

# Contents

## Part I Architecture and Applications

<b>1 Envisioned Network Architectures for IoT Applications .....</b>	3
P. Sarwesh, N. Shekar V. Shet, and K. Chandrasekaran	
1.1 Introduction .....	3
1.2 Network Level Challenges in IoT .....	5
1.2.1 Energy Efficiency .....	5
1.2.2 Reliability and QoS .....	6
1.3 Factors that Affect the Network Performance .....	6
1.3.1 Energy Hole (Node Overload) .....	7
1.3.2 Multi-Retransmissions.....	7
1.3.3 Collision.....	7
1.3.4 Control Packet Overhead .....	8
1.3.5 Delay .....	8
1.3.6 Motivation.....	8
1.4 Envisioned Network Architecture for Low Power IoT Networks ....	9
1.4.1 E-Health.....	9
1.4.2 Environmental Monitoring .....	10
1.4.3 Industrial Automation .....	11
1.4.4 Smart Grid .....	13
1.5 Suitability of Proposed Network Architectures for IoT Scenario and Network Assumptions .....	16
1.6 Conclusion .....	16
References .....	16
<b>2 A Measurement Study of Campus WiFi Networks Using WiFiTracer.</b>	19
Chengwei Zhang, Xiaojun Hei, and Brahim Bensaou	
2.1 Introduction .....	20
2.2 WiFi Measurement Platform .....	21
2.2.1 Measurement Framework Overview .....	22
2.2.2 WiFiTracer Architecture.....	22
2.2.3 Measurement Sampling Procedure.....	24

2.3	Sensing Result Analysis .....	25
2.3.1	Basic WiFi Dataset .....	26
2.3.2	General Analysis of WiFi Networks .....	26
2.3.3	Characterizing Public Campus WiFi Networks .....	30
2.4	Characterization of WiFi Connection Time.....	35
2.4.1	WiFi Connection Dataset.....	35
2.4.2	Characterizing Successful WiFi Connections .....	36
2.5	Related Work .....	39
2.6	Conclusion .....	40
	References .....	40
3	<b>People as Sensors: Towards a Human–Machine Cooperation Approach in Monitoring Landslides in the Three Gorges Reservoir Region, China</b> .....	43
	Zhenhua Li, Guoxuan Cheng, Wenming Cheng, and Hongbo Mei	
3.1	Introduction .....	43
3.2	Project Description.....	44
3.3	The Sensor-Based Monitor System .....	44
3.3.1	The Remote Sensing Monitoring System.....	45
3.3.2	The GPS System .....	45
3.3.3	The Comprehensive Monitoring System .....	47
3.4	The Human-Based Monitoring System: People as Sensors .....	47
3.5	The Monitoring and Early Warning Platform.....	49
3.6	Conclusions .....	50
	References .....	52
4	<b>Two Major Applications in Vehicular Ad Hoc Networks</b> .....	55
	Binbin Zhou, Zhan Zhou, Gang Pan, Shijian Li, Hexin Lv, and Tiaojuan Ren	
4.1	Introduction .....	56
4.2	Rear-End Collision Warning.....	57
4.2.1	Problem Description .....	58
4.2.2	Our Collaborative Real-Time Rear-End Collision Warning Algorithm .....	59
4.2.3	Evaluation .....	62
4.3	Automatic Incidents Detection .....	64
4.3.1	Problem Formulation .....	65
4.3.2	Our Automatic Incidents Detection Approach .....	65
4.3.3	Experiments and Analysis .....	67
4.4	Conclusion .....	69
	References .....	70
5	<b>Concurrency and Synchronization in Structured Cyber Physical Systems</b> .....	73
	Jitender Grover and Ram Murthy Garimella	
5.1	Introduction .....	74

5.2	Concurrent Cyber Physical Systems: Modeling .....	78
5.2.1	Concurrency in Cyber Physical Systems .....	78
5.2.2	Coordination and Maintenance of Concurrent Cyber Physical Systems.....	79
5.2.3	Design Issues: Concurrent CPSs .....	80
5.2.4	Modeling Linear Concurrent CPS .....	80
5.3	Synchronization of Concurrent Cyber Physical Systems .....	83
5.3.1	Networked Cyber Physical Systems: Synchronization .....	83
5.3.2	Clock's Synchronization: Multidimensional CPSs .....	84
5.4	Temporal Semantics: Design of Cyber Physical Systems.....	84
5.4.1	Classification of Cyber Physical Systems (CPSs).....	85
5.4.2	Real-Time CPSs: Temporal Semantics .....	86
5.4.3	Software System: Temporal Semantics .....	88
5.5	Reliability and Fault Tolerance: Concurrent Cyber Physical Systems .....	89
5.5.1	Fault Tolerance.....	89
5.5.2	Fault/Failure Localization: .....	89
5.5.3	Architectural Considerations: Cyber Physical Systems.....	90
5.5.4	Reliability and Fault Management Using Edge Servers .....	91
5.6	Agent Working in Different Conditions.....	92
5.7	Conclusion .....	94
	References .....	94

