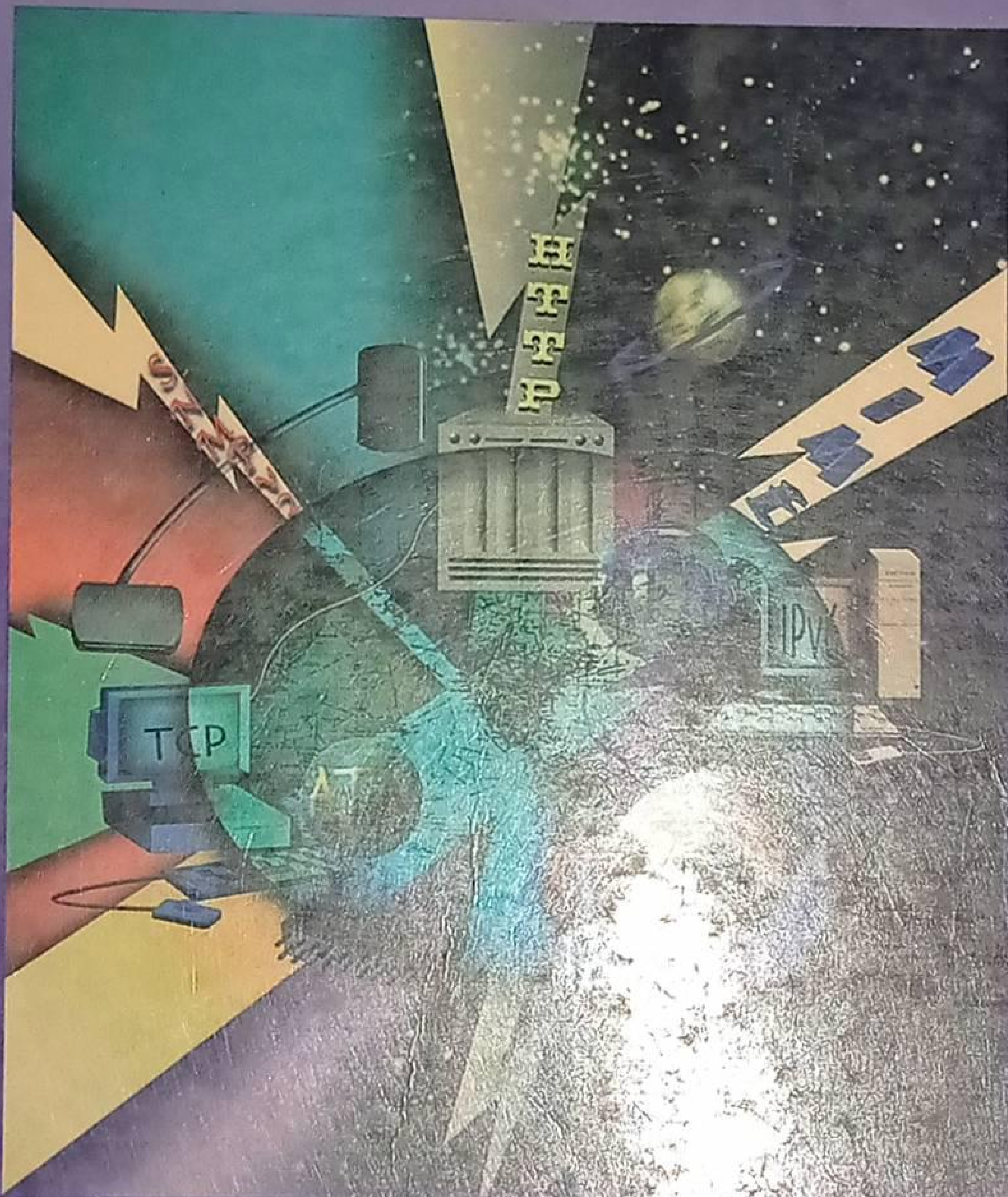


FIFTH EDITION

DATA AND COMPUTER COMMUNICATIONS



WILLIAM STALLINGS



BRIEF CONTENTS

CHAPTER 1 INTRODUCTION 1

PART ONE

Data Communications 33

CHAPTER 2 DATA TRANSMISSION 33
CHAPTER 3 TRANSMISSION MEDIA 73
CHAPTER 4 DATA ENCODING 95
CHAPTER 5 THE DATA COMMUNICATION INTERFACE 139
CHAPTER 6 DATA LINK CONTROL 157
CHAPTER 7 MULTIPLEXING 197

