

## Table of Contents

<b>Chapter 1. Introduction</b> . . . . .	1
Houda LABIOD	
<b>Chapter 2. Ad Hoc Networks: Principles and Routing</b> . . . . .	7
Stéphane UBÉDA	
2.1. Introduction. . . . .	7
2.2. Hertzian connection . . . . .	12
2.2.1. Physical layer impact. . . . .	12
2.2.2. Shared access to medium . . . . .	15
2.2.3. Flooding . . . . .	19
2.3. Routing . . . . .	21
2.3.1. Dynamic source routing (DSR). . . . .	23
2.3.2. Ad hoc on-demand distance vector (AODV). . . . .	25
2.3.3. Optimized link state routing (OLSR) . . . . .	26
2.3.4. Topology based on reverse-path forwarding (TBRPF) . . . . .	28
2.3.5. Zone-based hierarchical link state routing protocol (ZRP). . . . .	29
2.3.6. Location-aided routing (LAR) . . . . .	30
2.4. Conclusion . . . . .	32
2.5. Bibliography . . . . .	33
<b>Chapter 3. Quality of Service Support in MANETs</b> . . . . .	35
Pascale MINET	
3.1. Introduction to QoS . . . . .	35
3.1.1. Different QoS requirements. . . . .	36
3.1.2. Chapter structure . . . . .	36
3.2. Mobile ad hoc networks and QoS objectives . . . . .	37
3.2.1. Characteristics of mobile ad hoc networks and QoS . . . . .	37
3.2.1.1. Radio interference . . . . .	37

3.2.1.2. Limited resources . . . . .	38
3.2.1.3. Large dynamicity of a mobile ad hoc network . . . . .	39
3.2.1.4. Broadcast and multihop transmission . . . . .	39
3.2.1.5. Decentralized control . . . . .	39
3.2.2. Routing in mobile ad hoc networks . . . . .	40
3.2.2.1. AODV: a reactive routing protocol . . . . .	40
3.2.2.2. OLSR: a proactive routing protocol . . . . .	41
3.2.2.3. Comparative OLSR and AODV performance evaluation . . . . .	43
3.2.3. Realistic QoS objectives . . . . .	48
3.3. QoS architecture and relative QoS state of the art . . . . .	49
3.3.1. Different QoS components . . . . .	49
3.3.2. QoS models . . . . .	51
3.3.2.1. INSIGNIA approach . . . . .	51
3.3.2.2. SWAN approach . . . . .	52
3.3.2.3. FQMM approach . . . . .	52
3.3.2.4. Cross-layering approach . . . . .	53
3.3.3. QoS signaling . . . . .	53
3.3.4. QoS routing . . . . .	56
3.3.4.1. Complexity of QoS routing . . . . .	56
3.3.4.2. QoS extension of AODV . . . . .	57
3.3.4.3. QoS extensions of OLSR . . . . .	57
3.4. An example of QoS support: QoS OLSR . . . . .	57
3.4.1. Description of QoS OLSR . . . . .	58
3.4.2. Performance evaluation . . . . .	59
3.5. Conclusion . . . . .	61
3.5.1. Summary . . . . .	61
3.5.2. Perspectives . . . . .	62
3.6. Bibliography . . . . .	62
<b>Chapter 4. Multicast Ad Hoc Routing . . . . .</b>	<b>65</b>
Houda LABIOD	
4.1. Introduction . . . . .	65
4.2. Multicast routing in MANETs: a brief state of the art . . . . .	66
4.2.1. Classification . . . . .	66
4.2.2. Summary . . . . .	68
4.3. SRMP . . . . .	69
4.3.1. Description . . . . .	69
4.3.1.1. Selection criteria for FG nodes . . . . .	70
4.3.2. Operation . . . . .	72
4.3.2.1. Route request phase . . . . .	72
4.3.2.2. Reply phase and FG node selection . . . . .	72
4.3.2.3. Data forwarding . . . . .	73

