

Contents

Preface	xix
SECTION I	From Machine-to-Machine Communications to Internet of Things
CHAPTER 1	From Machine-to-Machine Communications to Internet of Things: Enabling Communication Technologies
HAMIDREZA SHARIATMADARI, SASSAN IRAJI, and RIKU JÄNTTI	
1.1	INTRODUCTION
1.2	IoT APPLICATIONS AND THEIR REQUIREMENTS
1.3	IoT CONNECTIVITY LANDSCAPE
1.3.1	IEEE 802.15.4
1.3.2	WiFi
1.3.3	Bluetooth
1.3.4	RFID and Ambient Backscattering
1.3.5	Dedicated Short Range Communications
1.3.6	Low Power Wide Area Network
1.3.7	Cellular Systems
1.4	CHALLENGES AND SOLUTIONS FOR CONNECTIVITY IN 5G ERA
1.4.1	Low-power Consumption
1.4.2	Enhanced Coverage
1.4.3	Ultra-reliable Low-latency Communications
1.4.4	Massive Number of Devices
1.4.5	Handling Small Bursts of Data
1.5	CONCLUSIONS
BIBLIOGRAPHY	
CHAPTER 2	Power Control for Reliable M2M Communication
LING WANG and HONGWEI ZHANG	
2.1	INTRODUCTION

2.1.1	History of Power Control in Cellular Networks	36
2.1.2	Objectives	38
2.1.3	Organization	39
2.2	M2M COMMUNICATION SYSTEMS	39
2.2.1	Co-channel Interference and Network Architecture	39
2.2.2	SINR Model and Link Reliability	40
2.2.3	Channel Dynamics and Statistical Models	42
2.2.4	Multiscale and Instantaneous Characteristics	45
2.3	POWER CONTROL THEORY	47
2.3.1	Feasible and optimal power control	48
2.3.2	Infeasibility of power control	49
2.4	POWER CONTROL APPROACHES FOR CONSTANT AND FADING CHANNELS	50
2.4.1	Conflict Graph-based Power Control for Constant Channels	50
2.4.2	Geometric Programming-based Power Control for Fading Channels	51
2.5	DISCUSSION ON ADAPTIVE POWER CONTROL FOR M2M COMMUNICATION SYSTEMS	52
2.6	EXTENSIVE STUDIES ON POWER CONTROL	54
2.7	OPEN CHALLENGES AND EMERGING TRENDS	57
	BIBLIOGRAPHY	58
CHAPTER 3	Enabling Geo-centric Communication Technologies in Opportunistic Networks	61
	YUE CAO, DE MI, TONG WANG, and LEI ZHANG	
3.1	INTRODUCTION	62
3.2	BACKGROUND	63
3.2.1	Opportunistic Networks (ONs)	63
3.2.2	Applications of ONs in Smart Cities	63
3.2.2.1	Vehicular Ad Hoc NETWORKs (VANETs)	63
3.2.2.2	Airborne Networks (ANs)	65
3.2.2.3	Mobile Social Networks (MSNs)	65
3.2.2.4	UnderWater Sensor Networks (UWSNs)	65
3.3	MOTIVATION AND CHALLENGES FOR GEOGRAPHIC ROUTING IN ONs	66
3.3.1	Geo-centric Technologies in Smart Cities	66
3.3.2	Introduction on Geographic Routing	66

3.3.3	Motivation for Geographic Routing in ONs	66
3.3.4	Challenges for Geographic Routing in ONs	67
3.4	TAXONOMY AND REVIEW OF GEOGRAPHIC ROUTING IN ONs	70
3.4.1	Destination Unawareness Class	71
3.4.2	Destination Awareness Class	72
3.4.2.1	Stationary Destination	72
3.4.2.2	Considering Mobile Destination via Real-time Geographic Information	76
3.4.2.3	Considering Mobile Destination via Historical Geographic Information	76
3.4.3	Hybrid Class	78
3.5	COMPARISON AND ANALYSIS	79
3.6	FUTURE DIRECTIONS	81
3.7	CONCLUSION	83
	BIBLIOGRAPHY	83
CHAPTER 4	Routing Protocol for Low Power and Lossy IoT Networks	89
	XIYUAN LIU, ZHENGGUO SHENG, and CHANGCHUAN YIN	
4.1	INTRODUCTION	90
4.2	RPL: AN OVERVIEW AND ITS KEY MECHANISMS	91
4.2.1	Routing Mechanism of RPL	91
4.2.2	Message Control Mechanism of RPL	92
4.2.3	RPL and Its Counterparts	94
4.3	RPL TOPOLOGY GENERATION METHODS	95
4.3.1	Objective Functions and Metrics	95
4.3.2	Multi-parents Consideration	97
4.4	RPL APPLICATIONS	98
4.4.1	RPL Application Overview	98
4.4.2	Application Scenarios	99
4.5	SECURITY ISSUES IN RPL	100
4.6	RPL PERFORMANCE EVALUATION IN LARGE-SCALE NETWORKS	103
4.6.1	Simulation Platforms	103
4.6.2	Framework Integration for OMNeT++	103
4.6.3	Configuration Details	105
4.6.4	Simulation of Cross-layer RPL Routing	107
4.7	CHALLENGES AND PROSPECT	111
4.8	CONCLUSION	113