## Part II Security and Privacy

6	<b>Survey on Access Control Models Feasible in Cyber-Physical Systems .....</b>	103
	Mikel Uriarte, Jasone Astorga, Eduardo Jacob, Maider Huarte, and Oscar López	
6.1	Introduction .....	103
6.2	Context-Related Features and Requirements .....	106
6.2.1	Constrained Device Classification .....	106
6.2.2	Constrained Networks .....	107
6.2.3	Life Cycle and Access Control Requirements.....	108
6.2.4	Use-Case-Driven Access Control Model .....	109
6.2.5	Security Policy .....	109
6.2.6	Security Architecture Overview.....	111
6.2.7	Cryptographic Schema and Key Establishment .....	113
6.3	Access Control Foundations .....	114
6.3.1	Policy-Driven Security Management .....	114
6.3.2	Access Control Models .....	115
6.4	Access Control Policy Languages .....	117
6.4.1	XACML .....	117
6.4.2	Ponder Policy Language.....	119
6.4.3	Rei Policy Language.....	120

6.4.4	Authorization Specification Language (ASL) .....	121
6.4.5	Obligation Specification Language (OSL) .....	121
6.4.6	Privacy-Focused Policy Languages .....	121
6.4.7	Capability-Based Access Control CapBAC .....	122
6.4.8	Discussion on Foundational Approaches .....	123
6.5	IoT Tailored Access Control Approaches .....	124
6.5.1	Authorization Framework for the IoT Based on XACML .....	125
6.5.2	Usage-Based Access Control Adapted to IoT (UCON) .....	128
6.5.3	CapBAC in IoT .....	130
6.5.4	Distributed CapBAC in IoT .....	131
6.5.5	Delegated CoAP Authentication and Authorization Framework (DCAF) .....	134
6.5.6	OSCAR .....	136
6.5.7	Ladon .....	138
6.5.8	Hidra .....	140
6.5.9	Discussion About IoT Taylored Access Control Solutions .....	143
6.6	Conclusions and Future Work .....	146
	References .....	149
7	<b>Security Challenges and Concerns of Internet of Things (IoT)</b> .....	153
	Aniruddha Bhattacharjya, Xiaofeng Zhong, Jing Wang, and Xing Li	
7.1	Introduction .....	154
7.2	Internet of Things Architectures, Properties, and Security Requirements .....	156
7.2.1	Architectures and Basic Properties .....	156
7.2.2	Main Security Requirements and Their Sub-Components .....	163
7.3	Constrained Application Protocol: Application Layer Connection-Less Lightweight Protocol for the Internet of Things .....	170
7.3.1	Constrained Application Protocol .....	170
7.3.2	Constrained Application Protocol–IP Security .....	171
7.4	Datagram Transport Layer Security Overview and Supporting Constrained Application Protocol .....	174
7.4.1	Datagram Transport Layer Security Protocol .....	174
7.4.2	Supporting Constrained Application Protocol .....	177
7.5	Case Studies and Open Research Issues .....	179
	References .....	182
8	<b>Cyber-Physical System Security Controls: A Review</b> .....	187
	Subhrajit Majumder, Akshay Mathur, and Ahmad Y. Javaid	
8.1	Introduction .....	187
8.2	Background .....	188
8.2.1	Cyber-Physical Systems .....	188
8.2.2	CPS Communications .....	190
8.2.3	CPS Models and Aspects .....	192
8.2.4	Security in CPS .....	196

8.3	CPS Security Threats .....	197
8.3.1	General CPS Threat Model.....	197
8.3.2	CPS Security Threats .....	198
8.4	CPS Security Vulnerabilities .....	200
8.4.1	Causes of Vulnerabilities .....	200
8.4.2	Vulnerabilities in ICS .....	201
8.4.3	Vulnerabilities in Smart Grid.....	203
8.4.4	Vulnerabilities in Medical Devices .....	205
8.4.5	Vulnerabilities in Smart Cars.....	207
8.5	Real-World CPS Attacks .....	209
8.5.1	Attacks on Industrial Control System (ICS).....	209
8.5.2	Attacks on Smart grids .....	216
8.5.3	Attacks on Medical Devices.....	218
8.5.4	Attacks on Smart Cars .....	219
8.6	Security Control and Solutions .....	221
8.6.1	General CPS Controls .....	221
8.6.2	Application-Specific Controls.....	222
8.7	Security Challenges .....	228
8.7.1	Challenges in General CPS.....	228
8.7.2	Challenge in ICS .....	228
8.7.3	Challenges in Smart Grids.....	229
8.7.4	Challenges in Medical Devices .....	230
8.7.5	Challenges in Smart Cars.....	230
8.8	Conclusion .....	231
	References .....	232
<b>Index</b>	.....	241