

- Preface p. xv
- Acknowledgments p. xix
- Chapter 1 Introduction p. 1
- Why Wireless? p. 3
- Characteristics of Wired and Wireless Networks p. 3
- Categories of User Information p. 5
- To dB or Not to dB p. 6
- Regulation of Unlicensed Bands p. 8
- FCC Part 15 Requirements p. 9
- General Rules for ISM Communication p. 10
- The 900 MHz ISM Band p. 11
- The 2.4 GHz ISM Band p. 13
- The 5.7 GHz ISM Band p. 15
- The 5.x GHz U-NII Bands p. 16
- 5.7 GHz ISM Versus 5.7 GHz U-NII p. 19
- Ultra-Wideband Operations p. 20
- FCC Product Certification p. 22
- Interference Temperature p. 22
- The OSI Model p. 23
- The IEEE 802 Standards and the OSI Model p. 25
- IEEE 802.11a/b/g WLAN (Wi-Fi) p. 26
- Market Applications p. 26
- Summary of Wi-Fi Operation p. 27
- The Wi-Fi Alliance p. 29
- IEEE 802.15.1 WPAN (Bluetooth) p. 29
- Market Applications p. 30
- The Bluetooth Protocol Stack p. 31
- Summary of Bluetooth Operation p. 33
- Bluetooth Special Interest Group p. 34
- IEEE 802.15.3 High-Rate WPAN (WiMedia) p. 35
- Market Applications p. 35
- Summary of Operations p. 36
- 802.15.3a Alt-PHY p. 37
- WiMedia Alliance p. 38
- IEEE 802.15.4 Low-Rate WPAN (ZigBee) p. 39
- Market Applications p. 39
- Summary of Operations p. 40
- 802.15.4a Alt-PHY p. 42
- ZigBee Alliance p. 43
- Sources of Interference in the Unlicensed Bands p. 43
- Wireless Network Coexistence Background p. 45
- Good Neighbor Policy p. 45
- Noncollaborative Nodes p. 46
- Collaborative Nodes p. 46
- General Coexistence Solutions p. 47
- Interference Modeling p. 48

- IEEE Standards Activity for Coexistence p. 49
- 802.15.2 p. 49
- 802.19 p. 50
- 802.11h p. 50
- Conclusion p. 51
- References p. 52
- Chapter 2 Indoor RF Propagation and Diversity Techniques p. 55
- Indoor RF Propagation Mechanisms p. 56
- Large-Scale Propagation Model p. 57
- Link Budget Equation p. 58
- Path Loss in the ISM and U-NII Bands p. 59
- The Effect of Wavelength on PL p. 59
- PL Exponent and Typical Values p. 60
- Estimating Range Using Maximum Allowable Path Loss (MAPL) p. 63
- Outdoor Point-to-Point Range Estimates at 5.x GHz p. 65
- IEEE Breakpoint Path Loss Model p. 66
- Estimating C/I Using the Simplified and Breakpoint PL Models p. 67
- Evaluation of Distance-Dependent PL Models p. 69
- Improving Accuracy of the Distance-Dependent Models p. 69
- Primary Ray Tracing for Improved Accuracy p. 70
- Direct Modeling of Partition Losses p. 71
- Range and C/I Estimation Using Primary Ray Tracing p. 75
- Multipath from a Coexistence Perspective p. 76
- Fading Characteristics p. 79
- Doppler Spread p. 81
- Delay Spread p. 85
- Doppler Spread and Delay Spread Channel Models p. 91
- ITU Recommendation for Propagation Modeling p. 93
- Path Loss (PL) Model p. 93
- Delay Spread p. 94
- Antenna Effects p. 94
- Object Movements p. 95
- Modeling the UWB Channel p. 96
- Diversity for Multipath and Interference Mitigation p. 97
- Types of Diversity p. 98
- Spatial Diversity in Wi-Fi p. 101
- Spectral Diversity in Bluetooth p. 104
- Temporal Diversity Using Error Control p. 105
- Smart Antennas and Space-Time Diversity p. 106
- Multiple-Input Multiple-Output Architecture p. 107
- Summary p. 110
- References p. 110
- Chapter 3 Basic Modulation and Coding p. 115
- Elementary Modulation Methods p. 116
- Phase Shift Keying (PSK) and Quadrature Amplitude Modulation (QAM) p. 118
- Differential PSK (DPSK) p. 118

