

JAMES E. GOLDMAN

APPLIED DATA COMMUNICATIONS

■
A BUSINESS-ORIENTED
APPROACH
■





APPLIED DATA COMMUNICATIONS

A BUSINESS-ORIENTED APPROACH

JAMES E. GOLDMAN

Purdue University



John Wiley & Sons, Inc.

New York  **Chichester**  **Brisbane**  **Toronto**  **Singapore**

ACQUISITIONS EDITOR: Beth Lang Golub
PRODUCTION MANAGER: Linda Muriello
MARKETING MANAGER: Debra Riegert
SENIOR PRODUCTION EDITOR: Marjorie Shustak
SENIOR DESIGNER: Ann Marie Renzi
MANUFACTURING MANAGER: Lori Bulwin
ILLUSTRATION COORDINATORS: Anna Melhorn/Rosa Bryant
ILLUSTRATIONS: Boris Starosta/Nick Nichols
COVER: Photograph by Michael Simpson/FPG
Designed by David Levy

This book was set in Palatino by ATLAS Graphics & Design, Inc. and printed and bound by R. R. Donnelley (Willard). The cover was printed by Phoenix Color Corp.

Recognizing the importance of preserving what has been written, it is a policy of John Wiley & Sons, Inc. to have books of enduring value published in the United States printed on acid-free paper, and we exert our best efforts to that end.

Copyright © 1995, by John Wiley & Sons, Inc.

All rights reserved. Published simultaneously in Canada.

Reproduction or translation of any part of this work beyond that permitted by Sections 107 and 108 of the 1976 United States Copyright Act without the permission of the copyright owner is unlawful.

Requests for permission or further information should be addressed to the Permissions Department, John Wiley & Sons, Inc.

Library of Congress Cataloging-in-Publication Data

Goldman, James E.

Applied data communications : a business-oriented
approach / James E. Goldman.

p. cm.

Includes bibliographical references and index.

ISBN 0-471-59217-X (acid-free paper)

1. Electronic data interchange. 2. Business—Communication
systems. 3. Computer networks—Planning. I. Title.

HF5548.33.G65 1995

658'.0546—dc20

94-9354

CIP

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

To Susan, Eric, and Grant

Preface

☐ **THE GROWING IMPORTANCE OF DATA COMMUNICATIONS**

As the business climate of the 1990s continues to evolve, many of the outcomes of this evolution point to an increasingly strategic role for data communications and networking. Increased emphasis on productivity, the dawn of the mobile professional, the flattening of managerial hierarchies, and the downsizing of corporate information systems all depend on well-designed corporate networks to varying degrees. As a result, there has been a corresponding increase in the demand for data communications professionals fluent in both the language of business as well as the language of data communications technology.

☐ **THE NEED FOR THIS BOOK**

Although several business data communications books have been written, none have placed an on-going emphasis on business orientation as concepts and technology change. None have equipped the student with thinking models through which data communications can be viewed objectively as technology inevitably changes in the future. That is where this book succeeds.

By equipping students first with the analytical models with which to organize data communications and networking requirements as well as the functionality of currently available technology to meet those requirements, this text teaches students how to *do* data communications analysis and design from a business-oriented perspective rather than merely telling students about data communications concepts and technology.

☐ **UNIQUE FEATURES OF THE BOOK**

Business Orientation

This book starts by familiarizing the student with the forces at work shaping the data communications industry, allowing the student to become an informed player, rather than a victim, of this technology-dominated industry. Realizing that the data communications industry itself is a product of interacting business forces is but a first step toward an awareness of the business orientation of data communications and networking analysis and design.

Thinking Models

Second, the text introduces students to key thinking models such as the top-down model and the Input-Processing-Output model that will be used throughout the text as tools for effective data communications and networking analysis and design. As introduced in Chapter 1, the top-down model forces data communications and networking systems to be viewed from the perspective of the information systems and

business objectives which those networks are required to support. Business objectives are discussed first, and final systems designs are always evaluated in terms of their ability to meet stated business objectives. As new data communications concepts and technology are introduced throughout the text, they are continually evaluated as to their proper application through the use of the top-down model.

