

Table of Contents

Introduction	xv
Chapter 1. Artificial Intelligence and Monitoring of Telecommunications Networks	1
Hassine MOUNGLA	
1.1. Introduction.	1
1.2. Network management goals	2
1.3. Monitoring needs of telecommunications networks	3
1.4. The telecommunications management network (TMN).	6
1.4.1. TMN management functions	6
1.4.2. TMN architecture.	7
1.5. Control in telecommunications networks	7
1.6. Some AI techniques for monitoring telecommunications networks.	9
1.6.1. Chronos: an expert system generator for monitoring telecommunications networks	9
1.6.2. Monitoring with model-based techniques.	11
1.6.3. Agent technology	12
1.6.3.1. Intelligent agent principles	13
1.6.4. Example of agent-based telecommunications network monitoring architecture	14
1.6.5. Telecommunications network management with mobile agents	15
1.6.5.1. Overview.	15
1.6.5.2. Mobile agents	15
1.6.5.3. Example of telecommunications network monitoring in the case of routing by ant colonies	16
1.7. Conclusion	18
1.8. Bibliography	18

Chapter 2. Adaptive and Programmable Management of IP Quality of Service	23
Miguel CASTRO, Dominique GAÏTI, Abdallah M'HAMED and Djamel ZEGHLACHE	
2.1. Introduction.	23
2.2. Open and programmable network technology	24
2.3. Active and programmable QoS management over IP	25
2.3.1. Programmable modules	28
2.3.1.1. Information	29
2.3.1.2. Statistic	29
2.3.1.3. Status	29
2.3.1.4. Label	30
2.3.1.5. Configuration	30
2.3.1.6. Notification	30
2.3.1.7. Behaviors	30
2.4. Architecture for adaptive and programmable management.	31
2.4.1. Legacy mechanisms	33
2.4.2. MMB	33
2.4.3. MAPI	34
2.4.4. Management kernel.	34
2.4.5. Core control	34
2.4.6. Hardware.	35
2.5. CLAM: a new language for adaptive and programmable management	35
2.6. Related studies	36
2.6.1. Behavioral networks	36
2.6.2. Smart packets	36
2.6.3. SENCOMM	37
2.6.4. General evaluation	38
2.7. Case studies.	39
2.7.1. Case study 1: web service optimization.	39
2.7.1.1. Scenario and metaconfiguration specification	39
2.7.1.2. Results and discussion	43
2.7.2. Case study 2: maximization of a given objective function.	45
2.7.2.1. Scenario and metaconfiguration specification	45
2.7.2.2. Results and discussion	47
2.7.3. Case study 3: adaptive control of equity	49
2.7.3.1. Scenario and metaconfiguration specification	49
2.7.3.2. Results and discussion	54
2.8. Conclusion and perspectives.	57
2.9. Bibliography	58

Chapter 3. Software Agents for IP Management	61
Anneli LENICA	
3.1. Introduction	61
3.2. IP networks and their management	62
3.2.1. IP networks	62
3.2.2. IP network evolution and associated problems	63
3.2.3. IP network management	65
3.3. The multi-agent paradigm	66
3.3.1. What is an agent?	66
3.3.2. When should MAS be used?	68
3.4. MAS for IP network management	71
3.4.1. MAS for specific network problems	71
3.4.2. Existing applications	72
3.4.2.1. Development of topology maps	72
3.4.2.2. Routing	73
3.4.2.3. Congestion control	74
3.4.2.4. Network monitoring	75
3.4.2.5. QoS	76
3.4.2.6. Continuity of services	76
3.4.2.7. Network simulation	77
3.5. Perspectives and conclusion	78
3.6. Bibliography	79
Chapter 4. The Use of Agents in Policy-based Management	83
Francine KRIEF	
4.1. Introduction	83
4.2. Policy-based management	85
4.2.1. The policies	85
4.2.2. Information model	86
4.2.3. Architecture	87
4.2.4. COPS protocol	88
4.2.5. Advantages and challenges	89
4.2.6. The agents and their advantage in network management	90
4.3. Provisioning and service control	91
4.3.1. Dynamic QoS provisioning in wired networks	92
4.3.1.1. Project I3	92
4.3.1.2. PDP agent model	94
4.3.2. Dynamic QoS provisioning in wireless networks	95
4.3.3. Prediction layer	95
4.3.4. Adaptation layer	96

