

NETWORKING

Computer Networking from LANs to WANs: Hardware, Software, and Security

Kenneth C. Mansfield Jr.
James L. Antonakos





Computer Networking from LANs to WANs: Hardware, Software, and Security

Kenneth C. Mansfield, Jr.
James L. Antonakos

 **COURSE TECHNOLOGY**
CENGAGE Learning™

Australia • Brazil • Japan • Korea • Mexico • Singapore • Spain • United Kingdom • United States

Copyright 2009 Cengage Learning. All Rights Reserved. May not be copied, scanned, or duplicated, in whole or in part.

**Computer Networking from LANs to
WANs: Hardware, Software, and
Security**

**Kenneth C. Mansfield, Jr. and
James L. Antonakos**

Vice President, Career and
Professional Editorial: Dave Garza
Executive Editor: Stephen Helba
Acquisitions Editor: Nick Lombardi
Managing Editor: Marah Bellegarde
Senior Product Manager:
Michelle Ruelos Cannistraci
Editorial Assistant: Sarah Pickering
Vice President, Career and
Professional Marketing:
Jennifer McAvey
Marketing Director: Deborah S. Yarnell
Senior Marketing Manager: Erin Coffin
Marketing Coordinator: Shanna Gibbs
Production Director: Carolyn Miller
Production Manager: Andrew Crouth
Content Project Manager:
Jessica McNavich
Design Assistant: Hannah Wellman
Cover photo or illustration: Photos.com
Production Technology Analyst:
Tom Stover
Manufacturing Coordinator:
Denise Powers
Copyeditor: Kathy Orrino
Proofreader: Sheila Zwiebel
Compositor: Cadmus Communications

© 2010 Course Technology, Cengage Learning

ALL RIGHTS RESERVED. No part of this work covered by the copyright herein may be reproduced, transmitted, stored or used in any form or by any means graphic, electronic, or mechanical, including but not limited to photocopying, recording, scanning, digitizing, taping, Web distribution, information networks, or information storage and retrieval systems, except as permitted under Section 107 or 108 of the 1976 United States Copyright Act, without the prior written permission of the publisher.

For product information and technology assistance, contact us at
Cengage Learning Customer & Sales Support, 1-800-354-9706

For permission to use material from this text or product, submit
all requests online at **cengage.com/permissions**

Further permissions questions can be emailed to
permissionrequest@cengage.com

Microsoft® is a registered trademark of the Microsoft Corporation.

Library of Congress Control Number: 2009923766

ISBN-13: 978-1-423-90316-1

ISBN-10: 1-423-90316-1

Course Technology

20 Channel Center Street
Boston, MA 02210
USA

Cengage Learning is a leading provider of customized learning solutions with office locations around the globe, including Singapore, the United Kingdom, Australia, Mexico, Brazil, and Japan. Locate your local office at: **international.cengage.com/region**

Cengage Learning products are represented in Canada by Nelson Education, Ltd.

For your lifelong learning solutions, visit **course.cengage.com**
Visit our corporate website at **cengage.com**

Printed in the United States of America

1 2 3 4 5 6 7 12 11 10 09

To our readers, who make everything possible.

Brief Table of Contents

PREFACE	xxiii
CHAPTER 1	
What Is a Computer Network?	1
CHAPTER 2	
Network Topology	21
CHAPTER 3	
Networking Hardware	39
CHAPTER 4	
Ethernet Technology	77
CHAPTER 5	
Token-Ring, FDDI, and Other LAN Technologies	117
CHAPTER 6	
Network Design and Troubleshooting Scenarios	137
CHAPTER 7	
Low-Level Protocols	169
CHAPTER 8	
The TCP/IP Protocols	191
CHAPTER 9	
IPX/SPX, AppleTalk, and Other Network Protocols	251
CHAPTER 10	
Switching and Routing	277
CHAPTER 11	
Network Management and Security	329
CHAPTER 12	
Electronic Mail	389
CHAPTER 13	
FTP and Telnet	421
CHAPTER 14	
Multimedia Networking	489
CHAPTER 15	
The Internet	525
CHAPTER 16	
Writing a Network Application	575
CHAPTER 17	
An Introduction to Networking with Windows	613
CHAPTER 18	
Windows Domains	643
CHAPTER 19	
UNIX and Linux	695
CHAPTER 20	
Other Network Operating Systems	737

v

CHAPTER 21	
Cryptography and Security	775
CHAPTER 22	
Security Hardware	805
CHAPTER 23	
Security Software	835
CHAPTER 24	
Forensic Techniques	861
GLOSSARY	913
INDEX	929