- Quadrature Phase Shift Keying (QPSK) p. 119
- Signal Constellations p. 120
- Quadrature Amplitude Modulation (QAM) p. 122
- PSK and QAM Performance in AWGN p. 123
- PSK Performance in Rayleigh Fading and Interference p. 127
- Frequency Shift Keying p. 130
- Frequency Deviation and Bandwidth p. 130
- Summary of Bluetooth Modulation Requirements p. 133
- FSK Performance in AWGN p. 133
- FSK Performance in Rayleigh Fading and Interference p. 134
- Error Control Coding p. 136
- Error Detection p. 137
- Automatic Repeat Request (ARQ) p. 140
- Error Correction p. 141
- Summary p. 149
- References p. 150
- Chapter 4 Advanced Modulation and Coding p. 151
- Direct Sequence Spread Spectrum (DSSS) p. 152
- DSSS Signal Construction p. 152
- DSSS Spreading Sequence Selection p. 156
- DSSS Multiple Access p. 160
- DSSS Processing Gain and Narrowband Signal Rejection p. 164
- Multipath Mitigation Using DSSS p. 165
- Frequency Hop Spread Spectrum (FHSS) p. 166
- FHSS Operation p. 166
- FHSS Synchronization p. 167
- FHSS Multiple Access p. 168
- Orthogonal Frequency Division Multiplexing (OFDM) p. 170
- OFDM Operation p. 171
- Wi-Fi OFDM Signal Composition p. 173
- OFDM Performance in AWGN p. 174
- Multipath Mitigation Using OFDM p. 177
- UWB Modulation and Coding p. 178
- UWB Signaling Methods p. 179
- UWB Performance in Fading and Interference p. 181
- Proposed 802.15.3a UWB Signaling p. 185
- WLAN and WPAN Modulation and Coding Summary p. 186
- IEEE 802.11b Wi-Fi p. 187
- IEEE 802.11a/g Wi-Fi p. 188
- IEEE 802.15.1 Bluetooth p. 190
- IEEE 802.15.3 WiMedia p. 190
- IEEE 802.15.4 ZigBee p. 191
- BER Comparisons p. 191
- Summary p. 192
- References p. 193
- Chapter 5 Radio Performance p. 195

- The 802.11 Wi-Fi Radio p. 197
- 802.11 Channel Sets p. 198
- 802.11 TX Performance p. 200
- 802.11 RX Performance p. 202
- Turnaround Times p. 209
- The 802.15.1 Bluetooth Radio p. 209
- 802.15.1 Channel Set p. 210
- 802.15.1 TX Performance p. 210
- 802.15.1 RX Performance p. 214
- The 802.15.3 WiMedia Radio p. 220
- 802.15.3 Channel Set p. 220
- 802.15.3 TX Performance p. 221
- 802.15.3 RX Performance p. 221
- Turnaround Times p. 223
- The 802.15.4 ZigBee Radio p. 223
- 802.15.4 Channel Set p. 223
- 802.15.4 TX Performance p. 224
- 802.15.4 RX Performance p. 225
- Turnaround Times p. 226
- Summary p. 227
- References p. 227
- Chapter 6 Medium Access Control p. 229
- MAC Performance Metrics and Analysis Background p. 231
- Measuring Network Throughput p. 231
- Channel States p. 232
- Poisson Arrival Process p. 233
- Contention-Free Channel Access p. 234
- Queuing p. 235
- Scheduled Access p. 238
- Demand Access p. 239
- Contention-Based Channel Access p. 242
- Network Model p. 242
- ALOHA p. 243
- Carrier Sense Multiple Access (CSMA) p. 247
- 802.11 Wi-Fi Operations p. 252
- Wi-Fi PHY Frame Structure p. 253
- Wi-Fi MAC Timing p. 255
- Distributed Coordination Function (DCF) p. 256
- Point Coordination Function (PCF) p. 263
- 802.15.1 Bluetooth Operations p. 265
- Packet Structure and Exchange p. 266
- Asynchronous Connectionless (ACL) Links p. 268
- SCO and eSCO Links p. 269
- 802.15.3 WiMedia Operations p. 270
- WiMedia PHY Frame Structure p. 271
- WiMedia MAC Functionality p. 272