4.3.5. Monitoring layer	96
4.3.6. Mobile agents for policy-based QoS provisioning	97
4.3.6.1. IST MANTRIP European project (IST-10921)	97
4.3.7. Dynamic service provisioning for mobile users	98
4.3.7.1. Main system components	98
4.3.8. Intelligent agents for dynamic security control	99
4.4. Agents and service contract negotiation	100
4.4.1. Service contract	100
4.4.2. An intelligent negotiation interface	101
4.4.2.1. Project RNRT ARCADE	102
4.4.3. Client-provider dynamic negotiation	104
4.4.4. Dynamic negotiation between providers	105
4.4.5. Dynamic services negotiation for mobile users	107
4.5. Management of emerging services	107
4.5.1. Emerging services	108
4.5.2. Dynamic management of emerging services	109
4.5.3. Dynamic management of group multimedia services	110
4.6. Conclusion	111
4.7. Bibliography	112
Chapter 5. Multi-agent Platforms	117
Zeina EL FERKH JRAD	
5.1. Introduction.	117
5.2. Towards a standardization of multi-agent technology	118
5.2.1. FIPA model	118
5.2.1.1. Illustration	119
5.2.2. KAOS model	121
5.2.3. General Magic model	122
5.3. Characteristics of a multi-agent platform	122
5.3.1. Methodological requirements for a multi-agent simulation platform	123
5.3.1.1. Technical axis	123
5.3.1.2. Domain axis	124
5.3.1.3. Development axis	124
5.3.2. Other forms of requirements for an agent platform	124
5.4. Multi-agent platform evaluation.	125
5.5. Examples of MAS platforms.	127
5.5.1. Platforms for simulation.	127
5.5.1.1. Cormas	129
5.5.1.2. Swarm	130
5.5.1.3. Geamas	131

5.5.2. Implementation platforms	131
5.5.2.1. Magique	133
5.5.2.2. Zeus	135
5.5.2.3. Jade	136
5.5.2.4. AgentBuilder	137
5.5.2.5. Jack Intelligent Agents	137
5.5.2.6. MadKit	138
5.5.2.7. DIMA	138
5.5.3. Mobility platforms	138
5.5.3.1. Grasshopper	139
5.5.3.2. Aglets	139
5.6. Conclusion	139
5.7. Bibliography	140
Chapter 6. Behavioral Modeling and Multi-agent Simulation	143
Leila MERGHEM-BOULAHIA	
6.1. Introduction	143
6.2. Traditional network modeling and simulation approaches	144
6.2.1. Queuing theory	145
6.2.2. Modeling by Petri nets	145
6.2.3. Modeling by process algebra	145
6.2.4. Limits	146
6.3. Multi-agent modeling and simulation	147
6.3.1. Multi-agent simulation steps	147
6.3.2. Contributions	148
6.4. Behavioral modeling	149
6.4.1. Principle	149
6.4.2. Contributions	150
6.5. Two-level behavioral model of a network node	151
6.5.1. Introduction	151
6.5.2. Role of the two behavioral levels	153
6.5.3. Agents	154
6.5.4. Model of two behavioral levels	154
6.5.4.1. Basic behavior model	154
6.5.4.2. Metabehavior model	155
6.5.5. Ensuring adaptability	156
6.5.5.1. Metabehavior rules	156
6.5.5.2. Arbitration between basic behavior decisions	157
6.5.5.3. Relations between basic behaviors	157
6.6. Perspectives and conclusion	158
6.7. Bibliography	159