Table of Contents

PREFACE	xxiii
PART 1	
Network Hardware	
CHAPTER 1	
What Is a Computer Network?	1
Computer Network Topology	2
Wired Networks Versus Wireless Networks	3
Representing Digital Data	4
Working with Digital Data	5
Communication Protocols	5
The Physical Layer	6
The Data-Link Layer	6
The Network Layer	6
The Transport Layer	6
The Session Layer	6
The Presentation Layer	6
The Application Layer	7
Ethernet LANs	7
Token-Ring LANs	9
Network Operating Systems	9
IEEE 802 Standards	11
Troubleshooting Techniques	11
Chapter Summary	12
Key Terms	13
Review Questions	14
Hands-On Projects	16
Case Projects	18
CHAPTER 2	
Network Topology	21
Physical Topology Versus Logical Topology	22
Fully Connected Networks	24
Star Networks	25
Bus Networks	26
Ring Networks	26
Hybrid Networks	27
Network Hierarchy	28
Subnets	29
Network Access Points	29
Public Networks Versus Private Networks	30
Troubleshooting Techniques	31
	vii

Chapter Summary	32
Key Terms	32
Review Questions	33
Hands-On Projects	35
Case Projects	38
CHAPTER 3	
Networking Hardware	39
Ethernet Cabling	40
The NIC	46
Token-Ring	52
Repeaters	53
Transceivers	54
Hubs	55
Bridges/Switches	56
Routers and Firewalls	58
Cable Modems	61
Satellite Network System	63
Exotic Hardware and Software	64
Troubleshooting Techniques	67
Chapter Summary	69
Key Terms	70
Review Questions	70
Hands-On Projects	72
Case Projects	74
CHAPTER 4	
Ethernet Technology	77
The Ethernet Frame Format	78
Preamble (7 bytes)	79
SFD (1 byte)	79
Destination Address (6 bytes)	79
Source Address (6 bytes)	79
Length (2 bytes)	80
Data (46 to 1500 bytes)	80
FCS (4 bytes)	80
Interframe Gap	80
CSMA/CD	82
No Collision During Frame	82
A Collision Occurs During the Frame	83
Detecting Errors	85
Jam Sequence	86
Random Waiting Period	86
Ethernet Controllers	86
10-Mbps Ethernet	87
10base5	89

10base2	89
10baseT	89
10baseF	92
10baseFL	92
10baseFB	92
10baseFP	92
100-Mbps Ethernet (Fast Ethernet)	93
100baseT4	94
100baseTX	96
100baseFX	96
100baseT2	98
Fast Link Pulses	98
Two Repeater Types	101
100VG-AnyLAN	101
1000-Mbps Ethernet (Gigabit Ethernet)	102
Carrier Extension	102
Frame Bursting	103
Single Repeater Type	103
Gigabit Ethernet Architecture	103
1000baseT	103
1000baseCX	104
1000baseSX	105
1000baseLX	105
10 Gigabit Ethernet	106
Wireless Ethernet	107
Types of Wireless LANs	108
Troubleshooting Techniques	109
MTU Affects Available Bandwidth	109
Jabber	109
Runts	110
Alignment Error	110
Cabling	110
Lost Termination	110
Excess Utilization	111
Chapter Summary	111
Key Terms	111
Review Questions	112
Hands-On Projects	114
Case Projects	116

CHAPTER 5

Token-Ring, FDDI, and Other LAN Technologies	117
Token-Ring	118
Token-Ring Topology	119
Token-Ring Frame Formats	120
Ring Management	121
Comparing Token-Ring and Ethernet	122
Token-Bus	123
FDDI	123
Broadband LANs	125

