

Contents

List of Figures	xxi
List of Tables	xxv
1 Executive Summary	1
1.1 Definition of Cooperating Objects	2
1.2 State of the Art in Cooperating Objects Research	2
1.2.1 Hardware	3
1.2.2 Algorithms	3
1.2.3 Non-functional Properties	5
1.2.4 Systems	6
1.2.5 Others	7
1.3 Innovative Applications	8
1.4 Market Analysis	9
1.5 Research Roadmap	9
1.5.1 Hardware	9
1.5.2 Algorithms	10
1.5.3 Non-functional Properties	11
1.5.4 System	11
1.5.5 Other	12
1.6 Conclusions	12
2 Introduction to Cooperating Objects	13
2.1 Definition	14
2.1.1 Cyber-Physical Systems	16
2.2 Research Areas	17
3 State of the Art in Cooperating Objects Research	19
3.1 Hardware	19
3.1.1 Hardware Platforms	20
3.1.1.1 Cooperating objects embedded into smart automation devices (hardware): shop floor with SOA	21

3.1.1.2	Cooperating objects (hardware) - Cross-layer with SOA	28
3.1.1.3	Hardware Platforms for WSNs	29
3.1.2	Sensors	37
3.1.3	Sensor Calibration	38
3.1.4	Energy Efficiency	39
3.1.5	Energy Harvesting	39
3.1.5.1	Mechanical Energy	40
3.1.5.2	Light Energy	40
3.1.5.3	Thermal Energy	40
3.1.5.4	Electromagnetic Energy	41
3.1.5.5	Energy from the Human Body	41
3.2	Algorithms	42
3.2.1	Synchronization	42
3.2.2	Localization	43
3.2.2.1	Technologies and measurement modalities	44
3.2.2.2	Range-based algorithms	44
3.2.2.3	Range-free algorithms	45
3.2.2.4	Target Tracking	45
3.2.3	MAC	45
3.2.4	Routing	47
3.2.5	Bandwidth Estimation and Admission Control	49
3.2.6	Clustering	50
3.2.7	Querying	51
3.2.8	Data Processing	52
3.2.8.1	Data Processing within a Sensor Network	52
3.2.8.2	Data Processing within a Broadcast Domain	54
3.2.9	Cooperation of Mobile Objects	56
3.2.10	Radio Resource Management	58
3.2.10.1	Frequency Adaptation	59
3.2.10.2	Transmit Power Control	60
3.2.10.3	Channel Access Timing	60
3.3	Non-functional Properties	61
3.3.1	Scalability	62
3.3.2	Timeliness (Throughput, Delay and Real-time)	63
3.3.3	Reliability and Robustness	65
3.3.4	Mobility	66
3.3.5	Security and Privacy	68
3.3.5.1	Security	68
3.3.5.2	Privacy	70
3.3.6	Heterogeneity	72
3.4	Systems	73
3.4.1	Operating Systems	73
3.4.2	Programming Abstractions and Middleware	75
3.4.2.1	Macroprogramming	75
3.4.2.2	Virtual Machines	76
3.4.2.3	Resource Naming	77

3.4.2.4	Task distribution	77
3.4.2.5	Adaptive Systems	78
3.4.2.6	Cross-Layer Interactions	79
3.4.2.7	Data Sharing	79
3.4.2.8	Service Invocation	81
3.4.2.9	Event Detection	81
3.4.2.10	Context Management	82
3.4.3	System Integration	82
3.4.4	Debugging and Management Tools	84
3.4.4.1	Diagnosis	84
3.4.4.2	Healing	86
3.5	Others	87
3.5.1	Modeling and Planning	87
3.5.1.1	Radio Link Quality	87
3.5.1.2	RF Interference	89
3.5.1.3	Deployment Planning	90
3.5.1.4	Node and Network Lifetime	91
3.5.1.5	Performance modeling and network dimensioning	92
3.5.1.6	Modeling Mobility	93
3.5.2	Testbed and Simulation Platforms	94
3.5.2.1	Generic Simulators	95
3.5.2.2	Specialized Simulators	97
3.5.2.3	Emulators	100
3.5.2.4	Testbeds	101
3.5.2.5	Testbed Directory	103
3.5.3	Standardization	110
3.5.3.1	ZigBee and the ZigBee Alliance	111
3.5.3.2	IP for Smart Objects and Cooperating Objects	113
3.5.3.3	The IP for Smart Objects (IPSO) Alliance	115
3.5.3.4	ETSI	116
3.5.3.5	Continua Alliance	118
3.5.3.6	WirelessHART	119
3.5.3.7	ISA SP100.11a	121
3.5.3.8	(Web) Services on Devices	122
3.6	Conclusions	124
4	Applications	125
4.1	Building, Home, and Industrial Automation	125
4.1.1	Building Automation	126
4.1.1.1	Business Drivers	126
4.1.1.2	Next steps	128
4.1.2	Home Control	128
4.1.2.1	Business Drivers	129
4.1.2.2	Visions for the Future	132
4.1.3	Industrial Automation	133
4.1.3.1	Energy Efficiency in Industry	134

