国外计算机科学教材系列

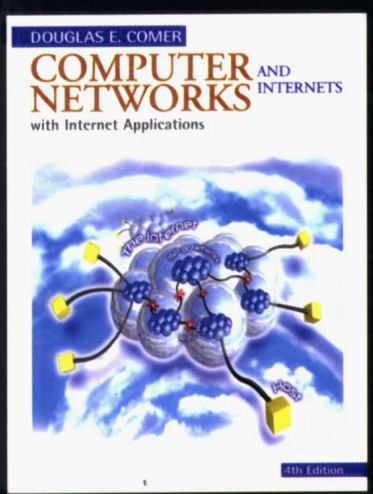
计算机网络与互联网

（第四版）

Computer Networks and Internets

with Internet Applications

Fourth Edition



英文版

[美] Douglas E. Comer 著

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北京 · BEIJING

内 容 简 介

本书由畅销书作家、计算机网络专家 Douglas Comer 撰写。全书共分为五个部分，第一部分概述了 Internet 应用的使用与构建；第二部分讲述数据传输的知识，内容包括传输介质、本地异步通信、长距离通信等；第三部分讲述包交换的问题，在叙述各类网络特性的基础上介绍了下一站路由、交换和协议分层，并结合以太网、FDDI、令牌环和 ATM 详述了包交换的过程；第四部分讲述网络互联，主要介绍了 TCP、ARP 协议；第五部分讲述网络应用，首先从客户/服务器模式开始，叙述了域名系统和应用中的域名识别，文件传输和 Web 浏览，包括动态 CGI 文档和活动 Java 文档的解释和应用。

本书适用于计算机专业本科高年级学生和缺少网络知识的低年级硕士生。

版权贸易合同登记号　图字：01-2004-2716

图书在版编目（CIP）数据

计算机网络与互联网 = Computer Networks and Internet with Internet Applications, Fourth Edition：第四版 /（美）科默（Comer, D. E.）著. -北京：电子工业出版社，2004.6
（国外计算机科学教材系列）
ISBN 7-120-00085-3

Ⅰ.计… Ⅱ.科… Ⅲ.①计算机网络-教材-英文②因特网-教材-英文 Ⅳ. TP393

中国版本图书馆 CIP 数据核字（2004）第 050523 号

责任编辑：赵红燕
印　　刷：北京兴华印刷厂
出版发行：电子工业出版社
　　北京市海淀区万寿路 173 信箱　邮编：100036
经　　销：各地新华书店
开　　本：787 × 980　1/16　　印张：47　字数：1053 千字
印　　次：2004 年 6 月第 1 次印刷
定　　价：69.00 元（附光盘 1 张）

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出 版 说 明

21世纪初的5至10年是我国国民经济和社会发展的重要时期，也是信息产业快速发展的关键时期。在我国加入WTO后的今天，培养一支适应国际化竞争的一流IT人才队伍是我国高等教育的重要任务之一。信息科学和技术方面人才的优劣与多寡，是我国面对国际竞争时成败的关键因素。

当前，正值我国高等教育特别是信息科学领域的教育调整、变革的重大时期，为使我国教育体制与国际化接轨，有条件的高等院校正在为某些信息学科和技术课程使用国外优秀教材和优秀原版教材，以使我国在计算机教学上尽快赶上国际先进水平。

电子工业出版社秉承多年来引进国外优秀图书的经验，翻译出版了“国外计算机科学教材系列”丛书，这套教材覆盖学科范围广、领域宽、层次多，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。这些教材涉及的学科方向包括网络与通信、操作系统、计算机组织与结构、算法与数据结构、数据库与信息处理、编程语言、图形图像与多媒体、软件工程等。同时，我们也适当引进了一些优秀英文原版教材，本着翻译版本和英文原版并重的原则，对重点图书既提供英文原版又提供相应的翻译版本。