ARCnet	126
Bluetooth	126
Troubleshooting Techniques	128
Network Troubleshooting Example	129
Chapter Summary	130
Key Terms	131
Review Questions	132
Hands-On Projects	134
Case Projects	135
CHAPTER 6	
Network Design and Troubleshooting Scenarios	137
Networking Two Computers	138
Networking a Small Lab	140
Networking a Small Business	142
Networking a College Campus	145
Remote Access Methods	147
Troubleshooting Techniques	149
Monitor Network Baseline Utilization	150
Checking the Hardware	150
Using Test Equipment	150
What's My IP?	150
Check the Network Neighborhood	152
Can You PING?	152
Baseband Versus Broadband	152
Chapter Summary	153
Key Terms	153
Review Questions	154
Hands-On Projects	156
Case Projects	160
PART 2	
Network Protocols	
CHAPTER 7	
Low-Level Protocols	169
Serial Data Communication	170
SLIP	171
PPP	172
PPPoE	173
Logical Link Control	173
NetBIOS	174
NetBEUI	177
Troubleshooting Techniques	181
Remote Access Trouble	181

Chapter Summary	182
Key Terms.....	183
Review Questions.....	184
Hands-On Projects.....	186
Case Projects.....	187
CHAPTER 8	
The TCP/IP Protocols.....	191
RFCs.....	195
IP.....	196
IP Addresses	200
Address Classes	201
TCP.....	202
Port Numbers	206
UDP.....	209
ARP and RARP.....	211
TCP/IP Support Protocols.....	216
DNS.....	216
BOOTP.....	217
Trivial FTP.....	218
DHCP.....	219
ICMP.....	220
SMTP.....	222
SNMP.....	222
HTTP.....	223
HTTPS.....	225
NTP.....	225
TCP/IP Applications.....	227
PING.....	227
TRACERT.....	230
NBTSTAT.....	231
NETSTAT.....	232
FTP.....	236
Telnet.....	236
IP Version 6 (IPv6).....	238
Protocol Analyzers.....	239
Troubleshooting Techniques.....	240
Chapter Summary	242
Key Terms.....	243
Review Questions.....	244
Hands-On Projects.....	246
Case Projects.....	249
CHAPTER 9	
IPX/SPX, AppleTalk, and Other Network Protocols.....	251
IPX/SPX.....	252
IPX.....	252
NCP.....	254

SPX	254
SAP	256
RIP	256
MLID	256
AppleTalk	256
DECnet	259
SNA	263
Troubleshooting Techniques	265
Chapter Summary	265
Key Terms	266
Review Questions	268
Hands-On Projects	271
Case Projects	274
CHAPTER 10	
Switching and Routing	277
Hubs versus Switches	278
Inside a Switch	281
Input Port Logic	281
Output Port Logic	282
Switching Fabric	282
Control Logic	282
Store-and-Forward Switching	284
Cut-Through Switching	284
Spanning Trees	285
Switches versus Routers	285
Routing Protocols	286
Autonomous Systems	290
Interior Gateway Protocols	294
Exterior Gateway Protocols	294
Classless Inter-Domain Routing	296
Distance-Vector Routing	298
RIP	299
Inter-Gateway Routing Protocol	300
Enhanced Inter-Gateway Routing Protocol	303
Link-State Routing	303
End System to Intermediate System	307
Intermediate System to Intermediate System	308
Integrated IS-IS	308
NetWare Link Services Protocol	309
Inter-Domain Routing Protocol	310
Exterior Gateway Protocol	310
Border Gateway Protocol	310
Policy Routing	312
Multi-Protocol Label Switching	312
Private Network-Network Interface	313

Layer 3 Switching	313
Inside an ISP	314
Troubleshooting Techniques	316
Trouble at the ISP	317
Chapter Summary	318
Key Terms	319
Review Questions	322
Hands-On Projects	325
Case Projects	327
CHAPTER 11	
Network Management and Security	329
Network Management	330
Disaster Recovery	332
Fault Tolerance	336
Protocol Analyzers	338
SNMP	339
Network Security	340
Threats	340
Viruses	342
Network Sniffers	343
Plain-Text Encryption	343
Kerberos	346
SSL	347
Public-Key Encryption	348
Certificates of Authority	349
PGP	349
Masquerading	350
Firewalls	351
Virtual LANs (VLANs)	353
Intrusion Detection Systems	356
Proxy Server	357
IP Security	357
Tunneling	358
L2TP	358
Denial-of-Service Attacks	360
Hardening	361
Storage Management	361
Network Attached Storage	361
User Management	371
Troubleshooting Techniques	372
Network Management	372
Network Security	372
Chapter Summary	372
Key Terms	376
Review Questions	381
Hands-On Projects	383
Case Projects	386