Business Cases

A real-world, practical approach to the industry is supported by the inclusion of business cases from professional periodicals in the text. Students are required to take real-world examples of implemented networking solutions and apply the facts of the case to the top-down model. In doing so, students are able to evaluate delivered networking functionality in terms of the implemented system's ability to deliver on stated business objectives. Additional questions are asked of the students as a means of gaining insight into objective evaluation of real-world networking solutions. In this way, students gain familiarity with the current trends in business data communications with the assurance of explanations and supporting conceptual material supplied by the text.

Abundant Diagrams

The text is generously endowed with over 360 diagrams illustrating real-world implementations and effective application of networking technology. The diagrams clearly illustrate how business problems are solved in real-world applications with the proper deployment of technology.

Process-Oriented Writing Style

The writing style of the text lends itself well to familiarizing the student with a process-oriented approach to data communications analysis and design. Problems or obstacles to implementation are clearly identified and then investigated and addressed in a logical manner. In this way, students are able to build problem-solving skills and practical thought processes by following the problem-solving logic I have mapped out. The book is easy to read while still serving as a comprehensive technical reference.



ORGANIZATION

Data communications means many different things to different people. As a result, course content of data communications courses varies widely among institutions due to instructor background, department philosophy, laboratory and technology availability, and other factors. This text contains an abundance of material for a first course in data communications regardless of course orientation. The book has been designed so that you can choose the chapters that best fit your course outline. Remaining chapters may prove to be interesting supplementary reading for students, or may even support a different course in data communications. It is my hope that the book will serve as a desk reference for data communications professionals, providing at least a starting point for solving a wide variety of data communications opportunities with a top-down, business oriented approach.



SUPPLEMENTS

Instructor's Manual

The instructor's manual for this text has been specially prepared to offer additional background information for instructors who may not possess a great deal of indus-

try experience in data communications. Teaching tips and annotations on diagrams included in the text offer suggested structure for lectures.

Technology Review sections for most chapters offer practical information on real-world data communications and networking technology associated with concepts covered in each chapter. Specific page number cross references to data communications technology catalogs such as Glasgal Communications' *Network Products Directory* and Black Box Corporation's *Black Box Catalog* are included in all Technology Review sections.

Articles reprinted from professional periodicals such as *Network World* and *LAN Times* are also included as supplementary material in the Instructor's Manual. These articles represent concrete examples of "tools of the trade" for the data communications professional. These articles can be shared with students or be used as background material for preparation of lectures. Suggested additional references for background information are also included for each chapter.

Suggested answers to end-of-chapter review questions and business case study questions are included in the instructor's manual as well.

Computerized Test Bank

In addition to the over 700 review questions included in the text, a computerized test bank with over 700 additional questions is available. Question styles are varied, including multiple choice, true/false, fill-in-the-blank, and short answer.

Multimedia Technology Supplement

A multimedia supplement that explains and illustrates key concepts and technology associated with each chapter is available on 3.5" diskettes. This supplement is especially useful for data communications courses that lack a laboratory equipped with actual technology to be examined. For example, after the concepts of modulation and demodulation are illustrated, modems and their proper implementation are illustrated in detail.



ACKNOWLEDGMENTS

I am indebted to a number of people for their assistance in this undertaking.

For assistance with industry insight early in the development process of the book I'd like to acknowledge Dick Curry of UNUM, Dan Breton of New England Telephone, and last but not least, Jim Palmieri of NYNEX.

For development of original illustrations for the text, as well as supplying insightful suggestions and never wavering support, special thanks go to Curt Snyder of Purdue University.

For his untiring efforts to develop a useful and high quality instructor's manual, as well as his ability to simplify the complex, I thank Dr. Mark Smith of the Computer Technology Department at Purdue University.