在图书选题上，我们大都选择国外著名出版公司出版的高校教材，如Pearson Education培生教育出版集团、麦格劳－希尔教育出版集团、麻省理工学院出版社、剑桥大学出版社等。撰写教材的许多作者都是蜚声世界的教授、学者，如道格拉斯·科默（Douglas E. Comer）、威廉·斯托林斯（William Stallings）、哈维·戴特尔（Harvey M. Deitel）、尤利斯·布莱克（Uyless Black）等。

为确保教材的选题质量和翻译质量，我们约请了清华大学、北京大学、北京航空航天大学、复旦大学、上海交通大学、南京大学、浙江大学、哈尔滨工业大学、华中科技大学、西安交通大学、国防科学技术大学、解放军理工大学等著名高校的教授和骨干教师参与了本系列教材的选题、翻译和审校工作。他们中既有讲授同类教材的骨干教师、博士，也有积累了几十年教学经验的老教授和博士生导师。

在该系列教材的选题、翻译和编辑加工过程中，为提高教材质量，我们做了大量细致的工作，包括对所选教材进行全面论证；选择编辑时力求达到专业对口；对排版、印制质量进行严格把关。对于英文教材中出现的错误，我们通过与作者联络和网上下载勘误表等方式，逐一进行了修订。

此外，我们还将与国外著名出版公司合作，提供一些教材的教学支持资料，希望能为授课老师提供帮助。今后，我们将继续加强与各高校教师的密切联系，为广大师生引进更多的国外优秀教材和参考书，为我国计算机科学教学体系与国际教学体系的接轨做出努力。

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Preface

Previous editions of *Computer Networks And Internets* have generated excitement. In addition to the hundreds of U.S. schools using the text in their networking courses, professionals have written to praise its use in industry, and enthusiastic comments have arrived about the foreign translations. The success is especially satisfying in a market glutted with networking books. This book stands out because of its breadth of coverage, logical organization, explanation of concepts, focus on the Internet, and wealth of supplemental materials for both students and instructors on the CD-ROM and on the Web site:

http://www.netbook.cs.purdue.edu

The new edition has been completely revised and updated, with three new chapters (24, 26, 33) and additional glossary entries. The CD-ROM and Web site have also been expanded.

Each new chapter responds to requests from instructors and readers. Chapter 24 introduces UDP, Chapter 26 explains Network Address Translation, and Chapter 33 covers IP telephony. Chapter 33 is especially relevant; students are likely to use an IP telephone.

The text answers the basic question "how do computer networks and internets operate?" in the broadest sense. It provides a comprehensive, self-contained tour through all of networking that describes low-level details such as data transmission and wiring, network technologies such as LANs and WANs, internetworking protocols, and application software. It shows how protocols use the underlying hardware and how applications use the protocol stack to provide functionality for users.

Much has been written recently about how a study of networking should be organized. There are two extremes: a strict bottom-up approach or a strict top-down approach. In bottom-up, one learns the lowest-level details, and then learns how the next higher levels use the lower-levels to provide expanded functionality. In top-down, one starts with a high-level application and only learns enough of the next lower layer to understand how the application can operate. Each approach has advantages. The traditional bottom-up approach presents the material in a logical manner so a reader understands how higher layers build on lower layers. A top-down approach begins with familiar applications (e.g., email), and provides a less rigorous introduction to the subject. We recommend a new, integrated approach that combines the best of top-down and bottom-up. The integrated approach provides early exposure to using and building net-

work applications while simultaneously delivering the material in a logical order. To implement the integrated approach, the new edition of *Computer Networks And Internets* has a companion laboratory manual, *Hands-On Networking*. *Computer Networks And Internets* explains the concepts, and the exercises in *Hands-On Networking* show how the concepts apply to real networks.

The text is intended for upper-division undergraduates or beginning graduate students, who have little or no background in networking. It does not use sophisticated mathematics, nor does it assume a knowledge of operating systems. Instead, the text defines concepts clearly, uses examples and drawings to illustrate how the technology operates, and states results of analysis without providing mathematical proofs.