BIBLIOGRAPHY		113
CHAPTER	5 ■ Resource Allocation for Wireless Communication Networks with RF Energy Harvesting	119
ELENA BOSHKOVSKA, DERRICK WING KWAN NG, and ROBERT SCHOBER		
5.1	INTRODUCTION	120
5.2	RECEIVER STRUCTURE	122
5.3	SWIPT COMMUNICATION NETWORKS	123
5.3.1	Channel Model	123
5.3.2	Non-linear Energy Harvesting Model	124
5.3.3	Channel State Information	127
5.3.4	Achievable System Data Rate	128
5.3.5	Problem Formulation and Solution	128
5.3.6	Numerical Example	132
5.4	WIRELESS POWERED COMMUNICATION NETWORKS	133
5.4.1	Channel Model	134
5.4.2	Problem Formulation and Solution	136
5.4.3	Numerical Example	138
5.5	CONCLUSION	140
5.6	APPENDIX	141
5.6.1	Proof of Theorem 1	141
BIBLIOGRAPHY		143
SECTION II Data Era: Data Analytics and Security		
CHAPTER	6 ■ Distributed Machine Learning in Big Data Era for Smart City	151
YUAN ZUO, YULEI WU, GEYONG MIN, CHENGQIANG HUANG, and XING ZHANG		
6.1	INTRODUCTION	152
6.2	THE STOCHASTIC GRADIENT DESCENT (SGD) IN PARALLELIZATION	155
6.2.1	Parallelized SGD Based on MapReduce	157
6.2.2	Online SGD in Round-robin	157
6.2.3	HOGWILD! for “Lock-free”	158
6.2.4	AsySVRG for asynchronous SGD Variant	159
6.2.5	ASGD with Single-sided Communication	160
6.3	THE NEWTON METHOD IN PARALLELIZATION	160
6.3.1	A truncated Newton Method: The Trust Region Newton Method (TRON)	162

6.3.2	The Distributed TRON Based on Spark and MPI	163
6.3.3	General Distributed Implementation of TRON	163
6.3.4	Matrix-vector Product Improvement for Inner Mechanism	164
6.4	THE PETUUM FRAMEWORK	164
6.5	THE CONVEX OPTIMIZATION DECOMPOSITION METHOD	166
6.5.1	An Implementation Example of ADMM	168
6.5.2	Other Work Relevant to Decomposition	169
6.6	SOME OTHER RESEARCH RELEVANT TO DISTRIBUTED APPLICATION	170
6.6.1	Evaluation of Parallel Logistic Regression	170
6.6.2	Conjugate Gradient Optimization	171
6.7	A CASE STUDY	171
6.8	CONCLUSIONS	172
	BIBLIOGRAPHY	172
CHAPTER 7	Security in Smart Grids	179
	JULIA SÁNCHEZ, AGUSTÍN ZABALLOS, RAMON MARTIN DE POZUELO, GUIOMAR CORRAL, and ALAN BRIONES	
7.1	INTRODUCTION TO CYBERSECURITY	181
7.1.1	Key Security Aspects for Any System	181
7.1.2	Network Vulnerability Assessment	183
7.1.2.1	Security Vulnerabilities	183
7.1.2.2	Security Policies and Standards	184
7.1.2.3	Security Methodologies and Procedures	186
7.1.2.4	Security Assessments	187
7.1.2.5	Network Security Testing Tools	187
7.1.2.6	Summary	188
7.2	AUTOMATED SECURITY ASSESSMENT	189
7.2.1	Global Architecture of an Automated Security Assessment	189
7.2.1.1	Base System Module	190
7.2.1.2	Management Module	190
7.2.1.3	Analysis Module	191
7.2.1.4	Testing Modules	192
7.2.2	The Communications Protocol	192
7.2.3	Other Considerations	193
7.3	SECURITY CONCERNS, TRENDS AND REQUIREMENTS IN SMART GRIDS	194

