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ISDN、B-ISDN 以及帧中继和 ATM

(英文版·第4版)

WILLIAM STALLINGS

ISDN AND BROADBAND ISDN WITH FRAME RELAY AND ATM

FOURTH EDITION



(美) William Stallings 著



机械工业出版社
China Machine Press

Prentice Hall

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出版者的话

文艺复兴以降，源远流长的科学精神和逐步形成的学术规范，使西方国家在自然科学的各个领域取得了垄断性的优势；也正是这样的传统，使美国在信息技术发展的六十多年间名家辈出、独领风骚。在商业化的进程中，美国的产业界与教育界越来越紧密地结合，计算机学科中的许多泰山北斗同时身处科研和教学的最前线，由此而产生的经典科学著作，不仅擘划了研究的范畴，还揭橥了学术的源变，既遵循学术规范，又自有学者个性，其价值并不会因年月的流逝而减退。

近年，在全球信息化大潮的推动下，我国的计算机产业发展迅猛，对专业人才的需求日益迫切。这对计算机教育界和出版界都既是机遇，也是挑战；而专业教材的建设在教育战略上显得举足轻重。在我国信息技术发展时间较短、从业人员较少的现状下，美国等发达国家在其计算机科学发展的几十年间积淀的经典教材仍有许多值得借鉴之处。因此，引进一批国外优秀计算机教材将对我国计算机教育事业的发展起积极的推动作用，也是与世界接轨、建设真正的世界一流大学的必由之路。

机械工业出版社华章图文信息有限公司较早意识到“出版要为教育服务”。自1998年始，华章公司就将工作重点放在了遴选、移译国外优秀教材上。经过几年的不懈努力，我们与Prentice Hall, Addison-Wesley, McGraw-Hill, Morgan Kaufmann等世界著名出版公司建立了良好的合作关系，从它们现有的数百种教材中甄选出Tanenbaum, Stroustrup, Kernighan, Jim Gray等大师名家的一批经典作品，以“计算机科学丛书”为总称出版，供读者学习、研究及度藏。大理石纹理的封面，也正体现了这套丛书的品位和格调。

“计算机科学丛书”的出版工作得到了国内外学者的鼎力襄助，国内的专家不仅提供了中肯的选题指导，还不辞劳苦地担任了翻译和审校的工作；而原书的作者也相当关注其作品在中国的传播，有的还专诚为其书的中译本作序。迄今，“计算机科学丛书”已经出版了近百个品种，这些书籍在读者中树立了良好的口碑，并被许多高校采用为正式教材和参考书籍，为进一步推广与发展打下了坚实的基础。

随着学科建设的初步完善和教材改革的逐渐深化，教育界对国外计算机教材的需求和应用都步入一个新的阶段。为此，华章公司将加大引进教材的力度，在“华章教育”的总规划之下出版三个系列的计算机教材：针对本科生的核心课程，剔抉外版菁华而成“国外经典教材”系列；对影印版的教材，则单独开辟出“经典原版书库”；定位在高级教程和专业参考的“计算机科学丛书”还将保持原来的风格，继续出版新的品种。为了保证这三套丛书的权威性，同时也为了更好地为学校和老师服务，华章公司聘请了中国科学院、北京大学、清华大学、国防科技大学、复旦大学、上海交通大学、南京大学、浙江大学、中国科技大学、哈尔滨工业大学、西安交通大学、中国人民大学、北京航空航天大学、北京邮电大学、中山大学、解放军理工大学、郑州大学、湖北工学院、中国国家信息安全测评认证中心等国内重点大学和科研机构在计算机的各个领域的著名学者组成“专家指导委员会”，为我们提供选题意见和出版监督。

“经典原版书库”是响应教育部提出的使用原版国外教材的号召，为国内高校的计算机教学度身订造的。在广泛地征求并听取丛书的“专家指导委员会”的意见后，我们最终选定了这30多种篇幅内容适度、讲解鞭辟入里的教材，其中的大部分已经被M.I.T.、Stanford、U.C. Berkley、C.M.U.等世界名牌大学采用。丛书不仅涵盖了程序设计、数据结构、操作系统、计算机体系结构、数据库、编译原理、软件工程、图形学、通信与网络、离散数学等国内大学计算机专业普遍开设的核心课程，而且各具特色——有的出自语言设计者之手、有的历三十年而不衰、有的已被全世界的几百所高校采用。在这些圆熟通博的名师大作的指引之下，读者必将在计算机科学的宫殿中由登堂而入室。