After an introduction that starts readers using and building network applications (Chapters 1—3), the body of the text is organized into four sections. The first section (Chapters 4—6) provides a brief explanation of how the underlying hardware works. The section explains the concept of a carrier signal, discusses modulating a carrier, and shows how a modem encodes data on a carrier wave for transfer. The section also discusses asynchronous, character-oriented data transmission, and defines terms such as *bandwidth* and *baud* that arise in later chapters.

The second section (Chapters 7—16) focuses on packet switching. The section introduces the motivation for using packets, and then describes basic network topologies and wiring schemes as well as the characteristics used to categorize networks as LANs, WANs, local loops, public or private, and connection-oriented or connectionless. The section also introduces the concepts of next-hop routing, switching, and protocol layering, with the terminology used for each. Finally, the section uses several common network technologies as examples, including Ethernet, ATM, and DSL.

The third section (Chapters 17—27) focuses on the Internet protocols. After discussing the motivation for internetworking, the section describes internet architecture and routers, internet addressing, address binding, and the TCP/IP protocols. Protocols such as IP, TCP, UDP, ICMP, and ARP are reviewed in more detail, allowing students to understand how the concepts relate to practice. Chapter 25 on TCP covers the important and deep topic of reliability in transport protocols.

The final section (Chapters 28—41) examines network applications. As with other sections of the text, coverage is quite broad — the section includes a discussion of both general principles and specific applications. The section begins by describing the client-server model that network applications use to communicate. The section then describes the socket API, and shows code from an example client and server that use sockets for communication. The section describes name resolution with the Domain Name System and applications such as e-mail, file transfer, IP telephony, and the Web (including an explanation of dynamic and active documents, with examples using CGI, Java, and JavaScript). In each case, the text describes the structure of the software, and explains how a client and server interact to provide the service. Chapter 38 discusses middleware, including both procedural and object oriented middleware technologies. Later chapters in the section discuss network security, and explain how application software can be used for network management. Finally, Chapter 41 considers the in-

teresting problem of initialization. The chapter shows how application-level software can achieve what seems to be impossible — use of protocol software to obtain the information needed to initialize the protocol software being used.

The text is ideally suited for a one-semester introductory course on networking taught at the senior level. Designed for a comprehensive course, it covers the entire subject from wiring to applications. In the undergraduate course at Purdue, for example, students have weekly lab assignments that cover a wide range of topics: network measurement, packet analysis, and network programming. By the time they finish our course, each student is expected to: know how an IP router uses a routing table to forward IP datagrams; describe how a datagram crosses the Internet; explain the difference between an Ethernet hub and an Ethernet switch; know how TCP identifies a connection and why a concurrent Web server can handle multiple connections to port 80; describe the conceptual differences between a bridge and an IP router; compute the length of a single bit as it travels across a 100BaseT network; explain why TCP is classified as end-to-end; distinguish between the CSMA/CD media access mechanism used by Ethernet and a token passing scheme; and know how DSL can send data over wires that are also being used for an analog telephone call.

The goal of a single course is breadth, not depth — to cover the subject, one cannot focus on a few technologies or a few concepts. Thus, the key to a successful course lies in maintaining a quick pace. To cover the fundamental topics in a semester, the lower-layer material in Part 2 can be condensed into a week, and the sections on networks and internetworking can be allocated five weeks each, leaving a few weeks for the section on applications and topics such as network management and security.

Instructors should impress on students the importance of concepts and principles: specific technologies may become obsolete in a few years, but the principles will remain. In addition, instructors should give students a feeling for the excitement that pervades networking.

Although no single topic is challenging, students may find the quantity of material daunting. In particular, students are faced with a plethora of new terms. Networking acronyms and jargon can be especially confusing; students spend much of the time becoming accustomed to using proper terms. To help students master terminology, Appendix 1 contains a glossary of terms and acronyms. To provide additional clarification, definitions in the glossary have been written independently rather than being taken verbatim from the text.

