大学计算机教育丛书（影印版）

FIFTH EDITION

DATA AND COMPUTER COMMUNICATIONS

数据通信与计算机通信

（第五版）

WILLIAM STALLINGS

清华大学出版社 · PRENTICE HALL

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清华大学出版社
Prentice-Hall International, Inc.

(京)新登字 158 号

图书在版编目(CIP)数据
数据通信与计算机通信:第 5 版:英文/(美)斯托林斯(Stallings, W.)著. —北京:清华大学出版社,1997.11
(大学计算机教育丛书)
ISBN 7-302-02722-6

Ⅰ.数… Ⅱ.斯… Ⅲ.①数据通信-英文②计算机通信-英文 Ⅳ.TN919

中国版本图书馆 CIP 数据核字(97)第 23701 号

出版者:清华大学出版社(北京清华大学校内,邮编 100084)
因特网地址:www.tup.tsinghua.edu.cn
印刷者:清华大学印刷厂
发行者:新华书店总店北京科技发行所
开 本:850×1168 1/32 印张:25.625
版 次:1997 年 11 月第 1 版 1997 年 11 月第 1 次印刷
书 号:ISBN 7-302-02722-6/TP·1411
印 数:0001～5000
定 价:40.00 元

出版前言

我们的大学生、研究生毕业后，面临的将是一个国际化的信息时代。他们将需要随时查阅大量的外文资料；会有更多的机会参加国际性学术交流活动；接待外国学者；走上国际会议的讲坛。作为科技工作者，他们不仅应有与国外同行进行口头和书面交流的能力，更为重要的是，他们必须具备极强的查阅外文资料获取信息的能力。有鉴于此，在国家教委所颁布的“大学英语教学大纲”中有一条规定：专业阅读应作为必修课程开设。同时，在大纲中还规定了这门课程的学时和教学要求。有些高校除开设“专业阅读”课之外，还在某些专业课拟进行英语授课。但教、学双方都苦于没有一定数量的合适的英文原版教材作为教学参考书。为满足这方面的需要，我们挑选了 7 本计算机科学方面最新版本的教材，进行影印出版。首批影印出版的 6 本书受到广大读者的热情欢迎，我们深受鼓舞，今后还将陆续推出新书。希望读者继续给予大力支持。Prentice Hall 公司和清华大学出版社这次合作将国际先进水平的教材引入我国高等学校，为师生们提供了教学用书，相信会对高校教材改革产生积极的影响。

清华大学出版社
Prentice Hall 公司

1997.11

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, as well as providing 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. The discussion is bolstered with examples from existing implementations.
- *Standards:* Standards have come to assume an increasingly important, indeed dominant, role in this field. An understanding of the current status and future direction of technology requires a comprehensive discussion of the role and nature of the related standards.

Plan of the Text

The book is divided into four parts:

I *Data Communications:* This part is 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.

II *Wide-Area Networks:* This part examines the internal mechanisms and technologies 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 frame relay and ATM.

III *Local Area Networks:* This part explores the quite different 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.

IV *Communications Architecture and Protocols:* This part explores both the architectural principles and the mechanisms required for the exchange of data among computers, workstations, servers, and other 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 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*: Part I, Chapters 8 (circuit switching), 9 (packet switching), 12 (protocols and architecture).
- *Communications Networks*: If the student has a basic background in data communications, then this course could cover Parts II and III, and Appendix A.
- *Computer Networks*: If the student has a basic background in data communications, then this course could cover Chapters 5 (data communication interface), 6 (data link control), and Part IV.

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 2 (data transmission) and 3 (transmission media), if the student has a basic understanding of these topics, Chapter 7 (multiplexing), Chapter 10 (frame relay), Chapter 14 (bridges), and Chapter 18 (network security).

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 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. The web page is at http://www.shore.net/~ws/DCC5e.html.

As soon as any typos or other errors are discovered, an errata list for this book will be available at http://www.shore.net/~ws/welcome.html.

WHAT'S NEW IN THE FIFTH EDITION

This fifth edition is seeing the light of day less than a dozen years after the publication of the first edition. Much has happened during those years. Indeed, the pace of change, if anything, is increasing. The result is that this revision is more comprehensive and thorough than any of the previous ones. As an indication of this, about one-half of the figures (233 out of 343) and one-half of the tables (48 out of 91) in this edition are new. Every chapter has been revised, new chapters have been added, and the overall organization of the book has changed.

To begin this process of revision, the fourth edition of this book was extensively reviewed by a number of professors who taught from that edition. 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. Highlights include

- *ATM*: The coverage of ATM has been significantly expanded. There is now an entire chapter devoted to ATM and ATM congestion control (Chapter 11). New to this edition is the coverage of ATM LANs (Sections 13.4 and 14.3).
- *IPv6 (IPng) and IPv6 Security*: IPv6, also known as IPng (next generation), is the key to a greatly expanded use of TCP/IP both on the Internet and in other networks. This new topic is thoroughly covered. The protocol and its internetworking functions are discussed in Section 16.3, and the important material on IPv6 security is provided in Section 18.4.
- *Wireless and Spread Spectrum*: There is greater coverage of wireless technology (Section 3.2) and spread spectrum techniques (Section 4.5). New to this edition is treatment of the important topic of wireless LANs (Sections 12.5 and 13.6).
- *High-speed LANs*: Coverage of this important area is significantly expanded, and includes detailed treatment of leading-edge approaches, including Fast Ethernet (100BASE-T), 100VG-AnyLAN, ATM LANs, and Fibre Channel (Sections 13.1 through 13.5).
- *Routing*: The coverage of internetwork routing has been updated and expanded. There is a longer treatment of OSPF and a discussion of BGP has been added.
- *Frame Relay*: Frame relay also receives expanded coverage with Chapter 10 devoted to frame relay and frame relay congestion control.
- *Network Security*: Coverage of this topic has been expanded to an entire chapter (Chapter 18).
- *Network Management*: New developments in the specification of SNMPv2 are covered (Section 19.2).

- *SMTP and MIME*: Multimedia electronic mail combines the basic functionality of the Simple Mail Transfer Protocol with the Multi-purpose Internet Mail Extension.
- *HTTP*: (Hypertext Transfer Protocol): HTTP is the foundation of the operation of the worldwide web (www). Section 19.3 covers HTTP.
- *TCP/IP*: TCP/IP is now the focus of the protocol coverage in this book. Throughout the book, especially in Part IV, there is increased discussion of TCP/IP and related protocols and issues.

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 second edition.

ACKNOWLEDGMENTS

This new edition has benefited from review by a number of people, who gave generously of their time and expertise. Kitel Albertson (Trondheim College of Engineering), Howard Blum (Pace University), Mike Borella (DePaul University), William Clark (University of Alaska, Anchorage), Joe Doupnik (Utah State University), Doug Jacobson (Iowa State University), Dave Mallya, Biswath Mukherjee (University of California, Davis), and Mark Pullen (George Mason University) reviewed all or part of the manuscript.

Steve Deering of Xerox PARC reviewed the material on IPv6. Ted Doty of Network Systems Corporation reviewed IP security. Henrik Nielson reviewed HTTP.

William Stallings

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CHAPTER 1

INTRODUCTION