

# Contents

<b>Abstract</b>	<b>v</b>
<b>Acknowledgements</b>	<b>iii</b>
<b>List of Figures</b>	<b>xi</b>
<b>Abbreviations and Acronyms</b>	<b>xv</b>
<b>1 Introduction</b>	<b>1</b>
1.1 Motivation . . . . .	2
1.2 Objectives . . . . .	7
1.2.1 Problem formulation and solution specification . . . . .	9
1.3 Scientific Contributions . . . . .	12
1.3.1 Scientific Publications . . . . .	12
1.3.1.1 Selected Papers . . . . .	12
1.3.1.2 Other Publications . . . . .	14
1.3.2 Research Projects . . . . .	14
1.4 Document Structure . . . . .	15
<b>2 Selected Papers</b>	<b>17</b>
2.1 Summary of the Selected Papers . . . . .	17

## CONTENTS

---

2.2	Selected Paper 1: Defeasible Planning through Multi-Agent Argumentation (CIMA-ICTAI 2010 and its extension in a Book) . . . . .	22
2.2.1	Introduction . . . . .	22
2.2.2	Background . . . . .	23
2.2.2.1	Defeasible Logic . . . . .	23
2.2.2.2	Partial-Order Planning . . . . .	26
2.2.3	Argumentation in POP . . . . .	28
2.2.4	Defeasible argumentation in a multi-agent system . . . . .	31
2.2.4.1	DefPlanner Algorithm . . . . .	33
2.2.4.2	Defeasible Argumentation Multi-Agent Process . . . . .	34
2.2.5	Example of application . . . . .	37
2.2.5.1	Searching for a Solution Plan . . . . .	40
2.2.6	Conclusions and related work . . . . .	45
2.3	Selected Paper 2: An architecture for Defeasible-Reasoning-based Cooperative Distributed Planning (CoopIS 2011) . . . . .	47
2.3.1	Introduction . . . . .	47
2.3.2	Related Work . . . . .	49
2.3.3	Background . . . . .	50
2.3.4	Elements of the MAPA Architecture . . . . .	52
2.3.4.1	The Agents' Planning Model and Arguments . . . . .	52
2.3.4.2	The Qualification Problem and Plan Definition . . . . .	54
2.3.4.3	Interferences among Actions and Arguments . . . . .	56
2.3.5	Cooperative Distributed Planning Protocol in the MAPA Architecture . . . . .	57
2.3.5.1	Plan Generation . . . . .	58
2.3.5.2	Plan Evaluation . . . . .	59
2.3.5.3	Plan Selection . . . . .	61

2.3.6	Evaluating the MAPA architecture within the context of a transit journey planning service . . . . .	63
2.3.6.1	Preliminaries . . . . .	65
2.3.6.2	Implementation . . . . .	68
2.3.7	Conclusions and Future work . . . . .	70
2.4	Selected paper 3: Multiagent Argumentation for Cooperative Planning in DeLP-POP (AAMAS 2011) and its extension in (ArgMAS 2012) . . . . .	71
2.4.1	Introduction . . . . .	71
2.4.2	Preliminaries . . . . .	73
2.4.2.1	DeLP: Defeasible Logic Programming . . . . .	73
2.4.2.2	DeLP-POP: A DeLP extension for POP planning . . . . .	75
2.4.2.3	A DeLP-POP extension for the qualification problem . . . . .	77
2.4.3	Argumentative Dialogues on Multi-agent Plans . . . . .	79
2.4.4	Argumentative-Dialogues-based Multi-Agent Planning . . . . .	83
2.4.4.1	Argumentative Plan Evaluation . . . . .	83
2.4.4.2	Dialogue-based $A^*$ plan search . . . . .	84
2.4.5	A scenario of validation . . . . .	87
2.4.6	Related Work . . . . .	92
2.4.7	Conclusions and Future Work . . . . .	92
2.5	Selected Paper 4: Defeasible Argumentation for Multi-Agent Planning in Ambient Intelligence Applications (AAMAS 2012) . . . . .	94
2.5.1	Introduction . . . . .	94
2.5.2	Components of the system . . . . .	97
2.5.2.1	Ambient Agents . . . . .	97
2.5.2.2	Context information . . . . .	98
2.5.2.3	Planning task . . . . .	99
2.5.2.4	Arguments versus Actions . . . . .	100