- 802.15.4 ZigBee Operations p. 274
- ZigBee PHY Packet Structure p. 274
- ZigBee MAC Functionality p. 275
- Summary p. 277
- References p. 278
- Chapter 7 Passive Coexistence p. 281
- General Analytic Model p. 282
- Periods of Stationarity p. 284
- Simplifying Assumptions p. 285
- Interference to the 802.15.1 Bluetooth Piconet p. 285
- Asynchronous Connectionless (ACL) Throughput in AWGN p. 286
- Standard and Enhanced Receiver C/I Performance p. 287
- Coexistence Among Multiple Bluetooth Piconets p. 290
- Bluetooth Packet Error Rate p. 291
- Bluetooth Packet Throughput p. 292
- Bluetooth Network Throughput p. 297
- Synchronous Connection-Oriented (SCO) Performance in Interference p. 298
- Coexistence Among Multiple 802.11 Wi-Fi Networks p. 300
- Co-Channel Interference (CCI) Performance Using CCA p. 300
- Hidden Terminals and Signal Capture p. 301
- Coexistence Between Wi-Fi and Bluetooth p. 304
- Wi-Fi Interfering with Bluetooth p. 305
- Bluetooth Interfering with Wi-Fi p. 311
- IEEE 802.15 TG2 Coexistence Analysis p. 318
- Models for Finding BER in Interference p. 319
- Wi-Fi and Bluetooth BER in Mutual Interference p. 321
- Wi-Fi FER and Bluetooth PER in Mutual Interference p. 325
- Enhancing Passive Coexistence Between Wi-Fi and Bluetooth p. 327
- The Two-Meter Rule p. 328
- Coexisting with 802.15.3 WiMedia p. 328
- WiMedia and Wi-Fi p. 329
- WiMedia and Bluetooth p. 331
- Coexisting with 802.15.4 ZigBee p. 332
- ZigBee and Wi-Fi p. 333
- ZigBee and Bluetooth p. 334
- ZigBee and WiMedia p. 335
- Coexistence Between 802.11a and UWB p. 335
- Analytical Modeling of UWB-on-OFDM Interference p. 336
- Summary p. 337
- References p. 339
- Chapter 8 Active Coexistence p. 341
- 802.11 Wi-Fi Noncollaborative Coexistence Mechanisms p. 342
- Dynamic Channel Selection p. 343
- Transmit Power Control (TPC) p. 344
- Rate Scaling and Fragmentation p. 345
- Adaptive Interference Suppression p. 348

- Mixed 802.11b and 802.11g Networks p. 350
- 802.15.1 Bluetooth Noncollaborative Coexistence Mechanisms p. 354
- Channel Classification p. 355
- TX Power Control p. 356
- Adaptive Packet Selection p. 357
- Adaptive Packet Scheduling p. 358
- Adaptive Frequency Hopping p. 360
- 802.15.3 WiMedia Noncollaborative Coexistence Mechanisms p. 364
- General Methods for WiMedia Coexistence p. 365
- WiMedia-on-WiMedia Interference Mitigation p. 367
- Enhancing WiMedia Coexistence with 802.15.1 Bluetooth p. 368
- 802.15.4 ZigBee Noncollaborative Coexistence Mechanisms p. 368
- General Methods for ZigBee Coexistence p. 369
- Collaborative Coexistence Solutions p. 370
- Remedial Methods for Collaborative Coexistence p. 371
- Collaborative Adaptive Hopping p. 373
- Collaborative Wi-Fi Frame Scheduling p. 373
- Deterministic Interference Suppression p. 373
- Alternating Wireless Medium Access (AWMA) p. 374
- Packet Traffic Arbitration (PTA) p. 375
- System-Level Integration Example p. 378
- Antenna Factors p. 379
- Antenna Isolation p. 380
- Smart Antennas: The Key to Enhanced Coexistence p. 383
- Summary p. 384
- References p. 385
- Chapter 9 Coexistence with Other Wireless Services p. 387
- Global Positioning System (GPS) p. 388
- Operational Overview p. 389
- GPS Signal Detection and Interference Effects p. 392
- UWB Interfering with GPS: Analytical Approach p. 396
- UWB Interfering with GPS: Empirical Approach p. 400
- Avionics p. 405
- EMI Standards and Airborne Wireless Operations p. 406
- Interference to Avionics from 2.4 GHz ISM Bluetooth-Class Transmissions p. 408
- Interference to Avionics from UWB Transmissions p. 413
- Integrating Bluetooth into a Cell Phone p. 416
- Out-of-Band Spurious Transmissions p. 416
- Protecting the GSM Receiver p. 417
- Protecting the Bluetooth Receiver p. 417
- Cordless Telephones p. 418
- Microwave Ovens p. 419
- Microwave Lighting p. 423
- Summary p. 424
- References p. 425
- Acronyms and Abbreviations p. 427

- Index p. 435