

经 典 原 版 书 库

Internet 技术基础

(英文版·第3版)

The

INTERNET

EVERYTHING YOU NEED TO KNOW
ABOUT COMPUTER NETWORKING
AND HOW THE INTERNET WORKS

THIRD EDITION

DOUGLAS E. COMER

Book

WEB & E-COMMERCE INSIDE

(美) Douglas E. Comer 著



机械工业出版社
China Machine Press

Prentice Hall

经典原版书库

(英文版·第3版)

Internet 技术基础

The Internet Book
(Third Edition)

(美) Douglas E. Comer 著



机械工业出版社
China Machine Press

English reprint edition copyright © 2002 by PEARSON
EDUCATION ASIA LIMITED and CHINA MACHINE PRESS.

The Internet Book, Third Edition by Douglas E. Comer, Copyright ©
2000. All rights reserved. Published by arrangement with Pearson
Education, Inc.

本书英文影印版由美国Prentice Hall公司授权机械工业出版社在
中国大陆境内独家出版发行, 未经出版者许可, 不得以任何方式抄袭、
复制或节录本书中的任何部分。

版权所有, 侵权必究。

本书版权登记号: 图字: 01-2001-5016

图书在版编目(CIP)数据

Internet技术基础(英文版·第3版)/(美)科默(Comer, D. E.)
著. - 北京: 机械工业出版社, 2002.1

(经典原版书库)

书名原文: The Internet Book, Third Edition

ISBN 7-111-09159-0

I. I... II. 科... III. 因特网 - 普及读物 - 英文 IV. TP393.4-49

中国版本图书馆CIP数据核字(2001)第051442号

机械工业出版社(北京市西城区百万庄大街22号 邮政编码 100037)

责任编辑: 华章

北京昌平奔腾印刷厂印刷·新华书店北京发行所发行

2002年1月第1版·2003年1月第2次印刷

880mm × 1230mm 1/32 · 12印张

印数: 3 001-5 000册

定价: 23.00元

凡购本书, 如有倒页、脱页、缺页, 由本社发行部调换

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中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、研究和收藏。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

联系电话：(010) 68995265

联系地址：北京市西城区百万庄南街1号

邮政编码：100037

专家指导委员会

(按姓氏笔画顺序)

尤晋元	王 珊	冯博琴	史忠植	史美林
石教英	吕 建	孙玉芳	吴世忠	吴时霖
张立昂	李伟琴	李师贤	李建中	杨冬青
邵维忠	陆丽娜	陆鑫达	陈向群	周伯生
周克定	周傲英	孟小峰	岳丽华	范 明
郑国梁	施伯乐	钟玉琢	唐世渭	袁崇义
高传善	梅 宏	程 旭	程时端	谢希仁
裘宗燕	戴 葵			

About The Author

Douglas Comer is a professor of computer science at Purdue University, where he teaches courses on computer operating systems and internetworking. One of the researchers who contributed to the Internet as it was being formed in the late 1970s and 1980s, he has served as a member of the Internet Architecture Board, the group responsible for guiding the Internet's development. In addition, he has written a popular series of textbooks that describe the technical details of the Internet, and presents lectures on the subject around the world. He is a Fellow of The Association for Computing Machinery (the major professional society in computer science) and editor of the scientific journal, *Software — Practice and Experience*.

Professor Comer has had Internet access from his home since the late 1970s, has had a direct connection with twenty-four hour per day service since 1981, and uses the Internet daily. His connection currently operates at 2.24 million bits per second, approximately fifty times faster than a dial-up modem. He wrote this book as a response to everyone who has asked him for an explanation of the Internet that is both technically correct and easily understood by anyone. An Internet enthusiast, Comer displays *INTRNET* on the license plate of his car.