PART TWO

Wide-Area Networks 229

CHAPTER 8 CIRCUIT SWITCHING 229
CHAPTER 9 PACKET SWITCHING 253
CHAPTER 10 FRAME RELAY 301
CHAPTER 11 ASYNCHRONOUS TRANSFER MODE (ATM) 327

PART THREE

Local Area Networks 363

CHAPTER 12 LAN TECHNOLOGY 363
CHAPTER 13 LAN SYSTEMS 401
CHAPTER 14 BRIDGES 465

PART FOUR

Communications Architecture and Protocols 497

CHAPTER 15 PROTOCOLS AND ARCHITECTURE 497
CHAPTER 16 INTERNETWORKING 527
CHAPTER 17 TRANSPORT PROTOCOLS 585
CHAPTER 18 NETWORK SECURITY 623
CHAPTER 19 DISTRIBUTED APPLICATIONS 627

xii BRIEF CONTENTS

APPENDIX A	ISDN AND BROADBAND ISDN	739
APPENDIX B	RFCs CITED IN THIS BOOK	771
GLOSSARY		773
REFERENCES		785
INDEX		791

CONTENTS

CHAPTER 1

INTRODUCTION 1

- 1.1 A Communications Model 2
 - 1.2 Data Communications 5
 - 1.3 Data Communications Networking 7
 - 1.4 Protocols and Protocol Architecture 11
 - 1.5 Standards 21
 - 1.6 Outline of the Book 22
- APPENDIX 1A STANDARDS ORGANIZATIONS 27
- APPENDIX 1B INTERNET RESOURCES 31

PART ONE

Data Communications 33

CHAPTER 2

DATA TRANSMISSION 33

- 2.1 Concepts and Terminology 34
 - 2.2 Analog and Digital Data Transmission 45
 - 2.3 Transmission Impairments 55
 - 2.4 Recommended Reading 64
 - 2.5 Problems 64
- APPENDIX 2A FOURIER ANALYSIS 67
- APPENDIX 2B DECIBELS AND SIGNAL STRENGTH 71

CHAPTER 3

TRANSMISSION MEDIA 73

- 3.1 Guided Transmission Media 75
- 3.2 Wireless Transmission 85

- 3.3 Recommended Reading 93
- 3.4 Problems 93

CHAPTER 4 DATA ENCODING 95

- 4.1 Digital Data, Digital Signals 97
- 4.2 Digital Data, Analog Signals 107
- 4.3 Analog Data, Digital Signals 115
- 4.4 Analog Data, Analog Signals 121
- 4.5 Spread Spectrum 128
- 4.6 Recommended Reading 132
- 4.7 Problems 132

APPENDIX 4A) PROOF OF THE SAMPLING THEOREM 136

CHAPTER 5 THE DATA COMMUNICATION INTERFACE 139

- 5.1 Asynchronous and Synchronous Transmission 140
- 5.2 Line Configurations 144
- 5.3 Interfacing 145
- 5.4 Recommended Reading 156
- 5.5 Problems 156

CHAPTER 6 DATA LINK CONTROL 157

- 6.1 Flow Control 159
- 6.2 Error Detection 164
- 6.3 Error Control 171
- 6.4 High-Level Data Link Control (HDLC) 176
- 6.5 Other Data Link Control Protocols 184
- 6.6 Recommended Reading 186
- 6.7 Problems 187

APPENDIX 6A PERFORMANCE ISSUES 190

CHAPTER 7 MULTIPLEXING 197

- 7.1 Frequency-Division Multiplexing 199
- 7.2 Synchronous Time-Division Multiplexing 205
- 7.3 Statistical Time-Division Multiplexing 219
- 7.4 Recommended Reading 226
- 7.5 Problems 226

PART TWO

Wide-Area Networks 229

CHAPTER 8

CIRCUIT SWITCHING 229

- 8.1 Switched Networks 230
- 8.2 Circuit-Switching Networks 231
- 8.3 Switching Concepts 234
- 8.4 Routing in Circuit-Switched Networks 240
- 8.5 Control Signaling 244
- 8.6 Recommended Reading 252
- 8.7 Problems 252

CHAPTER 9

PACKET SWITCHING 253

- 9.1 Packet-Switching Principles 253
- 9.2 Routing 264
- 9.3 Congestion Control 278
- 9.4 X.25 282
- 9.5 Recommended Reading 291
- 9.6 Problems 291

