

Table of Contents

Abstract	III
Resumen	V
Resum	VII
Table of Contents	IX
List of figures	XIV
List of tables	XVII
List of acronyms	XVIII
Chapter 1. Introduction	1
1.1. Introduction	1
1.2. Objectives and motivation	3
1.2.1. Objectives	3
1.3. Precedents	5
1.4. Memory organization	7
Chapter 2. State of the art	9
2.1. Introduction	9
2.2. Concept of Internet of Things and Everything (IoT & IoE)	10
2.2.1. Organizations and alliances working on the IoT.....	12
2.2.2. Concept according to the IETF	15
2.2.3. Concept according to some manufacturers	15
2.2.4. Concept according to Cisco	19
2.3. IoT-Networks	20
2.4. IoT-Architectures	20
2.4.1. Level-based architectures.....	21

2.4.1.1	Three levels architecture.....	21
2.4.1.2	Five levels architecture.....	22
2.4.2.	Computing based architectures	23
2.4.2.1	Cloud computing	23
2.4.2.2	Fog computing.....	24
2.4.2.3	Edge computing.....	25
2.4.2.4	Mobile edge computing (MEC).....	25
2.4.3.	Framework based architecture.....	25
2.4.3.1	OCF Architecture	25
2.4.4.	REST architecture	25
2.4.5.	HTTP Proxy Service (HPS) architecture.....	25
2.5.	M2M Interconnection	26
2.6.	IoT Interconnection Technologies.....	26
2.7.	IoT-Protocols	26
2.8.	Router.....	27
2.9.	IoT-Gateway	28
2.9.1.	Centralized Management.....	29
2.9.2.	Gateway agent.....	29
2.10.	IoT-Platforms	29
2.11.	IoT security	30
2.12.	Artificial Intelligence in IoT (IoT-AI).....	30
2.12.1.	Machine Learning (ML).....	30
2.12.1.1	Selection of the ML algorithm	30
2.13.	Conclusion.....	32
Chapter 3.	Proposed interconnection architecture	33
3.1.	IoE concept applied to this architecture.....	33
3.2.	Centrally managed architecture	33
3.3.	Architecture description	34
3.4.	Architecture components and their functions.....	34
3.4.1.	Layer 5 (l_5)	35
3.4.2.	Layer 4 (l_4).....	35

3.4.3.	Layer 3 (l_3).....	35
3.4.4.	Layer 2 (l_2).....	36
3.4.5.	Layer 1 (l_1).....	36
3.4.6.	Processing levels (L).....	36
3.4.7.	AI-Interface.....	37
3.4.8.	Pre-processing.....	37
3.5.	Operation of the Architecture.....	38
3.6.	IoT-Gateway.....	39
3.6.1.	Proposal.....	40
3.6.2.	Use of this architecture	40
3.6.2.1	Object + AI (Smart Things)	40
3.6.2.2	Router + AI (IoT-Gateway like G_0 node).....	41
3.6.2.3	Monitoring dashboard + AI (IoT-SmartPlatform).....	42
3.6.3.	Actors' integration	42
3.6.4.	AI Operation	44
3.6.5.	Algorithm to share resources	45
3.6.6.	DFSP Protocol	46
3.6.6.1	Header	46
3.6.6.2	Body.....	46
3.6.6.3	Message exchange rules.....	46
3.6.7.	M2M Communication.....	47
3.6.8.	MQTT PUBLISH/SUBSCRIBE Architecture	48
3.6.9.	Model for auto-tuning DFSP to IoT-Protocol.....	50
3.7.	Clustering.....	52
3.7.1.	Collaborative workgroups.....	53
3.7.2.	Network Model	53
3.7.3.	Algorithms implementation	57
3.8.	Routing.....	62
3.8.1.	Proposal model.....	63
3.8.2.	AI Technique	68
3.8.3.	Algorithms implementation	69
3.9.	Quality of Experience (QoE).....	70
3.9.1.	Intelligent System architecture.....	72
3.9.2.	Preprocessing and Classifying Algorithms	74

3.9.2.1	Data Preprocessing Process.....	74
3.9.2.2	Classifying Module	79
3.9.3.	Reinforcement Learning Module	82
3.9.3.1	Environment, States and Actions	82
3.9.3.2	Data Structure.....	85
3.9.4.	Rewards, Policy and Objective Function	86
3.10.	Conclusion.....	88
Chapter 4.	Test and evaluation of the proposed architecture.....	90
4.1.	Introduction	90
4.2.	Test on IoT-Gateway.....	90
4.2.1.	Implementation of the devices	90
4.2.2.	Testbed	91
4.1.	Test on clustering.....	96
4.1.1.	Implementation of the devices	97
4.1.2.	Considerations for the simulations	97
4.1.3.	Simulators	98
4.1.1.	Testbed	98
4.2.	Test on Routing.....	107
4.2.1.	Implementation of the devices	107
4.2.2.	Considerations for the simulations	108
4.2.3.	Simulators	108
4.2.4.	Clustering and routing	108
4.2.5.	Testbed	109
4.3.	Test on Quality of Experience (QoE).....	119
4.3.1.	Classification analysis	119
4.3.2.	QoE in Smart Home results.....	121
4.4.	Conclusion.....	124
Chapter 5.	Implementation of the proposed architecture	127
5.1.	Air quality monitoring in a smart city.....	127
5.1.1.	Proposal.....	127
5.1.2.	Interconnected data network (Integration cloud).....	130

5.1.3.	AI operation	132
5.1.4.	Performance test.....	134
5.1.5.	Environment sensors	135
5.1.6.	Testbed.....	135
5.2.	IoT-WLAN proximity network for Potentiostats.....	137
5.2.1.	Proposal.....	137
5.2.2.	Implemented this architecture	139
5.2.3.	Mobile Application (App).....	139
5.2.4.	Performance test.....	141
5.2.5.	Implementation of the devices	142
5.2.6.	Testbed.....	143
5.3.	Conclusion.....	146
Chapter 6.	Tests on real implementations.....	148
6.1.	Introduction.....	148
6.2.	IoT-HOME App	149
6.2.1.	M2M relation between sensor-actuator based on MQTT payload.....	149
6.2.2.	M2M relation between sensor-actuator using JSON into MQTT	150
6.3.	Real devices.....	153
6.4.	Conclusion.....	161
Chapter 7.	Conclusion and future lines of research.....	162
7.1.	Introduction.....	162
7.2.	Conclusion and contributions	162
7.3.	Future lines of research	164
7.4.	Faced problems	165
7.5.	Personal contributions	166
7.6.	Publications derived from the PhD Thesis.....	167
7.7.	Other publications.....	168
Chapter 8.	Bibliography	169