7.3.1	Requirements of the Smart Grid	196
7.3.2	Smart Grid Security Requirements Definition	197
7.4	SECURITY IN A CLOUD INFRASTRUCTURE AND SERVICES FOR SMART GRIDS	200
7.4.1	Security Concerns and Requirements in a Cloud Environment	200
7.4.1.1	Security Threats	202
7.4.1.2	Security Issues	202
7.4.1.3	Security Requirements	204
7.4.2	Use Case Analysis—FINESCE Cloud for Smart Grid Distribution	205
7.4.2.1	Use Case Description	205
7.4.2.2	Security Requirements Analysis	207
7.4.2.3	Security Audit	208
7.4.3	Summary	209
7.5	THE SMART GRID AS AN IoT	210
7.6	TOWARDS A SECURE AND SUSTAINABLE SMART GRID MANAGEMENT	212
7.6.1	A Sustainable Smart Grid Management	212
7.6.2	Software-Defined Network	213
7.6.3	Service Composition Paradigm	213
7.6.4	The Proof of Concept: A First Approach to Orchestrate Secured Smart Metering	214
7.7	CONCLUSIONS	218
7.8	ACKNOWLEDGEMENTS	219
	BIBLIOGRAPHY	219
CHAPTER 8	Secret Key Generation under Active Attacks	227
	WENWEN TU and LIFENG LAI	
8.1	INTRODUCTION	228
8.2	BASIC MODELS FOR KEY GENERATION WITH A PASSIVE ADVERSARY	231
8.2.1	Key Generation with Side Information at the Adversary	231
8.2.2	Key Generation with a Helper	233
8.2.3	Basic Model for Key Generation in Wireless Setting	234
8.3	KEY GENERATION WITH PUBLIC DISCUSSION ATTACKED	235
8.3.1	Model Modification	235
8.3.2	All or Nothing Result	236
8.3.3	Efficiently Checking the Simulatability Condition	238

8.4	KEY GENERATION WITH CONTAMINATED SOURCES	239
8.4.1	Two-Way Relay Channel Model	239
8.4.2	Efficiency of the Key Generation Algorithm	241
8.4.3	Attack Strategy and Power Allocation	243
8.4.3.1	Optimal Attack Strategy	243
8.4.3.2	Optimal Attack Power Allocation	245
8.5	KEY GENERATION WITH A BYZANTINE HELPER	247
8.5.1	System Model with a Byzantine Helper	247
8.5.2	Key Generation Scheme against the Byzantine Helper	248
8.5.2.1	A Key Generation Scheme Example	249
8.6	CONCLUSION	251
8.7	ACKNOWLEDGEMENT	251
	BIBLIOGRAPHY	251

SECTION III Towards Smart World from Interfaces to Homes to Cities

CHAPTER	9 ■ Applying Human–Computer Interaction Practices to IoT Prototyping	257
---------	--	-----

SALIM HANIFF, MARKKU TURUNEN, and ROOPE RAISAMO

9.1	INTRODUCTION	258
9.1.1	Internet of Things	258
9.1.2	Human–Computer Interaction	259
9.2	HCI METHODOLOGY	265
9.3	USE CASES	267
9.3.1	Smart Energy Monitoring	267
9.3.1.1	User’s Requirements	267
9.3.1.2	Hardware Implementation	268
9.3.1.3	Software Implementation	270
9.3.1.4	Discussion	273
9.3.2	Smart Lighting	276
9.3.2.1	User’s Requirements	277
9.3.2.2	Hardware Implementation	277
9.3.2.3	Software Implementation	279
9.3.2.4	Discussion	283
9.3.3	Seamless Home Automation	284
9.3.3.1	User’s Requirements	285

9.3.3.2	Hardware Implementation	286
9.3.3.3	Software Implementation	287
9.3.3.4	Discussion	289
9.4	CONCLUSION	290
	BIBLIOGRAPHY	291

CHAPTER 10 ■ Inclusive Product Interfaces for the Future: Automotive, Aerospace, IoT and Inclusion Design 295

