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国外优秀信息科学与技术系列教学用书

计算机通信与网络技术

（影印版）

COMPUTER COMMUNICATIONS AND NETWORKING TECHNOLOGIES

■ Michael A. Gallo
William M. Hancock

THOMSON

高等教育出版社
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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经济、科技、军事、教育和文化等产生了深刻影响。信息科学技术的迅速普及和应用，带动了世界范围信息产业的蓬勃发展，为许多国家带来了丰厚的回报。

进入 21 世纪，尤其随着我国加入 WTO，信息产业的国际竞争将更加激烈。我国信息产业虽然在 20 世纪末取得了迅猛发展，但与发达国家相比，甚至与印度、爱尔兰等国家相比，还有很大差距。国家信息化的发展速度和信息产业的国际竞争能力，最终都将取决于信息科学技术人才的质量和数量。引进国外信息科学和技术优秀教材，在有条件的学校推动开展英语授课或双语教学，是教育部为加快培养大批高质量的信息技术人才采取的一项重要举措。

为此，教育部要求由高等教育出版社首先开展信息科学和技术教材的引进试点工作。同时提出了两点要求，一是要高水平，二是要低价格。在高等教育出版社和信息科学技术引进教材专家组的努力下，经过比较短的时间，第一批引进的 20 多种教材已经陆续出版。这套教材出版后受到了广泛的好评，其中有不少是世界信息科学技术领域著名专家、教授的经典之作和反映信息科学技术最新进展的优秀作品，代表了目前世界信息科学技术教育的一流水平，而且价格也是最优惠的，与国内同类自编教材相当。

这项教材引进工作是在教育部高等教育司和高教社的共同组织下，由国内信息科学技术领域的专家、教授广泛参与，在对大量国外教材进行多次遴选的基础上，参考了国内和国外著名大学相关专业的课程设置进行系统引进的。其中，John Wiley 公司出版的贝尔实验室信息科学研究中心副总裁 Silberschatz 教授的经典著作《操作系统概念》，是我们经过反复谈判，做了很多努力才得以引进的。William Stallings 先生曾编写了在美国深受欢迎的信息科学技术系列教材，其中有多种教材获得过美国教材和学术著作者协会颁发的计算机科学与工程教材奖，这批引进教材中就有他的两本著作。留美中国学者 Jiawei Han 先生的《数据挖掘》是该领域中具有里程碑意义的著作。由达特茅斯学院 Thomas Cormen 和麻省理工学院、哥伦比亚大学的几

位学者共同编著的经典著作《算法导论》，在经历了 11 年的锤炼之后于 2001 年出版了第二版。目前任教于美国 Massachusetts 大学的 James Kurose 教授，曾在美国三所高校先后 10 次获得杰出教师或杰出教学奖，由他主编的《计算机网络》出版后，以其体系新颖、内容先进而倍受欢迎。在努力降低引进教材售价方面，高等教育出版社做了大量和细致的工作。这套引进的教材体现了权威性、系统性、先进性和经济性等特点。

教育部也希望国内和国外的出版商积极参与此项工作，共同促进中国信息技术教育和信息产业的发展。我们在与外商的谈判工作中，不仅要坚定不移地引进国外最优秀的教材，而且还要千方百计地将版权转让费降下来，要让引进教材的价格与国内自编教材相当，让广大教师和学生负担得起。中国的教育市场巨大，外国出版公司和国内出版社要通过扩大发行数量取得效益。

在引进教材的同时，我们还应做好消化吸收，注意学习国外先进的教学思想和教学方法，提高自编教材的水平，使我们的教学和教材在内容体系上，在理论与实践的结合上，在培养学生的动手能力上能有较大的突破和创新。

目前，教育部正在全国 35 所高校推动示范性软件学院的建设和实施，这也是加快培养信息科学技术人才的重要举措之一。示范性软件学院要立足于培养具有国际竞争力的实用性软件人才，与国外知名高校或著名企业合作办学，以国内外著名 IT 企业为实践教学基地，聘请国内外知名教授和软件专家授课，还要率先使用引进教材开展教学。

我们希望通过这些举措，能在较短的时间，为我国培养一大批高质量的信息技术人才，提高我国软件人才的国际竞争力，促进我国信息产业的快速发展，加快推动国家信息化进程，进而带动整个国民经济的跨越式发展。

教育部高等教育司

二〇〇二年三月

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To my father-in-law, Dr. Ralph Alberg, and to the memory of my mother-in-law, Elaine Alberg—two wonderful people who taught me about love and life.

