电信交换与网络课程的双语教材，也可作为相关人员的参考用书。

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序

2001年7月间，电子工业出版社的领导同志邀请各高校十几位通信领域方面的老师，商量引进国外教材问题。与会同志对出版社提出的计划十分赞同，大家认为，这对我国通信事业、特别是对高等院校通信学科的教学工作会很有好处。

教材建设是高校教学建设的主要内容之一。编写、出版一本好的教材，意味着开设了一门好的课程，甚至可能预示着一个崭新学科的诞生。20世纪40年代MIT林肯实验室出版的一套28本雷达丛书，对近代电子学科、特别是对雷达技术的推动作用，就是一个很好的例子。

我国领导部门对教材建设一直非常重视。20世纪80年代，在原教委教材编审委员会的领导下，汇集了高等院校几百位富有教学经验的专家，编写、出版了一大批教材；很多院校还根据学校的特点和需要，陆续编写了大量的讲义和参考书。这些教材对高校的教学工作发挥了极好的作用。近年来，随着教学改革不断深入和科学技术的飞速进步，有的教材内容已比较陈旧、落后，难以适应教学的要求，特别是在电子学和通信技术发展神速、可以讲是日新月异的今天，如何适应这种情况，更是一个必须认真考虑的问题。解决这个问题，除了依靠高校的老师和专家撰写新的符合要求的教科书外，引进和出版一些国外优秀电子与通信教材，尤其是有选择地引进一批英文原版教材，是会有好处的。

一年多来，电子工业出版社为此做了很多工作。他们成立了一个“国外电子与通信教材系列”项目组，选派了富有经验的业务骨干负责有关工作，收集了230余种通信教材和参考书的详细资料，调来了100余种原版教材样书，依靠由20余位专家组成的出版委员会，从中精选了40多种，内容丰富，覆盖了电路理论与应用、信号与系统、数字信号处理、微电子、通信系统、电磁场与微波等方面，既可作为通信专业本科生和研究生的教学用书，也可作为有关专业人员的参考材料。此外，这批教材，有的翻译为中文，还有部分教材直接影印出版，以供教师用英语直接授课。希望这些教材的引进和出版对高校通信教学和教材改革能起一定作用。

在这里，我还要感谢参加工作的各位教授、专家、老师与参加翻译、编辑和出版的同志们。各位专家认真负责、严谨细致、不辞辛劳、不怕琐碎和精益求精的态度，充分体现了中国教育工作者和出版工作者的良好美德。

随着我国经济建设的发展和科学技术的不断进步，对高校教学工作会不断提出新的要求和希望。我想，无论如何，要做好引进国外教材的工作，一定要联系我国的实际。教材和学术专著不同，既要注意科学性、学术性，也要重视可读性，要深入浅出，便于读者自学；引进的教材要适应高校教学改革的需要，针对目前一些教材内容较为陈旧的问题，有目的地引进一些先进的和正在发展中的交叉学科的参考书；要与国内出版的教材相配套，安排好出版英文原版教材和翻译教材的比例。我们努力使这套教材能尽量满足上述要求，希望它们能放在学生们的课桌上，发挥一定的作用。

最后，预祝“国外电子与通信教材系列”项目取得成功，为我国电子与通信教学和通信产业的发展培土施肥。也恳切希望读者能对这些书籍的不足之处、特别是翻译中存在的问题，提出意见和建议，以便再版时更正。

吴佑寿

中国工程院院士、清华大学教授

“国外电子与通信教材系列”出版委员会主任

出 版 说 明

进入21世纪以来，我国信息产业在生产和科研方面都大大加快了发展速度，并已成为国民经济发展的支柱产业之一。但是，与世界上其他信息产业发达的国家相比，我国在技术开发、教育培训等方面都还存在着较大的差距。特别是在加入WTO后的今天，我国信息产业面临着国外竞争对手的严峻挑战。

