

Contents

1	New Types of Air Interface Based on Filter Banks for Spectrum Sharing and Coexistence	1
	Yahia Medjahdi, Didier Le Ruyet, Daniel Roviras, and Michel Terré	
1.1	The Concept of Multicarrier Transmission.....	2
1.1.1	Gabor Analysis of Multicarrier Systems	2
1.1.2	Orthogonal and Biorthogonal Multicarrier Systems	3
1.2	Orthogonal Frequency Division Multiplexing (OFDM): Advantages and Drawbacks	4
1.3	Filter Bank Based Multicarrier Systems	4
1.3.1	Classes of FBMC	5
1.3.2	Filter Bank Transceivers	6
1.3.3	Equalization Techniques in FBMC	12
1.3.4	Polyphase Implementation of Filter Bank for Multicarrier Transmission	15
1.3.5	Review of Prototype Filter Design.....	21
1.4	Spectrum Sharing and Coexistence: FBMC Application.....	27
1.5	Conclusion	32
	References.....	32
2	Cognitive Interference Alignment for Spectral Coexistence	37
	Shree Krishna Sharma, Symeon Chatzinotas, and Björn Ottersten	
2.1	Introduction	38
2.1.1	Notation	39
2.2	Interference Alignment (IA) Fundamentals.....	39
2.2.1	Degrees of Freedom (DoF).....	40
2.2.2	IA Principle	41
2.2.3	Classification of IA Techniques.....	43
2.3	IA in Cognitive Radio Networks	48

2.4	Spectral Coexistence	50
2.4.1	Generic System Model	50
2.4.2	IA Precoding and Filtering	52
2.5	Practical Scenarios	54
2.5.1	Macrocell-Femtocell Coexistence in Spatial Domain	54
2.5.2	Multibeam-Monobeam Satellite Coexistence in Frequency Domain.....	55
2.6	Practical Challenges of IA	60
2.7	Chapter Summary	61
	References.....	61
3	Cooperative Spectrum Sensing.....	67
	H. Birkan Yilmaz, Salim Eryigit, and Tuna Tugcu	
3.1	Introduction.....	68
3.2	Spectrum Sensing Preliminaries	69
3.2.1	Spectrum Sensing in AWGN Channel.....	70
3.2.2	Spectrum Sensing in Rayleigh Channel	71
3.2.3	Spectrum Sensing in Nakagami-m Fading Channel	71
3.3	Cooperation and Fusion Strategies	72
3.3.1	Hard Fusion Strategies	73
3.3.2	Soft Fusion Strategies	73
3.4	Quantization Enhancements	74
3.4.1	Incentives for Utilizing Quantization	74
3.4.2	Local Quantization	74
3.4.3	Fusion Strategies.....	76
3.5	Effects of Imperfect Reporting Channel	78
3.6	Optimizing Detector That Uses Quantization.....	80
3.6.1	Threshold Optimization	80
3.6.2	Improving Weights and Threshold Optimization	81
3.6.3	Results	81
3.7	Cooperative Sensing Scheduling	82
3.7.1	Introduction	83
3.7.2	System Model.....	83
3.7.3	Problem Formulation	85
3.7.4	Performance Evaluation	90
3.8	Utilizing Sensing Results for REM Construction.....	92
3.8.1	REM Architecture	94
3.8.2	REM Quality Metrics.....	96
3.8.3	RSS Measurements in Fading Channels	97
3.8.4	REM Construction Techniques	99
3.8.5	Spatial Statistics Based Methods	100
3.8.6	Transmitter Location Determination Based Methods.....	103
3.9	Conclusion	104
	References.....	104

4 Medium Access Control Protocols in Cognitive Radio Networks 109
 Liljana Gavrilovska, Daniel Denkovski, Valentin Rakovic,
 and Marko Angjelicinoski

4.1 Introduction 110

4.2 C-MAC Protocol Classification and Systematization 112

4.3 Generic C-MAC Protocols Layout: The C-MAC Cycle 113

4.4 Overview of the Generic C-MAC Functionalities 115

 4.4.1 Spectrum Sensing Strategies 115

 4.4.2 Spectrum Sharing Strategies 119

 4.4.3 Control Channel Management Strategies 123

4.5 C-MAC Cycle Use Cases 126

 4.5.1 Cooperative Spectrum Sensing Based on
 Estimated Noise Power 126

 4.5.2 Coordinated Beamforming for Spectrum Sharing 132

 4.5.3 Asynchronous Rendezvous for Control
 Channel Management 138

4.6 Concluding Remarks 145

References 146

5 Dynamic Channel Selection for Cognitive Femtocells 151
 Gustavo Wagner Oliveira da Costa, Andrea Fabio Cattoni,
 Preben E. Mogensen, and Luiz A. da Silva