—MAG

To Margenia—my partner, friend, confidant, woman of infinite affection, infinite patience, and a really cool Mom.

—WMH

Preface

Computer Communications and Networking Technologies presents a comprehensive introduction to the study of its topic. Our book provides a discussion of the scope and dynamics related to (a) the manner in which computers communicate with each other, (b) how computers are grouped together to form networks, (c) the various networking concepts and issues that are key to the successful implementation of computer networks, and (d) the different networking implementation strategies and technologies currently available.

We wrote this book to provide an alternative to the current body of networking and data communications titles, which are too general, too specific, or too technical. For example, general networking books are usually narrow in scope and provide readers with a limited overview of topics without providing sufficient detail that will enable them to understand key network concepts thoroughly. On the other hand, several networking titles provide sufficient detail and coverage but limit their discussions to specific technologies (e.g., Ethernet or the Internet). Finally, technically-based network books are designed expressly for network engineers or computer scientists and present the material from a systems perspective, contain pseudocode or programming assignments, and provide detailed mathematical concepts or derivations involving calculus, probability theory, or queuing theory. Although many of these books are excellent for their respective audiences, they do not address adequately the educational needs of nontechnical students who endeavor to learn and understand — in sufficient detail — the "big picture" of computer networks.

Consequently, *Computer Communications and Networking Technologies* was written expressly for nonengineering students who are taking a first course in computer networks. It is most appropriate for students in two-year postsecondary schools, such as community colleges or professional trade/vocational schools, or for students in four-year colleges or universities. Thus, first- or second-year undergraduate students majoring in computer science, computer information science, or telecommunications will benefit most from using this textbook. Students from other fields, including mathematics, any of the sciences, business, and liberal arts, who are taking a computer-networking course as an elective, will also benefit from this textbook. Finally, engineering or engineering technology students, as well as computer and network professionals, will find this book a valuable resource that can help them fill in the gaps or tie together loose ends that might have accumulated during their years of study or field experience.

Given this target audience, our goal was to impart the highly technical information and issues involving computer communications and networking technologies in a manner that would be accessible to nearly all levels of readers. We believe we have succeeded in this goal. The topics and issues discussed in the book are explained fully and in an uncomplicated manner. Furthermore, our discussions are of considerable depth and of sufficient rigor for the target audience. Given its format and level of coverage, the book can be equated to a snorkeling adventure: We primarily stay at the surface to examine the features, attributes, technical issues, and concepts of computer networks and networking technologies. Occasionally, we hold our joint breath and dive under the surface to explore a particular concept more fully. We do not, however, examine in detail the underlying mathematical foundations of any particular topic (such an undertaking is better left for a scuba diving expedition). Instead, we offer a glimpse into this world through various figures, appendixes, and boxed text items. In this way, all students, including those with only an algebra background, will benefit from the presentation. Thus, students will not only acquire a thorough understanding of computer communications and networks, but will also have an appreciation for many of the issues and problems related to computer networking.

Organizational Structure

We have organized the material in *Computer Communications and Networking Technologies* in four major parts.

- **Part I: Computer Communications and Networking Basics.** This part represents the basic foundations of networking and comprises the first three chapters. Chapter 1 provides an overview of the various topics encompassing computer communications and networking. It treats many of the concepts it presents from a general perspective, and subsequent chapters elaborate them. The main purpose of this chapter is to get students initially engaged in the study of networking. Chapter 2 extends many of the concepts discussed in Chapter 1 and presents new networking terms and concepts. Chapter 3 provides a discussion of basic analog and digital communications concepts. Nearly all of the information contained in these first three chapters represents the foundation of computer communications and networking and is used throughout the remaining three parts of the book.
- **Part II: Physical, Data Link, and Network Layer Concepts.** The second part of the book comprises Chapters 4 through 8 and contains detailed coverage of various network standards and protocols. Chapter 4 discusses the physical concepts and issues related to networking. Chapter 5 addresses IEEE LAN standards and examines how data frames are constructed, how nodes control the flow of data during a transmission, and how data integrity is maintained via error control. Chapter 6 contains a separate discussion of various network hardware components. Chapter 7 provides information about internetworking and routing concepts. Chapter 8 is devoted to the Internet and the TCP/IP protocol suite including TCP/IP's two transport protocols, UDP and TCP. This part of the book provides students with the core networking concepts that are fundamental to the various local and wide area computer networks and networking technologies presented in Part III.