作为我国信息产业的专业科技出版社，我们始终关注着全球电子信息技术的发展方向，始终把引进国外优秀电子与通信信息技术教材和专业书籍放在我们工作的重要位置上。在2000年至2001年间，我社先后从世界著名出版公司引进出版了40余种教材，形成了一套“国外计算机科学教材系列”，在全国高校以及科研部门中受到了欢迎和好评，得到了计算机领域的广大教师与科研工作者的充分肯定。

引进和出版一些国外优秀电子与通信教材，尤其是有选择地引进一批英文原版教材，将有助于我国信息产业培养具有国际竞争能力的技术人才，也将有助于我国国内在电子与通信教学工作中掌握和跟踪国际发展水平。根据国内信息产业的现状、教育部《关于“十五”期间普通高等教育教材建设与改革的意见》的指示精神以及高等院校老师们反映的各种意见，我们决定引进“国外电子与通信教材系列”，并随后开展了大量准备工作。此次引进的国外电子与通信教材均来自国际著名出版商，其中影印教材约占一半。教材内容涉及的学科方向包括电路理论与应用、信号与系统、数字信号处理、微电子、通信系统、电磁场与微波等，其中既有本科专业课程教材，也有研究生课程教材，以适应不同院系、不同专业、不同层次的师生对教材的需求，广大师生可自由选择和自由组合使用。我们还将与国外出版商一起，陆续推出一些教材的教学支持资料，为授课教师提供帮助。

此外，“国外电子与通信教材系列”的引进和出版工作得到了教育部高等教育司的大力支持和帮助，其中的部分引进教材已通过“教育部高等学校电子信息科学与工程类专业教学指导委员会”的审核，并得到教育部高等教育司的批准，纳入了“教育部高等教育司推荐——国外优秀信息科学与技术系列教学用书”。

为做好该系列教材的翻译工作，我们聘请了清华大学、北京大学、北京邮电大学、南京邮电大学、东南大学、西安交通大学、天津大学、西安电子科技大学、电子科技大学、中山大学、哈尔滨工业大学、西南交通大学等著名高校的教授和骨干教师参与教材的翻译和审校工作。许多教授在国内电子与通信专业领域享有较高的声望，具有丰富的教学经验，他们的渊博学识从根本上保证了教材的翻译质量和专业学术方面的严格与准确。我们在此对他们的辛勤工作与贡献表示衷心的感谢。此外，对于编辑的选择，我们达到了专业对口；对于从英文原书中发现的错误，我们通过与作者联络、从网上下载勘误表等方式，逐一进行了修订；同时，我们对审校、排版、印制质量进行了严格把关。

今后，我们将进一步加强同各高校教师的密切关系，努力引进更多的国外优秀教材和教学参考书，为我国电子与通信教材达到世界先进水平而努力。由于我们对国内外电子与通信教育的发展仍存在一些认识上的不足，在选题、翻译、出版等方面的工作中还有许多需要改进的地方，恳请广大师生和读者提出批评及建议。

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Foreword

For a number of years, it has become the fashion to write books on analytic themes rather than on topics pertaining to practical systems and their synthesis. That has been so mainly for two reasons: Firstly, analytic themes lend themselves to elegant pedagogic presentation while engineering practices do not. Secondly, practical systems change rapidly, and become dated pretty fast while analytical theory remains valid for long periods of time. In any case, there are few books available on the current practice of telecommunication systems. That leads to a vicious circle – in the absence of books, the topic is not taught in universities, and as it is not taught in universities, books are not written. Thiagarajan Viswanathan has written a book which breaks this vicious circle, and makes a laudable attempt to fill a major gap.

In the next twenty years, we may expect to witness revolutionary changes in telecommunications practice. The foundations for such developments have already been laid in the form of ISDN. Hence, a book on telecommunications systems based on the newly accepted international practices is timely.

In the flurry and excitement of new developments, the tendency is to forget the pioneering past, and thereby lose the historical perspective so essential for scholarly study. I am, therefore, particularly pleased that his book does pay attention to the historical processes in telecommunication switching.

I am happy to commend this book to all telecommunication engineers.