5.1 Introduction 152

5.2 Overview of Femtocells and Challenges 153

5.3 System Model and Assumptions 154

5.4 Simulation Scenario 156

5.5 Potential Link Capacity Gain 159

5.6 Game Theoretic Analysis 160

5.7 Graph Theoretic Analysis 164

5.8 Distributed Methods for Channel Allocation 168

 5.8.1 Dynamic Channel Allocation 168

 5.8.2 Dynamic Reuse Selection 169

 5.8.3 Negotiated Reuse Selection 171

5.9 Results and Discussions 172

5.10 Concluding Remarks and Further References 178

References 179

6 Towards Cognitive Internet: An Evolutionary Vision 181
 Fabrizio Granelli, Dzmitry Kliazovich, and Neumar
 Malheiros

6.1 Introduction 182

6.2 Historical Perspective 182

 6.2.1 Legacy TCP/IP 182

 6.2.2 Motivation for Adaptation 183

- 6.3 Adaptive TCP/IP: Enabling Technologies 184
 - 6.3.1 Cross-Layer Design 184
 - 6.3.2 Distributed and Agent-Based Solutions 188
 - 6.3.3 AI-Based Reasoning and Learning 191
 - 6.3.4 Architectures to Support Adaptive Protocols..... 192
 - 6.3.5 Discussion 192
- 6.4 The Evolution to Cognitive Protocols 193
- 6.5 Conclusion 197
- References..... 198
- 7 Automatic Best Wireless Network Selection Based on Key Performance Indicators 201**

Stefano Boldrini, Maria-Gabriella Di Benedetto, Alessandro Tosti, and Jocelyn Fiorina

 - 7.1 Introduction..... 202
 - 7.2 Quality of Experience and KPIs 203
 - 7.2.1 VoIP Case 204
 - 7.3 Cognitive Engine 206
 - 7.4 Model Structure 206
 - 7.5 Experimentation 209
 - 7.5.1 Experimental Set-Up 209
 - 7.5.2 Experimental Data 210
 - 7.6 Conclusions and Future Work 212
 - References..... 213
- 8 Localization in Cognitive Radio Networks..... 215**

Ioannis P. Chochliouros, Ioanna Papafili, George S. Agapiou, Anastasia S. Spiliopoulou, Stelios Agapiou, Ronald Raulefs, and Siwei Zhang

 - 8.1 Cognitive Radio: An “Enabler” for Future Evolution of Communications Systems 216
 - 8.1.1 Realization of a More Efficient Use of Spectrum 217
 - 8.1.2 Enhancement of Users’ Experience..... 218
 - 8.1.3 Optimization of Networks..... 219
 - 8.1.4 Technical Requirements on Current CR Systems, as Identified by Actual Standardization Works 221
 - 8.1.5 CRNs for Further Network Deployment 222
 - 8.1.6 Conclusion 223
 - 8.2 Indoor Positioning and Horizontal Handover Employing RSSI Fingerprinting in OTE Labs 224
 - 8.2.1 Positioning Technique 225
 - 8.2.2 Experimental Setup 227
 - 8.2.3 Indoor Positioning Application 228
 - 8.2.4 Status and Finger Operations 228
 - 8.2.5 Find Operation 228

- 8.2.6 Accuracy of Indoor Positioning 232
- 8.2.7 Conclusion 233
- 8.3 Cognitive Cooperative Positioning 233
 - 8.3.1 Geo-Localization 234
 - 8.3.2 WHERE2 Project 235
 - 8.3.3 Multi-user Positioning 238
 - 8.3.4 Conclusions 240
- References 241
- 9 Challenges Towards a Cloud-RAN Realization 245**

Andreas Georgakopoulos, Dimitrios Karvounas, Vera Stavroulaki, Kostas Tsagkaris, and Panagiotis Demestichas

 - 9.1 Introduction 245
 - 9.2 Related Work 247
 - 9.3 Intelligence and Cognition in Cloud-RANs 248
 - 9.3.1 Elements of the Approach 248
 - 9.3.2 Benefits from the Cloud-RAN 250
 - 9.4 Future Considerations 253
 - 9.5 Conclusions 254
 - References 255
- 10 A Regulatory Perspective on Cognitive Radio and Spectrum Sharing 257**

