

Contents

Part I Fundamentals

1	Wireless Sensor Networks	3
1.1	Wireless Sensor Networks Fundamentals	3
1.1.1	Main Features of WSNs.	4
1.1.2	Issues Related to Energy Management.	5
1.2	Applications	7
1.3	IEEE 802.15.4 Technology	8
1.3.1	IEEE 802.15.4 Physical Layer	9
1.3.2	IEEE 802.15.4 Network Topologies and Operational Modes	10
1.3.3	IEEE 802.15.4 MAC Layer	13
1.3.4	Data Transfer Protocol and MAC Frames	16
1.3.5	The IEEE 802.15.4 Topology Formation Procedure.	18
1.4	Zigbee Upper Layers	19
1.4.1	Zigbee Topologies.	20
1.4.2	The Zigbee Tree-Based Topology	21
1.4.3	The Zigbee Mesh Topology	22
1.5	Current and Future Research on WSNs	23
1.5.1	Application-Agnostic Research Trends	24
1.5.2	Market- and Application-Driven Research Trends.	25
1.6	Further Readings	26
	References	26

Part II Distributed Processing

2	Distributed Detection of Spatially Constant Phenomena	31
2.1	Distributed Detection in Clustered Sensor Networks	32
2.1.1	Preliminaries on Distributed Binary Detection	32
2.1.2	Analytical Framework	35

2.1.3	Communication-Theoretic Characterization	39
2.1.4	Joint Communication/Information-Theoretic Characterization	44
2.1.5	Realistic Clustered Networks with Data Fusion	47
2.2	Extending the Lifetime of Clustered Sensor Networks	51
2.2.1	Sensor Network Lifetime under a Physical Layer QoS Condition	51
2.2.2	Analytical Computation of Network Lifetime	54
2.2.3	Numerical Results	58
2.2.4	Energy Budget	60
2.2.5	Noisy Communication Links	64
2.2.6	Throughput and Delay with Varying Sensor Network Lifetime	65
2.3	Impact of Different SNRs at the Sensors	67
2.3.1	Ideal Communication Links	68
2.3.2	Noisy Communication Links	69
2.3.3	Sensor SNR Profiles	70
2.3.4	Numerical Results	72
2.3.5	Experimental Validation	76
2.4	On the Interplay Between Decoding and Fusion	79
2.4.1	Distributed Channel Coding and Detection/Decoding/Fusion Strategies	79
2.4.2	Ideal Observations at the Sensors	81
2.4.3	Noisy Observations at the Sensors	85
2.4.4	Impact of Noisy Communication Links Towards the Relay	86
2.4.5	Numerical Results	88
2.5	Concluding Remarks	91
2.6	Further Readings	93
	References	95
3	Distributed Detection of Spatially Non-Constant Phenomena	101
3.1	Ideal Communication Links	101
3.1.1	MMSE Fusion Rule	102
3.1.2	Simplified Fusion Rule with a Single Boundary	106
3.1.3	Simplified Fusion Rule with Multiple Boundaries	107
3.2	Noisy Communication Links	109
3.2.1	MMSE Fusion Rule	109
3.2.2	Simplified Fusion Rule	111
3.3	Numerical Results	112
3.3.1	Ideal Communication Links	113
3.3.2	Noisy Communication Links	116
3.4	Computational Complexity	118
3.5	Concluding Remarks	119

3.6 Further Readings	119
References	120

Part III MAC and Connectivity

4 Tree-Based Topologies for Multi-Sink Networks	123
4.1 Aims of the Study	124
4.2 Channel and Link Models.	126
4.3 Connectivity Properties in PPP Fields	128
4.4 Reference Scenario	129
4.5 On the Design of Optimum Tree-Based Topologies.	130
4.5.1 The Multi-level Tree: Mathematical Analysis.	131
4.5.2 Mathematical Analysis Results	133
4.5.3 The Three-Level Tree: Simulation Environment	137
4.5.4 Simulation Results	140
4.6 Connectivity of Multi-Sink Multi-Hop WSNs in Bounded Regions.	147
4.6.1 Connectivity in Unbounded Single-Hop Networks	148
4.6.2 Connectivity in Bounded Single-Hop Networks	148
4.6.3 Connectivity in Bounded Multi-Hop Networks.	152
4.6.4 Energy Consumption	154
4.6.5 Numerical Results.	154
4.7 Concluding Remarks	157
4.8 Further Readings	157
References	158
5 Performance Analysis of the IEEE 802.15.4 MAC Protocol	161
5.1 The Non Beacon- and Beacon-Enabled MAC Protocols.	163
5.2 Reference Scenario and Model Assumptions.	164
5.3 The Non Beacon-Enabled Model.	166
5.3.1 Node States	166
5.3.2 Formulation of the Mathematical Model	167
5.3.3 Performance Metrics Derived from the Model	174
5.3.4 Numerical Results.	179
5.4 The Beacon-Enabled Model	186
5.4.1 Performance Metrics Derived from the Model	186
5.4.2 Formulation of the Mathematical Model of the CSMA/CA Algorithm	188
5.4.3 Performance Metrics Related to the CAP Portion	194
5.4.4 Numerical Results: The Star Topology	196
5.4.5 The Tree-Based Topology	201
5.4.6 Numerical Results: Tree-Based Topology	204

5.5	Comparison Between the Beacon- and Non Beacon-Enabled Modes	206
5.6	Concluding Remarks	208
5.7	Further Readings	209
	References	210
6	Area Throughput for Multi-Sink Wireless Sensor Networks	213
6.1	Aims of the Model	213
6.2	Assumptions and Reference Scenario	215
6.3	Evaluation of the Area Throughput	216
6.3.1	Joint MAC/Connectivity Probability of Success	216
6.3.2	Area Throughput	219
6.4	Numerical Results	219
6.4.1	The Optimum Aggregation Strategy	220
6.4.2	Comparing Beacon- and Non Beacon-Enabled Modes	224
6.5	Concluding Remarks	226
	References	226
 Part IV Cross-Layer Design		
7	Decentralized Detection in IEEE 802.15.4 Wireless Sensor Networks	231
7.1	Preliminaries	232
7.1.1	Decentralized Detection	232
7.1.2	The Access to the Channel	233
7.2	Impact of MAC on Decentralized Detection	235
7.3	Numerical Results	237
7.4	Concluding Remarks	244
	References	245
	 Index	 247

Sensor Networks with IEEE 802.15.4 Systems
Distributed Processing, MAC, and Connectivity
Buratti, C.; Martalo', M.; Verdone, R.; Ferrari, G.
2011, XVIII, 250 p., Hardcover
ISBN: 978-3-642-17489-6