P.V. Indiresan
President
The Institution of Electronics and
Telecommunication Engineers
New Delhi

Preface

Today's telecommunication network is a complex interconnection of a variety of heterogeneous switching systems. Electromechanical and electronic systems, direct and common control systems, and hard-wired and stored program control systems coexist. In a sense, it is a marvel that these systems work in close cooperation to offer a plethora of complex telecommunication services, often involving instantaneous information transfer across the globe. Presently, two important classes of telecommunication networks, viz. public switched telephone network (PSTN) and public data network (PDN) are in wide use. The newly emerging integrated services digital network (ISDN) is expected to be in place in the next 20 years or so as a result of the process of total digitalisation of telecommunication networks currently under way. This text is a treatment on both switching systems and telecommunication networks in a single volume.

The motivation for writing this text came when I taught regular full-semester and short-term courses on 'switching systems and networks' at the Indian Institute of Science, Bangalore. I keenly felt the absence of a suitable text for the purpose. This book is meant to fill this void and is designed for the final year undergraduate or the first year postgraduate students in electronics and communications engineering and allied subjects. It may be difficult to cover the entire text in one semester. Depending on other courses offered and the emphasis given in a programme, a teacher may like to omit one or two chapter, in a one-semester course.

I have attempted to give a balanced blend of theoretical and practical aspects in the text. Concepts and system level treatment are given emphasis. Analytical or mathematical treatment is introduced only to the extent required. Worked-out examples are given where considered necessary. All chapters contain exercises, and answers are provided for the selected exercises at the end of the book.

For over 40 years, telecommunications has largely been confined to the private domain of network operators. Research, development and even education have been pursued by a few firms and organizations. It is only recently that a large number of entrepreneurs have entered the field of telecommunications. Such new entrants should find this book to be a valuable asset. The coverage of recent topics like fibre optic communication systems and networks, time division switching systems, data networks, ISDN, and voice data integration schemes should interest the practising professionals.

I have devoted two full chapters to discuss at length, the somewhat outdated Strowger and crossbar systems, for two reasons. The first and most important one is pedagogical. Many fundamental concepts underlying the design of modern electronic exchanges have evolved from these systems. Secondly, most of the less developed and developing countries including India have operational Strowger and crossbar systems, often in large numbers.

Chapter 1 introduces the subject. In this chapter, the evolution of the telecommunication networks is briefly traced, starting from the invention of the telephone by Alexander Graham Bell and ending with the emerging ISDN. A classification scheme for the switching systems is presented. Basic network structures such as folded, nonfolded, blocking and nonblocking structures are introduced.

Chapter 2 deals with pulse dialling and Strowger automatic switching systems. A set of parameters to evaluate alternative designs of switching systems is introduced in this chapter. These parameters are generic in nature and are used throughout the text to compare different designs.

Chapter 3 discusses the dual tone multifrequency (DTMF) telephones and signalling, the common control concepts, and the crossbar switching systems.

Chapter 4 is devoted to stored program control (SPC) and multistage space division networks. Here, fault tolerant SPC architectures are discussed besides system and application software aspects. The enhanced telecommunication services that become possible with the introduction of SPC are then presented.

Chapter 5 lays the foundation for digital voice transmission. After covering linear quantisation, companding and CCITT *A*-law are discussed. This chapter ends with a presentation on CCITT time division multiplexing hierarchy.

Chapter 6 concentrates on time division switching. First, analog and digital time division switching techniques are discussed. The idea of time multiplexed input/output streams and the corresponding time division switching concepts are then presented. At the end, time-space combination configurations are discussed with real life examples.

Chapter 7 is devoted to fibre optic communication systems which are emerging as a major alternative to coaxial cable systems. This chapter covers types of optical fibres, optical sources and detectors, and deals with power losses in fibre optic systems giving related power budget calculations. This chapter concludes with a discussion on the practical application of fibre optic communication systems in telecommunication networks.