For all of their probing questions, youthful energy, and shared excitement over our data communications successes in the networking lab, I'd especially like to thank my students at Purdue University, West Lafayette, Indiana. Your quest for knowledge and your high expectations are the inspiration and energy source for my teaching.

I owe a special debt of gratitude to the dedicated and talented individuals who agreed to serve on the review team for this book. I appreciated your suggestions and guidance as we navigated previously uncharted territory in data communications and networking education. Special thanks to: Dave F. Allen, San Antonio College; Warren W. Benson, University of Nebraska-Omaha; James S. Cross,

Longwood College; Alan Dennis, University of Georgia; Frances Giodzinsky, Sacred Heart University; Akhil Kumar, Cornell University; J. David Naumann, University of Minnesota; Robert O'Brien, City University of New York–Baruch; Tapie Rohm, California State University–San Bernadino; Darcy Running, Hennepin Technical College; Satya Prakash Saraswat, Bentley College; Judith Scheeren, Westmoreland Community College; Jeane A. Schildberg, Chaffey Community College; James Van Speybroeck, St. Ambrose University; Scott Turner, Oklahoma State University; Margaret Whyte, University of Georgia, Robert Wilson, California State University–San Bernadino.

For their help and guidance in helping to transform fresh ideas into a finished product, I would like to thank all of my associates at John Wiley & Sons, especially Beth Lang Golub, Editor, David Kear, Editorial Assistant, and Marjorie Shustak, Production Editor.

Contents

INTRODUCTION	1
What Is Data Communications?	1
The Best Way to Approach Data Communications	1
About the Book	2
General Organization, 2 / Chapter Synopsis, 2	

CHAPTER 1

THE CURRENT STATE OF THE DATA COMMUNICATIONS INDUSTRY	5
Introduction	5
Data Communications as a System	6
Regulatory and Carriers	7
Divestiture and Deregulation, 7	
The Business of Deregulation and Divestiture	9
Politics and the Legislative and Judicial Processes	11
Role of Standards-Making Agencies in Data Communications	12
Why Are Standards Important?, 12	
How Does the Standards-Making Process Work?	12
Standards Making Organizations, 12 / The OSI Seven-Layer Model, 13 / The Standards Making Process, 15	
What Do Manufacturers Have to Gain/Lose From Standardization?	15
Development Precedes Standardization, 15 / The Economic Power of Standards, 15	
What Should Users Be Aware of Regarding Standards	16
Standards "Extensions", 16 / The Jargon Jungle, 17	
Data Communications Is Business	17
Technology as an Enabler	18
The I-P-O Model	19
Business Demand + Available Technology = Emerging Network Services	20
Bandwidth, 21	
Top-Down Approach	23
The Top-Down Model, 23	
Technology Investment vs. Worker Productivity	25
Overall Information Systems Architecture	25
The Role of the Data Communications Professional	26
Training for Data Communications Professionals	26
Job Opportunities for the Data Communications Professional	27
Critical Skills for Data Communications Professionals	27

Chapter Summary	28
Featured References	30

CHAPTER 2

INTRODUCTORY CONCEPTS	31
Introduction	32
Getting the Bits and Pieces of Data from Here to There	32
Encoding	34
Serial vs. Parallel	34
Communications Software	35
Parallel to Serial	36
Serial Port	36
Serial Cable or Modem Cable	36
DTE/DCE, 37 / RS-232 Communication between PC and Modem, 37 / Monitoring RS-232 Signals, 38	
Modem	38
Data Transmission Over a Dial-Up Phone Line	40
Analog Transmission	40
I-P-O: A Logical Model	42
Modulation/Demodulation	42
Modulation Techniques, 42 / Carrier Wave, 43 / Amplitude Modulation, 43 / Frequency Modulation, 43 / Phase Modulation, 43	
Baud Rate vs. BPS	44
Asynchronous vs. Synchronous Transmission	44
► <i>In Sharper Focus: More Than One Bit Per Baud</i>	46
Modem Standards	47
Hardware–Software–Media Analysis Methodology	47
Importance of Standards	49
Carrier Structure, Operation, and Services	49
Long Distance Carrier Operation and Services	49
Reenforcement of OSI Model Concepts	49
Dial-up Long Distance Services	50
Voice Grade Leased Lines	51
Two-Wire vs. Four-Wire	52
Implication of Two- vs. Four-Wire: Full- vs. Half-Duplex, 52	
Narrowband Digital Services	52
Broadband Digital Services	53
Chapter Summary	54
Featured References	56

