

# Contents

<b>1</b>	<b>Measurement and Modeling of Wireless Channels</b>	<b>1</b>
	David G. Michelson and Saeed S. Ghassemzadeh	
1.1	Introduction	1
1.2	A Brief History	3
1.3	Characterization of Wireless Channels	4
1.4	Development of New Channel Models	9
1.5	Measurement of Wireless Channels	11
1.6	Recent Advances in Channel Modeling	13
1.6.1	Channel Models for Ultrawideband Wireless Systems	13
1.6.2	Channel Models for MIMO-Based Wireless Systems	16
1.6.3	Channel Models for Body Area Networks	18
1.6.4	Channel Models for Short-Range Vehicular Networks	20
1.6.5	Channel Models for 60 GHz and Terahertz Systems	22
1.7	Conclusions	24
	References	25
<b>2</b>	<b>OFDM: Principles and Challenges</b>	<b>29</b>
	Nicola Marchetti, Muhammad Imadur Rahman, Sanjay Kumar, and Ramjee Prasad	
2.1	Introduction	29
2.2	History and Development of OFDM	30
2.3	The Benefit of Using Multi-carrier Transmission	31
2.4	OFDM Transceiver Systems	34
2.5	Analytical Model of OFDM System	35
2.5.1	Transmitter	35
2.5.2	Channel	37
2.5.3	Receiver	38
2.5.4	Sampling	41
2.6	Advantages of OFDM System	42
2.6.1	Combating ISI and Reducing ICI	42
2.6.2	Spectral Efficiency	43

2.6.3	Some Other Benefits of OFDM System	44
2.7	Disadvantages of OFDM System	45
2.7.1	Strict Synchronization Requirement	45
2.7.2	Peak-to-Average Power Ratio (PAPR)	45
2.7.3	Co-channel Interference in Cellular OFDM	46
2.8	OFDM System Design Issues	46
2.8.1	OFDM System Design Requirements	46
2.8.2	OFDM System Design Parameters	47
2.9	Multi-carrier Based Access Techniques	49
2.9.1	Definition of Basic Schemes	49
2.10	Single-Carrier vs Multi-carrier, TDE vs FDE	52
2.10.1	Single-Carrier FDE	52
2.10.2	Single-Carrier vs Multi-carrier, FDE vs TDE	54
2.10.3	Analogies and Differences Between OFDM and SCFDE	54
2.10.4	Interoperability of SCFDE and OFDM	56
2.11	OFDMA: An Example of Future Applications	58
2.12	Conclusions	60
	References	61
<b>3</b>	<b>Recent Advances in Low-Correlation Sequences</b>	<b>63</b>
	Gagan Garg, Tor Helleseth, and P. Vijay Kumar	
3.1	Introduction	63
3.2	Cyclic Hadamard Difference Sets	64
3.2.1	Introduction	64
3.3	The Merit Factor of Binary Sequences	71
3.3.1	Introduction	71
3.4	Low-Correlation QAM Sequences	76
3.4.1	Preliminaries	77
3.4.2	Quaternary Family $\mathbb{A}$	78
3.4.3	Canonical 16-QAM Family $\mathbb{CQ}$	78
3.4.4	Extensions and Improvements	80
3.4.5	Example: Generation of a 16-QAM Sequence	83
3.5	Low-Correlation Zone Sequences	84
3.6	Additional Notes	86
3.6.1	Merit Factor	86
3.6.2	QAM Sequences	87
3.6.3	Low-Correlation Zone Sequences	87
3.7	Conclusions	88
	References	88
<b>4</b>	<b>Resource Allocation in Wireless Systems</b>	<b>93</b>
	Jon W. Mark and Lian Zhao	
4.1	Introduction	93
4.2	System Model	95
4.3	The Inverse of $\Gamma_S$	99
4.4	Convergence of Power Distribution Law	100