More information can be found at:

<http://www.cs.purdue.edu/people/comer>

Preface

The Internet Book explains how computers communicate, what the Internet is, how the Internet works, and what services the Internet offers you. It is designed for readers who do not have a strong technical background — early chapters clearly explain the terminology and concepts needed to understand all the services. When you finish reading, you will understand the technology behind the Internet, will appreciate how the Internet can be used, and discover why people find it so exciting. In addition, you will understand the origins of the Internet and see how rapidly it has grown.

Instead of using mathematics, algorithms, or computer programs, the book uses analogies from everyday life to explain technology. For example, to explain why digital communication is superior to analog, the text uses an analogy of sending signals through fog with a flashlight. To explain how audio can be played back for the user at a steady rate when packets arrive in clumps, the text uses the analogy of many gallons of milk arriving at a supermarket in one shipment, but being sold one gallon at a time.

In addition to explaining the services users encounter such as e-mail, file transfer, and web browsing, the text covers key networking concepts such as packet switching, Local Area Networks, protocol software, and domain names. More important, the text builds on fundamentals — it describes basic Internet communication facilities first, and then shows how the basic facilities are used to provide a variety of services. Finally, the book includes an extensive glossary of technical terms with easy-to-understand definitions; readers are encouraged to consult the glossary as they read.

The third edition retains the same general structure as the previous edition, but adds four new chapters and updates material throughout. Chapter 2 surveys a variety of Web sites, and encourages readers to begin exploring the Web while they read. The other three new chapters are especially significant. Chapter 14 covers Internet connection technologies, including ADSL and cable modems, technologies which are now available to consumers. Chapters 29 and 30 cover the related topics of security and e-commerce, both of which are increasingly important. Chapter 29 explains encryption technology, and Chapter 30 shows how the technology is used to conduct business.

As with the previous edition, the book is divided into four main parts. The first part begins with fundamental concepts such as digital and analog communication. It also introduces packet switching, and explains the Local Area Network technologies that are used in most businesses.

The second part of the book gives a short history of the Internet research project and the development of the Internet. Although most of the history can be skipped, readers should pay attention to the phenomenal growth rate, which demonstrates that the technology was designed incredibly well — no other communication technology has remained as unchanged through such rapid growth.

The third part of the book explains how the Internet works, including a description of the two fundamental protocols used by all services: the Internet Protocol (IP) and the Transmission Control Protocol (TCP). Although they omit technical details, the chapters in this part allow students to understand the essential role of each protocol and gain perspective on the overall design.

The fourth part of the book examines services available on the Internet. In addition to covering browsers, plugins, CGI, and search engines used with the World Wide Web, chapters discuss e-mail, network newsgroups, file and fax transfer, and audio and video communication. In each case, the text explains how the service operates and how it uses facilities in the underlying system.

The Internet Book makes an excellent reference text for a college-level course on the Internet. Although presented in a nontechnical manner, the material is scientifically accurate. More important, in the twenty-first century, an educated person will need to know more than how to use a browser or set up a Web page — they should have some understanding of what goes on behind the scenes. They can acquire such knowledge from this text.

Instructors are encouraged to combine classroom lectures with laboratory sessions in which students see and use the technology first-hand. In all courses, early labs should focus on exploring a variety of services, including sending e-mail, using a browser, using a search engine, downloading files via FTP, listening to audio, and using an IP telephone, if one is available. I encourage all students, even those who have no interest in computers, to build a trivial Web page by hand. In addition to helping them see the relationship between tags in an HTML document and the resulting display, it shows students how a server transfers files on a computer disk to a browser. Seeing the relationship in labs helps students better understand as they read about the underlying process.

Lab projects later in the semester depend on the type of course. Business-oriented courses often focus students on using the Internet — labs require students to search the Internet for information and then use the information to write a short paper. Other courses use labs to focus on tools such as programs used to create a Web page. Some courses combine both by having students search for information and then create a Web page that contains links to the information. In any case, we have found that students enter Internet courses with genuine enthusiasm and motivation; a professor's task is merely to provide perspective and remind students throughout the semester why the Internet is so exciting.