APPENDIX 9A LEAST-COST ALGORITHMS 296

CHAPTER 10

FRAME RELAY 301

- 10.1 Background 302
- 10.2 Frame Relay Protocol Architecture 304
- 10.3 Frame Relay Call Control 307
- 10.4 User Data Transfer 313
- 10.5 Network Function 315
- 10.6 Congestion Control 316
- 10.7 Recommended Reading 325
- 10.8 Problems 325

CHAPTER 11

ASYNCHRONOUS TRANSFER MODE (ATM) 327

- 11.1 Protocol Architecture 328
- 11.2 ATM Logical Connections 329
- 11.3 ATM Cells 334
- 11.4 Transmission of ATM Cells 338

- 11.5 ATM Adaptation Layer 342
- 11.6 Traffic and Congestion Control 347
- 11.7 Recommended Reading 359
- 11.8 Problems 360

PART THREE

Local Area Networks 363

CHAPTER 12

LAN TECHNOLOGY 363

- 12.1 LAN Architecture 364
- 12.2 Bus/Tree LANs 337
- 12.3 Ring LANs 385
- 12.4 Star LANs 389
- 12.5 Wireless LANs 393
- 12.6 Recommended Reading 399
- 12.7 Problems 399

CHAPTER 13

LAN SYSTEMS 401

- 13.1 Ethernet and Fast Ethernet (CSMA/CD) 402
 - 13.2 Token Ring and FDDI 413
 - 13.3 100VG-AnyLAN 427
 - 13.4 ATM LANs 431
 - 13.5 Fibre Channel 435
 - 13.6 Wireless LANs 442
 - 13.7 Recommended Reading 447
 - 13.8 Problems 448
- APPENDIX 13A DIGITAL SIGNAL ENCODING FOR LANs 451
- APPENDIX 13B PERFORMANCE ISSUES 458

CHAPTER 14

BRIDGES 465

- 14.1 Bridge Operation 466
- 14.2 Routing with Bridges 470
- 14.3 ATM LAN Emulation 487
- 14.4 Recommended Reading 495
- 14.5 Problems 495

PART FOUR

Communications Architecture and Protocols 497

CHAPTER 15

PROTOCOLS AND ARCHITECTURE 497

- 15.1 Protocols 498
- 15.2 OSI 510
- 15.3 TCP/IP Protocol Suite 520
- 15.4 Recommended Reading 526
- 15.5 Problems 526

CHAPTER 16

INTERNETWORKING 527

- 16.1 Principles of Internetworking 529
- 16.2 Connectionless Internetworking 534
- 16.3 The Internet Protocol 541
- 16.4 Routing Protocol 549
- 16.5 IPv6 (IPng) 559
- 16.6 ICMPv6 578
- 16.7 Recommended Reading 582
- 16.8 Problems 582

CHAPTER 17

TRANSPORT PROTOCOLS 585

- 17.1 Transport Services 586
- 17.2 Protocol Mechanisms 591
- 17.3 TCP 610
- 17.4 UDP 619
- 17.5 Recommended Reading 619
- 17.8 Problems 620

CHAPTER 18

NETWORK SECURITY 623

- 18.1 Security Requirements and Attacks 624
- 18.2 Privacy with Conventional Encryption 627
- 18.3 Message Authentication and Hash Functions 638
- 18.4 Public-Key Encryption and Digital Signatures 649

- 18.5 IPv4 and IPv6 Security 659
- 18.6 Recommended Reading 664
- 18.8 Problems 665

CHAPTER 19

DISTRIBUTED APPLICATIONS 667

- 19.1 Abstract Syntax Notation One (ASN.1) 668
- 19.2 Network Management—SNMPV2 685
- 19.3 Electronic Mail—SMTP and MIME 697
- 19.4 Uniform Resource Locators (URL) and Universal Resource Identifiers (URI) 712
- 19.5 Hypertext Transfer Protocol (HTTP) 719
- 19.6 Recommended Reading 736
- 19.7 Problems 737

APPENDIX A

ISDN AND BROADBAND ISDN 739

- A.1 Overview of ISDN 740
- A.2 ISDN Channels 747
- A.3 User Access 750
- A.4 ISDN Protocols 752
- A.5 Broadband ISDN 764
- A.6 Recommended Reading 768
- A.7 Problems 768

APPENDIX B

RFCs CITED IN THIS BOOK 771

GLOSSARY 773

REFERENCES 785

INDEX 791