CHAPTER 3

PERSONAL COMPUTER CONNECTIVITY	57
Introduction	57
Modem Operation and Comparative Features	58
Business Motivation Behind Modem Design—The Top-Down Model, 58	
Future Value of the Top-Down Model	58
Current Enabling Technology and Concepts: The Network Model, 59	
Faster	59
New Modem Standards: V.32, 59	
► <i>In Sharper Focus: Trellis Coded Modulation and Modem Constellations</i>	61

Echo Cancellation, 62 / V.32bis, 62 / Fast Retrain, 62 / V. Fast, 62 / Beating the Standards to Market, 62 / Why V.32 and V.32bis Are Important to Business, 63 / V.42bis and MNP Class 5 Data Compression, 63 / How Data Compression Works, 63	
➤ <i>In Sharper Focus: Digital Transmission and DDS Services: A Business Analysis</i>	64
Cheaper	66
Modem Sharing, 66 / Compatibility with Older Modems, 68 / Handshaking, 68 / Hayes at Command Set, 68	
Reliable	68
Error Prevention, 69 / Error Detection, 70	
➤ <i>In Sharper Focus: Checksum Calculation: An In-Depth Look</i>	72
Error Correction, 74 / Backup for Leased Line Failure, 77	
Secure	78
Access Control, 78 / Password Protection, 78 / Dial-Back Security, 79 / Network Security Begins with User Integrity, 79 / Encryption, 79	
Communications Software	81
Role of Data Communications Software, 81 / Communications Software Features and Uses, 81 / The Top-Down Approach to Communications Software Analysis, 81 / Choosing the Best Communications Software for Your Use, 84	
➤ <i>In Sharper Focus: Network Model—Technical Features</i>	84
Further Research and the Impact of Changing Technology	94
Non-LAN PC Connectivity	94
Business Perspective of Peripheral Sharing, 96 / Business Activities of Peripheral Sharing, 96 / Business Analysis Questions Yield Technical Requirements, 97 / Technology Analysis Grid Maps Requirements to Solutions, 97	
➤ <i>In Sharper Focus: Technical Features vs. Current Technology</i>	98
Chapter Summary	106
Featured References	109
Case Study	110

CHAPTER 4

LOCAL AREA NETWORKS (LANs) AND LAN LOOK-ALIKES	113
An Overall Roadmap to Networking in Chapters 3–9	114
Business Needs—The Underlying Motivation	116
Business Activities Should Support Business Needs	117
Role of the Network Analyst as Intermediary	118
Business Analysis Questions Dig Deeper	118
User Issues, 119 / Budget Reality, 120 / Local Communication, 120 / Resource Sharing, 120 / Filesharing: Application Sharing, 121 / Distributed Data Access, 121 / Extended Communications, 121 / LAN Management and Administration, 122 / Accurate and Complete Budgets Are a Must, 122 / Anticipated Growth Is Key, 122	
Network Applications: What Can a LAN Do for You?	122
Network Printing, 123 / Network Printing Grows in Demand and Sophistication, 124 / Network Backup, 124 / Network Management, 127 / Network Security, 129	