The author thanks many people who have contributed to editions of this book. John Lin, Keith Rovell, Rob Slade, and Christoph Schuba read early versions and made suggestions. Dwight Barnette, George Polyzo, Donald Knudson, Dale Musser, and Dennis Ray sent the publisher reviews of a previous edition. Scott Comer provided a student perspective. As always, my wife, Chris, carefully edited the manuscript, solved many problems, and improved the wording.

Douglas E. Comer

March, 2000

Contents

Preface

Chapter 1 The Internet Has Arrived 1

- The World Is Changing* 1
- Numbers Do Not Tell The Story* 2
- Learning About The Internet* 3
- Understanding The Big Picture* 3
- Terminology And Technology* 4
- Growth And Adaptability* 4
- The Impact Of The Internet* 4
- Organization Of The Book* 4
- A Personal Note* 5

Chapter 2 Getting Started: Hands-On Experience 7

- Introduction* 7
- The Web: Sites And Pages* 8
- Web Browsers and Browsing* 8
- Using A Browser* 8
- Examples Of Web Sites And Services* 9
- Summary* 11

PART I Introduction To Networking

Chapter 3 Telephones Everywhere

15

<i>Introduction</i>	15
<i>A Communication Service</i>	15
<i>Selling Communication</i>	15
<i>Limited Access</i>	16
<i>High Cost</i>	17
<i>The Difficult Transition</i>	17
<i>Ubiquitous Access</i>	18
<i>Relevance To The Internet</i>	19

Chapter 4 The World Was Once Analog

21

<i>Introduction</i>	21
<i>Sound, Vibrations, And Analog Recording</i>	21
<i>Analog Electronic Devices</i>	22
<i>Many Electronic Devices Are Analog</i>	23
<i>The First Analog Communication</i>	23
<i>Analog Is Simple But Inaccurate</i>	23
<i>Sending An Analog Signal Across A Wire</i>	24
<i>Digital Music</i>	25
<i>The Digital Revolution</i>	25
<i>Computers Are Digital</i>	26
<i>Digital Recording</i>	26
<i>Using Digital To Recreate Analog</i>	26
<i>Why Digital Music?</i>	28
<i>Summary</i>	28

Chapter 5 The Once And Future Digital Network

31

<i>Introduction</i>	31
<i>The World Was Once Digital</i>	31
<i>A Telegraph Is Digital</i>	32
<i>Morse Code</i>	32
<i>Letters And Digits In Morse Code</i>	33
<i>Users Did Not Encounter Morse Code</i>	34
<i>Virtually Instant Communication</i>	34

<i>Speed Is Relative</i>	34
<i>The Telephone Became Digital</i>	35
<i>Relevance To The Internet</i>	35
<i>Binary Encoding Of Data On The Internet</i>	36
<i>Why Use Two Symbols?</i>	36
<i>Summary</i>	36

Chapter 6 Basic Communication

37

<i>Introduction</i>	37
<i>Communication Using Electricity</i>	37
<i>Signals On Wires</i>	38
<i>Information Coding</i>	38
<i>Modems Allow Two-Way Traffic</i>	39
<i>A Character Code For Digital Information</i>	40
<i>Detecting Errors</i>	41
<i>Summary</i>	43

Chapter 7 The Local Area Network Arrives

45

<i>Introduction</i>	45
<i>Motivation</i>	45
<i>Interchangeable Media</i>	46
<i>A Computer Consists Of Circuit Boards</i>	46
<i>Circuit Boards Plug Into A Computer</i>	46
<i>Connecting One Computer To Another</i>	47
<i>LAN Technologies</i>	48
<i>Connecting A Computer To A LAN</i>	49
<i>The Importance Of LAN Technology</i>	50
<i>Relationship To The Internet</i>	51