Because programming and experimentation are crucial to helping students learn about networks, laboratory experience is an essential part of any networking course. The lab manual, *Hands-On Networking*, describes experiments that can be performed on a variety of hardware, including a single computer or a set of computers on a local area network. Our curriculum at Purdue emphasizes packet analysis and socket programming. We begin the semester by having students construct client software to access the Web and extract data (e.g., write a program to print the current temperature). Chapter 3 explains the simple API that we give students; with our API, students can write working code before they learn about protocols, addresses, or sockets. Later in the semester, of

course, students learn to use the socket API. Eventually, they write a concurrent Web server (support for server-side scripting is optional). In addition to application programming, students also use the lab facilities to capture packets from a live network. They write programs that decode packet headers (e.g., Ethernet, IP, and TCP), and observe TCP connections.

Giving students access to a network builds enthusiasm and encourages experimentation — our experience shows that students who have access to a live network understand and appreciate the subject better. Thus, if a dedicated packet analyzer is not available, an analyzer can be created by installing appropriate shareware software on a standard PC.

The CD-ROM included with the text and the Web site both contain materials that will make teaching easier and help readers understand the material. For students without access to networking facilities, the CD-ROM contains examples of packet traces; students can write programs that read a trace and process packets as if they have been captured from the network. For instructors, the CD-ROM contains course materials, figures from the text that can be used in presentations, and animated figures that help clarify the concepts. The CD-ROM also contains materials not in the text, including photographs of network wiring and equipment as well as files of data that can be used as input to student projects.

To help both professors and students locate information, the CD-ROM includes a keyword search mechanism. When given a term, the search mechanism locates a definition from the online glossary as well as other items related to the term. Finally, the CD-ROM contains links to the Web site, which is updated continuously. Two electronic mailing lists have been established for the text: general information can be obtained from *netbook@cs.purdue.edu*; discussions about teaching the material occur on *netbook-inst@cs.purdue.edu*. To join one of the mailing lists, send an e-mail message to *netbook-request@cs.purdue.edu* or *netbook-inst-request@cs.purdue.edu* with the word *subscribe* in the body of the message. To avoid having the mail server send multiple copies of each message over the Internet, instructors are requested to establish a single local alias for all students at their site.

I thank all the people who have contributed to this edition of the book. Dennis Brylow and John Lin proofread chapters throughout the text. Jennifer Seitzer, Abdullah Abonamah, George Varghese, and Jim Griffioen reviewed earlier editions and made valuable comments. Mike Evangelista wrote the client and server application code in Chapter 3 as well as the API; he ported the API to Linux, Solaris, and Windows platforms. Ralph Droms prepared the CD-ROM, manages the Web materials, and reviewed several chapters. David Laverell created and manages the Web site for *Hands On Networking*. Special thanks go to my wife and partner, Christine, whose careful editing and helpful suggestions made many improvements throughout.

Douglas E. Comer

September, 2003

About The Author

Dr. Douglas Comer is an internationally recognized expert on TCP/IP protocols, computer networking, and the Internet. One of the researchers who contributed to the Internet as it was being formed in the late 1970s and 1980s, he was a member of the Internet Architecture Board, the group responsible for guiding the Internet's development. He was also chairman of the CSNET technical committee and a member of the CSNET executive committee.

Comer consults for industry on the design of computer networks. In addition to talks in universities, each year Comer teaches many onsite courses to networking professionals around the world. His operating system, Xinu, and implementation of TCP/IP protocols (both documented in his textbooks), have been used in commercial products.

Comer is a professor of computer science at Purdue University, where he teaches courses and does research on computer networking, internetworking, and operating systems. In addition to writing a series of best-selling technical books that have been translated into sixteen languages, he serves as the North American editor of the journal *Software — Practice and Experience.* Comer is a Fellow of the ACM.

Additional information can be found at:

www.cs.purdue.edu/people/comer

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