PART 3

Network Applications

CHAPTER 12

Electronic Mail 389

- What Is E-Mail? 390
- Simple Mail Transfer Protocol 390
- Format of E-Mail Messages 392
- E-Mail Client Software 393
- Sending an E-Mail Message 397
- Receiving an E-Mail Message Using the Post Office Protocol 399
- E-Mail Error Messages 399
- Access to E-Mail Using the Web 400
- Multipurpose Internet Mail Extensions 401
- Internet Message Access Protocol 404
- E-Mail Packet Capture 404
- Troubleshooting Techniques 411
- Chapter Summary 413
- Key Terms 414
- Review Questions 415
- Hands-On Projects 417
- Case Projects 419

CHAPTER 13

FTP and Telnet 421

- FTP Clients and Servers 422
 - FTP Commands 423
 - FTP Clients 425
 - Built-In FTP Clients 444
 - Secure FTP 445
 - FTP Servers 448
- Telnet Clients and Servers 460
 - Telnet Clients 464
 - Secure Telnet Communications 469
 - Telnet Servers 471
 - Telnet 3270 476
- Troubleshooting Techniques 477
 - FTP File Types 477
 - Directory Navigation 477
 - Product HELP 478
 - Telnet Keyboard Mapping 478
- Chapter Summary 479
- Key Terms 480
- Review Questions 481
- Hands-On Projects 483
- Case Projects 487

CHAPTER 14

Multimedia Networking	489
Image Files	490
GIF Images	490
JPG Images	491
PNG Images	493
Sound Files	494
WAV Files	494
MID Files	496
MP3 Files	496
The Digital Conversation	497
Transmitting Data over a Network	498
Voice-over-IP	500
Video	509
MPEG Files	510
Multicasting	510
Games	512
Troubleshooting Techniques	512
Bandwidth issues	512
CODEC issues	514
Quality of Service	514
Chapter Summary	515
Key Terms	516
Review Questions	518
Hands-On Projects	520
Case Projects	522

CHAPTER 15

The Internet	525
The Organization of the Internet	527
Network Address Translation	528
Internet Connection Sharing	528
Windows and the Internet	529
Other Operating Systems on the Internet	529
World Wide Web	530
HTML	531
XHTML	535
Cascading Style Sheets	536
CGI	537
Java	542
JavaScript	545
Virtual Private Networks	546
Instant Messaging	548
Setting Up a Web Server	550
Related Sites	559
Troubleshooting Techniques	560
Connecting to the Internet, Scenario #1	560

Connecting to the Internet, Scenario #2 561
 Connecting to the Internet, Scenario #3 561
 Problems with the Web server? 562
 Problems coding Web pages? 562
 Problems with programming? 562
Chapter Summary 562
Key Terms 564
Review Questions 566
Hands-On Projects 568
Case Projects 573

CHAPTER 16

Writing a Network Application **575**
 Client-Server Model 576
 Connection-Oriented Versus Connectionless Communication 577
 Sockets 577
 Network Programming Languages 583
 C/C++ 583
 C# 583
 Visual Basic 584
 Perl 585
 Java 585
 Network Applications 586
 Echo Server 586
 Time Server 587
 Tic-Tac-Toe 588
 Chat Server 588
 NETMAZE 592
 CGI IP Address Calculator 595
 Network Appliances 600
 IRP Device 600
 IPS Device 601
 LS100 601
 Interfacing 603
 Troubleshooting Techniques 603
Chapter Summary 604
Key Terms 605
Review Questions 606
Hands-On Projects 608
Case Projects 610

PART 4

Network Operating Systems

CHAPTER 17

An Introduction to Networking with Windows **613**
 Microsoft Networking 614
 The Network Neighborhood 615