4.3.3. Maintenance procedures . . . . .	73
4.3.3.1. Notification of neighbor existence mechanism . . . . .	74
4.3.3.2. Mesh refresh mechanism . . . . .	74
4.3.3.3. Link repair mechanism . . . . .	74
4.3.3.4. Pruning scheme . . . . .	75
4.4. Properties . . . . .	75
4.5. Simulation results and analysis . . . . .	76
4.6. Conclusion . . . . .	77
4.7. Bibliography . . . . .	77
<b>Chapter 5. Self-organization of Ad Hoc Networks: Concepts and Impacts</b>	<b>81</b>
Fabrice THEOLEYRE and Fabrice VALOIS	
5.1. Introduction . . . . .	81
5.2. Self-organization: definition and objectives . . . . .	82
5.2.1. Definition . . . . .	82
5.2.2. Principles and objectives . . . . .	82
5.2.3. Local or distributed decisions? . . . . .	84
5.3. Some key points for self-organization . . . . .	85
5.3.1. Emergence of global behavior from local rules . . . . .	85
5.3.2. Local interactions and node coordination . . . . .	86
5.3.3. Minimizing network state information . . . . .	86
5.3.4. Dynamic environment adaptation . . . . .	87
5.4. Self-organization: a state of the art . . . . .	87
5.4.1. Classification . . . . .	87
5.4.2. Virtual backbone . . . . .	88
5.4.2.1. Notations . . . . .	89
5.4.2.2. Connected dominating set . . . . .	89
5.4.2.3. Maximal independent set . . . . .	91
5.4.2.4. Localized minimum spanning tree . . . . .	92
5.4.2.5. Relative neighborhood graph . . . . .	93
5.4.3. Cauterization techniques . . . . .	94
5.5. Case study and proposition of a solution . . . . .	94
5.5.1. Motivations . . . . .	94
5.5.2. Construction of virtual topology . . . . .	95
5.5.2.1. Neighborhood discovery . . . . .	95
5.5.2.2. Backbone . . . . .	96
5.5.2.3. Service zones . . . . .	97
5.5.3. Maintenance of virtual topology . . . . .	98
5.5.3.1. Backbone . . . . .	98
5.5.3.2. Service zones . . . . .	100
5.5.4. Virtual topology properties . . . . .	101

5.6. Contribution of self-organization . . . . .	101
5.6.1. Energy saving . . . . .	102
5.6.2. Influence of self-organization on routing . . . . .	103
5.6.2.1. Intra-cluster routing . . . . .	103
5.6.2.2. Inter-cluster routing . . . . .	103
5.6.2.3. Performance . . . . .	105
5.7. Conclusion . . . . .	106
5.8. Bibliography . . . . .	107
<b>Chapter 6. Approaches to Ubiquitous Computing . . . . .</b>	<b>111</b>
Mohamed BAKHOUYA and Jaafar GABER	
6.1. Introduction. . . . .	111
6.2. Structured service discovery systems. . . . .	114
6.2.1. Systems based on an indexing mechanism . . . . .	114
6.2.1.1. Centralized indexing . . . . .	114
6.2.1.2. Decentralized indexing . . . . .	115
6.2.2. Systems based on distributed hash . . . . .	119
6.3. Unstructured service discovery systems . . . . .	120
6.3.1. Flooding-based mechanism . . . . .	120
6.3.2. Random walk-based mechanism . . . . .	123
6.4. Comparison between structured and unstructured systems . . . . .	124
6.5. Self-organizing and self-adaptive approach . . . . .	125
6.5.1. Server community construction approach . . . . .	126
6.5.1.1. SAgent server agent . . . . .	127
6.5.1.2. BAgent resource agent. . . . .	127
6.5.1.3. Mobile aAgent . . . . .	128
6.5.2. Request resolution . . . . .	129
6.5.2.1. Local reinforcement mechanism . . . . .	130
6.5.2.2. Global reinforcement mechanism . . . . .	132
6.5.2.3. Types of agents . . . . .	133
6.6. Simulation results . . . . .	135
6.7. Conclusion . . . . .	137
6.8. Bibliography . . . . .	137
<b>Chapter 7. Service Discovery Protocols for MANETs . . . . .</b>	<b>143</b>
Abdellatif OBAID and Azzedine KHIR	
7.1. Introduction. . . . .	143
7.2. Service discovery protocols . . . . .	146
7.2.1. Service discovery protocols in wired networks . . . . .	146
7.2.1.1. JINI . . . . .	146
7.2.1.2. UPnP . . . . .	148
7.2.1.3. SLP . . . . .	149

