

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

# 数据与计算机通信

(第六版 影印版)

## DATA & COMPUTER COMMUNICATIONS

(Sixth Edition)

■ William Stallings



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By William Stallings

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# 前 言

20 世纪末，以计算机和通信技术为代表的信息科学和技术，对世界的经济、军事、科技、教育、文化、卫生等方面的发展产生了深刻的影响，由此而兴起的信息产业已经成为世界经济发展的支柱。进入 21 世纪，各国为了加快本国的信息产业，加大了资金投入和政策扶持。

为了加快我国信息产业的进程，在我国《国民经济和社会发展第十个五年计划纲要》中，明确提出“以信息化带动工业化，发挥后发优势，实现社会生产力的跨越式发展。”信息产业的国际竞争将日趋激烈。在我国加入 WTO 后，我国信息产业将面临国外竞争对手的严峻挑战。竞争成败最终将取决于信息科学和技术人才的多少与优劣。

在 20 世纪末，我国信息产业虽然得到迅猛发展，但与国际先进国家相比，差距还很大。为了赶上并超过国际先进水平，我国必须加快信息技术人才的培养，特别要培养一大批具有国际竞争能力的高水平的信息技术人才，促进我国信息产业和国家信息化水平的全面提高。为此，教育部高等教育司根据教育部吕福源副部长的意见，在长期重视推动高等学校信息科学和技术的教学的基础上，将实施超前发展战略，采取一些重要举措，加快推动高等学校的信息科学和技术等相关专业的教学工作。在大力宣传、推荐我国专家编著的面向 21 世纪和“九五”重点的信息科学和技术课程教材的基础上，在有条件的高等学校的某些信息科学和技术课程中推动使用国外优秀教材的影印版进行英语或双语教学，以缩短我国在计算机教学上与国际先进水平的差距，同时也有助于强化我国大学生的英语水平。

为了达到上述目的，在分析一些出版社已影印相关教材，一些学校已试用影印教材进行教学的基础上，教育部高等教育司组织并委托高等教育出版社开展国外优秀信息科学和技术优秀教材及其教学辅助材料的引进研究与影印出版的试点工作。为推动用影印版教材进行教学创造条件。

本次引进的系列教材的影印出版工作，是在对我国高校的信息科学和技术专业的课程与美国高校的对比分析的基础上展开的；所影印出版的教材均由我国主要高

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校的信息科学和技术专家组成的专家组，从国外近两年出版的大量最新教材中精心筛选评审通过的内容新、有影响的优秀教材；影印教材的定价原则上应与我国大学教材价格相当。

教育部高等教育司将此影印系列教材推荐给高等学校，希望有关教师选用，使用后有什么意见和建议请及时反馈。也希望有条件的出版社，根据影印教材的要求，积极参加此项工作，以便引进更多、更新、更好的外国教材和教学辅助材料。

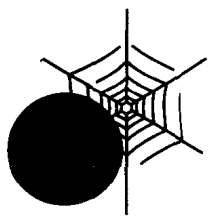
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教育部高等教育司

二〇〇一年四月

*For my great-hearted wife  
ATS  
and her constant companions Geoffroi  
and Princesse Kate Lan Kinetic  
and Duchess of Albany, Patroon Schuyler,  
Les Enfants du Paradis*





# WEB SITE FOR DATA AND COMPUTER COMMUNICATIONS

## *Sixth Edition*

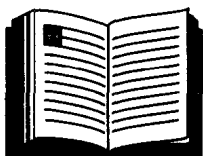
The Web site at <http://www.shore.net/~ws/DCC6e.html> provides support for instructors and students using the book. It includes the following elements.



## Course Support Materials

The course support materials include

- Copies of figures from the book in PDF format
- A detailed set of course notes in PDF format suitable for student handout or for use as viewgraphs
- A set of PowerPoint slides for use as lecture aids
- Computer Science Student Support Site: contains a number of links and documents that the student may find useful in his/her ongoing computer science education. The site includes a review of basic, relevant mathematics; advice on research resources, such as report repositories and bibliographies; and other useful links.
- An errata sheet for the book, updated at most monthly



## DCC Courses

The DCC6e Web site includes links to Web sites for courses taught using the book. These sites can provide useful ideas about scheduling and topic ordering, as well as a number of useful handouts and other materials.