- **Part III: Local and Wide Area Networking Technologies.** Chapters 9 through 15 examine specific LAN or WAN protocols, technologies, and services. Although most students' perception of computer networks revolves around the Internet and Ethernet, this is not the reality they will face when working in the field. Yes, nearly every organization has an Internet connection, and yes, nearly every organization has a local area Ethernet network. However, many organizations also have fully operational first-generation networks such as token ring or outdated second-generation networks such as FDDI. Furthermore, some of these same organizations also have frame relay, ATM, or ISDN connections. Given the diversity of networking technologies that exist in the field, we have provided separate chapters on the common ones students will most likely encounter. These include Ethernet (Chapter 9), Token Ring (Chapter 10), FDDI (Chapter 11), ISDN (Chapter 12), Frame Relay (Chapter 13), SMDS (Chapter 14), and ATM (Chapter 15).
- **Part IV: Related Networking Concepts, Applications, and Technologies.** The final three chapters provide information about several related networking topics: dialup and home networking (Chapter 16), network security issues (Chapter 17), and network convergence (Chapter 18), the merging of the technologies and applications discussed in all the previous chapters. Among the topics discussed in Chapter 18 is the current trend toward multiservice networking, which integrates traditional voice, video, and data applications.

Each chapter concludes with an End-of-Chapter Commentary. These commentaries consist of transitional material that identifies other chapters in the book containing additional information related to the current discussion. In a sense, they provide a notion of "where we are presently, where we were, and where we are going." As a result, students are able to link key concepts and issues from the current chapter to other chapters.

A Chapter Review is provided at the end of each chapter. This section consists of a bulleted-item list that summarizes the salient aspects of the chapter, a vocabulary check that contains key words and phrases introduced in the chapter, approximately 400 review exercises throughout, and suggested readings and references. Finally, five appendixes and a comprehensive 700-word glossary complement the book's nucleus. Appendix A contains information about vendor Ethernet prefixes. Appendix B presents a detailed example of how parity is used for single-bit error correction. Appendix C has guidelines for installing unshielded twisted-pair cable. Appendix D provides information about designing and analyzing networks as well as how to deal with network politics. Appendix E contains a brief overview of X.25.

Although the chapters are structured logically to follow each other and build on previously learned knowledge, this does not preclude their being read in any order. We wrote the chapters to be independent of each other. Throughout every chapter, key terms or concepts that were presented in an earlier chapter or discussed in a later chapter are explained in the current context with either a forward or backward reference that specifies the appropriate chapter or chapters where the term or concept is discussed more completely. These cross-references enable students to take a break from the current discussion so they can either refresh their knowledge of previously presented material or jump ahead to gain further insight into a specific topic. Thus, the cross-references effectively facilitate a deeper understanding of a given concept in the current context. Finally, throughout the entire presentation, illustrations, tables, and special boxed text items are included to promote further knowledge.

To the Instructor

This textbook is designed for use in a one-semester or one-quarter course. Ample material is included to provide you with a great amount of flexibility for its use. Clearly, the chapters you cover will be determined to a large extent by how the course is structured. Following are three suggestions for presenting this material based on one of the authors' teaching experiences.