4.4.1	With Zero Disturbance	100
4.4.2	With Nonzero Disturbance	102
4.4.3	With Power Constraints	103
4.4.4	Capacity Analysis	105
4.5	Optimal Data Rate Allocation	106
4.5.1	Assumptions	106
4.5.2	Optimal Spreading Factor (OSF) Selection	107
4.5.3	Rate Selection for GRP	107
4.6	Joint Rate and Power Adaptation	108
4.6.1	OSF-PC	108
4.6.2	GRP-PC	109
4.7	Numerical Results	111
4.8	Conclusions	115
	References	116
<b>5</b>	<b>Iterative Receivers and Their Graphical Models</b>	<b>119</b>
	Ezio Biglieri	
5.1	Introduction	119
5.2	MAP Symbol Detection	119
5.2.1	Factor Graphs and the Sum-Product Algorithm	121
5.2.2	The Basic Factorization	123
5.3	Channel and Codes: A Menagerie of Factor Graphs	124
5.3.1	Modeling the Channel	124
5.3.2	Modeling the Code	126
5.4	Equalization	127
5.5	Multiuser Detection	130
5.6	MIMO Detection	131
5.7	Multilevel Coded Modulation	133
5.8	Convergence of the Iterative Algorithm	133
5.9	Conclusions	135
	References	136
<b>6</b>	<b>Fundamentals of Multi-user MIMO Communications</b>	<b>139</b>
	Luca Sanguinetti and H. Vincent Poor	
6.1	Introduction	139
6.2	System Model	140
6.3	Capacity	141
6.3.1	Capacity Region of the Gaussian MIMO MAC	142
6.3.2	Gaussian MIMO Broadcast Channel	150
6.4	Open- and Closed-Loop Systems	158
6.4.1	Open-Loop Systems	159
6.4.2	Closed-Loop Systems	160
6.5	System Design	160
6.5.1	Receiver Design for Uplink Transmissions	160
6.5.2	Transmitter Design for Downlink Transmissions	161
6.6	Limited Feedback Systems	167

6.6.1	Channel Quantization	167
6.6.2	Random Beamforming	168
6.6.3	Transceiver Optimization	169
6.7	Conclusions	169
	References	170
<b>7</b>	<b>Collaborative Beamforming</b>	<b>175</b>
	Hideki Ochiai and Hideki Imai	
7.1	Introduction	175
7.2	System Model and Beam Patterns of Fixed Nodes	177
7.2.1	Array Factor and Beam Pattern	178
7.2.2	Beam Patterns of Linear Arrays	180
7.2.3	Beam Patterns of Circular Arrays	183
7.3	Collaborative Beamforming by Randomly Distributed Nodes	185
7.3.1	Definition	186
7.3.2	Average Beam Patterns	188
7.3.3	Distribution of Beam Patterns	190
7.3.4	Distribution of Maxima in Sidelobe	194
7.4	Conclusions	196
	References	197
<b>8</b>	<b>Cooperative Wireless Networks</b>	<b>199</b>
	Behnaam Aazhang, Chris B. Steger, Gareth B. Middleton, and Brett Kaufman	
8.1	Introduction	199
8.1.1	Overview	199
8.1.2	Physical Layer Cooperation	200
8.2	System Model	202
8.2.1	Wide Area Network	202
8.2.2	Multiple Flows and Flow Priority	203
8.2.3	Cooperative Building Blocks	204
8.3	Learning About the Environment: Network State Information	205
8.3.1	NSI Overhead Management	206
8.3.2	NSI Metric	206
8.4	Finding the Optimal Cooperative Path	207
8.4.1	Routing Cooperative Paths	207
8.4.2	Trellis Representation	208
8.4.3	Timing, Interference, and Duplexing Management	209
8.4.4	Traversal Algorithms	210
8.5	Network Discovery	210
8.5.1	Filling the Trellis: Gathering States, Edges, and NSI	211
8.5.2	Filling the Trellis: Metanodes	212
8.6	Conclusions	212
	References	213

