

Table of Contents

Introduction	xi
Chapter 1. Environmental Impact of Networking Infrastructures	1
Laurent LEFÈVRE and Jean-Marc PIERSON	
1.1. Introduction	1
1.2. Some definitions and metrics	5
1.3. State of the sites of consumption of the networks: the case of wired networks	7
1.4. Academic and industrial initiatives	11
1.5. Perspectives and reflections on the future	13
1.6. Bibliography	13
PART 1. A STEP TOWARDS ENERGY-EFFICIENT NETWORKS	17
Chapter 2. A Step Towards Energy-efficient Wired Networks	19
Aruna Prem BIANZINO, Claude CHAUDET, Dario ROSSI and Jean-Louis ROUGIER	
2.1. Introduction	19
2.2. Models of energy consumption	22
2.3. Energy-saving strategies	27
2.3.1. Transport applications and protocols	27
2.3.2. Communications links	31
2.4. The problem of energy-efficient routing	37
2.4.1. Model of energy consumption	37

2.4.2. Formulation of the problem	39
2.4.3. Experimental results	41
2.5. Conclusion	51
2.6. Bibliography	52

Chapter 3. A Step Towards Green Mobile Networks 59

Sami TABBANE

3.1. Introduction	59
3.1.1. Decreasing power: an imperative in a cellular radio network	60
3.1.2. Definition of and need for green cellular	60
3.2. Processes and protocols for green networks	63
3.2.1. Technologies on the radio interface	64
3.2.2. Adaptation of network activity to traffic	66
3.2.3. Traffic aggregation based on the delay	67
3.2.4. Store, carry and forward relaying	68
3.2.5. Combination of MS and BTS	68
3.2.6. Handover for optimization of the energy used	69
3.2.7. Cooperation between base transceiver stations	70
3.2.8. Increasing the capacity of the RAN and network core nodes	70
3.3. Architecture and engineering of green networks	71
3.3.1. Relaying and multi-hopping	71
3.3.2. Self-organizing networks (SONs)	73
3.3.3. Planning	74
3.3.4. Microcells and multi-RAT networks	75
3.3.5. A step towards all-IP and flat architecture	77
3.3.6. Reducing the number of sites by using smart antennas	77
3.3.7. Cooperation between BTSs	78
3.4. Components and structures for green networks	79
3.4.1. Power-efficient amplifiers	80
3.4.2. Elimination of feeders, use of fiber optics	81
3.4.3. Solar and wind power	81
3.4.4. Twin TRX	82
3.4.5. Cooling	82
3.5. Conclusion	83
3.6. Bibliography	83

Chapter 4. Green Telecommunications Networks	87
Guy PUJOLLE	
4.1. Introduction	87
4.2. Data centers	89
4.3. Wireless telecommunications networks	92
4.4. Terrestrial telecommunications networks	99
4.5. Low-cost and energy-efficient networks	105
4.6. The role of virtualization in “green” techniques	109
4.7. Conclusion	112
4.8. Bibliography	113
PART 2. A STEP TOWARDS SMART GREEN NETWORKS AND SUSTAINABLE TERMINALS	115
Chapter 5. Cognitive Radio in the Service of Green Communication and Networking	117
Hicham KHALIFÉ	
5.1. Introduction	117
5.2. Cognitive radio: concept and standards	120
5.2.1. Attempts at standardization	121
5.2.2. Research projects and initiatives	122
5.3. Various definitions of green in cognitive radio	124
5.3.1. Reducing the pollution of the radio spectrum	125
5.3.2. Reducing the exposure of individuals	126
5.3.3. Reducing the consumption of the equipment	126
5.4. Clean solutions offered by cognitive radio	126
5.4.1. Solutions for the spectrum and health	127
5.4.2. Actions at the level of equipment/infrastructure	127
5.4.3. Optimizing the communication parameters	129
5.4.4. Avenues for research and visions for the future	132
5.5. Use case: “Smart buildings”	135
5.6. Conclusion	138
5.7. Bibliography	138
Chapter 6. Autonomic Green Networks	141
Francine KRIEF, Maïssa MBAYE and Martin PERES	
6.1. Introduction	141
6.2. Autonomic networks	142
6.3. Self-configuring	144

6.3.1. Importance of self-configuring for green networks	145
6.4. Self-optimizing	145
6.4.1. Self-optimizing for green networks	147
6.5. Self-protecting	152
6.5.1. Protection of the executive support	154
6.5.2. Protection of the energy source	158
6.5.3. Protection of communications	162
6.6. Self-healing	165
6.6.1. Application to wireless sensor networks	167
6.6.2. Application to smart grids	170
6.7. Conclusion	170
6.8. Bibliography	171
Chapter 7. Reconfigurable Green Terminals: a Step Towards Sustainable Electronics	177
Lilian BOSSUET	
7.1. Sustainable electronics?	177
7.2. Environmental impact of electronic products during their lifecycle	181
7.2.1. Lifecycle of electronic products	181
7.2.2. Microelectronic manufacture	183
7.2.3. Usage of electronic products	191
7.2.4. Electronic waste products	192
7.3. Reduce, reuse, recycle and reconfigure	193
7.3.1. Reduce, reuse, recycle	193
7.3.2. Reconfiguring with the help of FPGAs	196
7.4. Examples of reconfigurable terminals	204
7.5. Conclusion	208
7.6. Bibliography	209
PART 3. RESEARCH PROJECTS ON GREEN NETWORKING CONDUCTED BY INDUSTRIAL ACTORS	215
Chapter 8. Schemes for Putting Base Stations in Sleep Mode in Mobile Networks: Presentation and Evaluation	217
Louai SAKER, Salah Eddine ELAYOUBI and Tijani CHAHED	
8.1. Motivation	217

8.2. Putting macro base transceiver stations in sleep mode	218
8.2.1. Structure of the base transceiver station	218
8.2.2. Model of energy consumption of the BTS	219
8.2.3. Principle of putting BTSs in sleep mode	220
8.2.4. Illustration of sleep mode. Case of multisystem 2G/3G networks	221
8.2.5. Implementation of sleep mode	223
8.3. Sleep mode in small-cell heterogeneous networks	225
8.3.1. Energy efficiency of small cells	227
8.3.2. Putting small cells in sleep mode	229
8.4. Conclusion and considerations on implementation	231
8.5. Bibliography	232
Chapter 9. Industrial Application of Green Networking: Smarter Cities	233
Vincent GAY, Paolo MEDAGLIANI, Florian BROEKAERT, J�r�mie LEGUAY and Mario LOPEZ RAMOS	
9.1. Introduction	233
9.2. Smart cities and green networking.	234
9.3. Techniques involved	237
9.3.1. Low-consumption communication protocols	237
9.3.2. Assistance in the deployment of sensor networks.	242
9.3.3. Low-consumption processor treatments	249
9.3.4. System integration of heterogeneous sensors	258
9.4. Conclusion	266
9.5. Bibliography	267
List of Authors	271
Index	275