Linda Doyle and Tim Forde

 - 10.1 Introduction 257
 - 10.2 A Means of Contextualising the Regulatory Perspective 259
 - 10.2.1 The Makers of the Rules 261
 - 10.3 The Supposedly Low Hanging Fruit: The TV White Spaces 263
 - 10.3.1 TV White Space Regulations in General 264
 - 10.3.2 A Global Summary of the State of Play 266
 - 10.3.3 The Outlook 269
 - 10.4 The Sharing Economy 270
 - 10.4.1 International Moves: PCAST, LSA and BSOs 271
 - 10.4.2 The 3.5 GHz Sharing Opportunity 277
 - 10.4.3 The 2.3 GHz Sharing Opportunity 279
 - 10.4.4 The Outlook 282
 - 10.5 Other Work of the IEEE 282
 - 10.5.1 IEEE DySPAN-SC 283
 - 10.6 Some Perspectives for the Future 284
 - 10.6.1 Systematising of Sharing and Cognitive Technologies ... 284
 - 10.6.2 Sharing Is Clearing 286
 - 10.7 Conclusion 287
 - References 287

11	Simulation of Cognitive Radio Networks in OMNeT++	291
	Giuseppe Caso, Luca De Nardis, and Oliver Holland	
11.1	Introduction.....	291
11.2	System Model	293
11.2.1	Operating Mode 1: Constant False Alarm Rate (CFAR).....	295
11.2.2	Operating Mode 2: Constant Detection Rate (CDR).....	296
11.3	OMNeT++: Objective Modular Network Testbed in C++	299
11.4	MiXiM: The Mixed Simulator.....	300
11.4.1	From a MiXiM-Based to a Cognitive Radio Scenario	302
11.5	Application of the CR Simulator to Open Research Issues	304
11.5.1	Cooperative Spectrum Sensing Based on Hard Decision Fusion Rules Under CFAR and CDR Constraints	305
11.5.2	Impact of Spatio-Temporal Correlation in Cooperative Spectrum Sensing for Mobile Cognitive Radio Networks	308
11.6	CR Simulator: Availability and Possible Collaborations	312
	References.....	312
12	Designing a CR Test Bed: Practical Issues	315
	Andrea Fabio Cattoni, Jakob Lindholm Buthler, Oscar Tonelli, Luiz A. da Silva, João Paulo Miranda, Paul Sutton, Floriana L. Crespi, Sergio Benco, Alberto Perotti, and Daniel Riviello	
12.1	Introduction.....	316
12.2	Evolution of Test Bed Research	317
12.2.1	Trends in Implementation-Based CR Research	317
12.2.2	Review of the State of the Art.....	319
12.2.3	Experimentation Methodology and Benchmarking	321
12.3	Practical Research Activities with a Test Bed	325
12.3.1	Understanding the Requirements of Your Own Research Application.....	326
12.3.2	Choice of the Hardware	327
12.3.3	Practical Test Bed Issues	328
12.3.4	Dealing with the HW	330
12.4	SW Platforms	332
12.4.1	Writing an Application	332
12.4.2	Running Experiments: Best Practices	349
12.5	Conclusion.....	358
	References.....	358

13 Low-Cost Testbed Development and Its Applications in Cognitive Radio Prototyping 361
 Tomaž Šolc, Carolina Fortuna, and Mihael Mohorčič

13.1 Introduction 361

13.2 Radio Front-Ends for Embedded Testbeds 363

 13.2.1 VESNA with the SNE-ISMTV Expansion 364

 13.2.2 Reconfigurable Integrated Transceivers 365

 13.2.3 Getting Closer to SDR with Custom Hardware 372

 13.2.4 Summary 373

13.3 Testbed Infrastructure 374

 13.3.1 LOG-a-TEC Testbed Deployment 374

 13.3.2 Network Design Constraints 378

 13.3.3 Performance Evaluation of the Management Network ... 380

 13.3.4 Measurements in Logatec 382

 13.3.5 LOG-a-TEC Testbed Access, Control and
 Reconfiguration 387

 13.3.6 Summary 388

13.4 Signal Generation Use Case 389

 13.4.1 Summary 393

13.5 An Interference Mitigation Use Case 393

 13.5.1 Summary of the PAPU Algorithm 394

 13.5.2 Experimental Set-Up 395

 13.5.3 The Adaptation of the Theoretical Framework..... 396

 13.5.4 Empirical Parameter Determination 398

 13.5.5 Experimental Results 400

 13.5.6 Summary 403

13.6 Summary of the Chapter 403

References 404



<http://www.springer.com/978-3-319-01717-4>

Cognitive Radio and Networking for Heterogeneous
Wireless Networks

Recent Advances and Visions for the Future

Di Benedetto, M.-G.; Fabio Cattoni, A.; Fiorina, J.; Bader,
F.; De Nardis, L. (Eds.)

2015, XXV, 405 p. 172 illus., Hardcover

ISBN: 978-3-319-01717-4