Chapter 8 is on traffic engineering which is the basis for the design and analysis of telecommunication networks. Grade of service (GOS) and blocking probability ideas are placed in proper perspective in this chapter. Basic concepts of modelling switching systems as birth-death stochastic processes are presented. Loss system and delay system models are discussed.

Chapters 9-11 deal with the three most important telecommunication networks: telephone networks, data networks and integrated services digital networks. Chapter 9 provides a comprehensive coverage of the telephone network aspects discussing subscriber loop systems, switching hierarchy, and transmission, numbering and charging plans. In addition, a brief description of the various transmission systems, viz. coaxial cable, ionospheric, troposcatter, microwave, and satellite communication systems, is given. Besides, a discussion on inchannel and common channel signalling systems is also included. Finally, this chapter presents the introductory concepts of the newly emerging cellular mobile communications.

Chapter 10 opens with a discussion on data transmission over PSTN and provides a detailed treament on open system interconnection (OSI) reference model. It then goes on to present important aspects of local and metropolitan area networks, and satellite based data networks. Basics of fibre optic data networks where considerable research interest lies at present are then dealt with. Other aspects discussed in this chapter include data network standards and internetworking.

In Chapter 11, after briefly discussing the motivation for ISDN, some of the new services that are possible in the context of ISDN are presented. ISDN architecture, user-network interface and ISDN standards are covered in this chapter. It is envisioned that artificial intelligence and expert systems would play a significant role in future telecommunication networks and hence a brief treatise on this topic is given. The chapter concludes with a discussion on some of the voice data integration schemes.

Chapter 12 discusses the streamlined packet transfer interface—Asynchronous Transfer Mode(ATM). ATM provides both real-time and non-real-time services, it supports a wide range of traffic, including synchronous TDM streams such as T-1, using the constant bit rate(CBR) service; compressed voice and video, using the real-time variable bit rate(rt-VBR) service; traffic with specific quality-of service requirements, using the non-real-time VBR(nrt-VBR) service; and IP-based traffic using the available bit rate(ABR), unspecified bit rate (UBR), and guaranteed frame rate(GFR) services.

In Chapter 13, after briefly discussing the usage of softswitch, the next 2 sections mainly introduce the Next Generation Networking(NGN) and its functional architecture.

I set out to write this text with an aim of giving a broad, yet fairly in-depth, and up-to-date coverage of telecommunication switching systems and networks. How far I have succeeded in this aim is for the readers to judge. I would be grateful for comments from the readers, especially students, teachers and practising professionals.

T. Viswanathan

Acknowledgements

Many have contributed to the successful preparation of this text. I would like to place on record my grateful thanks to each one of them.

I began writing this text when I was a Professor at the Indian Institute of Science (IISc), Bangalore, but wrote a major part of it while being the Director of the Indian National Scientific Documentation Centre (INSDOC), a constituent establishment of the Council of Scientific and Industrial Research (CSIR) of the Government of India. Financial support for the preparation of the manuscript came from the Curriculum Development Cell at IISc set up by the Ministry of Human Resource Development. The excellent infrastructural facilities of INSDOC and the gracious words of encouragement from Prof. S K Joshi, Director General, CSIR hastened the process of completing the text.

Shri J Gopal of the Department of Telecommunications put in considerable effort and reviewed the manuscript in a time-bound manner. Shri J M Jose, a research fellow at INSDOC, verified the worked-out examples and meticulously perused parts of the manuscript. He also rendered very valuable assistance in many other ways.

Smt. Chandrika Sridhar at IISc and Smt. Sushma Arora at INSDOC rendered their skillful services in word processing the handwritten manuscript. Both of them did their job so efficiently and delightfully that I had no hesitation in revising, modifying and correcting the computerised manuscript many times. Both of them went out of their way to meet deadlines and schedules.

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It is my experience that both science and religion have their roles to play in one's life. While science has helped me to think and reason rationally, religion has carried me beyond the realm of thought and reasoning. A great seer of India has blessed this effort and I feel that he has taken me one step nearer to God through this effort. It is with great humility that I offer this text at the feet of the Supreme Being.

T. Viswanathan

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