➤ <i>In Sharper Focus: Other Network Applications</i>	130
Network Database Considerations	132
Data Layer Analysis Questions, 132 / File Server Databases vs. Database Server Databases, 133 / The Language of Database Requests, 133	
➤ <i>In Sharper Focus: Key Database Attributes</i>	134
LANs and LAN Lookalikes	139
Printer Sharing Networks	141
File Transfer Software	142
➤ <i>In Sharper Focus: Device Drivers and Virtual Drives</i>	144
Zero Slot LANs	145
Similarities Among the Four Related Technologies, 145 / Software Zero Slot LANs vs. File Transfer Software, 145 / Hardware Zero-Slot LANs vs. Data Switches, 146 / Zero-Slot LANs—Applications, Capabilities, Limitations, 146 / Client-Server vs. Peer-to-Peer, 147	
DOS-Based LANs: Also Known as Peer-to-Peer LANs, Low Cost LANs, Alternate LANs	149
➤ <i>In Sharper Focus: Expanability/Upgradability</i>	151
Fully Integrated LANs	155
Applications, Functionality, Characteristics, 155 / Impressive Interoperability, 156 / Fast, Reliable Performance, 157 / LAN Administration and Security, 157 / Relationship of Physical Network Design to Logical Network Design, 158	
Chapter Summary	159
Featured References	161
Case Study	163

CHAPTER 5	LOCAL AREA NETWORKING TECHNOLOGY	166
	Introduction	167
	A Review of the Top-Down Model's Role in Technology Analysis	167
	The Technology Layer	167
	How Do All These Choices Fit Together?	167
	A Roadmap of Local Area Network Technology Choices	168
	A Networking Technology Analysis Model	169
	Application Choices	170
	Architecture Choice Revisited: Peer-to-Peer vs. Client to Server, 170 / Servers Come in Many Flavors, 171	
	Software Choices	173
	Operating Systems and Network Operating Systems, 173 / Operating System Analysis Questions, 173 / DOS—A Single User Heritage, 174 / OS/2—Multitasking from the Start, 174 / UNIX—Its Multiuser Minicomputer Heritage Shows, 175 / Operating System/Network Operating System Options, 176 / NETBIOS, The Redirector and the SMB Server, 177	
	➤ <i>In Sharper Focus: Tracing Software Communications from Client to Server</i>	181
	Adapter Card Driver Choices, 183	

➤ <i>In Sharper Focus: Open Standards for Network Adapter Card Drivers</i>	183
Network Choices	185
Access Methodology Choices, 185 / Two Flavors of Access Control: CSMA/CD and Token Passing, 185 / The MAC Sublayer and the OSI Reference Model, 186 / Access Methodologies × Network Topologies = Network Architecture, 187 / Logical and Physical Topology Choices, 187 / Network Architecture Choices, 191 / Impact of Network Architecture Choice, 191 / The Big Two: Ethernet and Token Ring, 191	
➤ <i>In Sharper Focus: Active MAUs</i>	193
FDDI and CDDI: The Future?, 194 / CDDI, 197	
Hardware Choices	198
Network Adapter Card Choices, 198 / Keepers of the MAC-Layer Protocol, 198	
➤ <i>In Sharper Focus: What Are the Differentiating Factors between Adapter Cards?</i>	200
Future Trends in Network Adapter Cards, 204 / The Positive and Negative Aspects of Network Monitoring, 204 / Terminal Emulation on the NIC Chip, 205 / LAN-Ready PCs, 205 / Token Ring Connectivity to UNIX, 205 / Wiring Center Choices, 206 / The Changing Role of the Wiring Center, 206 / Wiring Centers Technology Analysis, 208	
➤ <i>In Sharper Focus: Future Trends in Wiring Centers</i>	211
Media Choices, 212 / Three Varieties of Wireless Transmission, 217 / Wiring System Choices, 219	
Chapter Summary	221
Featured References	224
Case Study	225