Network Printing	617
Adding a New Local Printer	618
Adding a Network Printer Using TCP/IP	621
Sharing Files over a Network	625
Finding a Networked Computer	627
Working with Network Drives	628
Dial-Up Networking.	630
ICA Technology.	632
Connecting to the Internet.	632
Troubleshooting Techniques	633
Chapter Summary	637
Key Terms.	637
Review Questions.	638
Hands-On Projects	640
Case Projects	642
CHAPTER 18	
Windows Domains	643
Windows NT Operating System Logon	644
Windows NT Security Dialog Box.	646
Domains	648
Windows 2000	649
Windows 2000 Server.	650
Windows 2000 Professional	653
Windows NT Domains.	654
Basic Capabilities of Windows Server Operating Systems.	657
Client Support	657
Interoperability	658
Authentication	658
File and Print Services.	659
Application Support	659
Security	660
Adding a Client to a Windows Network	660
Logging onto a Network.	662
Running a Network Server	665
Dynamic Host Configuration Protocol	670
Remote Access Service	671
User Profiles	675
Security	677
Windows 2000 Domains.	677
Windows 2003 Server.	682
Windows 2008 Server.	684
Troubleshooting Techniques	685
Chapter Summary	687
Key Terms.	688
Review Questions.	689

Hands-On Projects	691
Case Projects	692
CHAPTER 19	
UNIX and Linux	695
Linux Environment	697
Linux Graphical User Environments	700
Installation and Configuration	701
Application Software	703
System Administration, Management, and Security	708
TCP/IP Network Management	710
Samba	712
Network Information Services	722
Network File System Services	723
Apache Web Server	725
Linux Documentation	727
Troubleshooting Techniques	728
Chapter Summary	729
Key Terms	730
Review Questions	731
Hands-On Projects	733
Case Projects	736
CHAPTER 20	
Other Network Operating Systems	737
NetWare	738
Installing/Upgrading NetWare	738
NetWare Timeline	739
NDS	739
HCSS	741
Menus, Login Scripts, and Messaging	744
Security	747
Management	749
Print Services	752
NetWare Client Software	752
Adding a NetWare Server to a LAN	755
Connecting to a NetWare Server	755
Open Enterprise Server	756
OpenVMS	756
Macintosh OS (Mac OS)	757
Mac OS X Details	757
Interoperability	759
Installing OS X	760
Macintosh Networking	761
Open Transport	763
File Systems	764
Print Services	765
Security	766

OS/2 Warp	767
Additional Network Operating Systems	767
Troubleshooting Techniques	768
Chapter Summary	768
Key Terms	769
Review Questions	770
Hands-On Projects	772
Case Projects	772

PART 5

Network Security and Forensics

CHAPTER 21

Cryptography and Security	775
History of Cryptography and Security	776
Symmetric Versus Asymmetric Encryption	776
Encryption Strength	778
Encryption Algorithms	783
Encryption Versus Hashing	787
Password Hashing	788
Digitally Signing an Email	788
Hash Algorithms	789
Steganography	789
Hiding Information inside a WAV File	791
Hiding Information inside a JPG Image	793
Troubleshooting Techniques	795
An Email Investigation	795
Testing a VPN Connection	796
Sometimes, You Just Have to Guess	796
Chapter Summary	796
Key Terms	797
Review Questions	798
Hands-On Projects	800
Case Projects	803

CHAPTER 22

Security Hardware	805
Media Vulnerabilities	806
Managed Switches	808
Security Vulnerabilities in a Switch	809
Firewalls	811
IDS Hardware	813
Authentication	814
Biometric Devices	814
Fingerprint Readers	814
Voice Authentication	817

Hand Geometry Readers 817
 Handwriting Authentication 817
 Facial Recognition 818
 Iris and Retinal Scanners 818
Fault Tolerance 819
 Adding Fault Tolerance to a Computer System 820
 Adding Fault Tolerance to a Computer Network 822
Physical Security 824
 Site Location 824
 Moat 824
 Lighting 824
 Fences 824
 Mantrap 825
 Cameras 825
 Motion and/or Heat Sensors 825
 Doors and Locks 825
 Windows 825
 Physical Security Plan 825
Troubleshooting Techniques 826
Chapter Summary 827
Key Terms 827
Review Questions 829
Hands-On Projects 831
Case Projects 833