PART II A Brief History Of The Internet

Chapter 8 Internet: The Early Years

55

<i>Many Independent Networks</i>	55
<i>The Proliferation Of LANs</i>	55
<i>Facts About LANs</i>	56
<i>LANs Are Incompatible</i>	57
<i>Wide Area Technologies Exist</i>	57
<i>Few WANs, Many LANs</i>	58
<i>WANs and LANs Are Incompatible</i>	58
<i>The Desirability Of A Single Network</i>	59
<i>The Department Of Defense Had Multiple Networks</i>	59
<i>Connecting Disconnected Machines</i>	60
<i>The Internet Emerges</i>	60
<i>The ARPANET Backbone</i>	60
<i>Internet Software</i>	61
<i>The Name Is TCP/IP</i>	61
<i>The Shock Of An Open System</i>	61
<i>Open Systems Are Necessary</i>	62
<i>TCP/IP Documentation Is Online</i>	63
<i>The Military Adopts TCP/IP</i>	64
<i>Summary</i>	64
<i>A Personal Note</i>	64

Chapter 9 Two Decades Of Incredible Growth

67

<i>Introduction</i>	67
<i>Disseminating The Software</i>	67
<i>Meanwhile, Back In Computer Science</i>	68
<i>The Internet Meets UNIX</i>	68
<i>The U.S. Military Makes A Commitment</i>	69
<i>The Internet Doubles In Size In One Year</i>	69
<i>Every Computer Science Department</i>	70
<i>Graduate Students Volunteer Their Time</i>	70
<i>The IAB evolves</i>	71
<i>The IETF</i>	72
<i>Doubling Again In A Year</i>	72
<i>The Internet Improves Science</i>	72

<i>NSF Takes A Leadership Role</i>	73
<i>Target: All Of Science And Engineering</i>	73
<i>NSF's Approach</i>	73
<i>The NSFNET Backbone</i>	74
<i>The ANS Backbone</i>	74
<i>Exponential Growth</i>	75
<i>A Commercial Assessment</i>	77
<i>The End Of Growth</i>	77

Chapter 10 The Global Internet

79

<i>Introduction</i>	79
<i>Early ARPA Networks</i>	79
<i>Electronic Mail Among Computers</i>	79
<i>BITNET And FIDONET</i>	80
<i>Networks In Europe</i>	80
<i>EBONE: The Internet In Europe</i>	82
<i>Backbones And Internet Hierarchy</i>	82
<i>Internet On All Continents</i>	83
<i>The World Of Internet after 1998</i>	84
<i>A Personal Note</i>	85

Chapter 11 A Global Information Infrastructure

87

<i>Introduction</i>	87
<i>Existing Infrastructure</i>	87
<i>Communication Infrastructure</i>	88
<i>The Internet Infrastructure</i>	90
<i>The Internet Offers Diverse Information Services</i>	90
<i>TCP/IP Provides Communication Facilities</i>	90
<i>A Personal Note</i>	91

PART III How The Internet Works

Chapter 12 Packet Switching

95

<i>Introduction</i>	95
<i>Sharing Saves Money</i>	95
<i>Sharing Introduces Delays</i>	95
<i>Sharing Wires</i>	96
<i>Selectable Channels</i>	96
<i>Sharing By Taking Turns</i>	97
<i>Packet Switching Avoids Delays</i>	98
<i>Each Packet Must Be Labeled</i>	98
<i>Computers Have Addresses</i>	98
<i>Packets Are Not All The Same Size</i>	99
<i>Packet Transmission Seems Instantaneous</i>	99
<i>Sharing Is Automatic</i>	99
<i>Network Hardware Handles Sharing</i>	100
<i>Many Devices Can Use Packet Switching</i>	100
<i>Relevance To The Internet</i>	100
<i>Summary</i>	101