PATRICK M. LANGDON

10.1	THE BACKGROUND TO THE PROBLEMS	296
10.1.1	The Ubiquity of IoT Technology, and Importance of Inclusive Design	297
10.1.2	What Is the Need for Inclusion?	298
10.1.3	The Inclusive Design Response	299
10.1.4	Health Induced and Situationally Induced Impairment	299
10.2	ADVANCED INTERACTION INTERFACES	300
10.2.1	The State of the Art	301
10.2.2	Solutions and Issues with User Modelling	301
10.3	THE INCLUSIVE ADAPTION APPROACH	302
10.4	CASE STUDY 1: FUTURE AUTOMOTIVE	303
10.4.1	Key Future HMI Design Elements	304
10.4.2	Visualisation of Key Concepts	307
10.5	CASE STUDY 2: FUTURE AEROSPACE	307
10.5.1	Need for Multimodal Solutions	308
10.5.2	Multimodal Interface Experiments	310
10.6	CASE STUDY 3: PREDICTIVE POINTING IN AUTOMOTIVE TOUCH SCREENS	310
10.7	CASE STUDY 4: ADAPTIVE MOBILE APPLICATIONS	312
10.7.1	The IU-ATC Project	314
10.7.2	Mobile Interfaces	314
10.8	DISCUSSION	315
	BIBLIOGRAPHY	317

CHAPTER 11 ■ Low Power Wide Area (LPWA) Networks for IoT Applications 323

KAN ZHENG, ZHE YANG, XIONG XIONG, and WEI XIANG

11.1	OVERVIEW ON 5G IoT	324
11.2	OVERVIEW ON LOW POWER WIDE AREA NETWORKS (LPWANS)	326

11.2.1	Application Scenarios of LPWANs	326
11.2.2	Classification of LPWANs	328
11.2.2.1	LPWAN Based on NB-IoT	329
11.2.2.2	LPWAN Based on IEEE 802.15.4k	335
11.3	IMPLEMENTATION OF LPWAN BASED ON IEEE 802.15.4K	339
11.3.1	Access Point (AP)	339
11.3.2	Devices	340
11.3.3	Experimental Results	342
11.4	LPWA-BASED AIR QUALITY MONITORING SYSTEM	343
11.4.1	System Architecture	345
11.4.1.1	Sensing Layer	345
11.4.1.2	Network Layer	347
11.4.1.3	Application Layer	347
11.4.2	Experimental Results and Analysis	348
11.4.2.1	Experimental Configurations	348
11.4.2.2	Results and Analysis	349
11.5	CONCLUSION AND OUTLOOK	351
	BIBLIOGRAPHY	353
CHAPTER 12	A Data-centered Fog Platform for Smart Living	357
	JIANHUA LI, JIONG JIN, DONG YUAN, MARIMUTHU PALANISWAMI, and KLAUS MOESSNER	
12.1	INTRODUCTION	358
12.1.1	Smart City	358
12.1.2	Internet of Things	360
12.1.3	Smart Living	362
12.1.4	Ad Hoc IoT	362
12.1.5	Gateway or Proxy Based IoT	363
12.1.6	Cloud Computing Based IoT	364
12.1.7	Fog Computing	364
12.2	EHOPES ELEMENTS AND DATAFLOW	366
12.2.1	EHOPES and Dataflow	366
12.2.2	Summary	368
12.3	FOG PLATFORM FOR EHOPES	369
12.3.1	State of the Art	369
12.3.2	Fog Edge Node (FEN)	369
12.3.3	Fog Server (FS)	370
12.3.4	Foglet (Middleware)	371

12.4	CASE STUDY AND EVALUATION	371
12.4.1	The Scenario	371
12.4.2	The Simulation	373
12.4.3	Simulation Results	374
12.5	CONCLUSION	375
	BIBLIOGRAPHY	375
CHAPTER 13	Resources and Practical Factors in Smart Home and City	379
	Bo TAN, LILI TAO, and NI ZHU	
13.1	INTRODUCTION	380
13.2	NOVEL USAGE OF RADIO RESOURCES	380
13.2.1	Current Situation and Challenges	380
13.2.2	Use of Outdoor Radio Signals	381
13.2.3	Use of Indoor Signals	383
13.2.4	The Trend	385
13.3	VIDEO RESOURCES	386
13.3.1	Introduction	386
13.3.2	Applications and Current Systems	387
13.3.3	Future Trends	389
13.4	PRACTICAL CONSIDERATIONS	390
13.4.1	Pervasive Sensing	390
13.4.2	Smart Cities in Reality	391
	BIBLIOGRAPHY	393
Index		399