CHAPTER 23

Security Software 835
 Packet Sniffing 836
 Port Scanning 839
 Additional Vulnerabilities 843
Password Cracking 844
 Guessing a Password 845
 Using Brute Force to Crack a Password 845
 Dictionary Attacks 846
 Preventing a Password Attack 846
Intrusion Detection 847
 Host-Based Intrusion Detection 848
 Network-Based Intrusion Detection 848
Secure Remote Access 849
Security Policies and Procedures 850
 Storage Media 850
 Portable Devices 851
 Software 851
 Services 851
 The Acceptable Use Policy 852
 Security Procedures 852
Troubleshooting Techniques 853
Chapter Summary 853
Key Terms 854
Review Questions 856

Hands-On Projects	858
Case Projects	860
CHAPTER 24	
Forensic Techniques	861
Forming a CSIRT.	862
The Incident Response Process	863
Pre-incident Preparation	863
Detection of Incidents	863
Initial Response to the Incident	863
Formulate a Response Strategy	864
Investigate the Incident	864
Report the Findings	865
Resolve the Incident	865
Digital Evidence Handling.	865
File Systems and Operating Systems.	867
FAT	868
NTFS	873
Operating Systems	875
Live Analysis Versus Static Analysis.	879
Where is the Information?.	880
Analyzing Network Traffic.	885
Malware Analysis.	887
An Encrypted Script, Part 1.	888
An Encrypted Script, Part 2.	890
Making the Code Harmless.	893
Legal and Ethical Issues	895
The Forensic Marketplace.	896
Troubleshooting Techniques	897
Chapter Summary	899
Key Terms.	899
Review Questions.	901
Hands-On Projects	904
Case Projects	912
GLOSSARY	913
INDEX	929



Preface

Computer networks are everywhere. They span the globe, interconnecting with each other, weaving a web of communication that extends outward to the domain of satellites orbiting above the earth. They fail; they heal themselves; they move staggering amounts of information between distant locations in an instant. They are in our schools, our businesses, and our homes.

The purpose of this textbook is to explain the mystery behind the computer network, its hardware and software components, how it connects with other networks, the services it provides, network design and implementation, how network problems can be solved, and the security aspects of networking and computing. Concepts and techniques are presented through real-world examples (such as examining all the packets captured while loading a Web page or sending e-mail). Whenever possible, the Internet is used to explain a new network service or mechanism. This includes heavy use of various sites located on the World Wide Web. We describe how many of the networking concepts are used in several network client-server applications, including a virtual reality network maze game (NetMaze), Java applets, and CGI programming examples.

Intended Audience

This book is suitable for all readers with an interest in computer networking and especially students in computer engineering technology, electrical engineering technology, networking technology, information technology, telecommunications technology programs, corporations, and the government.

- [download Kitten Heels in Kathmandu, Adventures of a Female Vagabond](#)
- [**The Pressured Cook: Over 75 One-Pot Meals In Minutes, Made In Today's 100% Safe Pressure Cookers here**](#)
- [download The Plausibility of Life: Resolving Darwin's Dilemma pdf, azw \(kindle\), epub, doc, mobi](#)
- [download *The Power of Infographics: Using Pictures to Communicate and Connect With Your Audiences \(Que Biz-Tech\)*](#)
- [**read online Human Evolution: A Very Short Introduction \(Very Short Introductions\)**](#)
- [The Light in the Piazza and Other Italian Tales \(Banner Books\) online](#)

- <http://reseauplatoparis.com/library/Recognizing-Music-as-an-Art-Form--Friedrich-Th--Vischer-and-German-Music-Criticism--1848-1887.pdf>
- <http://twilightblogs.com/library/Sexploration--The-Ultimate-Guide-to-Feeling-Truly-Great-in-Bed.pdf>
- <http://twilightblogs.com/library/The-Plausibility-of-Life--Resolving-Darwin-s-Dilemma.pdf>
- <http://hasanetmekci.com/ebooks/Wildlife-Photography--From-Snapshots-to-Great-Shots.pdf>
- <http://www.gateaerospaceforum.com/?library/Payback--Paul-Richter--Book-5-.pdf>
- <http://diy-chirol.com/lib/The-Light-in-the-Piazza-and-Other-Italian-Tales--Banner-Books-.pdf>