权威的作者、经典的教材、一流的译者、严格的审校、精细的编辑，这些因素使我们的图书有了质量的保证，但我们的目标是尽善尽美，而反馈的意见正是我们达到这一终极目标的重要帮助。教材的出版只是我们的后续服务的起点。华章公司欢迎老师和读者对我们的工作提出建议或给予指正，我们的联系方式如下：

电子邮件：hzedu@hzbook.com

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PREFACE

Perhaps the most important development in the computer-communications industry in the 1990s is the evolution of the integrated services digital network (ISDN) and its follow-on, the broadband ISDN (B-ISDN). The ISDN and B-ISDN have had a dramatic impact on the planning and deployment of intelligent digital networks providing integrated service for voice, data, and video. Further, the work on the ISDN and B-ISDN standards has led to the development of two major new networking technologies: frame relay and asynchronous transfer mode (ATM). Frame relay and ATM have become the essential ingredients in developing high-speed networks for local, metropolitan, and wider area applications.

INTENDED AUDIENCE

This book is intended for a broad range of readers who will benefit from an understanding of ISDN and B-ISDN concepts and the associated technologies of frame relay and ATM. This includes students and professionals in the fields of data processing and data communications, designers and implementers, and data communication and networking customers and managers. The book is designed to be self-contained. For the reader with little or no background in data communications, Part One and the appendices cover a number of basic topics

PLAN OF THE TEXT

The objective of this book is to provide a comprehensive technical survey of the protocols and architecture of ISDN and B-ISDN, including a detailed examination of frame relay and ATM.

The book divides into five parts. Part One deals with the fundamental technologies used in digital networks, including a discussion of digital transmission technology and a review of circuit switching and packet switching. Part Two is devoted to ISDN and examines the user-network interface architecture, protocols, and services. This part also describes Signaling System Number 7, a related facility. Part Three focuses on frame relay technology

and protocols and examines the critical issue of congestion control in frame relay networks. Part Four covers B-ISDN architecture and protocols. Part Five examines ATM-related protocols and surveys various techniques for traffic and congestion control in ATM networks.

The book includes an extensive glossary, a list of frequently used acronyms, and a bibliography. Each chapter includes problems and suggestions for further reading.

Throughout, there is an emphasis on both technology and on standards. The book provides a comprehensive guide to understanding the many recommendations issued by the ITU Telecommunication Standardization Sector (ITU-T), formerly the CCITT.

INTERNET SERVICES FOR INSTRUCTORS AND STUDENTS

There is a Web page for this book that provides support for students and instructors. The page includes links to relevant sites, transparency masters of figures in the book in PDF (Adobe Acrobat) format, and sign-up information for the book's internet mailing list. The Web page is at <http://www.shore.net/~ws/ISDN4e>. An Internet mailing list has been set up so that instructors using this book can exchange information, suggestions, and questions with each other and with the author. As soon as typos or other errors are discovered, an errata list for this book will be available at <http://www.shore.net/~ws>.

WHAT'S NEW IN THE FOURTH EDITION

In the four years since the third edition of this book was published, the field has seen continued innovations and improvements. In this new edition, I try to capture these changes while maintaining a broad and comprehensive coverage of the entire field. To begin this process of revision, the third edition of this book was extensively reviewed by a number of professors who teach the subject. The result is that, in many places, the narrative has been clarified and tightened, and illustrations have been improved. Also, a number of new "field-tested" problems have been added; the solutions manual, available to instructors, includes solutions to all of the problems in the book.

Two noteworthy changes in this edition are the inclusion of xDSL and the expansion of the coverage of ATM. The term *xDSL* refers to a family of digital subscriber line technologies that provide high-speed access to ISDN and other wide area networks over ordinary twisted-pair lines from the network to a residential or business subscriber. The book surveys xDSL and especially asymmetric digital subscriber line (ADSL) technology. Another important change is the expansion of the coverage of ATM. This includes additional details on the ATM adaption layer

(AAL), treatment of the new available bit rate (ABR) service, and updated and expanded treatment of ATM traffic and congestion control.

Other changes permeate the book. The third edition was based on the ITU-T recommendations through mid-1994. Since that time, most of these older recommendations have been updated and new ones have been added. In addition, the ATM Forum has filled in many of the gaps in the ITU-T specification of ATM and related protocols. These changes are reflected throughout the book. To aid readers in keeping up with this evolving field, pointers to relevant Web sites are found in the Recommended Reading section of many chapters.