## CONTENTS

---

2.5.2.5	Plans . . . . .	100
2.5.3	Multi-Agent Planning Protocol . . . . .	101
2.5.3.1	Overview of the Application Scenario . . . . .	104
2.5.3.2	Plan proposals process . . . . .	105
2.5.3.3	Plan evaluation process . . . . .	107
2.5.3.4	Plan selection process . . . . .	110
2.5.4	Experimental Evaluation . . . . .	111
2.5.5	Conclusions and Future Work . . . . .	113
2.6	Selected Paper 5: Context-Aware Multi-Agent Planning in Intelligent Environments (INS Journal 2013) . . . . .	116
2.6.1	Introduction . . . . .	116
2.6.2	Related Work . . . . .	118
2.6.2.1	Contributions of our model . . . . .	122
2.6.3	Background . . . . .	122
2.6.4	Definition of Components of the Context-Aware System . . . . .	124
2.6.4.1	Ambient Agents and Ambient Artifacts . . . . .	124
2.6.4.2	Context-Aware Information . . . . .	124
2.6.4.3	Planning Tasks . . . . .	125
2.6.4.4	Arguments versus Actions . . . . .	126
2.6.4.5	Plans . . . . .	128
2.6.5	Overview of the Ambient Intelligence Application Scenario . . . . .	131
2.6.5.1	Modeling the Health-Scenario with a Planning Language . . . . .	132
2.6.6	Context-Aware Multi-Agent Planning Protocol . . . . .	138
2.6.6.1	Plan Proposal Process . . . . .	139
2.6.6.2	Plan Evaluation Process . . . . .	142
2.6.6.3	Plan and Goal Selection Process . . . . .	145
2.6.7	Experimental Evaluation . . . . .	146

2.6.7.1	Experimental Settings . . . . .	146
2.6.7.2	Experimental Results . . . . .	147
2.6.7.3	Discussion . . . . .	152
2.6.8	Conclusions and Future Work . . . . .	153
2.7	Selected Paper 6: Argumentation-based Planning (Submitted AIJ 2015) . . . . .	155
2.7.1	Introduction . . . . .	155
2.7.2	Preliminary notions . . . . .	158
2.7.2.1	DeLP: a framework for defeasible argumentation . . . . .	159
2.7.2.2	POP: Partial Order Planning . . . . .	162
2.7.2.3	DeLP-POP: A first extension of POP with DeLP . . . . .	163
2.7.3	Components of Q-DeLP-POP . . . . .	164
2.7.3.1	Action-Argument Steps . . . . .	166
2.7.3.2	Conflicting situations . . . . .	168
2.7.3.3	Activation of Attacking Arguments . . . . .	174
2.7.4	Cooperative Planning Protocol . . . . .	177
2.7.4.1	Multi-Agent Planning Task . . . . .	177
2.7.4.2	Multi-Agent Search Protocol . . . . .	179
2.7.5	Experimental evaluation . . . . .	183
2.7.5.1	Performance analysis . . . . .	187
2.7.5.2	Quality of the solution plans . . . . .	191
2.7.6	Conclusions and Future Work . . . . .	193
<b>3</b>	<b>General discussion of the results</b>	<b>195</b>
3.1	Theoretical Model . . . . .	195
3.2	Language of Planning and Argumentation . . . . .	197
3.3	Framework for cooperative distributed planning . . . . .	199
3.4	Empirical Evaluation . . . . .	200

## **CONTENTS**

---

<b>4 Conclusions</b>	<b>203</b>
<b>References</b>	<b>207</b>