CHAPTER 6

CONNECTING LANS: INTER-NETWORKING	228
Introduction	229
Internetworking Category 1: Dialing Into and Out of the LAN	230
Business Uses of Remote Computing, 230 / LAN Dial-In/Dial-Out Design Methodology, 230 / Needs Analysis: What Do We Want to Do Once We've Connected?, 230 / Physical Topology, 231 / Logical Topology, 231 / Technology, 231	
Access Point 1: Remote PC to Local LAN-Attached PC	232
Remote Control Software, 233 / Utilizing LAN-Attached Resources, 234	
Access Point 2: Communications Servers	235
Access Point 3: LAN Modem or Dial-in Server	236
Communications Servers: Centralized Access, Processing, and Control, 236 / Communications Server's Role in the LAN, 237 / Communications Servers Comparative Features, 239	
➤ <i>In Sharper Focus: Dialing out from the LAN</i>	241
Internetworking Category 2: LAN-to-LAN Connections	244
The OSI Model and Internetworking Devices, 245 / Repeaters: Layer 1—The Physical Layer, 245 / Bridges: Layer 2—The Data Link	

Layer, 246 / MAC Sublayer Protocol: Types of Bridges, 247	
➤ <i>In Sharper Focus: Source Routing</i>	249
➤ <i>In Sharper Focus: Data Storms</i>	250
The Network Layer, 253 / Routers: The Network Layer Processors, 253	
➤ <i>In Sharper Focus: Determination of Best Path</i>	255
Internetworking Category 3: Micro-to-Mainframe/Minicomputer Connectivity	258
Micro-Mainframe vs. Peer-to-Peer Internetworking, 258 / Hierarchical Networks and Peer-to-Peer Networks, 259 / Classic SNA Architecture, 260 / PCs as 3270 Terminals, 261 / LAN-attached PCs as 3270 Terminals, 261 / Coax, Coax Everywhere: Coax Muxes and Baluns, 263 / Peer-to-Peer Internetworks Meet Hierarchical SNA, 263 / The SNA Architecture, 263 / The SDLC Protocol, 263 / SDLC's Nonroutability Yield Multiple Networks, 264 / Overcoming Incompatibilities, 265 / Three SNA/LAN Integration Challenges, 266 / Four Possible SNA/LAN Integration Solutions, 267 / Meeting the SNA/LAN Integration Challenge, 269 / APPN: IBM's Alternative to LAN-Based SNA/LAN Integration, 271 / APPN and the New SNA, 271 / Beyond SNA—Token Ring Integration: Crossing Company Boundaries, 271	
Internetworking Category 4: Integration of LANs and the UNIX Environment	273
TCP/IP and the Internet Suite of Protocols, 273 / Business Motivation for UNIX/LAN Integration, 274 / Typical Uses of LAN Access to UNIX Servers, 275 / Protocol Requirements for UNIX/LAN Integration, 275 / File Management System Compatibility, 275 / Terminal Emulation, 276 / Transport and Network Layer Protocols, 276 / UNIX/LAN Integration Implementation Alternatives, 276	
➤ <i>In Sharper Focus: Important Features and Options for Multiprotocol Software</i>	278
Internetworking Category 5: Macintosh Integration	280
Rationale—Business Uses, 280 / Compatibility Issues to be Overcome, 281 / The Spectrum of MAC Interoperability Opportunities, 281	
➤ <i>In Sharper Focus: Non-LAN Connectivity</i>	282
Network Architecture, 283 / Peer-to-Peer or Low-End Networks, 284 / The Appletalk Suite of Protocols and the OSI Model, 285 / Gateways Offer Occasional Mac/PC LAN Connectivity, 285 / Routers Support Appletalk Protocols, 286	
➤ <i>In Sharper Focus: 10BaseT Hubs Support Appletalk over Localtalk and Ethernet</i>	287
The Final Frontier of Mac Integration—Full Featured LANs, 287	
➤ <i>In Sharper Focus: Server Based Options</i>	288
Internetworking in Perspective	288
Internetworking Design, 289 / Start at the Top: Business Motivation, 289 / The Application and Data Layers: Deliver Business Interoperability Requirements, 289 / The Network Layer: Protocol	

Mix and Match, 290 / The Technology Layer: Delivering the Business Solution, 290 / The Future of Internetworking, 291