## Useful Web Sites

The DCC6e Web site includes links to relevant Web sites, organized by chapter. The links cover a broad spectrum of topics and will enable students to explore timely issues in greater depth.



## Internet Mailing List

An Internet mailing list is maintained so that instructors using this book can exchange information, suggestions, and questions with each other and the author. Subscription information is provided at the book's Web site.



## Simulation Tools

The Web site includes links to the *cnet* Web site and the *modeling tools* Web site. These packages can be used to analyze and experiment with protocol and network design issues. Each site includes downloadable software and background information. The instructor's manual includes more information on loading and using the software and suggested student projects. See Appendix C for more information.



# PREFACE

## OBJECTIVES

This book attempts to provide a unified overview of the broad field of data and computer communications. The organization of the book reflects an attempt to break this massive subject into comprehensible parts and to build, piece by piece, a survey of the state of the art. The book emphasizes basic principles and topics of fundamental importance concerning the technology and architecture of this field and provides a detailed discussion of leading-edge topics.

The following basic themes serve to unify the discussion:

- **Principles:** Although the scope of this book is broad, there are a number of basic principles that appear repeatedly as themes and that unify this field. Examples are multiplexing, flow control, and error control. The book highlights these principles and contrasts their application in specific areas of technology.
- **Design approaches:** The book examines alternative approaches to meeting specific communication requirements.
- **Standards:** Standards have come to assume an increasingly important, indeed dominant, role in this field. An understanding of the current status and future direction requires a comprehensive discussion of the related standards.

## PLAN OF THE TEXT

The book is divided into five parts:

- I. **Overview:** Provides an introduction to the range of topics covered in the book. In addition, this part includes a discussion of protocols, OSI, and the TCP/IP protocol suite.
- II. **Data Communications:** Concerned primarily with the exchange of data between two directly connected devices. Within this restricted scope, the key aspects of transmission, interfacing, link control, and multiplexing are examined.

- III. Wide Area Networks:** Examines the internal mechanisms and user-network interfaces that have been developed to support voice, data, and multimedia communications over long-distance networks. The traditional technologies of packet switching and circuit switching are examined, as well as the more recent ATM. A separate chapter is devoted to congestion control issues.
- IV. Local Area Networks:** Explores the technologies and architectures that have been developed for networking over shorter distances. The transmission media, topologies, and medium access control protocols that are the key ingredients of a LAN design are explored and specific standardized LAN systems examined.
- V. Networking Protocols:** Explores both the architectural principles and the mechanisms required for the exchange of data among computers, workstations, servers, and other data processing devices. Much of the material in this part relates to the TCP/IP protocol suite.

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

The book is intended for both an academic and a professional audience. For the professional interested in this field, the book serves as a basic reference volume and is suitable for self-study. As a textbook, it can be used for a one-semester or two-semester course. It covers the material in the Computer Communication Networks course of the joint ACM/IEEE Computing Curricula 1991. The chapters and parts of the book are sufficiently modular to provide a great deal of flexibility in the design of courses. The following are suggestions for course design:

- **Fundamentals of Data Communications:** Parts One (overview) and Two (data communications) and Chapters 9 through 11 (circuit switching, packet switching, and ATM).
- **Communications Networks:** If the student has a basic background in data communications, then this course could cover Parts One (overview), Three (WAN), and Four (LAN).
- **Computer Networks:** If the student has a basic background in data communications, then this course could cover Part One (overview), Chapters 6 and 7 (data communication interface and data link control), and Part Five (protocols).

In addition, a more streamlined course that covers the entire book is possible by eliminating certain chapters that are not essential on a first reading. Chapters that could be optional are Chapters 3 (data transmission) and 4 (transmission media), if the student has a basic understanding of these topics; Chapter 8 (multiplexing); Chapter 9 (circuit switching); Chapter 12 (congestion control); Chapter 16 (internetworking); and Chapter 18 (network security).

## SERVICES FOR INSTRUCTORS AND STUDENTS

There is a Web site for this book that provides support for students and instructors. The site includes links to relevant sites, transparency masters of figures in the book,

and sign-up information for the book's Internet mailing list. The Web page is at <http://www.shore.net/~ws/DCC6e.html>; see the section, "Web Site for Data and Computer Communications," following this Preface, for more information. 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>.