7.2.2. Service discovery in ad hoc networks . . . . .	150
7.2.2.1. Post-Query . . . . .	150
7.2.2.2. KONARK . . . . .	151
7.2.2.3. GSD. . . . .	151
7.2.2.4. Allia. . . . .	152
7.2.3. Service discovery with routing . . . . .	152
7.2.3.1. Koodli and Perkins protocol . . . . .	153
7.2.3.2. SEDIRAN . . . . .	153
7.3. Conclusion . . . . .	162
7.4. Bibliography . . . . .	162
<b>Chapter 8. Distributed Clustering in Ad Hoc Networks and Applications .</b>	<b>165</b>
Romain MELLIER and Jean-Frédéric MYOUPPO	
8.1. Introduction. . . . .	165
8.2. State of the art . . . . .	166
8.2.1. Clustering in two hop clusters . . . . .	167
8.2.1.1. Gerla and Tsai approach. . . . .	168
8.2.1.2. Distributed clustering for ad hoc networks (DCA): weight notion introduction . . . . .	172
8.2.1.3. Distributed clustering for better mobility support: DMAC (distributed and mobility-adaptive clustering). . . . .	177
8.2.1.4. Generalization of distributed approach limiting mobility impact: GDMAC . . . . .	179
8.2.2. Clustering at more than two hops . . . . .	181
8.3. Clustering in networks where mobile devices may have the same weight . . . . .	183
8.4. Applications . . . . .	184
8.4.1. Initialization problem in k hop networks . . . . .	185
8.4.2. Mutual exclusion in k hop networks. . . . .	185
8.5. Conclusion . . . . .	190
8.6. Bibliography . . . . .	191
<b>Chapter 9. Security for Ad Hoc Routing and Forwarding . . . . .</b>	<b>195</b>
Sylvie LANIEPCE	
9.1. Introduction. . . . .	195
9.2. Reminders on routing protocols in ad hoc networks . . . . .	196
9.2.1. Reactive protocols . . . . .	196
9.2.1.1. Dynamic source routing (DSR). . . . .	196
9.2.1.2. Ad hoc on-demand distance vector (AODV) routing. . . . .	197
9.2.2. Proactive protocol . . . . .	198
9.2.2.1. Destination-sequenced distance vector (DSDV) routing. . . . .	198

9.3. Routing threat model in ad hoc networks . . . . .	199
9.3.1. Ad hoc network characterization for security . . . . .	199
9.3.2. Classification of attack objectives . . . . .	200
9.3.3. Basic attacks and security counter measures . . . . .	200
9.4. Routing security . . . . .	202
9.4.1. SRP: secure routing for mobile ad hoc networks . . . . .	202
9.4.2. Secure ad hoc on-demand distance vector (SAODV) routing . . . . .	204
9.4.3. Ariadne . . . . .	205
9.4.4. ARAN: authenticated routing protocol for ad hoc networks . . . . .	209
9.4.5. Secure dynamic source routing (SDSR) . . . . .	210
9.4.6. EndairA . . . . .	212
9.5. IP datagram forwarding security . . . . .	213
9.5.1. Monitoring-based techniques . . . . .	213
9.5.1.1. Watchdog and pathrater . . . . .	213
9.5.1.2. CORE: collaborative reputation . . . . .	214
9.5.1.3. CONFIDANT: cooperation of nodes – fairness in dynamic ad hoc networks . . . . .	215
9.5.1.4. SAFE: securing packet forwarding in an ad hoc network . . . . .	216
9.5.1.5. Improvement propositions . . . . .	217
9.5.1.6. Summary . . . . .	218
9.5.2. Technique based on packet acknowledgement . . . . .	219
9.5.3. Cooperative incentive techniques based on virtual money . . . . .	220
9.6. Conclusion . . . . .	220
9.7. Acknowledgements . . . . .	221
9.8. Bibliography . . . . .	221
<b>Chapter 10. Fault-Tolerant Distributed Algorithms for Scalable Systems . . . . .</b>	<b>225</b>
Sébastien TIXEUIL	
10.1. Introduction . . . . .	225
10.2. Distributed algorithms and wireless communications . . . . .	226
10.3. Fault-tolerant distributed algorithms . . . . .	228
10.3.1. Fault taxonomy in distributed systems . . . . .	228
10.3.2. Fault-tolerant algorithm categories . . . . .	230
10.4. The limits and problems caused by a large-scale system . . . . .	232
10.4.1. Hypotheses about the system . . . . .	232
10.4.2. Hypotheses on the applications . . . . .	235
10.5. Solutions for large-scale self-stabilization . . . . .	238
10.5.1. Restricting the nature of the faults . . . . .	238
10.5.1.1. Detecting and correcting errors . . . . .	238
10.5.1.2. Preservation of predicates . . . . .	239
10.5.2. Limiting the geographic extent of faults . . . . .	242
10.5.2.1. k-stabilization . . . . .	243