Chapter 7. Behavioral Modeling and Simulation: An Example in Telecommunications Networks	163
Leila MERGHEM-BOULAHIA	
7.1. Introduction.	163
7.2. Basic behaviors adapted to networks	164
7.2.1. Queue management basic behaviors	164
7.2.1.1. “Careful” basic behavior	165
7.2.1.2. “Finder” basic behavior	165
7.2.1.3. “Suspicious” basic behavior	166
7.2.1.4. Economy basic behavior.	167
7.2.2. Scheduling basic behaviors	167
7.2.2.1. Fair basic behavior	168
7.2.2.2. Inequitable basic behavior.	168
7.2.2.3. Moderate basic behavior.	168
7.2.3. Routing basic behaviors	168
7.2.3.1. “Conservative” basic behavior	168
7.2.3.2. “Disloyal” basic behavior	169
7.3. Metabehaviors	169
7.3.1. Queue management metabehavior	169
7.3.2. Scheduling metabehavior	170
7.3.3. Routing metabehavior	171
7.4. Simulation components and parameters	171
7.4.1. Objects	171
7.4.2. Agents	172
7.4.3. Parameters	173
7.5. A few results	174
7.5.1. Impact of queue management basic behaviors	174
7.5.2. Impact of scheduling basic behaviors	176
7.5.3. Impact of queue management metabehavior rules.	178
7.5.4. Impact of scheduling metabehavior rules.	179
7.6. Discussion	179
7.7. Conclusion and perspectives.	181
7.8. Bibliography	182
Chapter 8. Multi-agent System in a DiffServ Network: Behavioral Models and Platform	185
Nada MESKAOUI	
8.1. Introduction.	185
8.2. Quality of service – existing solutions and their problems	186
8.2.1. RTP/RTCP.	186

8.2.2. IntServ/RSVP	187
8.2.3. DiffServ	187
8.3. Agents, multi-agent systems and architectures	188
8.3.1. Agents	188
8.3.2. MAS	190
8.4. Towards intelligent and cooperative telecommunications networks	191
8.4.1. Node structure.	192
8.4.2. Agent components	193
8.4.3. Agent behavioral model	194
8.4.3.1. Model 1.	195
8.4.3.2. Model 2.	196
8.5. Simulation – platform, topology and results	200
8.5.1. Platform	200
8.5.2. Topology and configuration.	201
8.5.3. Simulation results.	203
8.5.3.1. Simulation no. 1.	203
8.5.3.2. Simulation no. 2.	204
8.5.3.3. Simulation no. 3.	205
8.5.3.4. Simulation no. 4.	205
8.6. Conclusion	209
8.7. Bibliography	209
Chapter 9. Intelligent Agent Control Simulation in a Telecommunications Network	213
Hugues LECARPENTIER	
9.1. Introduction.	213
9.2. Network management and control by intelligent software agents	215
9.2.1. Agent-based admission control.	215
9.2.2. Project Tele-MACS	215
9.2.3. Project Hybrid.	215
9.2.4. Route selection by mobile agents	216
9.2.5. Cooperative mobile agents for network mapping	216
9.2.6. Project MAGNA	216
9.3. Simulating the behavior of intelligent agents in a communication network	217
9.3.1. Simulation of behavioral quality of service network control	217
9.3.2. Intelligent control simulation of a DiffServ network	217
9.3.3. Comparison and choice of a platform	218
9.4. Detailed simulator presentation	218
9.4.1. Structure of an INET node	219
9.4.1.1. Services provided by the CSL layer	220