## PROJECTS FOR TEACHING DATA AND COMPUTER COMMUNICATIONS

For many instructors, an important component of a data communications or networking course is a project or set of projects by which the student gets hands-on experience to reinforce concepts from the text. This book provides an unparalleled degree of support for including a projects component in the course. The instructor's manual not only includes guidance on how to assign and structure the projects, but also includes a set of suggested projects that covers a broad range of topics from the text, including research projects, simulation projects, analytic modeling projects, and reading/report assignments. See Appendix C for details.

## WHAT'S NEW IN THE SIXTH EDITION

This sixth edition is seeing the light of day less than 15 years after the publication of the first edition. Much has happened during those years. Indeed, the pace of change, if anything, is increasing. In this new edition, I try to capture these changes while maintaining a broad and comprehensive coverage of the entire field. To begin the process of revision, the fifth 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.

Beyond these refinements to improve pedagogy and user friendliness, there have been major substantive changes throughout the book. Every chapter has been revised, new chapters have been added, and the overall organization of the book has changed. Highlights include the following:

- **xDSL:** 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 Subscribe Line (ADSL) technology.
- **Gigabit Ethernet:** The discussion on 100-Mbps Ethernet has been updated and an introduction to Gigabit Ethernet has been added.
- **Available bit rate (ABR) service and mechanisms:** ABR is a relatively recent addition to the offerings for ATM networks. It provides enhanced support for IP-based data traffic.

- **Congestion control:** A separate chapter is now devoted to this topic. This unified presentation clarifies the issues involved. The chapter includes expanded coverage of ATM traffic management and congestion control techniques.
- **IP multicasting:** A new section is devoted to this important topic.
- **Integrated and differentiated services, plus RSVP:** There have been substantial developments since the publication of the fifth edition in enhancements to the Internet to support a variety of multimedia and time-sensitive traffic. A new chapter covers integrated services, differentiated services, other issues related to quality of service (QoS), and the important RSVP reservation protocol.
- **TCP congestion control:** This continues to be an area of active research. The book includes a new section surveying this topic.

In addition, throughout the book, virtually every topic has been updated to reflect the developments in standards and technology that have occurred since the publication of the fifth edition.

## QUALITY CONTROL

An expanded effort has been made to assure a high level of quality in the production of the book. More time and resources have been devoted to a careful proof-reading of the text in both the manuscript and page proof stages by both the author and the publisher. In addition, numerous volunteers from the professional community were recruited, each of whom was responsible for carefully reading just one chapter to check for technical errors and typographical errors. Each chapter of the book has benefited from two of these reviews. My thanks to Mel Adams, Navin Kumar Agarwal, Ferdinand N. Ahlberg, David Airlie, Tom Allebrandi, Maurice Baker, Rob Blais, Art Boughan, Frank Byrum, George Cherian, Christian Cseh, Dr. Mickael Fontaine, Charles Freund, Bob Furtaw, Andrew Gallo, Gary Gapinski, Sundar Gopal, Phil Guillemette, David Hoffman, Dr. Jun Huang, Prasad Kallur, Gary Kessler, Steven Kilby, John Kristoff, David Lucantoni, Kenneth Ma, Eddie Maendel, Richard Masoner, Mark McCutcheon, John McHarry, Mittal Monanim, Dr. John Naylor, Robert Olsson, Mike Patterson, Mahbubur Rashid, Jeffrey Rhodes, Monika Riffle, Peter Russell, Ahmet Sekercioglu, Rayaz Siddiqu, Dick Smith, Dave Stern, Omesh Tickoo, Scott Valcourt, Dominick Vanacore, Eko Wibowo, Craig Wiesner, and Jeffrey Wright.

Finally, Arthur Werbner reviewed and verified all of the homework problems and solutions.

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went way beyond the call of duty in providing numerous detailed comments on technical and pedagogical matters. Others who were very helpful are Thomas Milham (Devry Institute of Technology), Gregory B. Brewster (DePaul University), Marc Delvaux (GlobeSpan Semiconductors), Robert E. Morris (Devry Institute of Technology), and Matt Mutka (Michigan State University).

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