10.5.2.2. Time-adaptive self-stabilization . . . . .	244
10.5.3. Classification. . . . .	246
10.5.4. Limiting the classes of problems to solve. . . . .	247
10.5.4.1. Localized problems. . . . .	247
10.5.4.2. Tolerating malicious entities . . . . .	249
10.6. Conclusion . . . . .	251
10.7. Bibliography . . . . .	251
<b>Chapter 11. Code Mobility in Sensor Networks . . . . .</b>	<b>257</b>
Fabrcio A. SILVA, Linnyer B. RUIZ, Jose M. NOGUEIRA, Thais R. BRAGA and Antonio A.F. LOUREIRO	
11.1. Introduction . . . . .	257
11.2. Concepts linked to code mobility . . . . .	258
11.2.1. Process and object migration . . . . .	259
11.2.2. Code mobility . . . . .	259
11.2.3. Wireless sensor networks and code mobility . . . . .	260
11.3. Project paradigms of code mobility systems. . . . .	261
11.3.1. Client/server . . . . .	261
11.3.2. Remote evaluation . . . . .	262
11.3.3. Code on demand. . . . .	262
11.3.4. Mobile agent . . . . .	263
11.4. Mobile agents. . . . .	263
11.4.1. Mobile agent components . . . . .	265
11.4.2. Mobile agent system models . . . . .	266
11.4.2.1. Agent model . . . . .	266
11.4.2.2. Life cycle model. . . . .	266
11.4.2.3. Computing model . . . . .	267
11.4.2.4. Security model. . . . .	267
11.4.2.5. Communication model . . . . .	267
11.4.2.6. Navigation model . . . . .	267
11.5. Modeling mobile agent systems for wireless sensor networks . . . . .	268
11.5.1. Agent model . . . . .	268
11.5.2. Life cycle model. . . . .	268
11.5.3. Computing model . . . . .	269
11.5.4. Security model. . . . .	269
11.5.5. Communication model . . . . .	270
11.5.6. Navigation model . . . . .	270
11.6. State of the art . . . . .	271
11.6.1. Remote and single hop reprogramming . . . . .	271
11.6.2. Multihop reprogramming . . . . .	272
11.6.3. Virtual machine reprogramming . . . . .	274
11.6.4. Mobile target location application . . . . .	275

11.7. Case study: mobile agents in WSN management . . . . .	276
11.7.1. Objectives . . . . .	276
11.7.2. Models . . . . .	277
11.7.2.1. CS model . . . . .	277
11.7.2.2. Mobile agent model. . . . .	277
11.7.3. Evaluation . . . . .	278
11.7.3.1. Results in relation to energy usage . . . . .	279
11.7.3.2. Discussion . . . . .	282
11.8. Conclusion . . . . .	282
11.9. Bibliography . . . . .	282
<b>Chapter 12. Vehicle-to-Vehicle Communications: Applications and Perspectives . . . . .</b>	<b>285</b>
Rabah MERAIHI, Sidi-Mohammed SENOUCI, Djamal-Eddine MEDDOUR and Moez JERBI	
12.1. Introduction . . . . .	285
12.2. Properties and applications . . . . .	287
12.2.1. Properties of VANETs . . . . .	287
12.2.2. VANET applications . . . . .	289
12.2.2.1. Alert in case of accidents . . . . .	290
12.2.2.2. Alert in case of abnormally slow traffic (traffic jam, roadworks, bad weather, etc.). . . . .	290
12.2.2.3. Collaborative driving . . . . .	290
12.2.2.4. Highway hot spot . . . . .	291
12.2.2.5. Parking management . . . . .	291
12.3. State of the art and study of the existing situation . . . . .	292
12.3.1. Projects and consortiums. . . . .	292
12.3.2. Study of the existing situation. . . . .	294
12.3.2.1. Routing . . . . .	294
12.3.2.2. Data dissemination and diffusion. . . . .	297
12.3.2.3. Mobility models for vehicular networks. . . . .	299
12.3.2.4. MAC and physical layers . . . . .	301
12.3.2.5. Security in vehicular networks . . . . .	302
12.4. Conclusion . . . . .	303
12.5. Bibliography . . . . .	304
<b>List of Authors . . . . .</b>	<b>309</b>
<b>Index . . . . .</b>	<b>313</b>