Chapter Summary	292
Featured References	295
Case Study	297
Case Study	299

CHAPTER 7

BASIC PRINCIPLES OF WIDE AREA NETWORKING 303

Introduction 303

Basic Principles of Wide Area Networks 304

WAN Technical Principles are Motivated by Business Principles, 304 / Packetizing and Multiplexing, 305 / A Parcel Shipping Analogy, 306 / Generalized Packetizing, 306 / Multiplexing in Detail, 308 / Switching: Getting Voice or Data from Here to There, 315 / Circuit Switching vs. Packet Switching, 316 / Connection-Oriented vs. Connectionless Packet-Switched Networks, 318 / Switched Virtual Circuits and Permanent Virtual Circuits, 319 / Overhead in Connection-Oriented Networks, 319

X.25 Defines Standard Interface to Packet-Switched Networks 319

Inside the X.25 Photocol Stack, 321 / Important Standards Related to X.25, 321 / A Business Perspective on Circuit-Switching vs. Packet Switching, 323

Wide Area Network Switching and Transmission Architectures 324

Major Components of a Wide Area Network Architecture, 324 / Switching and Transmission Capabilities Determine Services, 325 / Switching Architectures: Current and Emerging, 326 / Fast Packet Switching: Frame Relay and Cell Relay, 327 / Cell Relay: A Switching Alternative to Frame Relay, 333

➤ In Sharper Focus: ATM Cell Structures 333

ATM Implementation, 335 / Added Functionality Offered by ATM, 336 / Conclusion: Where Does ATM Fit in the Larger Scheme?, 336

Chapter Summary 337

Featured References 340

Case Study 342

CHAPTER 8

EMERGING WIDE AREA NETWORKING SERVICES & TECHNOLOGY 344

Introduction 344

Data Dial-Tone: SMDS—Switched Multimegabit Data Service 345

What Is a MAN? Metropolitan Area Networks, 345 / Metropolitan Area Network and SMDS Are Not Synonymous, 346 / Distributed Queue Dual Bus: IEEE 802.6, 346 / FDDI-II, 350 / DQDB Reliability, 350 / SMDS Interfaces User Data With the MAN, 352

➤ In Sharper Focus: Highlights of SMDS Architecture and Standards 352

ISDN: Integrated Services Digital Network 354

What Is ISDN?, 354 / Two Service Levels: BRI and PRI, 354 / ISDN Uses and Services, 356

➤ In Sharper Focus: ISDN Voice-Related Services 356

Frame Relay Is an ISDN Service, 356 / ISDN Network Service Availability, 357 / ISDN Incompatibilities, 357 / SS7 Provides Intelligent Network Interoperability, 357 / Transcontinental ISDN Project 1992, 359 / ISDN to X.25 Interfaces, 359 / Getting Data onto ISDN, 359 / ISDN/LAN Interconnection, 360 / Operational Features of ISDN PC Adapters, 361 / Multirate ISDN: Bandwidth on Demand?, 363	
A Look at Transmission Services	363
Circuit Switched Transmission Services, 363 / Digital Transmission Standards, 364	
➤ <i>In Sharper Focus: Framing Multiple Channels per T-1</i>	364
Digital Service Hierarchy, 365 / Leased/Private Lines, 366 / SONET: Synchronous Optical Network, 366	
➤ <i>In Sharper Focus: Virtual Tributaries in SONET</i>	368
Conclusion: So What Is SONET?, 368 / SONET + ATM = B-ISDN, 368 / B-ISDN Services, 368 / Putting It All Together, 369	
Business Uses of Wide Area Network Services	369
Overall Wide Area Network E-mail Architecture, 370 / OSI Model Uncovers E-mail Incompatibilities, 371 / Wide Area E-mail Integration Challenges, 371 / E-mail Single Solution Gateways, 372 / E-mail Universal Backbones, 372	
➤ <i>In Sharper Focus: A Closer Look at X.400</i>	373
➤ <i>In Sharper Focus: X.500 Architecture</i>	375
E-mail Messaging Servers, 375 / E-mail Backbone Switches, 376 / Important Attributes of E-mail Interoperability Products, 377 / E-mail Goes Client-Server, 377 / EDI—Electronic Data Interchange, 380 / EDI Standards, 381	
➤ <i>In Sharper Focus: EDI Standards Development</i>	381
EDI Translation and Transmission, 381 / Some Potential Pitfalls of EDI, 381 / VANs—Value Added Networks Save Time and Effort: For a Price, 382 / VAN Access and Pricing, 383	
Chapter Summary	384
Featured References	386
Case Study	389