Chapter 13 Internet: A Network Of Networks

103

<i>Introduction</i>	103
<i>Network Technologies Are Incompatible</i>	103
<i>Coping With Incompatibility</i>	104
<i>Two Fundamental Concepts</i>	104
<i>Using A Computer To Interconnect Networks</i>	106
<i>Interconnecting Computers Pass Packets</i>	107
<i>Interconnecting Computers Are Called Routers</i>	107
<i>Routers Are The Building Blocks Of The Internet</i>	108
<i>Routers Accommodate Multiple Types Of Networks</i>	108
<i>Routers Can Interconnect WANs And LANs</i>	109
<i>Interconnecting Networks Was Revolutionary</i>	110
<i>Summary</i>	110

Chapter 14 ISPs And Network Connections 111

<i>Introduction</i>	111
<i>Internet Service Providers And Fees</i>	111
<i>Customer Connections Form The Last Mile</i>	112
<i>Leased Circuits Are Expensive</i>	112
<i>Most Individuals Choose Dial-up Access</i>	113
<i>The Important Concept Of Continuous Connectivity</i>	113
<i>Instantaneous Access Changes Use</i>	114
<i>Newer Technologies Offer Inexpensive Dedicated Access</i>	115
<i>Wireless Can Reach Everyone</i>	117
<i>A Personal Note</i>	117

Chapter 15 IP: Software To Create A Virtual Network 119

<i>Introduction</i>	119
<i>Protocol: An Agreement For Communication</i>	119
<i>Basic Functionality: The Internet Protocol</i>	120
<i>IP Software On Every Machine</i>	120
<i>Internet Packets Are Called Datagrams</i>	120
<i>The Illusion Of A Giant Network</i>	121
<i>The Reality Of Internal Structure</i>	122
<i>Datagrams Travel In Packets</i>	123
<i>Every Computer Is Assigned A Unique Address</i>	123
<i>Internet Addresses</i>	124
<i>An Odd IP Address Syntax</i>	124
<i>IP Addresses Are Not Random</i>	124
<i>An Example Trip Through The Internet</i>	125
<i>Summary</i>	126

Chapter 16 TCP: Software For Reliable Communication 127

<i>Introduction</i>	127
<i>A Packet Switching System Can Be Overrun</i>	127
<i>TCP Helps IP Guarantee Delivery</i>	129
<i>TCP Provides A Connection Between Computer Programs</i>	130
<i>The Magic Of Recovering Lost Datagrams</i>	130
<i>TCP Retransmission Is Automatic</i>	131
<i>TCP And IP Work Together</i>	131
<i>Summary</i>	132

Chapter 17 Clients + Servers = Distributed Computing 133

<i>Introduction</i>	133
<i>Large Computers Use Networks For Input And Output</i>	133
<i>Small Computers Use Networks To Interact</i>	134
<i>Distributed Computing On The Internet</i>	134
<i>A Single Paradigm Explains All Distributed Computing</i>	135
<i>Programs Are Clients Or Servers</i>	136
<i>A Server Must Always Run</i>	137
<i>Summary</i>	137

Chapter 18 Names For Computers 139

<i>Introduction</i>	139
<i>People Prefer Names To Numbers</i>	139
<i>Naming A Computer Can Be Difficult Or Fun</i>	140
<i>Computer Names Must Be Unique</i>	141
<i>Suffixes On Computer Names</i>	141
<i>Names With Many Parts</i>	142
<i>Domain Names Outside The US</i>	143
<i>Translating A Name To An Equivalent IP Address</i>	143
<i>Domain Name System Works Like Directory Assistance</i>	144
<i>Computer Name Lookup Is Automatic</i>	144
<i>IP Addresses And Domain Names Are Unrelated</i>	146
<i>Summary</i>	147

Chapter 19 Why The Internet Works Well 149

<i>Introduction</i>	149
<i>The Internet Works Well</i>	149
<i>IP Provides Flexibility</i>	150
<i>TCP Provides Reliability</i>	151
<i>TCP/IP Software Was Engineered For Efficiency</i>	151
<i>TCP/IP Research Emphasized Practical Results</i>	152
<i>The Formula For Success</i>	152
<i>Summary</i>	153