9.4.1.2. Data transmission service	221
9.4.1.3. Node identification service	222
9.4.1.4. Routing service	223
9.4.1.5. Neighborhood management service	223
9.4.1.6. Packet filtering services	223
9.4.1.7. CSL layer composition.	224
9.5. Software agent architecture	224
9.5.1. Events monitor	226
9.5.2. Cleaner	227
9.5.3. Message interface.	227
9.5.4. Task interface	229
9.5.5. Manager	229
9.6. Illustration	229
9.6.1. Quality of service control for voice over IP	229
9.6.2. Presentation of agents and routers used	230
9.7. Conclusion	231
9.8. Bibliography	231
Chapter 10. Agents and 3rd and 4th Mobile Generations	233
Badr BENMAMMAR	
10.1. Introduction	233
10.2. Agent technology	234
10.2.1. Definition of an agent	234
10.2.1.1. Mobile agents	235
10.2.1.2. Intelligent agents	237
10.2.1.3. Multidimensional characteristics of an agent	237
10.3. Introduction to UMTS.	238
10.3.1. VHE	239
10.3.2. Application of agents in UMTS.	241
10.3.2.1. Service procurement	241
10.3.2.2. Improvement of different existing components	246
10.3.2.3. Web access for UMTS	248
10.4. Introduction to WLAN	253
10.4.1. Application of agents in wireless networks	254
10.4.1.1. Localization of mobile hardware	254
10.4.1.2. Efficiency improvement of a mobility protocol	255
10.4.1.3. Adaptation of handover to user requirement	255
10.4.1.4. Signaling control	256
10.4.1.5. Decrease of wireless access	256
10.4.2. Problems related to the application of MAS in wireless environments	256

10.5. 4 th generation mobile network	256
10.5.1. Definition of 4 th generation	256
10.5.2. User expectations for mobile 4G networks	257
10.5.3. Technical conditions to achieve 4 th mobile generation	258
10.5.4. Application of agents in 4G mobile networks	258
10.6. Conclusion	263
10.7. Bibliography	264
Chapter 11. Learning Techniques in a Mobile Network	267
Sidi-Mohammed SENOUCI	
11.1. Introduction	267
11.2. Learning	269
11.2.1. Unsupervised learning	269
11.2.2. Supervised learning	269
11.2.3. Reinforcement learning	270
11.2.3.1. Resolution methods.	271
11.2.3.2. Application of reinforcement learning techniques – state of the art	273
11.3. Call admission control.	275
11.3.1. Problem formulation	275
11.3.2. Implementation of algorithm	276
11.3.2.1. Implementation	277
11.3.2.2. Exploration.	277
11.3.3. Experimental results	278
11.4. Dynamic resource allocation.	280
11.4.1. Problem formulation	281
11.4.2. Algorithm implementation.	282
11.4.2.1. Implementation	282
11.4.2.2. Exploration.	283
11.4.3. Experimental results	283
11.5. Conclusion	284
11.6. Bibliography	286
Chapter 12. An Experimental Example of Active Networks: The Amarrage Project	289
Nadjib ACHIR, Yacine GHAMRI-DOUDANE and Mauro FONSECA	
12.1. Introduction	289
12.2. Description of the Amarrage project	291
12.2.1. Objectives	291
12.2.2. Contributions.	292

12.2.2.1. Sub-project 1	292
12.2.2.2. Sub-project 2	292
12.2.2.3. Sub-project 3	293
12.2.2.4. Sub-project 4	295
12.2.2.5. Sub-project 5	295
12.3. Active networks: active architecture example for the control and management of DiffServ networks	296
12.3.1. DiffServ	298
12.3.1.1. DiffServ service life cycle	300
12.3.2. Policy-based control	300
12.3.3. Description of architecture components	302
12.3.3.1. Management and control application plan	302
12.3.3.2. Service provider control plan	303
12.3.3.3. Active operating system plan	303
12.3.3.4. Active router execution environment plan	303
12.3.3.5. Active router data plan	304
12.3.4. Capsule filtering at the level of data plan	305
12.3.5. Active router resource monitoring	305
12.3.6. Definition of QoS policies	306
12.3.7. Definition and deployment of TCB	307
12.3.8. Sensor deployment	309
12.3.9. Implementation of DACA architecture	310
12.3.10. Evaluation of DACA architecture behavior	312
12.4. Conclusion	315
12.5. Bibliography	315
List of Authors	317
Index	319