## CONTENTS

PREFACE
INTRODUCTION.
O1.1 USES OF COMPUTER NETWORKS 3  O1.1.1 Business Applications 3  O1.1.2 Home Applications 6  O1.1.3 Mobile Users 9  O1.1.4 Social Issues 12
0 1.2 NETWORK HARDWARE 14 1 0 1.2.1 Local Area Networks 16 0 1.2.2 Metropolitan Area Networks 18 0 1.2.3 Wide Area Networks 19 1.2.4 Wireless Networks 21 1.2.5 Home Networks 23 1.2.6 Internetworks 25
1.3.1 Protocol Hierarchies 26 01.3.2 Design Issues for the Layers 30 01.3.3 Connection-Oriented and Connectionless Services 32 1.3.4 Service Primitives 34 1.3.5 The Relationship of Services to Protocols 36

1

014 REFERENCE MODELS 32 o 1.43 A Comparison of the OSI and TCP/IP Reference Models o (1.4.2) The TCP/IP Reference Model 41 O LALThe OSI Reference Model 37 1.4.5 A Critique of the TCP/IP Reference Model 48 4.4.4 A Critique of the OSI Model and Protocols 46 £

1.5 EXAMPLE NETWORKS 49 1.5.1 Line inscine. Oriented Networks: X.25, Frame Relay, and ATM 3

1.5.4 Wireless LANs: 802.11 68 1.5.3 Ethernet 65

1.6 NETWORK STANDARDIZATION 71 1.6.3 Who's Who in the Internet Standards World 75 1.6.2 Who's Who in the International Standards World 74 1.6.1 Who's Who in the Telecommunications World 71

1.7 METRIC UNITS 77

1.8 OUTLINE OF THE REST OF THE BOOK

1.9 SUMMARY 79

## 2 THE PHYSICAL LAYER

2.1 THE THEORETICAL BASIS FOR DATA COMMUNICATION \85) 2.1.1 Fourier Analysis 86

2.1.2/Bandwidth-Limited Signals 86

1/5 The Maximum Data Rate of a Channel 89

\$2.2 GUIDED TRANSMISSION MEDIA | 90 02.2.3 Loaxial Cable 92 O 2.2.2 Twisted Pair 91 © 2.2.1 Magnetic Media 90 2.2 Fiber Optics 93

2.3 WRELESS TRANSMISSION 1100 2.3.2 Radio Transmission 103 2.3.1 The Electromagnetic Spectrum 100

85

2.8 SUMMARY 177

THE DATA LINK LAYER

္သ



O 3. NDATA LINK LAYER DESIGN ISSUES (184 o 3.1.2 Framing 187 o 3.1.3 Error Control 0 31.4 Flow Control 192 © 3.1.1 Services Provided to the Network Layer 184 191

CONTENTS

2.3.4 Infrared and Millimeter Waves 2.3.3 Microwave Transmission 104 106

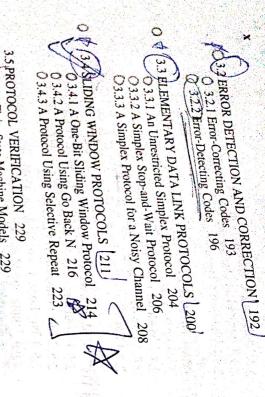
2.4 COMMUNICATION SATELLITES (109) 2.4.3 Low-Earth Orbit Satellites 114 2.4.1 Geostationary Satellites 109 2.3.5 Lightwave Transmission 107 2.4.2 Medium-Earth Orbit Satellites 113

O 2.5 THE PUBLIC SWITCHED TELEPHONE NETWORK 2.4,4 Satellites versus Fiber 117 2.5.1 Structure of the Telephone System 119

(2.5.5 Switching 146 ( map) 2.5.3 The Local Loop: Modems, ADSL, and Wireless 124 2.5.2 The Politics of Telephones 122 2.5.4 Trunks and Multiplexing 137

2.6 THE MOBILE TELEPHONE SYSTEM 152 2.6.2 Second-Generation Mobile Phones: Digital Voice 157 2.6.3 Third-Generation Mobile Phones: Digital Voice and Data 166 2.6.1 First-Generation Mobile Phones: Analog Voice 153

2.7 CABLE TELEVISION 169 2.7.4 Cable Modems 173 2.7.3 Spectrum Allocation 172 2.7.2 Internet over Cable 170 2.7.5 ADSL versus Cable 175 2.7.1 Community Antenna Television 169



3.5.1 Finite State Machine Models 229
3.5.2 Petri Net Models 232

3.6 EXAMPLE DATA LINK PROTOCOLS 234
3.6.1 HDLC—High-Level Data Link Control 234
3.6.2 The Data Link Layer in the Internet 237

4.5 BROADBAND WIRELESS [302]

4.4.1 The 802.11 Protocol Stack 292
4.4.2 The 802.11 Physical Layer 293
4.4.3 The 802.11 MAC Sublayer Protocol
4.4.4 The 802.11 Frame Structure 299

4.4.5 Services 3-1

4.5.1 Comparison of 802.11 with 802.16 4.5.2 The 802.16 Protocol Stack 305 4.4 WIRELESS LANS [292]

34.3.9 IEEE 802.2: Logical Link Control 290

4.3.7 Fast Ethernet 283

.3.8 Gigabit Ethernet

4.3.5 Ethernet Performance 279
4.3.6 Switched Ethernet 281

4.3.10 Retrospective on Ethernet 291

3.7 SUMMARY 242

## O 4 THE MEDIUM ACCESS CONTROL SUBLAYER 247

4.1.1 Static Channel Allocation in LANs and MANs 248
4.1.2 Dynamic Channel Allocation in LANs and MANs 248
4.3 MILLIES C. C. 249

4.2 MULTIPLE ACCESS PROTOCOLS 251

4.2.1 ALOHA | 251|
4.2.2 Carrier Sense Multiple Access Protocols | 255 | 4.2.4 Limited-Contention Protocols 259

4.2.5 Wavelength Division Multiple Access Protocols 261

4.2.6 Wireless LAN Protocols 267

4.5.3 The 802.16 Physical Layer 306
4.5.4 The 802.16 MAC Sublayer Protocol 307
4.5.5 The 802.16 Frame Structure 309

O 4.6 BLUETOOTH 310 (Upar Upar 5c)
4.6.1 Bluetooth Architecture 311
4.6.2 Bluetooth Applications 312
4.6.3 The Bluetooth Protocol Stack 313
4.6.4 The Bluetooth Radio Layer 315
4.6.5 The Bluetooth Baseband Layer 315
4.6.6 The Bluetooth L2CAP Layer 316
4.6.7 The Bluetooth Frame Structure 316

4.7 DATA LINK LAYER SWITCHING 318
4.7.1 Bridges from 802.x to 802.y 320
4.7.2 Local Internetworking 322
4.7.3 Spanning Tree Bridges 324
4.7.4 Remote Bridges 325
4.7.5 Repeaters, Hubs, Bridges, Switches, Routers, and Gateways 326

CONTENTS

O" 4.3 ETHERNET 271

4.3.2 Manchester Encoding 274

4.3.1 Ethernet Cabling 271

4.3.4 The Binary Exponential Backoff Algorithm 278

4.3.3 The Ethernet MAC Sublayer Protocol [275]

CONTE

4.8 SUMMARY 337

4.7.6 Virtual LANs 329