Perspective	Suggested Chapters	Comments
A less technical approach that focuses on general concepts, the Internet, Ethernet, and home networking	• Part I: Chapters 1 and 2 • Part II: Chapters 4 through 8 • Part III: Chapter 9 • Part IV: Chapter 16	1. One week per chapter, except three weeks for Chapter 8 and two weeks for Chapter 9. 2. Combine selected material from Chapter 6 with Chapters 5 and 7.
A more technical approach that focuses on different networking technologies	• Part I: Chapters 1, 2, and 3 • Part II: Chapters 4 through 8 • Part III: Chapters 9 through 15	1. One week per chapter. 2. Combine selected material from Chapter 6 with Chapters 5 and 7.
A middle-of-the-road approach that provides a comprehensive overview of most text material	• Part I: Chapters 1 and 2 • Part II: Chapters 4 through 8 • Part III: Chapters 9, 12, 13, 15 • Part IV: Chapters 16 and 17	1. One week per chapter, except two weeks for Chapter 9. 2. Combine selected material from Chapter 6 with Chapters 5 and 7. 3. Combine selected material from Chapter 8 throughout all presentations.

Accompanying the textbook is an instructor's resource and solutions manual, which contains chapter outlines and answers to all of the chapter exercises. Additionally, sample chapter examinations with solutions are provided to facilitate test construction. You may find more support online at www.brookscole.com.

To the Student

Computer Communications and Networking Technologies serves as an excellent foundation on which future and current network managers and administrators can build a solid knowledge base of data communications standards and present and emerging network technologies. After reading this book, you will have accrued a greater understanding of and appreciation for networks and networking. This book will help you understand basic networking terminology, components, applications, protocols, architectures, standards, and implementation strategies. Please note that this is *not* a "how-to" book. We do not provide specific information relative to network management or configurations. Thus, the material contained here will not help you perform such tasks as setting up a domain name server, configuring a network printer, or installing or managing an office network. However, your knowledge, appreciation, comprehension, and awareness of the concepts involved in such activities will be more acute after reading this book. To quote a former

student who was taught using earlier drafts of this material in a data communications and networking course: "The material cleared a lot of things up for me. It tied together a lot of loose ends I had for 10 years as a network administrator."

Additionally, a companion textbook published by Digital Press, *Networking Explained,* is available as a supplementary resource. *Networking Explained* covers essentially the same material contained in this textbook except it employs an easy-to-follow question-and-answer format. We structured the question–answer format to emulate a conversation between a networking professional and the reader. The questions are representative of those asked by individuals who are interested in computer networks and who wish to gain additional understanding of the subject. Users of *Networking Explained* have found the conversational tone engaging, informative, and entertaining.

Acknowledgments

Many people contributed considerably, either directly or indirectly, in the preparation of this material. It is therefore justifiable that these individuals be acknowledged. First of all, we are grateful to the authors of the articles, books, RFCs, and other reference material listed at the end of each chapter. These publications served as invaluable resources for confirming that our illustrations and material are accurate, complete, and up-to-date. Next, we thank the many reviewers of the manuscript for their suggestions and thought-provoking comments. They did a yeoman's job and their constructive criticisms strengthened the quality of this book greatly. They include Prasad Aloni of Drexel University, Ron Fulle of Rochester Institute of Technology, Arnold Meltzer of George Washington University, Krishna Sivalingam of Washington State University, Eugene Styer of Eastern Kentucky University, and Michael Whitman of Kennesaw State University.

It is with pleasure that we also acknowledge and thank the editorial staff of Brooks/Cole. In particular, an especially warm "thank you" is extended to our editor, Kallie Swanson, who, on a routine follow-up to a several years' earlier submission, actively solicited this project. We are also extremely appreciative of the collaboration among Kallie, publisher Bill Stenquist of Brooks/Cole, and associate editor Pam Chester and former publisher Phil Sutherland of Digital Press. Through a unique, cooperative arrangement between the two publishing companies, we were permitted to use our trade book, *Networking Explained,* which is published by Digital Press, as the basis for much of the material contained within this textbook. A note of gratitude is also extended to production editor Dustine Friedman of The Book Company and to production coordinator Kelsey McGee of Brooks/Cole, who were together responsible for the overall production of this book. We are particularly grateful to copy editor Frank Hubert.

This book also benefited from the contributions of many former students at Rollins College and Florida Institute of Technology, as well as from participants of seminars and workshops we conducted at various regional and national conferences.

Finally, we extend our personal gratitude to our wives, Jane and Margenia, for their support, patience, understanding, and love throughout this entire project.

Michael A. Gallo
William M. Hancock

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