4.1.3.2	Integration of intelligent energy management systems	135
4.1.4	Industrial Automation and Wireless	138
4.1.4.1	Business Drivers	138
4.1.4.2	Industrial Applications Visions	138
4.1.5	Manufacturing	139
4.1.5.1	Digital Factories	140
4.1.5.2	Smart Factories	141
4.1.5.3	Virtual Factories	141
4.1.6	Wireless Device Strategies	142
4.1.6.1	Discrete Manufacturing	142
4.1.6.2	Process Manufacturing	145
4.1.6.3	New Wireless-enabled Applications	146
4.2	Energy	146
4.2.1	Cooperation of SmartHouses and SmartGrid	148
4.2.2	Electricity Monitoring and Management	149
4.2.3	The role of the Smart Meter	150
4.2.4	Research Challenges and directions	153
4.3	Logistics	155
4.3.1	Characteristics of Cooperating Objects in Logistics	155
4.3.2	Challenges and Trends in Logistics Cooperation	156
4.4	Transportation	158
4.4.1	Aerial Transportation	158
4.4.2	Road Transportation	161
4.4.3	Intelligent transport challenges: Automotive example	161
4.5	Environmental Monitoring	163
4.5.1	Driving Forces	163
4.5.2	State of the Art	164
4.5.3	Trends	164
4.5.4	Challenges	168
4.6	Healthcare and Assisted Living	168
4.6.1	Assisted Living	169
4.6.2	Activity Recognition Systems	170
4.6.3	Gait Analysis	170
4.6.4	Emotion Recognition Systems	170
4.6.5	Design Frameworks	171
4.6.6	Trends and Open Challenges	172
4.7	Security	173
4.7.1	Deployment	174
4.7.2	Data Acquisition	174
4.7.3	Distributed Data Processing	174
4.7.4	Lifecycle Cost	175
4.7.5	Performance	175
4.8	Conclusions	175

5	Market Analysis	177
5.1	Market Predictions	177
5.2	Cooperating Objects for Monitoring and Control	179
5.3	Market Evolution	179
5.4	The CONET Survey	182
5.5	Conclusions	185
6	Research Roadmap	187
6.1	Hardware	187
6.1.1	Hardware Platforms	188
6.1.2	Sensors	190
6.1.3	Energy Efficiency	190
6.1.4	Energy Harvesting	191
6.1.5	Timeline	192
6.1.6	Conclusions	193
6.2	Algorithms	194
6.2.1	Synchronization	195
6.2.2	Localization	195
6.2.3	MAC	196
6.2.4	Routing	197
6.2.5	Bandwidth Estimation and Admission Control	198
6.2.6	Clustering	198
6.2.7	Querying	199
6.2.8	Data Processing	200
6.2.9	Cooperation of Mobile Objects	201
6.2.10	Radio Resource Management	201
6.2.11	Timeline	202
6.2.12	Conclusions	203
6.3	Non-functional Properties	204
6.3.1	Scalability	205
6.3.2	Timeliness	206
6.3.3	Reliability and Robustness	207
6.3.4	Mobility	208
6.3.5	Security and Privacy	209
6.3.6	Heterogeneity	210
6.3.7	Timeline	211
6.3.8	Conclusions	212
6.4	Systems	213
6.4.1	Operating Systems	213
6.4.2	Programming Abstractions and Middleware	214
6.4.3	System Integration	216
6.4.4	Debugging and Management Tools	216
6.4.5	Timeline	217
6.4.6	Conclusions	218
6.5	Others	219
6.5.1	Modeling and Planning	220

6.5.1.1	RF Interference	220
6.5.1.2	Radio Link Quality	220
6.5.1.3	Lifetime estimation	221
6.5.1.4	Network Planning	221
6.5.1.5	Performance modeling and network dimensioning	221
6.5.2	Testbed and Simulation Platforms	222
6.5.3	Standards	223
6.5.4	Timeline	223
6.5.5	Conclusions	224
6.6	Conclusions	225
7	Conclusions	227
	References	229

The Emerging Domain of Cooperating Objects

Marron, P.J.; Karnouskos, S.; Minder, D.; Ollero, A. (Eds.)

2011, XXVII, 271 p., Hardcover

ISBN: 978-3-642-16945-8