<b>9</b>	<b>Interference Rejection and Management</b>	217
	Arun Batra, James R. Zeidler, John G. Proakis, and Laurence B. Milstein	
9.1	Introduction	217
9.2	Self-Interference Among Cooperating Systems	218
9.2.1	Interference Suppression to Enable Spectrum Sharing	218
9.2.2	Effects of Interference on Channel State Estimation	220
9.3	Interference Mitigation in Block-Modulated Multicarrier Systems	223
9.3.1	Interference Mitigation in an Uncoded Multicarrier System	224
9.3.2	Interference Mitigation in Coded Multicarrier Systems	233
9.3.3	Doppler Sensitivity of OFDM in Mobile Applications	235
9.4	Interference Suppression in Broadcast MIMO Systems	236
9.4.1	Linear Precoding of the Transmitted Signals	237
9.4.2	Nonlinear Precoding of the Transmitted Signals: The QR Decomposition	239
9.4.3	Vector Precoding	244
9.4.4	Lattice Reduction Method for Precoding	246
9.5	Conclusions	247
	References	248
<b>10</b>	<b>Cognitive Radio: From Theory to Practical Network Engineering</b>	251
	Ekram Hossain, Long Le, Natasha Devroye, and Mai Vu	
10.1	Introduction	251
10.2	Information-Theoretic Limits of Cognitive Networks	253
10.2.1	Cognitive Behavior: Interference Avoidance, Control, and Mitigation	253
10.2.2	Information-Theoretic Basics	254
10.2.3	Interference Avoidance: Spectrum Interweave	255
10.2.4	Interference Control: Spectrum Underlay	256
10.2.5	Interference Mitigation: Spectrum Overlay	259
10.3	Cognitive Sensing with Side Information	264
10.4	Interference Analysis	266
10.4.1	A Network with Beacons	267
10.4.2	A Network with Primary Exclusive Regions	268
10.5	Practical Cognitive Network Engineering: Interference Control Approach	269
10.5.1	Single-Antenna Case	270
10.5.2	Multiple Antenna Case	273
10.6	Practical Cognitive Network Engineering: Interference Avoidance Approach	273
10.6.1	Single-Hop Case	274
10.6.2	Multi-hop Case	282
10.7	Conclusions	283
	References	284

<b>11</b>	<b>Coded Bidirectional Relaying in Wireless Networks</b>	291
	Petar Popovski and Toshiaki Koike-Akino	
11.1	Introduction	291
11.2	Preliminaries	293
11.3	Two-Way Relaying with Decoding at the Relay	295
11.3.1	The Uplink Phase	295
11.3.2	The Broadcast Phase	296
11.3.3	Improved Broadcast Strategies	297
11.3.4	Numerical Illustration	300
11.4	Two-Way Relaying Without Decoding at the Relay	302
11.4.1	Amplify-and-Forward (AF)	302
11.4.2	Denoise-and-Forward (DNF)	303
11.4.3	Compress-and-Forward (CF)	305
11.4.4	Numerical Illustration and Variations	306
11.5	Achieving the Two-Way Rates with Structured Codes	307
11.5.1	Parity-Check Codes for Binary Symmetric Channels	307
11.5.2	Gaussian Channel	309
11.6	Signaling Constellations for Finite Packet Lengths	312
11.6.1	XOR Denoising	312
11.6.2	Adaptive Denoising with Quintary Cardinality	313
11.6.3	End-to-End Throughput Performance	314
11.7	Conclusions	315
	References	316
<b>12</b>	<b>Minimum Cost Subgraph Algorithms for Static and Dynamic Multicasts with Network Coding</b>	317
	Fang Zhao, Muriel Médard, Desmond Lun, and Asuman Ozdaglar	
12.1	Introduction	317
12.2	Problem Formulation	320
12.2.1	Wireline Networks	320
12.2.2	Wireless Networks	322
12.3	Decentralized Min-cost Subgraph Algorithms for Static Multicast	324
12.3.1	Subgradient Method for Decentralized Subgraph Optimization	325
12.3.2	Convergence Rate Analysis	328
12.3.3	Initialization and Primal Solution Recovery	334
12.3.4	Simulation Results	335
12.4	Min-cost Subgraph Algorithms for Dynamic Multicasts	340
12.4.1	Nonrearrangeable Algorithm	340
12.4.2	Rearrangeable Algorithms	342
12.4.3	Simulation Results	345
12.5	Conclusions	347
	References	348