ACKNOWLEDGMENTS

This new edition has benefited from review by a number of people, who gave generously of their time and expertise. I would like to thank Pierre Catala, Texas A&M; Thomas Gannon, Worcester Polytechnic Institute; Elsa Valeroso, University of North Dakota; Subbarao Wunnava, Florida International University; Ibrahim Habib, City College of NY; Robert Blackshaw, GeoTrain Corporation; Tawfig Alrabiah, University of Pittsburgh; Teik Kheong Tan, TTK Consulting; Kenneth Molloy, KM Associates Inc.

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CHAPTER 1

INTRODUCTION

This book is a survey of ISDN and broadband ISDN (B-ISDN) together with the key networking technologies of frame relay and asynchronous transfer mode. Both the standardization of ISDN and B-ISDN and the development of frame relay and ATM have been driven by market pressures to reduce the cost of voice and data transmission and to expand networking services to provide high speed data and video capability. In this chapter, we discuss some of the key factors driving the nature and pace of evolution in these areas.

1.1 THE ARRIVAL OF ISDN

Rapid advances in computer and communication technologies have resulted in the increasing merger of these two fields. The lines have blurred among computing, switching, and digital transmission equipment, and the same digital techniques are being used for data, voice, and image transmission. Merging and evolving technologies, coupled with increasing demands for efficient and timely collection, processing, and dissemination of information, have led to the development of integrated systems that transmit and process all types of data. The ultimate goal of this evolution is something that is referred to as the integrated services digital network (ISDN).

The ISDN is intended to be a worldwide public telecommunications network to replace existing public telecommunications networks and deliver a wide variety of services. The ISDN is defined by the standardization of user interfaces and implemented as a set of digital switches and paths supporting a broad range of traffic types and providing value-added processing services. In practice, there are multiple networks, implemented within national boundaries, but from the user's point of view, the eventual widespread deployment of ISDN will lead to a single, uniformly accessible, worldwide network.

The impact of ISDN on both users and vendors will be profound. To control ISDN evolution and impact, a massive effort at standardization is

under way. Although ISDN standards are still evolving, both the technology and the emerging implementation strategy are well understood.

Even though ISDN has yet to achieve the universal deployment hoped for, it is already in its second generation. The first generation, sometimes referred to as **narrow-band ISDN**, is based on the use of a 64-kbps channel as the basic unit of switching and has a circuit-switching orientation. The major technical contribution of the narrowband ISDN effort has been **frame relay**. The second generation, referred to as **broadband ISDN** (B-ISDN), supports very high data rates (100s of Mbps) and has a packet-switching orientation. The major technical contribution of the broadband ISDN effort has been **asynchronous transfer mode** (ATM), also known as cell relay.

A sample of the trends that are driving ISDN and B-ISDN is as follows:

- Computers are joining together instead of standing alone. The percentage of personal computers that have communications capability is rising. While yesterday's corporate computer was a stand-alone device, businesses today rely on a mix of small, medium, and large computers that can share resources (e.g., printers), share data, and exchange messages. Our analytical tools have sprouted wires; more and better wires are coming, and the wires will extend everywhere.
- Cellular radio is making communications mobile. Automobiles, taxis, and boats are becoming workstations. People can not only talk via cellular radio phones; they can also transmit data by linking up their portable computers. Look for the development of cellular phone/computer combinations. In time, automobiles will provide communication/computer systems as options. Any vehicle, then, will be a unit that can link up to the global information network.
- Computers for personal use will be ubiquitous. This will be especially so for students (from elementary school on up) and "knowledge workers," who deal primarily with paper—documents, reports, numbers. Many office workers have at least one workstation at the office and one at home. Furthermore, most people will own a powerful portable and possibly a wearable model—a very personal computer (VPC). The hotels you stay at in the future may have personal computers in their rooms as amenities; some hotels already do. Computing power will be at every hand; and, most important, each computer will tap into the network.
- The volume and richness of data are increasing dramatically. The first-generation personal computers have given way to the latest Windows and Macintosh systems, with color and high-quality graphics. New applications in the office environment are being developed that require much higher networking capacity, and desktop image processors will soon increase network data flow by an unprecedented rate. Examples of these applications include digital fax machines, document image processors, and graphics programs on personal computers. Resolutions as high as 400×400 per page are typical for these applications. Even with compression techniques, this will generate a tremendous data communications load. In addition, optical disks are beginning to reach technical maturity and are being developed toward realistic desktop capacities exceeding 1 Gbyte.
- Voice recognition and natural language processing technology will increase the intelligence of systems and networks. These have been two of the most difficult applications to develop, but they are now gradually emerging from