CHAPTER 9

ENTERPRISE NETWORKING AND CLIENT/SERVER ARCHITECTURES	394
Introduction	395
The Business of Downsizing	395
Elements of Distributed Information Systems Architecture	396
A Physical Outlook on Client-Server Architectures, 396 / Client-Server vs. Mainframe-Terminal Architectures, 397 / Enterprise Network Delivers Client-Server Independence, 398 / Why Rightsize? Some Success Stories, 399	
➤ <i>In Sharper Focus: Client/Server Success Stories</i>	400
The Negative Side of Rightsizing: Wongsizing?, 401 / The People Architecture of Client-Server, 402 / Major Paradigms of the	

Information Age, 403 / The Importance of People Issues to Data Communications Professionals, 403	
Distributed Computing: Clients and Servers Share Processing Load	404
Key Attributes of Distributed Computing: Transparency, Scalability, 405 / Distributed Processing: Basic Communications, 406 / Client Based Tools for Distributed Application Development, 409	
Database Distribution: The Substance of Distributed Processing	410
Distributed Database Management Systems: Database Engines, 411 / Key Characteristics of Distributed Database Management Systems, 412 / Operating System Compatibility, 412 / Transport Protocol Compatibility, 412 / Database-to-Database Interoperability, 413 / Database Distribution Issues, 413	
➤ <i>In Sharper Focus: Distributed Databases Triggers and Stored Procedures</i>	414
Front-End Tools Transform Distributed Data into Useful Information, 415 / DDE Add-On Utilities, 415	
➤ <i>In Sharper Focus: Emerging Windows Connectivity Standards: ODBC and WOSA</i>	416
Front-End Tools for MultiPlatform Client-Server Applications Development, 416 / Distributed Database Connectivity via SQL, 417 / Lack of SQL Standardization Provides Market Opportunity, 418 / Simpler Solutions for Simpler SQL Connectivity, 418	
The Role of Enterprise Networks: Delivering Distributed Processing and Databases	419
What Is an Enterprise Network?, 419 / Basic Concepts of Enterprise Networks, 419 / Architectures, 420 / Backbones, 421	
➤ <i>In Sharper Focus: Advantage of Collapsed Backbones in Superhubs</i>	424
Structured Enterprise Network Design, 426 / The Client Server Top-Down Model for Enterprise Network Analysis and Design, 426	
Management of the Client-Server Architecture	429
Client-Server Components to Be Managed, 429 / Integrated Client-Server Management, 429 / The Role of Standards in Client-Server Management: Management Architecture Basics, 430 / Standards for Agents, Managers, and MIBs, 430	
➤ <i>In Sharper Focus: Standards for Management Information Transport Protocols</i>	431
Middleware: Holding Together the Client-Server Architecture	435
Middleware Functionality, 435 / Middleware and the OSI Model, 435 / Middleware Establishes Multiple Sessions, 435 / Delivering Network Transparency, 437 / Network Transport Protocols APIs, 438 / Middleware Replaces Network Specific APIs, 438	
➤ <i>In Sharper Focus: Middleware Delivers a Variety of Inter-Process Communications Needs</i>	439
Standards and the Client-Server Architecture	443
ISO Produces OSI Model, Protocols, 443 / OSF: Non-Proprietary, Consortium-Based Standards, 444 / SAA and NAS: Proprietary,	