<b>13 Ultra Mobile Broadband (UMB)</b>	351
Masoud Olfat	
13.1 Introduction	351
13.2 UMB Overall Architecture	352
13.3 UMB Physical Layer	355
13.3.1 Superframe Structure	356
13.3.2 UMB FL Channelization	360
13.3.3 Reverse Link in UMB	366
13.4 UMB MAC Layer	374
13.5 Other PHY/MAC-layer features in UMB	384
13.6 Conclusions	386
References	386
<b>14 Mobile WiMAX</b>	389
Masoud Olfat	
14.1 Introduction	389
14.2 Standardization Process	390
14.2.1 WiMAX Forum	391
14.3 WiMAX Network Architecture	393
14.3.1 Network Reference Models	394
14.3.2 ASN profiles	395
14.3.3 Mobility Management	397
14.4 Physical Layer	399
14.4.1 S-OFDMA Frame Structure	401
14.4.2 Subchannel Permutation	402
14.4.3 Frame Structure	406
14.4.4 Channel Coding	407
14.4.5 Multiple Antenna Modes in Mobile WiMAX	409
14.4.6 Power Control and Link Adaptation	413
14.5 Medium Access Control Layer	416
14.5.1 Quality of Service	420
14.5.2 Power Saving Mode	421
14.5.3 Multicast Broadcast Services	422
14.5.4 Handoff	423
14.5.5 Security and Authentication in WiMAX	425
14.6 WiMAX Performance	426
14.7 Future Work Toward IMT-Advanced	427
14.7.1 Conclusions	428
References	429
<b>15 An Overview of 3GPP Long-Term Evolution Radio Access Network</b>	431
Sassan Ahmadi	
15.1 Introduction	431
15.1.1 Chronology of 3GPP Air Interface Technology Development	432

15.1.2	3GPP LTE System Requirements .....	433
15.2	Overall Network Architecture .....	434
15.3	LTE Protocol Structure .....	436
15.4	Overview of the LTE Physical Layer .....	438
15.4.1	Multiple Access Schemes .....	438
15.4.2	Operating Frequencies and Bandwidths .....	439
15.4.3	Frame Structure .....	442
15.4.4	Physical Resource Blocks .....	443
15.4.5	Modulation and Coding .....	444
15.4.6	Physical Channel Processing .....	444
15.4.7	Reference Signals .....	446
15.4.8	Physical Control Channels .....	448
15.4.9	Physical Random Access Channel .....	450
15.4.10	Cell Search .....	452
15.4.11	Link Adaptation .....	452
15.4.12	Multi-antenna Techniques in LTE .....	453
15.5	Overview of the LTE Layer 2 .....	454
15.5.1	Logical and Transport Channels .....	455
15.5.2	ARQ and HARQ in LTE .....	458
15.5.3	Packet Data Convergence Sublayer (PDCP) .....	458
15.6	Radio Resource Control Functions (RRC) .....	458
15.7	Mobility Management and Handover in LTE .....	460
15.8	LTE Performance .....	462
15.9	Future Work Toward IMT-Advanced .....	462
15.10	Conclusions .....	464
	References .....	464
<b>Index</b>	.....	<b>467</b>





<http://www.springer.com/978-1-4419-0672-4>

New Directions in Wireless Communications Research

Tarokh, V. (Ed.)

2009, XXVI, 469 p., Hardcover

ISBN: 978-1-4419-0672-4